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☆

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☆

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حضرت عبدالحق شہ میر ثالثؒ کی نعت گوئی

حضرت سید عبدالحق شہ میر ثالثؒ خاندانِ شہ میریہ کے چشم و چراغ ہیں۔ آپ کی ولادت ۱۸۷۱ء میں شہر کڈپا میں ہوئی اور ۱۹۳۵ء میں اس دارِ فانی سے کوچ کر گئے۔ آپ ایک صوفی باصفا اور عالم باعمل بزرگ تھے۔ آپ شاعر بھی تھے اور نثر نگار بھی۔ آپ کا شعری سرمایہ دیوان شاہ میر ہے جو ۱۹۲۱ء میں زیورِ طبع سے آراستہ ہوا تھا۔ اس دیوان سے متعلق حضرت محمود بخاریؒ اپنی تصنیف شہ میری اولیاء میں لکھتے ہیں:

''دیوان شاہ میر' حضرت شاہ میر کے کلام حمد و نعت' سلام و منقبت کا لاجواب مجموعہ ہے۔ دیوان کیا ہے! تصوف کا خزانہ' مُعارف کا گنجینہ' عشقِ حقیقی کا پیغام' حُبِ نبوی کا لبریز جام ہے۔'' (ص:۱۱۲)

دیوان شاہ میر میں حضرت شہ میر ثالثؒ نے وافر نعتیں کہی ہیں اور خوب کہی ہیں۔ بقول میر انیسؔ: ''ایک پھول کا مضمون ہو تو سو رنگ سے باندھوں'' کے مصداق حضرت نے حضور اکرم حضرت محمد صلی اللہ علیہ وسلّم کی تعریف و توصیف میں عقیدت کے رنگ برنگ پھول نچھاور کیے ہیں۔ آپ کے کلام کے مطالعہ سے بخوبی اندازہ ہوتا ہے کہ یہ ایک عاشقِ رسول کا کلام ہے۔ جس میں آمد ہی آمد ہے۔ اپنی نعتیہ شاعری پر آپ کو خود ناز تھا۔ کہتے ہیں:

گوہرِ نعتِ رسولِ عربی سے پُر ہے
مرے دیوان کا لے کر یہ خزانہ دیکھو
جتنی غزلیں ہیں سب نعتِ حضرت میں ہیں
قابلِ وصف میرا یہ دیوان ہوا

حضرت کا کلام اپنے اجداد کے کلام کے مقابلے میں کافی نکھرا ہوا ہے۔ انہوں نے کلاسیکی شعری روایات بالخصوص تغزل کی آمیزش سے اپنے نعتیہ کلام کو آراستہ کیا ہے۔ پروفیسر مظفر علی شہ میری نے اپنی تصنیف: حضرت عبدالحق شہ میر ثالثؒ۔ حیات' شخصیت اور فن'' میں یوں رقم طراز ہیں:

''انہوں نے اپنے خاندانِ صوفیہ کے مخصوص موضوعاتِ شاعری کے اظہار اور زبان و بیان میں جو جدت و ندرت پیدا کی ہے' اس کی حیثیت نعتیہ و ذوقیہ شاعری میں اجتہاد کیا ہے۔ ان کے نعتیہ کلام میں غزل کا لوچ اور مٹھاس رچ بس کر باہم شیر و شکر ہو گئے ہیں۔ یہ اپنی نوعیت کا جدید رنگ ہے جو ان کے شعرائے سَلَف کے یہاں نہیں ملتا۔'' (ص:۴۲)

حضرت شہ میر ثالثؒ کی صاف زبان' شائستہ بیانی' سادگی و سلاست' نرم و شیریں لہجے نے شہ میری اولیا کے کلام میں آپ کو منفرد مقام عطا کیا ہے۔ جس کا آپ کو خود احساس تھا۔ فرماتے ہیں:

میں نازاں ہوں رسول اللہ کی مدحت سرائی پر
کوئی شہ میر مجھ جیسا غزل خواں ہو نہیں سکتا

حضرت شہ میر ثالثؒ کے نعتیہ کلام میں سرکارِ دو عالم حضرت محمد مصطفیٰ صلی اللہ علیہ وسلّم کی عظمت و بزرگی کا بیان' اوصاف حمیدہ کا عقیدت سے بھرا اظہار، قد و قامت' صورت و سیرت کا ذکر' دیدار مصطفیٰ کی تمنا اور مدینہ منورہ کی سرزمین سے محبت کا والہانہ اظہار ملتا ہے۔ ان موضوعات کو حضرت نے نہایت عمدگی سے شعر کے قالب میں ڈھالا ہے۔ حضرت کا نعتیہ



اردو ادب کے فروغ میں مذہبی ادب کا کردار

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ستار فیضیؔ کی شاعری میں مذہبی عناصر

ڈاکٹر محمد نثار احمد

اسوسی ایٹ پروفیسر، شعبہ اردو ایس-وی-یونیورسٹی، تروپتی (آندھرا پردیش)

جناب ستار فیضی کا نام شیخ عبدالستار ہے۔ قلمی نام ستار فیضی اور تخلص فیضیؔ۔ یکم جون 1965 (انیس سو پینسٹھ عیسوی) کو کڈپہ میں پیدا ہوئے۔ اردو میڈیم سے تعلیم حاصل کی۔ انھیں اردو سے والہانہ محبت ہے۔ 1989ء (انیس سو نواسی عیسوی) میں اردو کے مدرس بنے۔ اُس وقت سے آج تک انھوں اردو درس و تدریس اور اردو شعر و ادب کے لیے اپنے آپ کو وقف کر دیا۔ اِن دنوں ستار فیضی کڈپہ ضلع میں میدکور کے ضلع پریشد اردو ہائی اسکول میں اسکول اسسٹنٹ کی حیثیت سے خدمات انجام دے رہے ہیں۔

ستار فیضی آندھرا پردیش کے اہم اور ممتاز شعراء میں شمار کئے جاتے ہیں۔ انہوں نے شاعری میں مختلف اصناف پر طبع آزمائی کی ہے۔ حمد، نعت، مناجات، منقبت، غزل اور نظم کے علاوہ انھوں نے کہانیاں اور مضامین بھی لکھے ہیں۔ ان کی کہانیاں اور نظمیں مختلف اخبارات، رسائل و جرائد میں شائع ہوتے ہیں۔ چند ایک کے نام یہ ہیں: گل بوٹے ممبئی، بچوں کی دنیا دہلی، الحیات رانچی، روشن ستارے حیدرآباد، دعوت دہلی، الہدیٰ نیپال، ندائے صالحات کڈپہ، قومی صحافت لکھنؤ، صدائے بسمل جارکھنڈ، تریاق ممبئی، ماہنامہ اردو دنیا، ماہنامہ تریاق، بدرِ کامل ناندیڑ کے علاوہ سالار و یکلی، روزنامہ سیاست، روزنامہ اعتماد اور روزنامہ رہنمائے دکن میں ان کے مضامین شائع ہوتے ہیں۔

ستار فیضی کا مجموعۂ کلام ''دھنک'' کے نام سے اردو اکیڈمی آندھرا پردیش کی جزوی مالی تعاون سے 2014ء شائع ہو چکا ہے۔ ان کے مضامین کا مجموعہ ''مہک'' اور شعری مجموعہ ''کسک'' زیرِ طبع ہے۔ سرورِ کونین کے نام سے ایک شراکتی نعتیہ مجموعہ بھی اردو اکیڈمی کے مالی تعاون سے منظرِ عام پر آ چکا ہے۔ اس کے علاوہ ''چھتیس حرکاتی نظمیں''، ''فیضی کے سو 100 شعر''، ''فیضی کی پچاس پہیلیاں''، ''ایکٹیوٹی بک''، ''لطیفوں کا مجموعہ ''مسکان''، بچوں کی نظمیں ''غنچہ غنچہ''، ''بھارت میرا مہان'' اور گذشتہ دنوں ان کی نعتوں پر مشتمل ایک مجموعہ ''شاہِ اُمَم'' کے نام سے شائع ہو چکا ہے۔ ستار فیضی صاحب نے تیلگو میں بھی چند کتابچے شائع کئے ہیں۔ اردو ساہتیہ نُو رتنالو، بھکتی مُکتی، بھارتیہ پرمُکھا مسلم مہیللو، وغیرہ شائع ہو چکے ہیں۔

ستار فیضی کی ادبی شخصیت کی کئی جہتیں ہیں۔ ستار فیضی نے اپنی شاعری میں مذہبی موضوعات کو مختلف جہتوں میں پیش کیا ہے۔ حمد و نعت اور دعا و مناجات کے علاوہ دیگر منظومات میں بھی دینی، اسلامی اور

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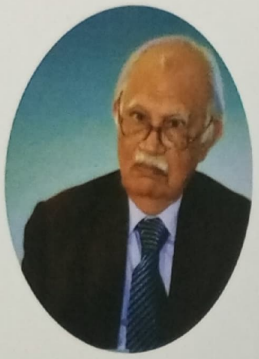
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پروفیسر قاضی حبیب احمد

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Edited By:
Dr S. Mohamed Yassir
Hafiz Mohammed Saifi Oomeri

"پروفیسر بی شیخ علی
حیات اور خدمات"



مرتب ڈاکٹر محمد نصر اللہ خان

اسسٹنٹ پروفیسر، شعبۂ اردو، کرناٹک اسٹیٹ اوپن یونیورسٹی، میسورو

ناشر

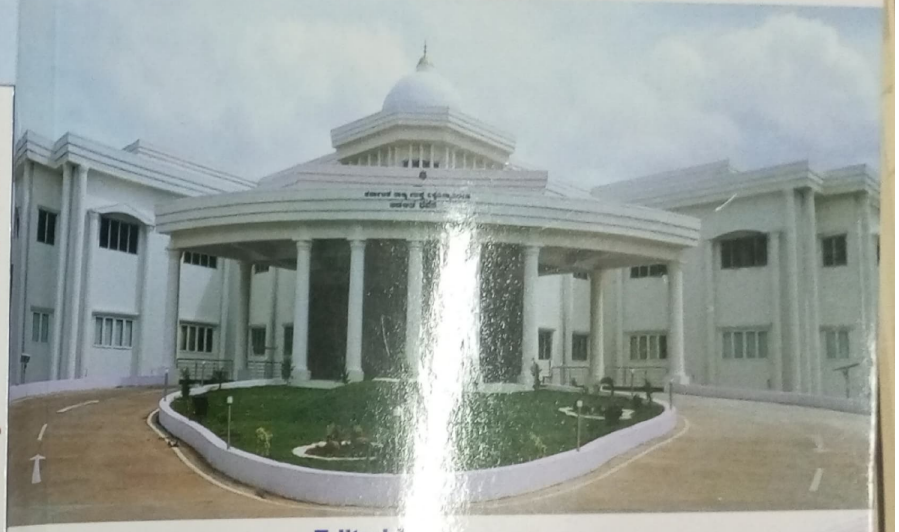
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مکتا گنگوتری، میسورو، 570006

2023

"Prof. B. Sheik Ali Hayath Aur Khidmaath"

"پروفیسر بی شیخ علی حیات اور خدمات"



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پروفیسر بی شیخ علی کی تعلیمی خدمات - ایک جائزہ

ڈاکٹر محمد نثار احمد

صدر شعبۂ اردو، ایس۔ وی۔ یونیورسٹی

تروپتی، آندھرا پردیش

پروفیسر شیخ علی کی شخصیت کرناٹک ہی نہیں بلکہ جنوبی ہند کی قد آور شخصیت تھی۔ انہوں نے ہندوستان اور بیرون ہند بھی اپنی تحقیقات اور تصنیفات کے ذریعے ایک بلند مقام حاصل کیا۔ پروفیسر شیخ علی ایک مشہور مؤرخ، فلسفۂ تاریخ کے رمز شناس، محقق اور مصنف تھے۔ ان کا دائرہ کار صرف تاریخ تک محدود نہیں تھا بلکہ مذہب، ادب، صحافت اور سماجیات و سیاسیات پر بھی انہیں گہرا عبور حاصل تھا۔ ان کی شخصیت ہمہ جہت شخصیت تھی۔ وہ مختلف عہدوں پر فائز رہے۔ ان کی تعلیم میسور یونیورسٹی، علی گڑھ مسلم یونیورسٹی اور لندن یونیورسٹی میں ہوئی۔ انہوں نے ان دونوں یونیورسٹیوں سے تاریخ میں پی ایچ ڈی کی ڈگری حاصل کی یعنی علی گڑھ مسلم یونیورسٹی اور لندن یونیورسٹی۔

انہوں نے اپنی مادر علمی میسور یونیورسٹی سے اپنی تدریسی خدمات کا آغاز کیا۔ تقریباً چالیس سال پروفیسر کی حیثیت سے خدمات انجام دینے کے بعد ملک کی دو مؤقر یونیورسٹیوں کے وائس چانسلر کی حیثیت سے شاندار کارنامے انجام دیئے۔ یونیورسٹی آف گوا اور منگلور یونیورسٹی میں ان کی گراں بہا خدمات کا اعتراف کیا جاتا ہے۔ یہ اعزاز بہت کم افراد کو حاصل ہوتا ہے۔

اعلیٰ تعلیمی اداروں میں اعلیٰ تعلیم حاصل کرنے اور شاندار تدریسی خدمات انجام دینے کی وجہ سے انہیں تعلیم کی اہمیت اور افادیت کا بخوبی اندازہ تھا۔ تعلیمی اداروں کے انتظام اور نظم و نسق کے سلسلے میں طویل ترین تجربہ ان کے ساتھ تھا۔ وہ ہمیشہ قوم و ملت کی تعلیمی ترقی کے لیے فکرمند رہتے تھے۔ ان کا ایقان تھا کہ تعلیمی ترقی ہی کے ذریعے قوم و ملت کی ترقی ہو سکتی ہے۔

پروفیسر شیخ علی تعلیم کی اہمیت اور علم کی فضیلت کے بارے میں ایک جگہ لکھتے ہیں:

''اسی لیے کہتے ہیں کہ قوموں کا مستقبل درسگاہوں میں ڈھلتا

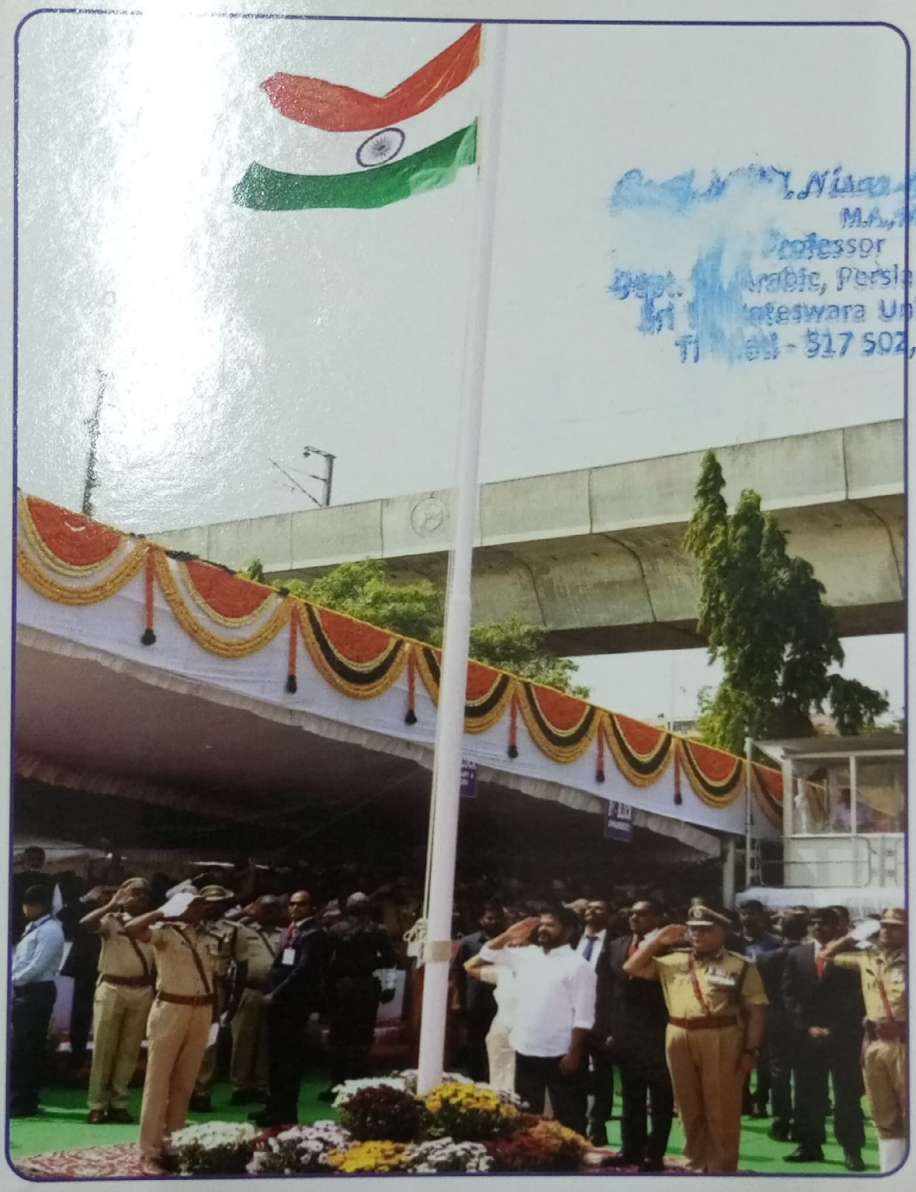
ہے اور قوموں کے معمار معلم ہوتے ہیں۔ علم ہی ایک ایسی واحد دولت ہے جو لٹانے سے بڑھتی ہے اور بچانے سے گھٹتی ہے۔ مذہب اسلام کی ابتداء اقراء یعنی پڑھنے کے حکم سے شروع ہوئی۔ یہ قرآن مجید کی پہلی وحی ہے۔ جو رسول اکرم صلی اللہ علیہ وسلم پر نازل ہوئی۔'' (ارمغانِ سالار، ص:68)

پروفیسر شیخ علی ایک ماہر تعلیم تھے۔ انہوں نے فلسفۂ تعلیم کی مشہور شخصیات کا گہرا مطالعہ کیا تھا۔ وہ خاص طور پر عالم اسلام کے مفکرین سے متاثر تھے جن میں مولانا رومی، حافظ شیرازی، امام غزالی، سرسید احمد خان، علامہ شبلی نعمانی، مولانا حالی، علامہ اقبال، مولانا ابوالکلام آزاد اور ڈاکٹر ذاکر حسین وغیرہ قابل ذکر ہیں۔ ان مفکرین کے افکار اور تعلیمی تصورات سے متاثر ہو کر انہوں نے ان افکار کو اپنے فکر و نظر میں شامل کر لیا تھا۔ وہ ان بزرگوں کی تعلیمی خدمات کے معترف تھے۔ انہوں نے اپنے مضامین میں خاص طور پر تعلیمی تصورات کا ذکر کیا ہے۔ انہوں نے ماہر تعلیم ڈاکٹر ذاکر حسین پر انگریزی میں ایک کتاب کرناٹک کے گورنر خورشید عالم خان کے ساتھ لکھی جسے ساہتیہ اکیڈمی نے شائع کیا۔ پروفیسر ابوالکلام قاسمی نے اس کا اردو ترجمہ کیا ہے۔ اس کتاب میں پروفیسر شیخ علی نے نہایت عمدہ اسلوب میں ڈاکٹر ذاکر حسین کے تعلیمی تصورات کو مبسوط اور مفصل پیش کیا ہے۔ اصلاحِ نصاب کے سلسلے میں سابق صدر جمہوریہ ہند ڈاکٹر ذاکر حسین کے حوالے سے ایک جگہ لکھتے ہیں:

''ایک اور اہم بات یہ ہے کہ ہمارے طرزِ تعلیم میں اصلاح چاہیے۔ ڈاکٹر ذاکر حسین صاحب ماہر تعلیم نے تعلیمی اسلوب کے جو طریقے سکھائے ہیں، ان کی تعمیل چاہیے۔ انہوں نے کہا کہ انگریزوں نے تعلیم کا جو مقصد قرار دیا تھا، وہ اب تک باقی ہے یعنی نوکری۔ اس کو بدل کر اخلاقی شخصیت کی تعمیر تعلیم کا مقصد ہونا چاہیے۔ مقصد کے تعین کی کسوٹی تہذیب ہے۔'' (ارمغانِ سالار، ص:76)

پروفیسر شیخ علی کی تعلیمی خدمات کے سلسلے میں قابل ذکر پہلو یہ ہے کہ وہ ایک طرف الامین تعلیمی تحریک سے وابستہ رہے۔ اس کے روحِ رواں اور سرپرست کی حیثیت سے ابتداء

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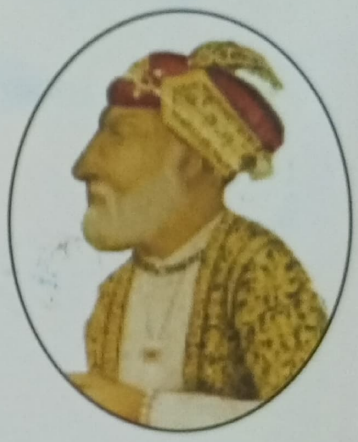
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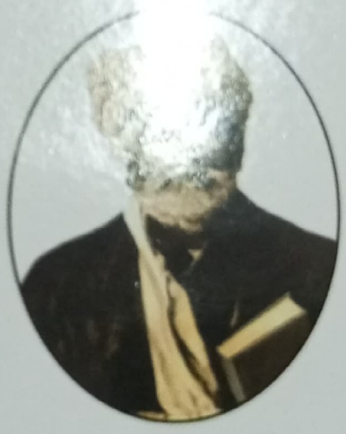
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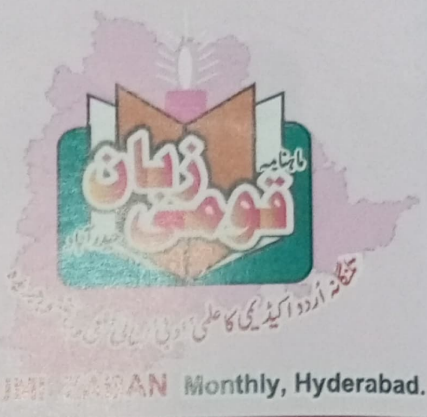
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پروفیسر محمد علی اثر



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''قومی زبان'' میں شائع شدہ مضامین میں اظہار کردہ خیالات سے ادارہ کا متفق ہونا ضروری نہیں ہے۔

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میرؔ کے کلام میں سادگی اور پُرکاری

خدائے سخن میر تقی میرؔ (ولادت 1722 - وفات 1810) اردو کے ممتاز ترین شعراء میں سب سے نمایاں مقام کے حامل ہیں۔ ان کے کلام کی گوناگوں خصوصیات کی وجہ سے ان کی اہمیت آج بھی اردو دنیا میں امتیازی مقام اور اہمیت کی حامل ہے۔ مستقبل میں بھی ان کے کلام کو اہمیت دی جاتی رہے گی۔

میرؔ کے کلام میں بہت سی ایسی خصوصیات ہیں، جن کی وجہ سے میرؔ کو یہ مقام و مرتبہ حاصل ہوا ہے کہ ان کو خدائے سخن قرار دیا گیا۔ ان کے کلام کے بہتر نشتر تو مشہور ہیں ہی، اس کے ساتھ ساتھ ان کے کلام میں سادگی، سلاست، تاثیر اور اثر آفرینی کی خصوصیات ان کو اردو کے شعرا میں ممتاز اور منفرد مقام عطا کرتے ہیں۔

سادگی اور پُرکاری دراصل میرؔ کے کلام کی نمائندہ اور ممتاز خصوصیت ہے۔ میرؔ کے کلام میں الفاظ و معنی کی سطح پر پیچیدگی کے بجائے سادگی کا غلبہ زیادہ ہے۔ وہ سہل اور آسان الفاظ کے ذریعہ عام فہم اسلوب میں اپنے خیالات کو پیش کر کے متاثر کرنے کا گُر جانتے ہیں۔ میرؔ نے اسی سادگی کے ذیعہ اپنی پُرکاری کا جادو جگایا ہے۔ ان کا یہ جادو سر چڑھ کے بولتا ہے۔ تاثیر اور تاثُر کا وفور میرؔ کے کلام کی جان ہے۔ اسی خصوصیت نے ان کے کلام کو ایک نئی جہت عطا کی ہے۔

میر تقی میرؔ کا خیال ہے کہ ان کے اشعار اگرچہ کہ خواص کو پسند ہیں لیکن ان کے مخاطب عوام ہیں۔ گویا خواص اپنے طور پر پسند کرتے ہیں جب کہ خود انہوں نے عوام کو مخاطب کیا ہے۔ وہ خود کہتے ہیں:

شعر میرے ہیں گو خواص پسند
پر مجھے گفتگو عوام سے ہے

میرؔ کے کلام میں یہی وہ خصوصیت ہے کہ وہ خود خواص میں بھی مقبول ہیں اور عوام میں بھی۔ انہوں نے عوام سے گفتگو کرنے کو ترجیح دی اور خواص خود ان کے کلام کی جانب التفات کرنے پر مجبور ہیں۔ اس سے ان کے مزاج اور شعری رجحان کا بخوبی اندازہ لگایا جا سکتا ہے۔ میرؔ کو خود اس بات کا بھی احساس تھا کہ ان کے کلام میں جو روانی اور سلاست ہے، یہی ان کی شاعری کا کمال ہے اور اس کا اظہار انہوں نے اپنے ایک شعر میں یوں کیا ہے:

میرؔ، دریا ہے، سنے شعر زبانی اس کی
اللہ اللہ رے، طبیعت میں روانی اس کی

میرؔ کے کلام میں نہ کوئی ایہام ہے نہ ابہام ہے۔ ان کے یہاں صنائع اور بدائع یا پھر فنی مرصع کاری بھی نہیں لیکن ان کی سادگی اور سلاست نے ان کو مقبولیت عطا کی ہے۔ میرؔ کے شعر یوں متاثر کرتے ہیں۔ جذبات کی صداقت اور تجربات کی حقیقت بیانی کے ساتھ ان کے اظہار میں وہ دلکشی اور جاذبیت ہے کہ وہ متاثر کرتے ہیں اور تاثر بھی دیرپا

مضامین

Prof K.V.Saritha
Department of Biotechnology

Vegetos
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RESEARCH ARTICLES

Effect of modified MS medium on in vitro propagation of *Indigofera barberi* Gamble An endemic hepatoprotective, recalcitrant medicinal plant of Seshachalam Biosphere reserve

G. Sindhu Reddy[1] · K. V. Saritha[1]

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Abstract
Indigofera barberi belongs to Fabaceae is an endangered, high valued endemic erect, perennial under shrub. Therefore standardization of micropropagation protocol is desirable for its *ex situ* conservation. The present study describes micropropagation protocol for *I. barberi* using nodal explants. Three culture media (MS, B5 and WPM) tested for shoot initiation. MS medium was chosen based on better bud break and shoot initiation. Further, different strengths of MS major salts tried and 100% of shoot initiation observed on MS (major – HS) containing BAP/ Zeatin (0.5 mg/L) /Adenine sulphate (25 mg/L). Maximum shoot multiplication rate (17.4 ± 0.01) and shoot length (2.10 ± 0.18 cm) attained by using MS (major – HS (Half strength)) with 0.5 mg/L each BAP, KN and $AgNO_3$. Rhizogenesis of regenerated shoots successfully achieved on ½ strength MS with 1.0 mg/L IBA with root number (8.2 ± 0.44) and length (6.73 ± 0.26 cm). Hardening and acclimatization was successful with 80% of survival rate of plantlets.

Keywords *Indigofera barberi* · Culture media · Plant growth regulators · In vitro culture

Introduction

Indigofera barberi Gamble (*I.barberi)* is a rare, valuable endemic erect, perennial under shrub belongs to Fabaceae family. It is mainly distributed in Kadapa, Kurnool and Chittoor districts (Sheshachalam hills) of Andhra Pradesh at an elevation of 300 to 700 m (Madhava chetty et al. 2013). Entire plant including flowers of this plant is used traditionally as folklore medicine in India to cure liver diseases, pectic ulcers, diabetes, renal diseases, skin diseases and also as antihelminthic (Srinivasan and Sathyanarayana 2014a; Devi 2011; Palani et al. 2009, Madhava chetty et al. 2008). Pharmacognostical investigation carried out on the leaves and stems of *Indigofera barberi* (Srinivasan and Sathyanarayana 201b). Leaf extract has been used effectively for treatment of wounds, cuts, burns and boils (Sreelatha et al. 2013). This plant is also used in dealing of certain diseases like urolithiasis, arthritis & hypertension (Jaya sankar et al. 2014). The whole plant showed antimicrobial (Sreelatha et al. 2013), leaves exhibit antifungal (Srinivas et al. 2013) and ethanolic extracts of whole plant exhibit antioxidant activity (Jaya sankar et al. 2014). The leaf powder of *I. barberi* used as a dye and colouring agent (Sreelatha et al. 2013). Hepatoprotective potential of *I. barberi* evaluated using isolated compound from *I. barberi* in in vitro studies on HepG2 cells (Srinivasan 2019).

Despites of its multipurpose medicinal and economic importance, this plant species is critically endangered due to habitat destruction, fragmentation of population and poor seed germination (Jaya sankar et al. 2014). It is enlisted as an endangered plant (Sreelatha et al. 2013, Nayar and Sastry, 1990). In vitro regeneration of plant offers a potential solution not only for conservation but also for rapid propagation of rare, valuable, and endangered plants which can be used to release to their natural habitat or for mass cultivation for production of pharmaceutical product of interest (Costa et al. 2003; Nalawade and Tsay 2004). The studies on tissue culture of *I. barberi* Gamble have not been attempted. This is the first report on tissue culture of *I. barberi* Gamble.

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GREEN APPLICATION AND PROSPECTS OF WOUND HEALING APPLICATIONS ON ZEBRA FISH USING *Bougainvillea glabra* DERIVATIVES

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ABSTRACT

In traditional medicine, inflammatory disorders are treated with a variety of plants and herbs. Given the numerous side effects of modern medicine, indigenous drugs with fewer side effects should be sought out as a better alternative for treating inflammation with Bougainvillaea glabra Linn. It is now widely acknowledged that medicinal plants play an important role in traditional health care practices, providing insights into new areas of drug research and biodiversity conservation. Inflammation is a complex biological response by vascular tissues to harmful stimuli such as pathogens, damaged cells, and irritants. It is the organism's protective attempt to remove injurious stimuli while also initiating the tissue healing process, and it is thought to be the primary cause of rheumatoid arthritis. Drugs used to treat pain and inflammation have toxic side effects when taken on a long-term basis. As a result, efforts are being made to investigate promising plants, which could lead to the development of newer or safer drugs.

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Antibacterial Activites and Anti Inflamatatory of Bougainvillea glabra- An Review

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ABSTRACT
The Nyctaginaceae family includes the climbing plant known as Bougainvillaea, or Bougainvillaea glabra, which is native to South America. Because of the colour of its bracts, which are often referred to as "flowers" and are composed of bracts, which are the striking parts, and the true flowers, which are small and white, the Bougainvillaea is widely acknowledged for its significance in horticulture. In traditional medicine, Bougainvillaea is commonly used to treat gastrointestinal disorders, respiratory conditions like bronchitis, asthma, and cough, as well as insecticidal and antibacterial properties. Information regarding the botanical description, ecological significance, phytochemistry, antimicrobial toxicology, and traditional uses of B. glabra are compiled in this review.

KEYWORDS
Bracts, traditional medicine, antimicrobial, Phytochemistry

Date of Submission: 25-05-2024 Date of acceptance: 06-06-2024

I. OVERVIEW

According to estimates from the World Health Organisation, 80% of people in developing nations still get their primary medical care from traditional medicines, which are primarily plant-based medications. Although many dangerous and deadly side effects have recently been reported, herbs are supposed to be safe [1]. Therefore, research into the antimicrobial qualities of herbs is desperately needed as it will aid in the treatment of a number of illnesses brought on by microbes. Numerous plant families are important sources of natural antimicrobials and serve as reservoirs for potent chemotherapeutics. Consequently, plant extracts have been utilised for a vast range of applications for thousands of years. The genus *Bougainvillae*, which belongs to the *Nyctaginaceae* (4 O'clock) plant family, contains 18 species, three of which are horticulturally important:

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ESTIMATION OF ANTIBIOTIC RESIDUEs IN AQUACULTURE PRODUCTS (FISH AND FISHERY PRODUCTS) AS PER 2002/657/EC GUIDANCE

K.VANITHA[1], T.GEETHARATHAN*[1], M.HEMALATHA[2]

Department of Biotechnology, Sri Venkateswara University, Tirupati, A.P.

Abstract:

In recent years, antibiotics have been used widely in intensive shrimp culture and this may lead to their contamination of the environment. Surveys on residues of Nitro furan metabolites [AOZ, AMOZ, AHD, SEM], Chloramphenicol in water and mud in shrimp ponds in mangrove areas were conducted in then or this well as in south of Viet Namin July and August,2002.The results show that these antibiotics are found in all samples in both shrimp ponds and surrounding canals. The highest concentrations ofNitrofuranmetabolites[AOZ,AMOZ,AHD,SEM].Chloramphenicolare1.04,2.39,6.06,and2.50ppm in waters amples;and734.61,820.49,2615.96,426.31ppm(based on wet mud weight), respectively. The comparison of antibiotics residues between study sites and types of shrimp ponds will be discussed in this paper. The results also suggest that antibiotics residues may cause harmful effect on ecosystems in the study sites. An analytical method based on LCMS was developed and optimized in order to determine the most useful antibiotics (Nitrofuranmetabolites [AOZ, AMOZ, AHD, SEM], Chloramphenicol) used in aquaculture. A simple extraction procedure, without any clean-up step, was evaluated in order to obtain maximum analyte recovery from shrimp samples (Machobrachiumrosenbergi, Machobrachiummalcolmsoni, Panaeusmonodo, Fenneropanaeusindicus, Litopanaeus Vannamei, and Litopanaeus).

Keywords: Aquaculture, Antibiotics, Shrimps, Nitro furan metabolites, LCMS.

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Introduction:

Inhalation of pollutants such as volatile organic compounds (VOCs) has been shown to have many side-effects on human health. A group referred to as BTEX (benzene, toluene, ethyl benzene and the three isomers of xylene) has been found to be potentially hazardous to environmental and human health. These volatile chemicals are genotoxic compounds. Inhaling these volatile compounds can produce DNA damage in the form of strand breaks. If the level of such DNA damage is high, result in somatic mutations and also in certain genetic effects and it can produce pathological changes in various tissues or systems in the body. This may be carried over to subsequent generations. Hence it is highly important to test the chemical compounds in the environment of man for their mutagenicity. In the present study clearly indicates that the level of DNA damage in petrol pump workers is significantly high, if such damage persists in them it may leads to clinical problems. They should take preventive measures to reduce the exposure to such vapor and thereby avoid clinical problems in future.





Dr.T.Geetharathan has been working as Academic Consultant in the dept of Biotechnology, S.V.University, Tirupati, since 2016. She has published 15 research papers in reputed journals& contributed 30 papers in the International and national conferences & published 2 books. She got Uttama Adyapika Award in 2022 and Best Woman Scientist Award in 2023.

FOR AUTHOR

Geetharathan Thayyuru

To Evaluate the Prolonged exposure to BTEX Compounds on human genetics

Human Exposure of Volatile Chemicals

LAP LAMBERT Academic Publishing

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Weighted Gene Co-expression Network Analysis of Glioblastoma Gene Expression Microarray Data

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Abstract

Glioblastoma is a highly aggressive and lethal form of brain cancer characterized by its complex molecular landscape. Understanding the underlying gene expression patterns and their relationships is essential for unraveling the mechanisms driving this disease. In this study, we conducted a Weighted Gene Co-expression Network Analysis (WGCNA) on Glioblastoma gene expression microarray data to identify co-expressed gene modules and potential key regulatory genes associated with the disease. Utilizing a comprehensive dataset of Glioblastoma samples, we performed quality control and preprocessing to ensure the reliability of the data. WGCNA was employed to construct a weighted gene co-expression network, enabling the identification of modules of co-expressed genes. The correlation between these modules and clinical characteristics such as patient survival, tumor grade, and other relevant factors was assessed. Additionally, we conducted functional enrichment analysis to gain insights into the biological processes and pathways associated with the identified gene modules. Our findings revealed distinct gene modules associated with Glioblastoma progression and patient outcomes. Notably, we identified key hub genes within these modules, which may serve as potential biomarkers or therapeutic targets. Furthermore, functional enrichment analysis provided a comprehensive understanding of the biological processes and pathways influenced by these co-expressed gene modules. In conclusion, our Weighted Gene Co-expression Network analysis of Glioblastoma gene expression microarray data has shed light on the complex gene interactions and regulatory networks underlying this aggressive brain cancer. This knowledge may ultimately contribute to the development of novel diagnostic and therapeutic strategies, improving the prognosis for Glioblastoma patients..

Keywords: *Glioblastoma, Weighted Gene Co-Expression, Potential Biomarkers, Diagnostic And Therapeutic Strategies*

1. Introduction

Glioblastoma, also known as Glioblastoma Multiforme (GBM) is an aggressive type of cancer most commonly occurred in supratentorial region (frontal, temporal-parietal, and occipital lobes) and also rarely located in cerebellum and very rare in the spinal cord(1). It forms from cells called astrocytes that support nerve cells and spreads easily within months(2,3) and one of the most aggressive, invasive, and undifferentiated type of tumor which eventually results death within a short period of time. The median survival rate from the time of diagnosis was just 15 months(4,5). And 90% of glioblastoma multiforme cases develop from glial cells by multistep tumorigenesis and remaining 10% from secondary neoplasm, takes 4-5 years to develop(6). GBM, which develops as a fresh or new grows within 3 months with symptoms such as headaches, nausea, and symptoms similar to stroke and further during the progress of the disease may cause unconsciousness(7,8). The incidence of central nervous system (CNS) tumors in India ranges from 5 to 10 per 0.1 million populations with an increasing trend and accounts for 2% malignancies. This is usually from the hospitalized data of a neuro-oncology, where the majority of tumors are high-grade Glioma's accounting for 59.5% of all CNS tumors with higher urbanized male population (9). Overall, the incidence rate in males was 1.62 times higher than females across the globe(10). In the case of the United States, the incidence rate of

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PUBLICATIONS & BOOKS

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CHAPTER

12

Enigmatic role of T cells in pancreatic ductal adenocarcinoma: An introspective study

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Abstract

By 2030, pancreatic ductal adenocarcinoma is predicted to be the second most common cause of cancer deaths. In pancreatic cancers, T-cell numbers are limited in the tumor microenvironment without eliciting any anti-tumor activity. Recent studies showed that triggering T-cells to elicit anti-tumor activity may provide better outcomes in immunologically cold cancers like pancreatic cancer. To improve the outcome in a 5-year survival period of a pancreatic cancer patient, the identification of factors downregulating T cell activity in the tumor microenvironment plays an important role in the development of effective translational therapy. In this review, we summarized the role of T cells and their phenotypes in pancreatic cancer progression and pathogenesis, mechanisms behind T-cell exhaustion, and T-cell-based immunotherapies to understand the factors involved in T cell inactivation are crucial for the development of effective translational therapies.

Abbreviations

APC	antigen-presenting cells
CAFs	cancer-associated fibroblasts
CAR T cell	chimeric antigen receptor T cells
CDKN2A	cyclin-dependent kinase inhibitor 2A
CTLA-4	CTL-associated antigen 4
CTLs	cytotoxic T-lymphocytes
EGFR	epidermal growth factor receptor
ERK	extracellular receptor kinases

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Abstract:

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Keywords: Aquaculture, Antibiotics, Shrimps, Nitro furan metabolites, LCMS.

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Introduction:

AMTIMICROBIAL ACTIVITY OF TISSUE FROM BIVALVE, MOLLUSKA, GASTROPODA FROM PARANGIPETTAI SOUTH EAST

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ABSTRACT

Bivalvia are a group of marine and freshwater mollusks that used to be known as the lamellibranchiate and pelecypoda. They have bodies that are compressed laterally and are enclosed by a shell that has two hinged parts. The radula and odontophore, two common moll scan organs, are absent from bivalves as a group. They include the freshwater clams, oysters, cockles, mussels, and scallops, among many other families. The majority feed on filters. Ctenidia, which are specialized organs for breathing and feeding, have developed from the gills. The majority of bivalves bury themselves in sediment, a relatively safe place from predators. Others rest their bodies on the sea floor or on rocks or other hand surfaces. A few bivalves, for example, the scallops and document shells, can swim. The shipworms live inside materials like wood, clay, or stone that they bore into.

KEYWORDS

Antimicrobial activity, tissues.

INTRODUCTION

A bivalve's shell is made of calcium carbonate and consists of two valves, which are typically similar to one another. These are connected along one edge by a flexible ligament that

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PHOSPHATE SOLUBILIZING MICROORGANISMS ASSOCIATED WITH MANGROOVE SOIL IN EAST COASTAL OF INDIA

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1. INTRODUCTION

Phosphate solubilizing bacteria (PSB) are beneficial bacteria capable of solubilizing inorganic phosphate from insoluble compounds. P-Solubilization ability of Rhizosphere microorganisms is considered to be one of the most important traits associated with plant phosphate nutrition[1]. It is generally accepted that the mechanism of mineral phosphate solubilization by PSB strains is associated with the release of low Molecular weight organic acids, through which their hydroxyl and carboxyl groups chelate the actions bound to phosphate, there by converting it into soluble forms. PSB have been introduced to the Agricultural community as phosphate Biofertilizer[2], [3], [o4], [5].

Microbial biodiversity inmangrove ecosystem is one of thedifficult areas of biodiversity research.Study of biogeography, communityassembly and ecological processes inmangrove ecosystem require extensiveexploration, isolation and identificationof potential microorganisms havingspecificity for recalcitrant compounds[6].Physical and chemical factors ofmangrove ecosystem control theabundance and activities of bacteria inmangrove environment. Mangroveforests in India are productiveecosystems and sensitive to theenvironmental changes. In themangrove ecosystem, microorganismsperform various activities such asphotosynthesis[7], nitrogen fixation[8],methanogenesis[9],agarolysis,production[10] of antibioticsand enzymesetc., result in high productivity[11], [12].

Special Mangrove soil niches possess valuable microbial resources. Unfortunately, up to the present, so far there is very little knowledge on the mangrove soil microbial communities. It mainly due to the limitations of research methods. Cultureindependent approaches based on 16S rRNA, 18S rRNA gene analysis open the window to study microbial diversity in mangrove soil. The progress had achieved about studying on mangrove soil microbial species diversity, metabolic diversity and treating environmental pollutions was summarized in the paper. In addition, the bright future of mangrove soil microorganisms was describedPhosphate (p) is one of the major essential Macronutrients for plants and is applied to soil in the same form of phosphate fertilizer[11], [13], [14].

However, a large portion of soluble inorganic phosphate, which is applied to the soil as chemical fertilizer is immobilized rapidly and become unavailable to plants. Currently the main purpose in managing soil phosphate is to optimize crop production and minimize p loss from soils. PSB have attracted the attention agriculturists as soil Inoculumns to improve planet growth and yieald. When PSB as Inoculants increase p uptake by plants. Simple inoculation of seeds with PSB gives crop yield response equivalent to 30kg p2 O5 ha or 50 percent of the need for phosphatic fertilizers. Alternatively, PSB can be applied through Fertigation Or in hydroponic operations. Many different strains of then bacteria have been identified as PSB including pantoea agglomerans, mycobacterium lacvaniforms and pseudomonas putida[15], [16].

Additionally, phosphate (p) compounds are capable of immobilizing heavy metals, especially ph, in contaminated environments through phosphate – heavy metal precipitation. However, most p compounds are not readily soluble in soils so it is not readily used for metal immobilization[17].

Some soil bacteria, isolated from the root region ofplants, are known to enhance growth of the plants. These beneficial free-living soil bacteria are termedas plant growth promoting rhizobacteria (PGPR).These include nitrogen-fixing azotobacters andphosphate solubilizing bacteria etc. The beneficialeffect of PGPR is mediated through either direct orindirect mechanisms [18]. The direct effectsare most commonly attributed to the production ofplant hormones such as auxins, gibberellins andcytokinins; or by supplying biologically fixednitrogen. The PGPR also improve growth byindirectmechanisms such as, suppression of bacterial, fungaland nematode pathogens, and production ofsiderophores, HCN, ammonia, antibiotics, volatilemetabolites etc. [18]. Some studies areavailable for the beneficial bacteria associated withthe natural mangrove habitats [19].However, no such studies are available foratificially developed mangrove habitats. Hence, tHence, thepresent study has been undertaken to isolate andenumerate the azotobacters and phosphateHence, thephosphatesolubilizing bacteria associated with the rhizospheresoil of mangrove tree species, and to relate them withthe nutrient levels.

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Obesity associated pancreatic ductal adenocarcinoma: Therapeutic challenges

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ABSTRACT

Obesity is a prominent health issue worldwide and directly impacts pancreatic health, with obese individuals exhibiting a significant risk for increasing pancreatic ductal adenocarcinoma (PDAC). Several factors potentially explain the increased risk for the development of PDAC, including obesity-induced chronic inflammation within and outside of the pancreas, development of insulin resistance and metabolic dysfunction, promotion of immune suppression within the pancreas during inflammation, pre- and malignant stages, variations in hormones levels (adiponectin, ghrelin, and leptin) produced from the adipose tissue, and acquisition of somatic mutations in tumor once- and suppressor proteins critical for pancreatic tumorigenesis. In this manuscript, we will explore the broad impact of these obesity-induced risk factors on the development and progression of PDAC, focusing on changes within the tumor microenvironment (TME) as they pertain to prevention, current therapeutic strategies, and future directions for targeting obesity management as they relate to the prevention of pancreatic tumorigenesis.

1. Introduction

The epidemiology of obesity and pancreatic ductal adenocarcinoma (PDAC) is of significant interest due to the strong association between these conditions [1]. Obesity is a global public health concern. In the United States, over 30% of individuals are overweight (BMI>25), with 50% of those individuals being severely overweight (BMI>30). Obese individuals are more likely to develop cardiovascular diseases, type 2 diabetes, hypertension, and certain cancers, including PDAC [2,3]. The occurrence of overweightness (obesity) has steadily increased over recent decades [4]. In contrast, PDAC, while relatively rare compared to other cancer types, ranks among the deadliest [5]. Development of PDAC is associated with several risk factors, including smoking, a family history of PDAC, chronic pancreatitis, specific genetic syndromes, and obesity, which is the focus of this review [6].

Obesity is a pivotal modifiable risk factor associated with the incidence of PDAC [7], mainly exerting its impact on the progression of PDAC through various mechanisms, including the promotion of chronic inflammation [8], the influence of adipose tissue derived soluble mediators on oncogenic Kirsten rat sarcoma viral oncogene homolog (KRAS) signaling [9], the presence of single-nucleotide polymorphisms (SNPs) associated with childhood obesity [10], and the disruption of metabolic pathways [11]. Notably, obesity driven chronic inflammation leads to dysregulation of adipocytokines, insulin resistance, and sex hormones [12]. Furthermore, the inflammation of obesity-associated adipose tissue has garnered significant attention due to its effect on the activity of KRAS, a prominent oncogenic driver in PDAC [13]. An immunosuppressive tumor microenvironment (TME) is also implicated in the correlation between obesity and PDAC [14]. In conclusion, comprehending the intricate connections between obesity and PDAC and recognizing the multifaceted risk factors associated with PDAC enriches our understanding of this complex disease and presents

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Narrative Review

Resveratrol: biology, metabolism, and detrimental role on the tumor microenvironment of colorectal cancer

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A substantial increase in colorectal cancer (CRC)–associated fatalities can be attributed to tumor recurrence and multidrug resistance. Traditional treatment options, including radio- and chemotherapy, also exhibit adverse side effects. Ancient treatment strategies that include phytochemicals like resveratrol are now widely encouraged as an alternative therapeutic option. Resveratrol is the natural polyphenolic stilbene in vegetables and fruits like grapes and apples. It inhibits CRC progression via targeting dysregulated cancer-promoting pathways, including PI3K/Akt/Kras, targeting transcription factors like NF-κB and STAT3, and an immunosuppressive tumor microenvironment. In addition, combination therapies for cancer include resveratrol as an adjuvant to decrease multidrug resistance that develops in CRC cells. The current review discusses the biology of resveratrol and explores different mechanisms of action of resveratrol in inhibiting CRC progression. Further, the detrimental role of resveratrol on the immunosuppressive tumor microenvironment of CRC has been discussed. This review illustrates clinical trials on resveratrol in different cancers, including resveratrol analogs, and their efficiency in promoting CRC inhibition.

Key words: *analogs, colorectal cancer, multidrug resistance, tumor microenvironment, resveratrol.*

INTRODUCTION

Colorectal cancer (CRC) is the second most recurrent malignant disease recorded globally, accounting for approximately 10% of diagnosed cancers and deaths.[1] As estimated by the American Cancer Society, the novel cases of CRC diagnosed in 2023 will be approximately 153 020, and predicted deaths of approximately 52 550.[1] The incidence and fatality rate varies with gender and geographical location. Higher incidence and mortality rates have been predicted in males than in females and in more developed countries. In addition to age, dietary habits and factors, including smoking, alcoholism, obesity, and lack of physical exercise, have been associated with the increased risk of CRC.[2,3] The advancement of CRC or the progression of conventional adenomas results from the accumulation of various genetic mutations and epigenetic alterations.[4] These are also called chromosomal instability, causing microsatellite stable and unstable tumors. Table 1 shows the development of CRC and related pathways. Surgical resection is the primary treatment option for localized CRC. Additional treatment options include pre- and postoperative conventional therapies,

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Neoantigens and cancer-testis antigens as promising vaccine candidates for triple-negative breast cancer: Delivery strategies and clinical trials

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ABSTRACT

Immunotherapy is gaining prominence as a promising strategy for treating triple-negative breast cancer (TNBC). Neoantigens (neoAgs) and cancer-testis antigens (CTAs) are tumor-specific targets originating from somatic mutations and epigenetic changes in cancer cells. These antigens hold great promise for personalized cancer vaccines, as supported by preclinical and early clinical evidence in TNBC. This review delves into the potential of neoAgs and CTAs as vaccine candidates, emphasizing diverse strategies and delivery approaches. It also highlights the current status of vaccination modalities undergoing clinical trials in TNBC therapy. A comprehensive understanding of neoAgs, CTAs, vaccination strategies, and innovative delivery methods is crucial for optimizing neoAg-based immunotherapies in clinical practice.

1. Introduction

Cancer vaccines (CVs) leverage the host's immune system's specific targeting capability to selectively eliminate malignant cells [1]. CVs prompt the immune system to recognize antigens present in tumor cells. The effectiveness of CVs is influenced by the immunogenicity and avidity of the tumor antigens, which impact their ability to stimulate an immune response [2].

The landscape of tumor antigens can be categorized into three distinct groups, each with unique implications for cancer therapy. Tumor-associated antigens (TAAs) exhibit broad expression in both cancer and normal tissues, potentially posing a risk of autoimmune responses. On the other hand, cancer-specific neoantigens (neoAgs) arise from somatic mutations and hold promise as ideal vaccine targets despite their individuality. In contrast, cancer-testis antigens (CTAs) are a group of proteins typically found in the testis, abnormally expressed in various types of cancers. They offer a convenient avenue for developing off-the-shelf CVs, given their consistent expression across various cancers [3].

NeoAgs differ from CTAs in terms of their origin, expression pattern, and specificity. NeoAgs arise in cancer cells due to mutations in genes, leading to the expression of abnormal proteins or protein fragments. They are not expressed in normal cells and are highly specific to individual patients. In contrast, CTAs are typically expressed in germ cells, aberrantly expressed in cancer cells, and not in normal adult cells. They

Abbreviations: CV, cancer vaccine; TAA, tumor-associated antigens; NeoAg, neoantigen; APC, antigen-presenting cells; TNBC, triple negative breast cancer; OS, overall survival; TME, tumor microenvironment; NPs, nanoparticles; NGS, next-generation sequence; TSA, tumor specific antigen; pDNA, plasmid DNA; DDR, DNA damage response; PP2A, protein phosphatase 2 A; RB, retinoblastoma protein; MLH1, MutL homolog 1; CTAs, Cancer testis antigens; ICIs, immune checkpoint inhibitors; CAR, chimeric antigen receptor; ADCs, antibody-drug conjugates; CTLs, cytotoxic T lymphocytes; AAT, alpha 1-antitrypsin; AsiCs, aptamer-linked small-interfering RNA chimeras; PADIs, protein arginine deiminases; AC4ManNAZ, tetra acetyl-*N*-azidoacetyl-mannosamine; MDP, ManNAZ-DBCO-Pam3CSK4; OSNs, organ-specific cancer neoAgs; meAAV, modified adeno-associated virus; NVs, nanovaccines; GP, glucan particles; α-GC-Lip, α-Galactose ceramide/cationic liposome complex; CpG, cytosine-phosphodiester-guanine; MDSC, myeloid-derived suppressor cell; DCs, dendritic cells; ICD, immunogenic cell death; TMEV, Theiler's murine encephalomyelitis virus; iMBs, immunotheranostic microbubbles; IgG, immunoglobulin G.

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RESEARCH ARTICLE

Functional analysis and screening small molecules to RpfF protein in *Xanthomonas oryzae* involved in rice bacterial blight disease

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Abstract

Xanthomonas oryzae pv. *oryzae* (Xoo) is an important rice pathogen. This is a vascular pathogen entering the plant *via* the hydathodes causing rice bacterial blight. It has been known that most regulation of pathogenicity factor F (RpfF) genes in *Xanthomonas* regulates virulence in response to the diffusible signal factor (DSF). The RpfF recognized as an attractive drug target in bacterial rice blight disease. In this study, we performed the gene-gene interaction of RpfF and pathway functional analysis. 3D structure of RpfF protein was predicted using a homology modelling tool Swiss-Model and refined by molecular dynamics (MD) simulation. The refined model protein was predicted structural assessment using various tools such as PROCHECK, ERRAT, and VERIFY-3D. We have collected 2 500 rifampicin analogues from Zinc Database by virtual screening. The screened compounds were docked into the active site of the RpfF protein using AutoDock Vina in PyRx Virtual Screening Tool. Furthermore, docking result and *in silico* ADMET analysis described that the compounds ZINC03056414, ZINC03205310, ZINC08673779, ZINC09100848, ZINC09729566, ZINC11415953, ZINC12810788, ZINC24989313, ZINC27441787 and ZINC32739565 have best binding energies and less toxicity than reference compound. This study revealed that the active site residues such as HIS-118, HIS-147, THR-148, ARG-179, ASP-207, ARG-240 and THR-244 are key roles in the pathogenicity. It could be beneficial in the design of small molecule therapeutics or the treatment of rice bacterial blight disease.

Keywords: RpfF, virtual screening, molecular dynamics, docking, Zinc Database

1. Introduction

The genus *Xanthomonas* comprises an important group of Gram-negative plant pathogenic bacteria, which infect approximately 350 different plants, and cause great economic losses worldwide (Watt *et al*. 2005; Buttner and Bonas 2010). One member of this genus, *Xanthomonas oryzae* pv. *oryzae* (Xoo) is an important rice pathogen. This is a vascular pathogen entering the plant *via* the hydathodes causing bacterial rice blight (Ray *et al*. 2000). Symptoms are observed at the tillering stage, disease incidence increases

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BOOK CHAPTER

Chapter 6

Single-Cell RNA Sequencing (scRNA-Seq) Data Analysis of Retinal Homeostasis and Degeneration of Microglia

Madhu Sudhana Saddala, Srilatha Mundla, Naina Patyal, and Srujanika Dash

Abstract

Single-cell RNA sequencing (scRNA-seq) experiment reveals previously unseen molecular features. The number of sequencing procedures and computational data analysis approaches has been increasing rapidly in recent years. This chapter provides a general idea of the single-cell data analysis and visualization. An introduction and practical guidance for the 10× sequencing data analysis and visualization are presented. Basic data analysis approaches are highlighted, followed by quality control of data, filtering in cell level and gene level, normalization, dimensional reduction, clustering analysis, and marker identification.

Key words Microglia, Retinal degeneration, Diabetic retinopathy, scRNA-Seq, Visualization

1 Introduction

Diabetic retinopathy (DR) is the leading cause of vision loss in individuals 20–75 years of age. It remains a frightening prospect to patients and physicians as the causes remain unclear. While DR has been described classically as a microvascular disease, recent evidence suggests that changes to retinal microglia are an early feature of retinopathy [1–3].

The retinal microglia cells showed two different activation forms, pro-inflammatory (M1) and anti-inflammatory (M2) by sensome [4, 5]. The sensome signals are promote the microglial cells to activate numerous pathological signals like secretion of neurotoxins, cytokines, and chemokines, local proliferation, migration, and enhanced phagocytosis. These responses and the loss of restrictive switch mechanisms may contribute to retinal tissue impairment and pro-apoptotic actions in retinal degeneration (RD) [6]. The study of microglia at different stages of diabetes, and its interaction with peripheral leukocytes and retinal cells, is

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JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A review on phytochemical, biological and pharmacological properties of *Andrographis echioides.*

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Abstract:

Andrographis echioides (Acanthaceae) is widely distributed in South Asian nations and is recognized for its potent biological properties in the Indian Materia Medica. phytochemical analysis reveals this plant rich in flavonoids, phenols, terpenoids, steroids, tannins, and saponins. It consist of high bioactive compounds profile which are responsible for various biological properties like anti-inflammatory, anti-bacterial, hepatoprotective, antioxidant, antidiuretic, and antidiabetic effects. *Andrographis echioides* is a high potent medicinal property plant used as remedy for various diseases in traditional system of medicine.

Key Words: *Andrographis echioides*, phytochemical, antioxidant, antimicrobial.

Introduction:

Medicinal plants plays a crucial role in traditional herbal medicine to treat various diseases and disorders in the Global scenario. Globally there are 80,000 plant species that have been recognized and utilized as medicines (1). In developing countries reports states that around 75-80% of people and 25% of people in developed countries utilizes traditional system of medicine for the first line of medication (2, 3). Medicinal plant derived bioactive compounds utilized as a potent source for alternative medicine to treat various health conditions (4).

Andrographis echioides (L.) Nees commonly called as "False water willow". It is an erect herb widely distributed in India and Sri Lanka (5). In traditional system of medicine this herb is used as folk medicine for the treatment of

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Whole genome characterization of *Jaagsiekte Sheep Retrovirus* isolated from OPA infected sheep (India) and structural assessment (*In-silico*) of proteins of JSRV

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ABSTRACT

The study was conducted from 2017 to 2021 in sheep and goat population from Krishna, Guntur and Chittoor districts of Andhra Pradesh. A total of 1256 clinically unhealthy animals out of which 420 animals were manifested respiratory emaciated symptoms based on wheelbarrow test, all aged between 3 months to 4 years. Molecular diagnosis confirmed 38 samples out of 420 samples confirmed by wheelbarrow test. The prevalence rate of JSRV induced OPA is 3.02 % the less infection rate was observed in male as compared to females' animals and this prevalence during the late winter seasons. The size of 7462 bp genome was sequenced from pathomorphological diversified animal lung sample. The genomic analysis reveals a total of 506 SNPs variants were recorded. The phylogenetic studies reveal, the isolated strain is very similar to South African strains but it diversified from UK and China strain. The structural and functional assessment studies based on derived amino acid sequence showed nonsignificant changes in 3D structures of proteins encoded by the JSRV genome. The substitution mutations both at Nucleotide and Amino acid sequence level suggest neutral evolution and they are under minimal evolutionary pressure.

1. Introduction

Sheep farming plays a significant role in the livelihood of the rural folk in India. As per FAOSTAT, 2019 the sheep population in India is about 75.5 millions. Diseases caused by different etiological agents viz. bacteria, viruses and parasites pose a threat to animal's health and production. In addition to several viral diseases, retroviruses can cause two important contagious tumours viz. Ovine Pulmonary Adenocarcinoma (OPA) and Enzootic nasal tumour (ENA) in sheep and goats that have a great impact on health and productivity of the animals.

OPA, also known as Sheep Pulmonary Adenomatosis (SPA) was first described in South Africa during 19th century (York and Querat, 2003) and thereafter, OPA was identified in many countries around the world including India (Damodaran, 1960). OPA is a naturally occurring transmissible adenocarcinoma of lungs in sheep caused by an exogenous *Jaagsiekte Sheep Retrovirus* (exJSRV). It belongs to the family Retroviridae, subfamily Orthoretrovirinae and genus Beta retrovirus. JSRV causes oncogenic transformation of the differentiated epithelial cells of the lungs especially type II pneumocytes and Clara cells (Nisbet et al., 1970; Hod et al., 1977; Rosadio et al., 1988a). The sheep genome also contains about twenty seven endogenous retroviruses that are closely related to JSRV known as endogenous *Jaagsiekte Sheep Retroviruses* (enJSRVs) and the loci are vertically transmitted. Further, it was demonstrated that exogenous JSRV was specifically associated with

Abbreviations: JSRV, *Jaagsiekte sheep retrovirus*; EnJSRV, endogenous *Jaagsiekte sheep retrovirus*; ExJSRV, exogenous *Jaagsiekte sheep retrovirus*; OPA, Ovine pulmonary adenocarcinoma; H & E, hematoxylin and eosin; U3-hn-PCR, U3 hemi-nested polymerase chain reaction; OIE, The Office International des Epizooties; BRV, Beta retrovirus; WGS, Whole-genome sequencing.

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Discovery of novel peptide deformylase inhibitors: Ensemble complex-based pharmacophore modeling, docking and binding affinity studies

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ADMET

ABSTRACT

Pseudomonas aeruginosa infections are quickly increasing in association with a variety of illnesses, necessitating the development of novel medications. This study employed an *in silico* technique to find PDF inhibitors against *P. aeruginosa* Peptide deformylase (PaPDF). PaPDF's structure is comparable to that of other PDFs; however, binding site studies found that PaPDF has a smaller pocket than *Staphylococcus aureus*, covering the S1 and S2 sub pockets, and maintains a conserved hydrophobic nature. The Zn metal binding site of modified PaPDFs was examined using molecular dynamics, and the results revealed that Cys92Ala differed from His134Ala and His138Ala, respectively. Complex-based pharmacophore investigation revealed three significant pharmacophoric characteristics within the pocket: two hydrophobic and one H-bond acceptor. This allows us to perform virtual screening using the ChemBride database to uncover a variety of potential hits with specific inhibitory characteristics. Several restrictions, including docking and molecular mechanics/general born-volume integral implicit solvent (MM/GBVI), were applied, and the top-ranked ligands were tested for inhibitory characteristics against key residues in the active site. Furthermore, the bioavailability and toxicity prediction identified seven potential leads and suggested future research into the design and synthesis of a unique class of PaPDF inhibitors.

1. Introduction

Multidrug-resistant (MDR) bacteria are a significant clinical challenge in current treatment and have been a public health concern for decades. Increasing resistance to the existing and excessive use of antibiotics, as well as a drop in antibiotic development, highlight the significant failure to manage antibacterial infections and are viewed as a major obstacle in resolving the problem. The MDR Gram negative bacteria *P. aeruginosa*, *E. coli*, *A. baumanii*, and K. pneumonia bacteria are the second most dangerous pathogens, with infections that are genuinely untreatable and promising pharmacological targets for developing powerful inhibitors. Among these, *P. aeruginosa* infections are spreading dramatically alongside diverse disorders, posing numerous challenges to medical treatment. Peptidyl deformylase (PDF) is a broad-spectrum therapeutic pharmacological target, although strong inhibitors have yet to be developed. PDF is ubiquitous in bacteria, parasites, and mammals, and it plays an important function in removing the N-formyl group from freshly produced polypeptides [1–5]. PDFs are classified into three types: Type-I occurs in Gram-negative bacteria, certain Gram-positive bacteria, and all eukaryotes, Type-II in Gram positive bacteria and mycoplasma, and Type-III in Archaea, Kinetoplast, Trypanosoma, and Leishmania [6]. All PDFs share approximately 65 % homology and three conserved substrate binding pockets: S1, S2, S3, and a metal [7]. The S1 pocket is hydrophobic and has equivalent binding patterns in both Gram-positive and Gram-negative bacteria. It helps to remove the formyl group by allowing the methionine of the newly produced polypeptide chain to bind. The S2′ and S3' pockets differ in residue composition, size, and shape, with a large entrance tunnel that protrudes into the solvent. The metal binding site contains a variety of metals, including Ni2+, Co2+, Zn2+, and Fe2+, and it coordinates ligand binding using three conserved motifs HEXXH. Furthermore,

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DATA ANALYSIS AND MACHINE LEARNING TOOLBOX

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ABSTRACT

Exploratory data analysis and machine learning are the building blocks of data science. Every person on average produces terabytes of data per day. As a result, the amount of data that is available on the web has increased astronomically in the past decade. Most of us wish to analyze the data and create a machine learning model that suits the data but because of lack of coding knowledge not many are able to do so. There has been a need to develop a system where the data analysis and building machine learning models can be done with just a few mouse clicks. In this project, we try to bring exploratory data analysis and machine learning techniques under a single roof. The front-end for this project is built upon the streamlit for effective user interface of the user.

Keywords: Exploratory data analysis (EDA), machine learning, regression, classification, clustering, visualization.

I. INTRODUCTION

One of the key steps of exploratory data analysis is data visualization. Data visualization refers to the presentation of data in graphical form, such as charts and graphs to make it easier to understand and analyze. Visualization is used in various fields to reveal patterns that are not always apparent from tables or text. Effective data visualization requires careful selection of appropriate charts and graphs, and attention to design elements such as color and layout. Good data visualization can help people make informed decisions. Machine learning is a subset of artificial intelligence that involves developing algorithms and statistical models that allow computer systems to improve their performance based on a specific task by learning from data, without being explicitly programmed. In machine learning, models are trained on a dataset to find patterns, which can be applied to new data to make predictions. Some of the uses of machine learning are natural language processing, classification, regression, clustering, object detection, recommendation systems. EDA, data visualization and machine learning are all linked with one another. Before we build a machine learning model, it's always necessary to clean the data. Data cleaning involves finding missing values, replacing the missing values with appropriate values, finding outliers, and replacing them, encoding the non-numeric features, transforming the numeric features. Once the data cleaning is done, the data will be split into train and test sets. The train set is used to fit the model and the test set is used for evaluation so we can get an EDA is a mandatory step to be performed before we do any sort of machine learning. There are no systems which provide a simple interface to perform EDA and machine learning. In this project, an effort is made to develop a simple user interface where both EDA and machine learning can be done easily. The user interface is developed using python's streamlit library. The user interface contains drag and drop component for dataset uploading, buttons for performing various actions like finding nulls, creating box plots, creating histograms and scatter plots, generating a data report, building machine learning models, training the model and finally to do predictions.

II. LITERATURE SURVEY

[1]. In the first research paper, they have developed an interactive web application that simplifies and automates the exploratory data analysis stage and is extremely user-friendly and easy to use. The web application is named QuickViz. This web application can be utilized by those who don't have any prior knowledge of programming as this tool doesn't require any coding to execute EDA procedures. Users just must upload their dataset and examine the results of descriptive and graphical EDA techniques through the QuickViz tool, aiding them in gaining insights and patterns from data.

[2]. In this research paper, automation of machine learning process is done using PyCaret and streamlit. Machine learning applications for the industry have seen significant growth and attention in recent years. As a result, there is a significant need for Machine learning engineers across the business, but increasing their productivity is still a major problem. For time-consuming Machine learning pipeline operations such as data pre-processing, feature engineering, model selection, hyperparameter optimization, and prediction result

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analysis, Automated Machine Learning (AutoML) has arisen as a solution. In this research, we examine the condition of the AutoML application, which aims to automate ML operations. Using Streamlit, the AutoML application is made to provide a user interface.

[3]. In this research paper, a comprehensive and up-to-date review of the state of the art in AutoML is presented. According to the deep learning pipeline, they have introduced AutoML methods – covering data preparation, feature engineering, hyperparameter optimization, and neural network search. Building a machine learning or deep learning pipeline needs a lot of resources and trained experts. To reduce these development costs, a novel idea of automating the entire pipeline of machine learning has emerged.

[4]. As big data becomes ubiquitous across domains, and more and more stakeholders aspire to make the most of their data, demand for machine learning tools has spurred researchers to explore the possibilities of automated machine learning (AutoML). AutoML tools aim to make machine learning accessible for non-machine learning experts (domain experts), to improve the efficiency of machine learning, and to accelerate machine learning research. But although automation and efficiency are among AutoML's main selling points, the process still requires human involvement at several vital steps, including understanding the attributes of domain-specific data, defining prediction problems, creating a suitable training data set, and selecting a promising machine learning technique. These steps often require a prolonged back-and-forth that makes this process inefficient for domain experts and data scientists alike and keeps so-called AutoML systems from being truly automatic.

In this research paper, they have introduced a new classification system for AutoML systems. They have highlighted the subtasks which are still done manually – generally by a data scientist and explained how this limits domain experts' access to machine learning. They have introduced a novel level – based taxonomy for AutoML systems.

III. TOOLS USED

The tools used are NumPy, Pandas, Matplotlib, Seaborn, Plotly, Scikit-Learn, XGBoost, Streamlit, PyGWalker, and pandas-profiling, GitHub, Streamlit Cloud. The techniques used are Data visualization using tools such as matplotlib, seaborn, and plotly. EDA uses pandas, NumPy, PyGWalker, and pandas-profiling. Machine learning and prediction using Scikit-Learn and XGBoost. User interface using Streamlit. Version controlling is done using GitHub. The app that is developed is hosted on Streamlit's cloud platform for faster performance.

IV. METHODOLOGY

The developed system is more of a general-purpose tool so based on the dataset and based on the problem statement the approach and methodology will change. Hence the most general steps followed for any data science project are only described. There are two stages in the project. Exploratory data analysis (EDA) and machine learning (ML).

Methodology used in EDA:

The data on which we wish to apply the EDA is imported. As a first step, the top five or ten rows of the data will be displayed so we can familiarize ourselves with the data. Then the information about the data will be obtained. The information will contain column name, non-null count, and its data type. Then the data will be described. The description of the data will contain count, mean, standard deviation, minimum value, percentiles, and maximum value. All these are applied only to numerical columns. Once the description of data is done, the null values in each column are counted and are displayed against their respective column names. Histograms are used to understand the distribution of each column. Scatter plots are used to know how two columns are correlated with each other and to see if there is a trend between them. An interactive element is placed to select the column names for both histogram and scatter plots. Encoding is a most important and must step in EDA. The common encoding techniques label encoding, and one hot encoding are applied to the selected columns. In the last step of EDA, the heatmap of correlation matrix is generated so we can see how each column is correlated with each other.

Methodology used in ML:

Three types of machine learning techniques are implemented in this project. Regression, classification, and clustering. All these techniques follow a common framework of implementation. Initially the data will be split into training and test. Then the model will be created and is trained on the training set. Once the training is

done, a form will be displayed. The form takes input to perform predictions. The following techniques are implemented in regression: linear regression, lasso regression, ridge regression, elastic net, and extreme gradient boosting regression. All these will be applied on the uploaded dataset separately and the regression evaluation metrics like mean absolute error, mean squared error, and root mean squared error of each of these models will be computed and compared in a table. In classification, the following techniques are implemented: logistic regression, support vector machines, gaussian naïve bayes, multinomial naïve bayes, k nearest neighbors, decision tree and random forest. Just as in regression, each of these models are applied separately on the dataset and then the classification evaluation metrics like accuracy, precision, recall and f1-score are computed and are compared in a table. For clustering, only the most used k-means algorithm is implemented. The elbow method which calculates the best value of k is also implemented. Unsupervised learning is only used to find patterns in the data so we can get better understanding of how data is clustered. So, no evaluation metrics will be available for clustering.

Methodology used in deployment:

After building the project, it must be made available so it can be accessed and used with ease. So, to make the tool accessible, we need to deploy it. Deployment can be done in multiple hosting platforms like render.com and Heroku. Since the project is developed using streamlit, it would be better to deploy the project to streamlit cloud. Streamlit cloud increases the speed of execution of streamlit apps and provides better performance.

V. CONCLUSION

With the help of this data analysis and machine learning toolbox, it will be easy to do exploratory data analysis and then apply various machine learning algorithms on the data. Furthermore, no downloading of any software is required. All we need is a device with active internet. Different analysis techniques can be applied to the data with just a click. All the machine learning algorithms are implemented inside the project, and we can build them with just a click. Anyone who has knowledge of data can easily use the tool and can-do EDA and machine learning.

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VI. FUTURE SCOPE

With the help of this data analysis and machine learning toolbox, it will be easy to do exploratory data analysis and then apply various machine learning algorithms on the data. Furthermore, no downloading of any software is required. All we need is a device with active internet. Different analysis techniques can be applied on the data with just a click. All the machine learning algorithms are implemented inside the project, and we can build them with just a click. Anyone who has knowledge of data can easily use the tool and can-do EDA and machine learning.

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ANALYSIS AND CLASSIFYING OF PLANT DISEASE BASED ON IMAGE DATASET USING UNSUPERVISED LEARNING TECHNIQUES

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ABSTRACT

The increasing prevalence of plant diseases poses a significant threat to global food security. Traditional methods of disease detection and classification are often labor-intensive and time consuming. In this study, we propose a novel approach for the analysis and classification of plant diseases based on image datasets using unsupervised learning techniques. Our methodology leverages the power of unsupervised learning algorithms to automatically identify patterns and structures within the image data without the need for labeled training examples. This approach offers several advantages, including scalability, adaptability to diverse datasets, and the ability to discover previously unknown disease patterns. We begin by collecting a comprehensive image dataset consisting of healthy plant leaves as well as leaves affected by various diseases. Next, we preprocess the images to enhance their quality and extract relevant features. We then apply unsupervised learning algorithms such as clustering to partition the dataset into distinct groups based on similarities in leaf characteristics.

Keywords: Plant Disease Diagnosis, Image Classification, Deep Learning, Agricultural Automation, Computer Vision, Crop Health Monitoring, Automated Disease Detection.

I. INTRODUCTION

The increasing prevalence of plant diseases poses a significant threat to global food security, necessitating efficient methods for disease detection and classification. Traditional approaches are often laborious and time-consuming. In response, this study proposes a novel approach leveraging unsupervised learning techniques for automatic analysis and classification of plant diseases using image datasets. By eliminating the need for labeled training examples, unsupervised learning offers scalability and adaptability to diverse datasets. The methodology involves collecting an extensive image dataset comprising healthy and diseased plant leaves, preprocessing the images, and applying unsupervised learning algorithms such as clustering. This introduction outlines the necessity of such methods and sets the stage for the innovative approach presented in this study.

II. RELATED WORK

The general process of using traditional image recognition processing technology to identify plant diseases is shown in Dubey and Jalal used the K-means clustering method to segment the lesions regions, and combined the global color histogram (GCH) color coherence vector (CCV) local binary pattern (LBP), and completed local binary pattern (CLBP) was used to extract the color and texture features of apple spots. The three kinds of apple diseases were detected and identified based on improved support vector machine (SVM), and the classification accuracy reached 93% Chai et al studied four tomato leaf diseases, including early blight and late blight leaf mildew and leaf spot, and extracted 18 characteristic parameters such as color, texture, and shape information of tomato leaf spot images, using stepwise discriminant and Bayesian discriminant principal component analysis (PCA), respectively. Principal component analysis and fisher discriminant methods were used to extract the characteristic parameters and construct the discriminant model. The accuracy of the two methods reached 94.71% and 98.32%, respectively. Li and He selected 5 kinds of apple leaf diseases (speckled deciduous disease, yellow leaf disease, round spot disease, mosaic disease, and rust disease) as the research objects. By extracting 8 features of the apple leaf spot image, such as color, texture, and shape. The BP neural network model was used to classify and recognize the diseases, and the average recognition accuracy reached 92.6%. Guan et al. extracted 63 parameters including morphology, color, and texture features of rice leaf disease spots, and applied step-based discriminant analysis and Bayesian discriminant method to classify and recognize three rice diseases.

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III. METHODOLOGY

A. Design

Step1: Preprocessing of Automatic Leaf Detection of Plant Disease

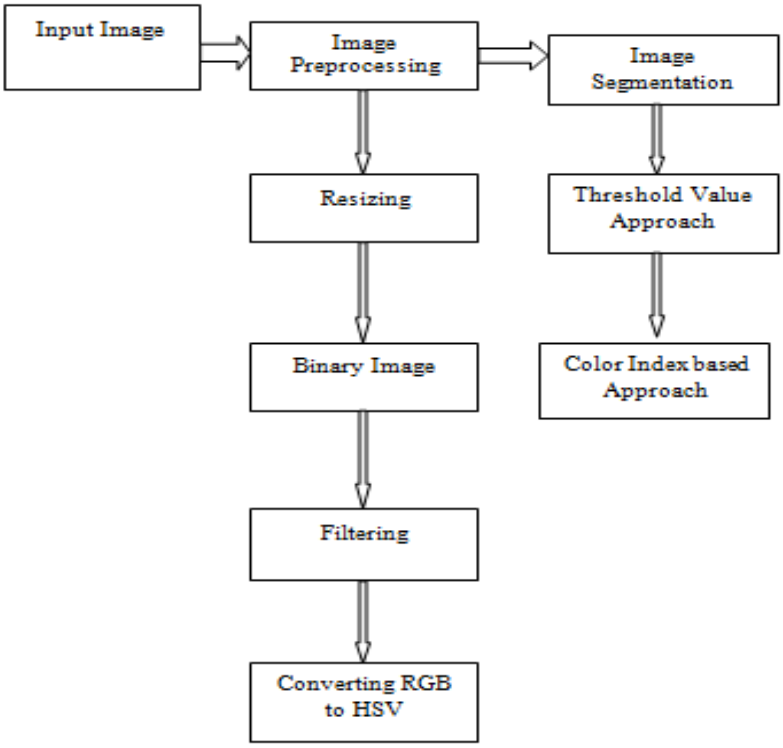


Figure 1: Preprocessing of Automatic Leaf Detection

Step2: Feature Extraction of Process Flow Chart

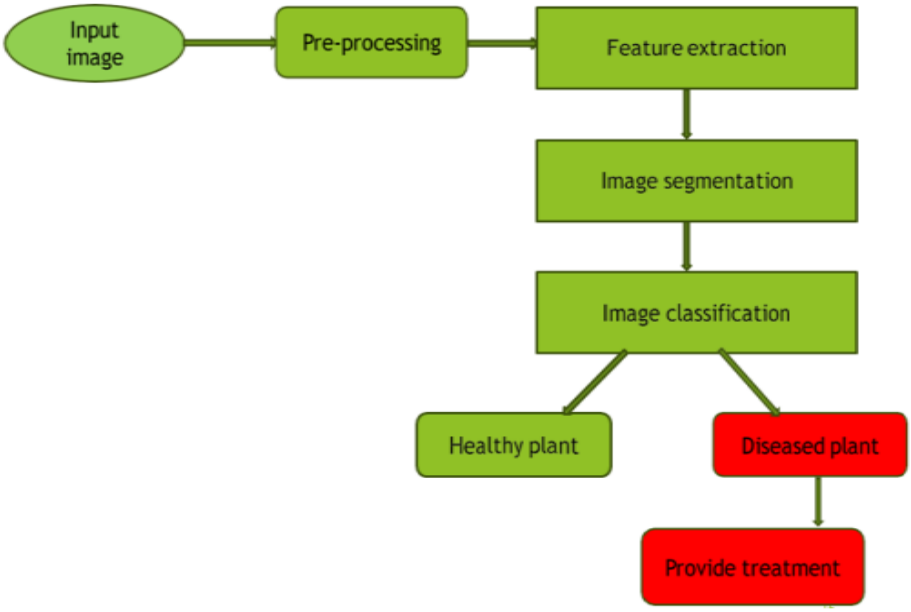


Figure 2: Feature Extraction of Process Flow Chart

We implement feature extraction using GLCM (Gray-Level Co-occurrence Matrix) to capture texture information from plant disease images. GLCM analyzes pixel intensity relationships to quantify texture patterns within the images. This technique enables the extraction of discriminative features, which are crucial for unsupervised learning-based disease classification. By incorporating GLCM-based feature extraction, we enhance the ability to differentiate between healthy and diseased plant tissues, contributing to more accurate

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analysis and classification of plant diseases.

B. Methods and Algorithms

In our study, we employ deep neural network (DNN) and convolutional neural network (CNN) methodologies for analyzing and classifying plant diseases from image datasets. DNNs offer powerful feature learning capabilities, while CNNs are specialized for image-based tasks, enabling us to extract intricate patterns and structures from the data. Leveraging these techniques, we aim to achieve accurate disease classification without the need for labeled training examples, thus streamlining the analysis process and enhancing scalability.

C. Convolutional Neural Networks (CNN)

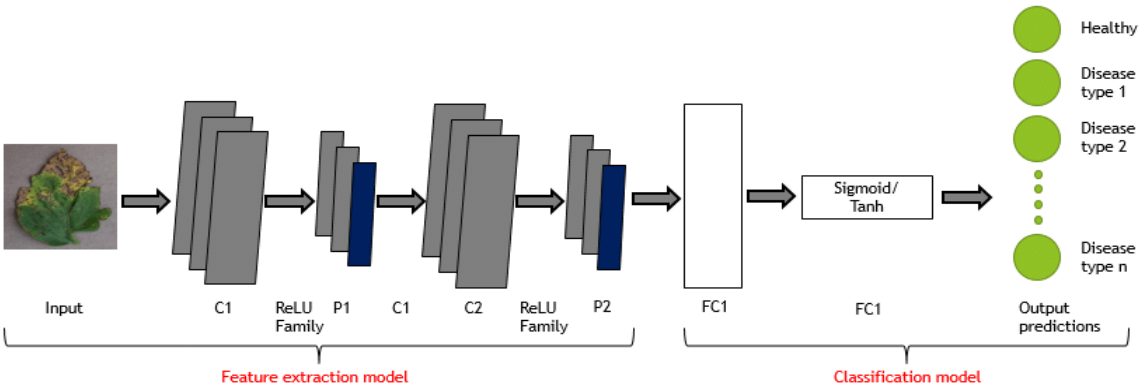


Figure 3: Convolution Neural Network Architecture

Utilizing Convolutional Neural Networks (CNNs), we deploy a deep learning architecture tailored for the analysis and classification of plant diseases from image datasets. CNNs leverage hierarchical feature extraction to automatically learn discriminative features from input images, enabling accurate disease classification. Through convolutional layers, pooling layers, and fully connected layers, CNNs capture spatial hierarchies and patterns within the image data, facilitating robust disease identification. Fine-tuning pre-trained CNN models enhances classification performance, while transfer learning enables adaptation to varying datasets, optimizing model generalization

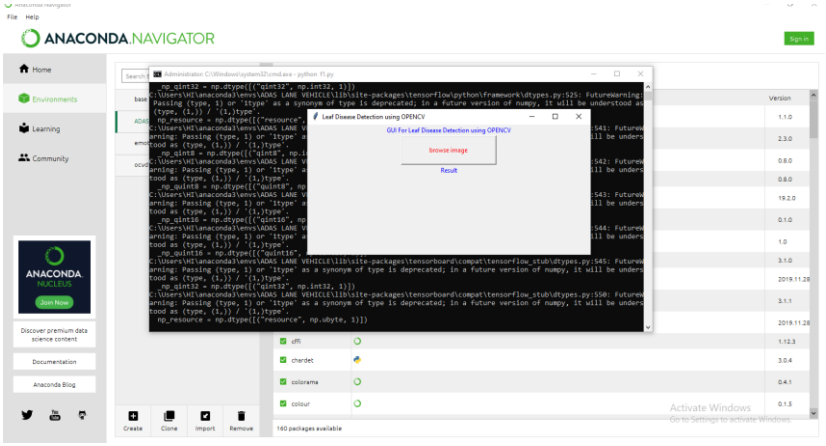
D. Types of Leaf Diseases

There are two main types of leaf diseases: biotic and abiotic agents. Living organisms are called biotics, and nonliving organisms are called abiotics. Diseases caused by biotic agents include insects, bacteria, fungi, and viruses. At the same time, an abiotic agent includes extremes of temperature, excess moisture, poor light, poor soil, and insufficient nutrients. Although leaf diseases cause significant crop losses and directly affect the economy and animal and human health, yield losses can be reduced and specific toxoids can be adopted to battle specific pathogens if diseases are appropriately diagnosed and detected early.

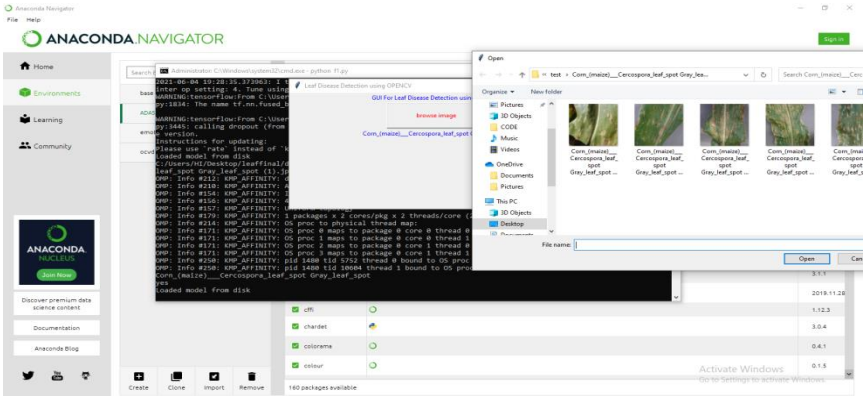
IV. RESULTS

The unsupervised learning techniques effectively clustered the plant image dataset, revealing distinct patterns among healthy and diseased plants. The classification accuracy achieved demonstrates the efficacy of the approach in accurately identifying plant diseases without the need for labeled data. Through visual inspection and quantitative evaluation, we confirmed the ability of the model to differentiate between healthy and diseased plant leaves. The interpretability of the clustering results provides valuable insights into disease patterns and can aid in disease diagnosis and management strategies. Overall, our results highlight the potential of unsupervised learning techniques for automated plant disease analysis and classification.

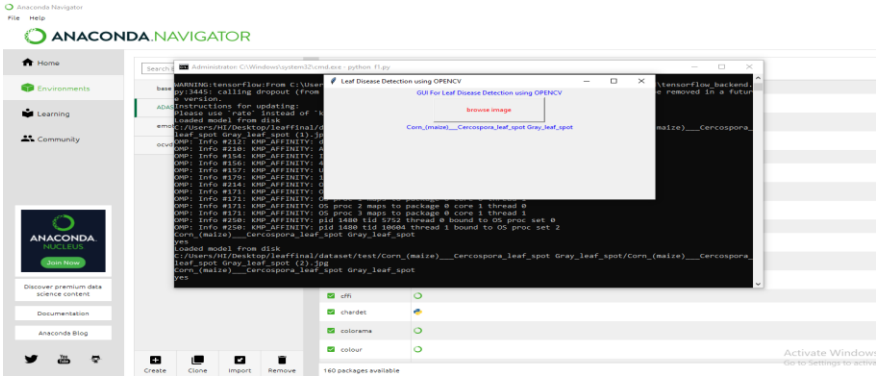
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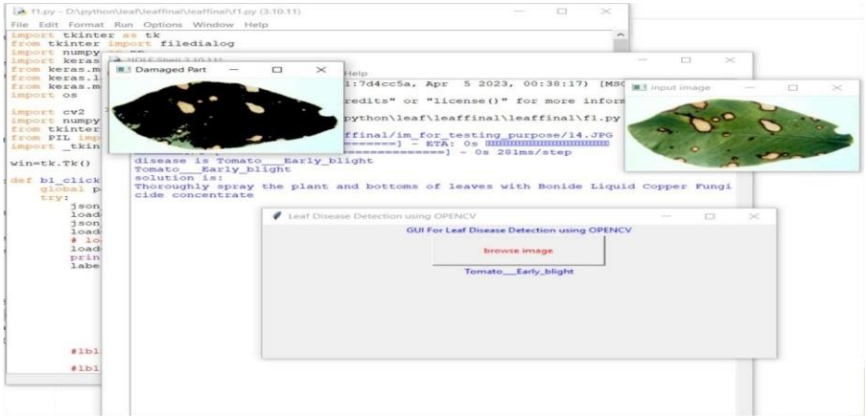
GUI for Leaf disease detection using OPENCV



Browsing the Image



Classification of Plant Disease Detection



Damage Detection Result

V. CONCLUSION

In conclusion, our study demonstrates the potential of unsupervised learning techniques for analyzing and classifying plant diseases from image datasets. By leveraging these techniques, we achieved accurate disease classification without the need for labeled training data. Our findings highlight the scalability and adaptability of unsupervised learning approaches in detecting and categorizing plant diseases, paving the way for more efficient and automated disease management strategies. Further research could explore the integration of domain knowledge to enhance the interpretability and robustness of the classification results.

VI. FUTURE SCOPE

In the future, advancements in unsupervised learning techniques could enhance the accuracy and efficiency of plant disease classification. Integration with emerging technologies like deep learning may enable more robust feature extraction and pattern recognition. Additionally, collaborative efforts could lead to larger and more diverse image datasets, improving the generalization capabilities of models. Further research into interpretability methods could provide deeper insights into disease patterns and aid in the development of targeted management strategies. The incorporation of real-time monitoring systems and IoT devices may facilitate early detection and proactive disease management practices. Overall, the continuous evolution of technology and interdisciplinary collaboration holds promise for addressing challenges in plant disease analysis and classification.

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Fake Account Prediction In Social Media Using Deep Learning And NLP

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[1]Sri venkateswara University, Tirupati, India

Abstract: The rise of social media has permeated every aspect of daily life in the Internet era, having an impact on a wide range of industries, including politics, education, and business. Fake accounts are becoming more of a problem on well-known sites like Facebook, Instagram, Twitter, and LinkedIn. In social media, fake accounts are used to spread misinformation, carry out illegal tasks like spamming, promoting phishing sites, and committing financial fraud. Numerous existing techniques exist, including machine learning, graph-based, and hybrid techniques. The combination of deep learning with NLP increases accuracy. The features of an account are given to the deep learning model, which obtained about 97% accuracy and the posts of the account are categorized by the Bert algorithm, which obtained about 98% accuracy.

Keywords—Fake Accounts, Natural Language Processing, Machine Learning Deep Learning, BERT Algorithm.

I. INTRODUCTION

The globe has seen the emergence and escalating popularity of social media platforms like Facebook, Twitter, Instagram, etc. in recent years. The major social platforms facing the problem of fake accounts. Social media platforms perform their own techniques to decrease and eliminate fake accounts. A fake profile on social media is a representation of an individual, group, or business that does not actually exist or that has displayed information that is false in some other way or even fraudulent. Fake accounts are created manually or computer generated called bots or cyborgs meaning half-human and half-bot. The problem with fake accounts is that they create an unhealthy social environment, spread malicious content, and Fake Engagement. Some companies sell accounts for following others, liking, and sharing content. The major reasons for fake engagement are that fake accounts are used to show off a large fan base, hike votes, criticism, spread rumors, and trustworthiness among others. There are different types of Fake accounts as mentioned in [1] they categorized accounts on social media. Table 1.1 shows the different types of fake accounts. Bot Accounts can be useful for humans for many good purposes to automate different tasks but the usage of bots for malicious purpose is a great effect on the traffic generated in social media. All these different types of fake accounts are common on social network platforms.

Table 1.1 Types of Fake Accounts

Type of account	Definition
Sock puppet Account	Sock puppet accounts aim to deceive others or to promote someone or something
Sybil Account	Multiple accounts are manually created by malicious users to attack the trusted network.
Bot account	A Computer program that performs various tasks quickly and automatically.
Hacked Account	A compromised account or hacked account is defined as a real account user does not have control over. Might be credentials are stolen.

The work is organized so that Section II discusses a literature survey and Section III discusses the proposed methodology. Section IV mentions the Dataset and its features. Section V discusses the Implementation and design and mentions the steps for the proposed algorithms. Results are mentioned in Section VI followed by the conclusion and future scope.

II. LITERATURE SURVEY

Each type of account is detected by using different methods. Different existing methods such as Machine learning, graph-based, and Hybrid methods are used to distinguish real and fake accounts. The study [2] proposed a method called Social Engagement based News Authenticity detection (SENAD) which detects the authenticity of news articles shared on Twitter based on the authenticity and bias of the users engaging with these articles with an accuracy of 93.7%. To detect Fake images the method called CredNN which is a combination of Error Level Analysis and sentiment analysis with an accuracy of 76%.

A. Machine learning approaches:

In the article [3], a study was conducted on VK(Russian app). They used different machine learning methods like Gaussian Naive Bayes, Bernoulli Naive Bayes, Support vector machine, Decision Tree, and Random Forest. All algorithms' accuracy range from 80% to 97%. Random forest algorithm has the highest 97% accuracy.

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Methodologies used to Detect Sarcasm in Sentiment Classification

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ABSTRACT

Research into Natural Language Processing (NLP) is one of the exciting and popular fields today. Sentiment classification of texts is crucial in the discipline of NLP. Sarcasm is a kind of sentiment where individual people convey their feelings or opinion about a particular topic indirectly i.e., they write something which is completely different from what they meant. Sarcasm detection comes under Sentiment analysis. An expression of criticism is called a sarcasm statement. People express their opinions on social media like YouTube, blogs, Facebook, and Twitter in a sarcastic manner. People express sarcastic statements through comments on Daily News, TV shows, political parties, etc. Perfect understanding and analysis of the sarcastic sentences are the most important factor to enhance the performance of sentiment analysis. This paper will discuss the amount of research work done on sarcasm recognition, types of sarcasm, methodologies for sarcasm detection, challenges, and the field's potential in the future.

Keywords—Sentiment analysis, Twitter, Deep Learning, Sarcasm Detection

I. INTRODUCTION

One of the most fascinating research fields is sentiment analysis, which allows researchers to examine and evaluate "a person's emotions, sentiment context, opinions, and feelings regarding a topic or incident."[1] An example of a sarcastic statement is: "I relish suffering #sarcasm". In this example, the word "relish" shows a positive sentiment but, the scenario is negative as "no one like suffering". So, the field of sentiment analysis mainly focuses on text mining. Because there are no facial emotions, it is particularly challenging to discern sarcasm in the text. Here, when people communicate with others based on their slang, tone, expression, and body gesture it is pretty easy to detect sarcasm. Due to the lack of these clues, the task of sarcasm detection in the text is difficult.

Over recent years, people are more connected with social media. With E-commerce sites like Myntra, Flipkart, Amazon, etc., and social networking sites like Facebook, Twitter, YouTube, etc., people get habituated to the usage of the internet. They post their opinions, feelings, and comments on a particular topic or event. The data from these sites increased exponentially and this can be an example of Bigdata. Nowadays, most of organizations and political parties are very interested to know public opinion. For example, if people want to purchase any product on an e-commerce site they go through the reviews of a particular product. This information is needed for promotions, especially since the political parties are showing more interest in sentiment analysis to know public opinion on their respective schemes. To find the pulse of the public, sentiment analysis came into existence. Sarcasm in sentiment is a major research problem. Because, if a sarcastic utterance is included in a statement, it can modify both the sentence's intended meaning and the sentiment analysis conclusion. [1]

Diana Maynard and Mark Greenwood [3] proved that indicating sarcastic words can strengthen the performance of sentiment analysis effectively. Efficient sarcasm detection requires proper training in learning models. There are many studies done on how, why, and when sarcasm is expressed.

Several different datasets are used for sarcasm detection, the Twitter dataset is one of many datasets that are utilized for sarcasm detection. For Indian languages, the lack of annotated datasets is a challenging task. The morphological richness of Indian languages like Telugu, Hindi, Tamil, Malayalam, etc. presents an additional problem for researchers. Telugu has a significant influence over other Indian languages. Most Telugu-speaking users on social media began conversing in their mother tongue. The examination of the conveyed text will be improved with the use of an automatic sentiment analyzer that includes a sarcasm detection approach. The paper is divided into various sections such as a literature review, challenges, characteristics, approaches, etc., to give in-detail work done on sarcasm detection in various languages.

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Artificial Intelligence and Deep Learning Methods for Ophthalmic Image Processing: A Review

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Dr. Humera Khanam.M [2],
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Abstract:

In Medical Imaging, deep learning techniques are gaining the attention and trust of experts for predicting diseases at early stages. The mixture of artificial intelligence and medical knowledge facilities improves the accuracy of detecting diseases. Motivated by these advances, this paper performs a literature review focused on screening eye diseases, classification, and segmentation based on eye images. Artificial Intelligence has shown high accuracy with high specificity and sensitivity in screening and excavation images. This paper presents a systematic survey on the two major types of eye diseases, detection of glaucoma and diabetic retinopathy. Accordingly, we confirmed whether Artificial Intelligence strategies might be useful in distinguishing eye illnesses with high precision and minimal expense, which might advance patient strengthening and help clinical specialists.

Index Terms: Artificial Intelligence, Deep Learning, Classification, Segmentation, Machine Learning, Fundus Image, Convolutional Neural Network.
DOI Number: 10.14704/nq.2022.20.10.NQ55786 **NeuroQuantology 2022; 20(10):8021-8031**

Introduction:

Artificial Intelligence has taken control over every field, including Biomedical. Especially Deep Learning has a great impact on Image Analysis and Data Analysis. The applications of DL in ophthalmology image processing are discussed in this review, which mainly falls into two sections. 1) Detection & grading of diseases. 2) Segmentation. The main motive of detecting and identifying the disease is to analyze the disease found in a block of images. In Future work, multi-class classification can be used to know a disease's severity level more than just predecting it. Decomposition of anatomical structures from picture element wise description, such as retinal vessels, drusen, haemorrhages, or optic disks. Image analysis is divided into several parts segmentation, Feature Analysis, and Classification. Feature extraction can be done either physically or automatically. In physically feature extraction, it requires more description of the relevant features for a given problem and the execution method to extract those features. Without human intervention, deep networks or specialized algorithms are used for automated characteristic extraction. Convolutional Neural Networks (CNNs) are a popular and preferred automatic feature characteristic technique in clinical image processing[50]. In this review, publications about automatic and manual detection methods are covered. Techniques for Ophthalmic information

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QUESTION ANSWERING SYSTEM WITH NATURAL LANGUAGE INTERFACE TO DATABASE

Dr. M.Humera Khanam*

S.Venkata Subbareddy*

Abstract:

Question Answering (QA) is an area of natural language processing research aimed at providing human users with a convenient and natural interface for accessing information. Nowadays, the need to develop accurate systems gains more importance due to available structured knowledge-bases and the continuous demand to access information rapidly and efficiently. The need to store data in an organized manner so that searching, retrieving and maintaining of data becomes easier. To efficiently operate these database, knowledge of Structures Query Language (SQL)becomes essential. But the usage of SQL restricts the access to databases from the users who don't have the knowledge of them. A need for interface comes into the picture to enable the access of these databases even to a non-expert users. This paper describes the design to develop Telugu language Question Answering system to database.

This paper describes about question answering system using Natural Language Interface to a database. Here we use the rule based algorithm for train the systems question classifier to achieve a high accuracy ratio.

Keywords —Natural Language Processing (NLP), Natural Language Interface To Database (NLIDB), Question Answering System(QAS), Structured Query Language(SQL).

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Kidney Stone Detection Using Deep Learning Techniques

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Abstract: Ultrasound imaging is one of the most common imaging techniques used to diagnose abnormal and normal kidney transplants. Detection of kidney stones using ultrasound imaging is a challenge as they involve low contrast and speckle sound. This challenge is overcome by using the appropriate image processing techniques. This Article introduces a method of detecting kidney stones through a separate image processing step. The first step is to preview the image. Image enhancement is part of a process that was previously used to enhance an image. Next, image separation is a processed one using a shareholder capture method. Performed on the image. Finally, different images are analyzed to locate the stone.

Keywords: Ultrasound Imaging Techniques, Kidney Stones, Image Processing, Kidney Stone Analysis, Median Filter, Noise Filtering.

Techniques Using: Matlab, Speckle noise removal.

INTRODUCTION

Kidney stones are formed when chemicals in your urine form crystals in your kidneys and the crystals grow over time. Kidney stones are increasing worldwide and most people with kidney disease do not notice the disease as it damages the organs a little before showing any symptoms. The kidneys are bean-shaped organs and are locates on either side of the spine. The main function of the kidneys is to regulate the electrolyte balance in the blood. The formation of kidney stones is caused by congenital urinary retention, cysts.

Various types of kidney stones such as straiten, deer antlers and renal calculi stones were analyzed. Kidney stone is a strong concretion or crystalline formed by the kidneys from food minerals in the urine. To eliminate this painful disease the kidney stone is detected by ultrasound images and then removed by surgical procedures such as breaking the stone into small pieces, Which are then passed through the urinary tract. If the size of the stone grows to at least 3 millimeters, then they can back and many light up to the end, Classification of urinary stones is based on the location or chemical composition of the kidneys (Nephrolithiasis), urethra (Ureterolithiasis), or bladder (Cystolithiasis).

The stone may be located inside the small and large calyces of the kidneys or in the urethra. In medical imaging techniques, ultrasonography is used because it is flexible, portable, does not use radiation and has a relatively low cost. The great disadvantages of ultrasound image is that it contains low quality images with low contrast and repetitive dot sound making it a challenging task to find kidney stones. The speckle sound present in the image lowers its quality which when disturbing the interpretation and diagnosis.

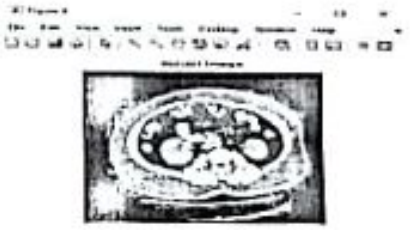


Fig 1: Kidney Stone Image.

Kidney failure may be life threatening. It is there for important to detect early kidney stones. Accurate diagnosis of the kidney stone is important to ensure surgical resection. Ultrasound imaging of the kidneys incorporates speckle sound difficult to perform. So in order to produce an effective stone detection system, dot filtering is one of the most important and possible misdiagnosis that many occur due to differences in the knowledge of forensic pathologists followed by fragmentation and analysis of the stone structure in order to detect the stone automatically.

RELATED JOB

This section provides an overview of the various techniques available for obtaining kidney stones using a variety of images. Detection of kidney stones in the human body is a tedious task, as if improperly detected this could lead to life

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DATA ANALYSIS AND MACHINE LEARNING TOOLBOX

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ABSTRACT

Exploratory data analysis and machine learning are the building blocks of data science. Every person on average produces terabytes of data per day. As a result, the amount of data that is available on the web has increased astronomically in the past decade. Most of us wish to analyze the data and create a machine learning model that suits the data but because of lack of coding knowledge not many are able to do so. There has been a need to develop a system where the data analysis and building machine learning models can be done with just a few mouse clicks. In this project, we try to bring exploratory data analysis and machine learning techniques under a single roof. The front-end for this project is built upon the streamlit for effective user interface of the user.

Keywords: Exploratory data analysis (EDA), machine learning, regression, classification, clustering, visualization.

I. INTRODUCTION

One of the key steps of exploratory data analysis is data visualization. Data visualization refers to the presentation of data in graphical form, such as charts and graphs to make it easier to understand and analyze. Visualization is used in various fields to reveal patterns that are not always apparent from tables or text. Effective data visualization requires careful selection of appropriate charts and graphs, and attention to design elements such as color and layout. Good data visualization can help people make informed decisions. Machine learning is a subset of artificial intelligence that involves developing algorithms and statistical models that allow computer systems to improve their performance based on a specific task by learning from data, without being explicitly programmed. In machine learning, models are trained on a dataset to find patterns, which can be applied to new data to make predictions. Some of the uses of machine learning are natural language processing, classification, regression, clustering, object detection, recommendation systems. EDA, data visualization and machine learning are all linked with one another. Before we build a machine learning model, it's always necessary to clean the data. Data cleaning involves finding missing values, replacing the missing values with appropriate values, finding outliers, and replacing them, encoding the non-numeric features, transforming the numeric features. Once the data cleaning is done, the data will be split into train and test sets. The train set is used to fit the model and the test set is used for evaluation so we can get an EDA is a mandatory step to be performed before we do any sort of machine learning. There are no systems which provide a simple interface to perform EDA and machine learning. In this project, an effort is made to develop a simple user interface where both EDA and machine learning can be done easily. The user interface is developed using python's streamlit library. The user interface contains drag and drop component for dataset uploading, buttons for performing various actions like finding nulls, creating box plots, creating histograms and scatter plots, generating a data report, building machine learning models, training the model and finally to do predictions.

II. LITERATURE SURVEY

[1]. In the first research paper, they have developed an interactive web application that simplifies and automates the exploratory data analysis stage and is extremely user-friendly and easy to use. The web application is named QuickViz. This web application can be utilized by those who don't have any prior knowledge of programming as this tool doesn't require any coding to execute EDA procedures. Users just must upload their dataset and examine the results of descriptive and graphical EDA techniques through the QuickViz tool, aiding them in gaining insights and patterns from data.

[2]. In this research paper, automation of machine learning process is done using PyCaret and streamlit. Machine learning applications for the industry have seen significant growth and attention in recent years. As a result, there is a significant need for Machine learning engineers across the business, but increasing their productivity is still a major problem. For time-consuming Machine learning pipeline operations such as data pre-processing, feature engineering, model selection, hyperparameter optimization, and prediction result

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Live-Face Mask Detection System(OpenCV)

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***Abstract*— The aim of this paper is to depict a system created which detects whether a person has worn a mask or not. For achieving this aim, a dataset consisting of 18236 images of people wearing a mask and without a mask is created. Using the same dataset, 101 layers deep, ResNet-101 convolutional neural network is trained.**

Keywords*— *Acquisition, Image Enhancement, Image Restoration, Color Image Processing, Image Compression, Segmentation, Object Detection & Recognition and Pooling Layer.

I. INTRODUCTION

This is the ongoing time of the COVID-19 pandemic. It has become necessary for the people to wear masks when they go out, especially when they go to a place which has the potential of getting crowded. It becomes a challenging task to monitor a group of people. If some individuals roam without a mask, they can become an origin of spreading COVID19 to other persons which risks others' lives.

To overcome this arduous and challenging task, the solution is to put artificial surveillance which can continuously monitor a group of people. To accomplish this task, we need a system that can recognize the face of the people from the image captured. From these recognized faces, we need to detect whether there is a mask worn or not. A few deep learning models exist which can be used for face-detection. But they lack in terms of accuracy.

Hence to achieve this goal, we have used ResNet-101. We deployed this model on the RaspberryPI board and integrated a web camera to capture images. The system constructed here by us can capture real-time images and from those images detect whether the people have worn a mask or not.

II. LITERATURE SURVEY

By and large, the vast majority of the publication relies on face construction and identity recognition when wearing a face mask. while our emphasis is on recognizing the individuals, who are not wearing face masks to help in diminishing the transmission and spreading of the COVID-19. A few developers built up facemask wearing condition identification techniques. The previous work includes the systems which characterize three classifications of facemask-wearing conditions. The classifications are correct facemask wearing, partial facemask wearing (ie nose not covered), and no facemask wearing. The developers who created the system before, have applied the Principal Component Analysis (PCA) on masked and unmasked faces to recognize an individual. Accuracy of face recognition using the PCA is extremely influenced by wearing masks in these systems. The precision of the system dropped below 70% when the perceived face is covered with masks. The developers proposed a technique that utilized for eliminating glasses from a human frontal facial picture. The eliminated part was recreated utilizing recursive compensation using PCA reproduction. Out of many systems developed, one is using YOLOv3 algorithm for face detection which secured 93.9% accuracy. Another proposed system included the use of a novel GAN-based network which is developed to remove masks covering face area automatically and regenerate the image by building the missing hole. The output of the system was consisting of a completely natural-looking face image. Another proposed system was designed to detect the presence or absence of a mask in the room. The aim of this system is to reduce the false positive face detections. This system secured approximately 95% accuracy. A system with 88% accuracy found that is made for deep learning real-time face emotion classification and recognition using a VGG-16 to classify seven facial expressions. We analyzed all applicable and available methods. Going through all these limitations and methods, we created a system, with efforts to eliminate the issues previous works have. Our proposed research project of the face mask detection system has accomplished 96.02% accuracy.

III. PROPOSED SYSTEM

The proposed model consisted of two key components, the first one is a deep transfer learning ResNet 101 as a feature extractor and the second one is a basic machine learning algorithm decision tree. ResNet is one of the most powerful deep neural networks which has proven the best results when used as a feature extractor. Subsequently, after feature extraction, a decision tree algorithm is used for classification. The following image depicts the working mechanism of the system.

A ResNet is a type of deep transfer learning based on residual learning. ResNet models are proved to be the most efficient models to diminish the problem of vanishing gradients that have their specific residual block. 101-layers deep ResNet-101 starts with a convolutional layer and ends with fully connected layers which have replaced VGG16 layers by faster R-CNN.

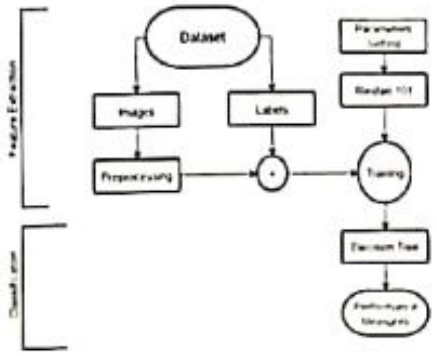


Figure1: Algorithmic flow of the proposed system

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3.4.5 Number of research papers per teacher in the Journals notified on UGC website during the year 2023-24

S.V.U. College Arts

S.No.	Title of paper	Name of the author/s	Department of the teacher	Name of journal	Year of publication	ISSN number	Link to the recognition in UGC enlistment of the Journal
1	"Allure of the 'Indo-Pacific' and dynamics of regional cooperation after COVID-19,"	Prof. M. Prayaga	Centre for Southeast Asian & Pacific Studies	Mukt Shabd Journal	2023	347-3150	10.0014.MSJ.2023.V11I04.0086781.114300
2	"Shanghai Cooperation Organisation (SCO) and India's Role in its Regional Development and Stability,"	Prof. M. Prayaga	Centre for Southeast Asian & Pacific Studies	North Asian International Research Journal of Social Science & Humanities,	2023	2454-9827	10.5575/nairjssh.2022.9.6.21
3	"India-ASEAN Centrality in the emerging Security Architecture in the Indo-Pacific,"	Prof. M. Prayaga	Centre for Southeast Asian & Pacific Studies	India-ASEAN Partnership : A Gamechanger in the Indo-Pacific	2023	978-92-93402-14-1	
4	"Causes for the Conflict in Baluchistan"	Prof. G. Vijaykumar Reddy	Centre for Southeast Asian & Pacific Studies	Mukt Shabd Journal	2023	2347-3150	10.0014.MSJ.2023.V11I04.0086781.114300
5	"Role of Women in Tourism Sector"	Prof. G. Vijaykumar Reddy	Centre for Southeast Asian & Pacific Studies	Parishodh Journal	2023	2347-6648	
6	India, Indian Ocean Strategic and Energy Security"	Prof. G. Vijaykumar Reddy	Centre for Southeast Asian & Pacific Studies	Parishodh Journal	2023	2347-6648	
7	A Historical Study of Feminist Movements in the Roots of Social Reform Movement in Andhra Pradesh"	Prof. G. Vijaykumar Reddy	Centre for Southeast Asian & Pacific Studies	International Journal of Research and Analytical Reviews	2024	2349-5138	
8	"Feminist Perspective Historians, Authors and Activities in Andhra Pradesh	Prof. G. Vijaykumar Reddy	Centre for Southeast Asian & Pacific Studies	Journal of Information and Computational Science	2024	1548-7741	
9	"Economic – Co-operation between India and Japan"	Prof. V. Ramesh Babu	Centre for Southeast Asian & Pacific Studies	North Asian International Research Journal of Social Science &Humanities	2023	2454-9827	
10	"Exports and Imports between India and Japan: A Study",	Prof. V. Ramesh Babu	Centre for Southeast Asian & Pacific Studies	Parishodh Journal	2023	2347-6648	
11	India –China Political and Economic Relations: An Overview"	Dr.V.Ramesh Babu	Centre for Southeast Asian & Pacific Studies	Mukt Shabd Journal	2023	2347-3150	
12	"An Overview of Digital Banking System In India"	Dr.V.Ramesh Babu	Centre for Southeast Asian & Pacific Studies	Parishodh Journal	2023	2347-6648	
13	A Study on Economic Development of Tourism Industry in India and Andhra Pradesh",	Dr.V.Ramesh Babu	Centre for Southeast Asian & Pacific Studies	North Asian International Research Journal of Business Economics & Management	2023	2277-1018	
14	"Role of Service Sector in the Growth of Indian Economy: A Study"	Dr.V.Ramesh Babu	Centre for Southeast Asian & Pacific Studies	GIS Science Journal	2024	1869-9391	
15	"Study on Evolution of Women's Position in Higher Education in India"	Dr.V.Ramesh Babu	Centre for Southeast Asian & Pacific Studies	North Asian International Research Journal of Social Sciences & Humanities	2024	2454-9827	
16	The Impact of Indian Diaspora in Indo-Pacific Region: India's Interest	Dr. M.Padmaja	Centre for Southeast Asian & Pacific Studies	INDIA-ASEAN Partnership A Game Changer in the Indo-Pacific:"	2023	ISBN:978-92-93402-14-1,	
17	"Cambodian Killing fields	Dr. M.Padmaja	Centre for Southeast Asian & Pacific Studies	Global Journal for Research Analysis	2024	2277-8160,	
18	Women Empowerment and Micro-Finance groups in Cambodia Kham phang floating village	Dr. M.Padmaja	Centre for Southeast Asian & Pacific Studies	Global Journal for Research Analysis	2024	2277-8160,	
19	Cambodia Floating Village Kampong Seam Reap	Dr. M.Padmaja	Centre for Southeast Asian & Pacific Studies	Global Journal for Research Analysis	2023	2277-8160,	
20	Self help groups and microfinance: A study on Livelihood and Empowerment of the pulla Yerukula Trible in SPSR Nellore District of Andhrapradesh"	Dr. M.Padmaja	Centre for Southeast Asian & Pacific Studies	International Journal of Recent Research in Social Sciences and Humanities (IJRRSS)	2023		
21	"Pilgrims Amenities at Tirumala and Tirupati : A Comprehensive Study"	Dr. V. Thimmappa	Centre for Southeast Asian & Pacific Studies	International Journal of Research and Analytical Review (IJRAR)	2023	2349-5138	https://www.ijrar.org/papers/IJRAR23D1833.pdf
22	Marine Tourism in India: Opportunities and Challenges	Dr. V. Thimmappa	Centre for Southeast Asian & Pacific Studies	North Asian International Research Journal of Social Sciences & Humanities,	2024	2454-9827	DOI: 10.5575/nairjssh.2024.10.03.01
23	Community Empowerment Through Ecotourism: Study of Talakona in Tirupati District	Dr. V. Thimmappa	Centre for Southeast Asian & Pacific Studies	Proceedings of the Andhra Pradesh History Congress	2024	2320-057X	https://aphistorycongress.com/wp-content/uploads/2025/01/APHC-Proceedings-of-the-46th-
24	A study on knowledge regarding the effect of junkFood on health among adolescent girls	Dr. D. Ramana	Centre for Women's Studies	International Journal of Research and Analytical Reviews – IJRAR	Volume 11 Issue 1 March 2024	2349-5138	http://www.ijrar.org/viewfull.php?&p_id=IJRAR24A3210
25	Political participation of women in Rayalaseema Region in Andhra Pradesh: A Brief Analysis of 2004 to 2019 state Legislative Assembley Elections	Dr. D. Ramana	Centre for Women's Studies	Indian Journal of Women and Development	Vol. 17 issue: 1 May, 2024	2231-3974	https://portal.issn.org/resource/ISSN/2231-3974
26	Overview of Women's Rights in India	Dr. D. Raja Rajeswari	Centre for Women's Studies	Indian Journal of Women and Development	Vol. 16 issue: 2	2231-3974	https://portal.issn.org/resource/ISSN/2231-3974
27	A Study on Knowledge and Attitude About Menstruation and Menstrual Hygiene Among Secondary School	Dr. D. Raja Rajeswari	Centre for Women's Studies	International Journal of Creative Research Thoughts IJCRT	Volume 12, Issue 3 March, 2024	2320-2882	http://www.ijcrt.org/viewfull.php?&p_id=IJCRT2403751
28	A study on knowledge regarding the effect of junk Food on health among adolescent girls	Dr. D. Raja Rajeswari	Centre for Women's Studies	International Journal of Research and Analytical Reviews - IJRAR	Volume 11 |Issue 1 |March 2024	2349-5138	http://www.ijrar.org/viewfull.php?&p_id=IJRAR24A3210
29	First woman Pilot in Indian History – A Case Study	Dr. D. Raja Rajeswari	Centre for Women's Studies	Indian Journal of Women and Development	Vol. 17 issue: 1 May, 2024	2231-3974	https://portal.issn.org/resource/ISSN/2231-3974

30	First woman Pilot in Indian History – A Case Study	Dr. K. Srilatha Kishori	Centre for Women's Studies	Indian Journal of Women and Development	Vol. 17 issue: 1 May, 2025	2231-3974	https://portal.issn.org/resource/ISSN/2231-3974
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Accountancy

AWARENESS ON MOBILE COMMERCE: A CASE STUDY AT NAGARI MANDAL OF CHITTOOR DISTRICT IN ANDHRAPRADESH

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ABSTRACT Mobile commerce also known as E-commerce involves using wireless handheld devices like cell phones and tablets to conduct commercial transactions online, including the purchase and sale of goods and services bills, banking services through online. Mobile Commerce is mixture of information and communication technology, mobile technology and internet. The main objective of this paper focus on mobile commerce and e commerce status like that mobile operations, internet usages in india, and Geographical profile of various levels of the respondents, awareness and utilization of different services in Nagari mandalam of chittoor district in Andhra Pradesh.

KEYWORDS : M-Commerce, Geographical profiles and utilization of mobile network services

INTRODUCTION:

Mobile commerce is refers to the buying and selling of goods and services through wireless handhelds devices such as smart phones and tablets. M-Commerce is a form of E-Commerce that enables users to access online shopping platforms without the use of desktop computer. Over time, contents delivery through wireless devices had become faster, more secure. As a result mobile commerce had grown rapidly use specific industries includes the financial and telecommunications, service and retail in information services. Mobile commerce adopted today are hotel booking and reservation, purchasing airline tickets, purchasing movie tickets and restaurant booking and reservation, online shopping through Amazon, Flipkart, Big basket and the list goes on. Booking of the cab through Ola and Uber is prevalent and well appreciated by all in India.

Mobile Commerce

Mobile commerce is a large subset of electronic commerce, a model where firms or individuals conduct business over the internet. As of 2023, nearly 97 percent of the Americans own a cell phone, and 85 percent of the them owned a Smartphone. This is up from 35percent in 2011. Now a day many product and services can transacted via m-commerce, including banking, investing and purchasing books, plane tickets and digital music etc. the rapid growth of mobile commerce has been driven by several factors including increased wireless handheld devices computing power, a proliferation on m-commerce applications, and resolution of security issues.

Mobile commerce adopted today are hotel booking and reservation, purchasing airline tickets, purchasing movie tickets and restaurant booking and reservation, online shopping through Amazon, Flipkart, Big basket and the list goes on. Booking of the cab through Ola and Uber is prevalent and well appreciated by all in India.

Need for the Study

The mobile cellular market is the fastest growing market regarding subscriber numbers and popularity in India. The substantial increase of the mobile users is linked with greater adoption for mobile commerce in India. As the Internet started to proliferate in many parts of the world, the mobile phone penetration also grew rapidly. With the development of wireless and mobile technologies, Mobile Commerce is expected to make a substantial impact on the business. Mobile commerce is quite popular in the developed countries, but in India, it is in a growing stage and yet to take off. At present, Indian users indulge in mobile purchases for high-value transactions such as entertainment services, games, and music downloads. The convergence of the two fastest growing industries- the internet and the mobile communication- has led to the creation of an emerging market for mobile commerce.

Objectives of the Study

The specific objectives of the study are:

- To study the socio-economic and demographic variables among mobile commerce service users in Nagari mandal.
- To identify the level of awareness of mobile commerce service users.
- To examine the use of mobile commerce services.

Research Methodology of the Study

This study is on both the primary data is collected through a well structured questionnaire to address the research questions. The relevant secondary data was collected from various journals, magazines, news papers, published information and details on websites for the study.

Limitations of the Study

- This study is constrained to Nagari Mandal of chittoor District only.
- The behavior of the people belonging to rest of Nagari.
- This study cannot be generalized, due to quick changes in technology, Customer preferences.

Status of M- Commerce & E-commerce In India:

Now a day's mobile commerce has touched in every field of human life. People use internet for various purpose which includes emails, academic, financial and non financial information like that music video games on internet, chatting on online job searching, online banking etc,. India has day by day increasing in the number of internet and mobile commerce users in india.

Table No.1 Mobile Operators in India: Key Statistics

Telecom Operator	Total Subscriber
Airtel	22,92,67,770
VI	13,67,25,060
Reliance Communications	42,87,78,364
BSNL	2,70,66,371

Source: Internet

From the above table No.1 shows that with the growing momentum of wireless revolution and Mobile commerce explosion, it is evident that mobile devices are becoming a critical component of the new digital economy.

Table No.2 Internet penetration: India Vs World

Country	Percentage
America	96.6%
USA	98%
Japan	94%
Brazil	81.3%
China	71.3%

India	47%
France	93%

Source. Published by Statistical Research Department. July 7th 2022

As can be seen from the Table No.2, compared to the developed/ developing markets, the internet penetration in India is insufficient and hence there exist a huge potential. With the introduction of free unlimited internet access, JIO has captured 369 million customers.

From the above table illustrates the growth pattern and development over the period and the impact of the internet and mobile technology. It spells out the mobile internet users in India among urban and rural people in India. Majority of rural Indian people have started using more of internet related services are the basic reasons for the speedy growth of mobile commerce in India.

Data Analysis And Interpretation

The well framed questionnaire is used to bring out the required data regarding customer perception on the impact of mobile commerce. The collected data were analyzed and interpreted for understanding the impact of mobile commerce. The analysis is carried by using descriptive statistics.

Descriptive Analysis

In this study the descriptive analysis is used in exploring the following domains:

- Demographic profile of the respondents
- Level of awareness of mobile commerce
- Usage of mobile commerce services

From the below Table No. 3 describes various demographic profiles of the respondents namely Gender, Age, Educational qualification, marital status Occupation, Monthly income, Family size, Family type and location within Nagari Mandal. The data analysis, the demographic profiles of the respondents are:

I. 55.00% of the respondents are Male, and 45.00% of the respondents are female. ii.15.00% of the respondents belong to less than 20 years age group. One-third of the respondents belong to 21 – 30 years age group (38.75%). Then 32.5% of the respondents belong to 31 – 40 years age group. Only 13.75% of the respondents belong to above 50 years age group. It shows that younger generation is towards mobile commerce.

Table No.3 Demographic Profile of the Respondents

Demographic variables		Frequency	Percentage
Gender	Male	44	55.00
	Female	36	45.00
Age	< 20 years	12	15.00
	21-30years	31	38.75
	31-40 years	26	32.5
	>50 years	11	13.75
Education	School level	13	16.25
	Diploma Level	10	12.5
	Graduate Level	33	41.25
	PG Level	15	18.75
	Others	9	11.25
Marital status	Married	47	58.75
	Unmarried	33	41.25
Occupation	Student	22	27.5
	Housewife	11	13.25
	Self-employed	10	12.50
	Employed	33	41.25
	Retired	4	5.00
Monthly income	<Rs.15,000	25	31.25
	15001- 30,000	36	45.00
	30001- 40,000	16	20.00
	Above 40,000	3	3.75
Family size	2-4 members	26	32.50
	5-6 members	41	51.25
	> 6members	13.	16.25
Family type	Joint family	35	43.75
	Nuclear family	45	56.25
Located in Nagari Mandal	Yes	80	100.00
	No	-	-

Source: Primary Data

iii. Half of the respondents have completed graduation level 41.25%. Almost one-fourth of the respondents are diploma holders 12.5%. 18.75% of them are postgraduates, and 16.25% of them have completed until school level. 11.25% of the respondents have chosen others as their option, which shows that some of the respondents are having other than listed qualification, but also they are able to use mobile commerce. iv. Majority of the respondents are married 58.75% and 41.25% of them are unmarried. v.One third 27.50% of the respondents are students. Nearly 41.25% of the respondents are working in an employees in the organisation, and 12.50% of the respondents are self-employed. 13.75% of them are homemakers, and 5.00% of the respondents are retired. vi. Almost 31.25% of the respondents' monthly income is less than 15000 rupees. 45.00% of their incomes lie between Rs. 15001 –30000 and 20.00% of them earn more than Rs. 30,001-40,000. 3.75% of them earn above Rs.40000. vii. The majority 51.25% of the respondents responded that there are five to six members in their family, 32.50% of their families have two to four members and only 16.25% of them have more than six members in their family. viii. Considering 56.25% they belong to a nuclear family, and 43.75% of the respondents belong to the joint family. ix. 80 respondents 100.00% are from Nagari mandal.

Analyses of level of awareness of mobile commerce namely types of Smartphone, type of connection, the network provided, grocery store, dealer, in respect of the frequency and percentage is given in Table No. 4 below:

Table No.4 Level of Awareness of Mobile Commerce

Particulars		Frequency	Percentage
Type of your Smartphone	Android	62	77.50
	Keypad	8	10.00
	Apple	9	11.25
	Others	1	1.25
Type of Connection	Post paid	20	25.00
	Prepaid	60	75.5
Network provider	Airtel	20	25.00
	BSNL	11	13.75
	IDEA	8	10.00
	JIO	41	51.25
	Others	0	0
Mobile Usage per Month	<Rs.300	20	25.00
	Rs.300-Rs.500	32	40.00
	Rs.500-Rs.700	9	11.25
	Rs.700-Rs.1000	7	8.75
	>Rs.1000	12	15.00

Source: Primary Data

Interpretation:

From the above table No. 4 shows that, i. More than half of the respondents 77.5% have the android type of smart phones, 11.25% of them have apple mobile phones, 10.00% of them have windows (keypad), and 1.25% of them responded that they use other types of operating system. ii. 75.50% of the respondents are using pre-paid, and 25.00% of the respondents are using the post paid connection. iii. Half of the respondents network provider is JIO 51.25%, 25% of the respondents are using Airtel, 13.75% of the respondents are using BSNL, 10.00% of them are using IDEA, networks respectively. More than 60% of the respondents have done their recharge/top up in grocery stores, through a dealer and by internet also. v.

The majority 25.00% of the respondents spend less than Rs.300 per month for mobile. 40.00% of their monthly usage is between Rs.300 – Rs.500. 11.25% of the respondent's usage is between Rs.500 – Rs.700. 8.75% of them have spent Rs.700 to Rs.1000, and only 15.00% of the respondents have spent more than Rs.1,000 for their mobile usage on a monthly basis.

Table No.5 Utilization of Mobile Commerce Services

Usage	Never	Rarely	Some-times	frequently	Always	Total
Internet	4 (5.00)	29 (35.25)	2 (2.5)	9 (11.25)	36 (45.00)	80
Entertainment	20 (25.00)	8 (10.00)	30 (37.5)	15 (18.75)	7 (8.75)	80
Message (Whats App / Hike)	7 (8.75)	11 (13.75)	17 (21.25)	36 (45.00)	9 (11.25)	80

Video Calling (Skype /Viber/IMO)	9 (11.25)	8 (10.00)	57 (71.25)	5 (6.25)	1 (1.25)	80
Shopping (eBay/Amazon / Myntra / Snapdeal)	24 (30.00)	7 (8.75)	23 (28.75)	19 (23.75)	7 (8.75)	80
Navigation (GPS)	39 (48.25)	19 (23.75)	11 (13.75)	7 (8.75)	4 (5.00)	80
VIRTUAL Wallets like paytm/mPass etc.	8 (10.00)	16 (20.00)	29 (36.25)	14 (17.7)	13 (16.25)	80

Source: Primary Data

Interpretation

The maximum mean score is 45% in a, always which is for surfing internet. The next score for utilization of mobile commerce is attained by Entertainment 37.5% in some times, it shows that most of them are using mobile commerce for entertainment purpose. Then they use mobile commerce for the sake of messaging 45.00% in frequently, then video calling 71.25% in some times. The mean of shopping, wallets like Paytm and GPS are below average. Half of the respondents used it for entertainment, internet and messaging. Since the standard deviation is more than one, it shows that there is more deviation in the level of agreement for usage.

Findings and suggestions

Findings

- It is observed that majority (75%) of the respondents have two to four family members. More than half of 56.25% them belong to the nuclear family.
- Students and employed respondents have invariably adopted Mobile commerce.
- Almost 45 % of the respondents monthly income is less than Rupees 30,000.
- It is found that Android type of Smartphone is used most in the market, followed by windows type.
- It is observed that majority of the Nagari mandalam customers are using a pre-paid connection from the service provider.
- During the study period, it is found that more than half 51.25% of the respondents network provider is JIO and about 25% of the respondents are using Airel.
- It is found that Mobile commerce services are utilised mostly for the entertainment purposes like music, cinema ticket booking and travel. This is followed by surfing internet, messaging like WhatsApp and video calling and online chatting etc,.
- It is found that most of the respondents are use of mobile commerce. They use multiple SIM cards and indulge in mobile transactions with the available kind of internet access.
- Majority of the respondents agree that mobile commerce application is very useful for quick search, which infers that they have a wide variety of alternatives during their state of purchase.
- It is observed that 82.20% of the respondents are willing to recommend their family and relatives to use mobile commerce services.

Suggestions

Based on the observations and findings of the study, the following recommendations are made to improve mobile commerce eco-system for the service provider and policy changes are given below:

- Majority of the 85% in Nagari customers are using a pre-paid type of connection and Android type of Smartphone. Any Business promotion shall target prepaid customers in android platform so that the reach is the maximum instantly and bring positive results.
- It is evident from the study that the parameters such as speed, user friendliness, easy to use and compatibility are major influencing factor for the adoption of mobile commerce services.
- What"s App, Navigation and Shopping usages are more in home town. It is recommended to service provider to focus on location based services (e.g. directions for travelling, information about of the nearest store, etc.
- Due to dynamic and ever changing business environment the tele-communication sector in India has to evolve refined model to suit new policy measures and regulatory mechanism which will certainly make customer delight and improve service satisfaction by assessing the periodical survey.

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CUSTOMERS SATISFACTION LEVAL OF INTERNET BANKING SERVICES: A CASE STUDY ON PAKALA MANDAL OF CHITTOOR (Dt.) IN ANDHRA PRADESH

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ABSTRACT:

Now a day's technology has play a key role in modern society. Each and every task in the banking sector is digitalized. From the account opening to money transfer through online mode, eliminating the need for customers to visit banks and wait in long queues. This operation is very easy to customers and banking institutions. Online banking also encourages competition among banks to offer their customers better services and draw in a growing number of customers. To check the level of customer satisfaction among the 60 numbers randomly chosen. Online bill pay, money transfer, any time and any where use, update information, deliver services and save time and energy are directly related to customer satisfaction words internet banking in Pakala mandalam of chittoor district in Andhra Pradesh.

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Key words: Information Technology, Customer satisfaction, Banking sector

INTRODUCTION

Banking is a highly information intensive activity and relies mostly on information technology to acquire, process and deliver the quality information to all the users. Automated delivery of banking products and services to its customers through electronic communication like internet is referred as internet banking. Banks find that to retain their demanding customers, innovation and updation along with the provision of convenient, reliable and expedient services is very important. Today, almost all the Indian banks are trying to differentiate themselves in the competitive industry and align their offerings to the constantly evolving customer needs and developments in technology in everywhere in India. Globalization and deregulations helped banks expand their reach beyond countries which made them more competitive and therefore looking forward offering internet banking services, to maximize profits as well as retain customers. However, this cannot be achieved without high quality service which when satisfied, results in improved customer satisfaction. To make customers' banking more convenient, efficient and effective it is very important to ascertain the customers' perception of overall service quality and their satisfaction with online banking services.

Conceptual frame work:

E-banking refers to banking operations, with which the customers can carry out transaction through internet, which is completely safe and secure. E- banking encourages paperless or cashless transaction in everywhere in india.

Internet Transaction: Banking facility provided the customers through the customers are able to perform a number of monetary& internet using transactions, through the bank websites.

Mobile banking: almost all the banks have designed their mobile applications with which you can perform transactions at your fingertips, which is smart phones, internet, mobile application and banking services in your bank account.

ATM: ATM is not a just a machine with which you can withdraw cash as and when required, bit it also allows you to check your accounts status , deposit funds, transfer funds, change debit card pin, personal identification number

Debit Card: now a day's debit cards used in our day to day life so as to perform end number of transactions. Debit cards are linked to the customer's bank account and so the customer's only needs to swipe the card, in order to make payment at point of sale (POS) outlets, online shopping. ATM withdrawals, in this way the amount is deducted from the customer's account directly.

Credit card: it is just like a debit card, a credit card is also a payment card which the banks issue to the customers on their on their request, after checking their credit score and history. It enables the cardholders to borrow funds up to the pre-approached limit and make a payment. The maximum limit is granted by banks with

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issue the card. The card holder promises to repay the amount within a stipulated time period. Otherwise some charges for the issue of credit card.

Point of Sale (PoS) : PoS system refers to the point, in terms of date, time and place, where the customer makes a payment, using a plastic card for the purchase made or services received.

Electronic Data Interchange (EDI): EDI is a new mode of communicating information between businesses electronically using a standardized format.

Electronic fund transfer: when money is transferred electronically from one bank to another bank. It cover direct debit, direct deposits, wire transfers, RTGS, NEFT,etc,.

OBJECTIVES OF THE STUDY

This research has been carried out with the following objectives.

- To identify the factors influencing the customers to opinion for Internet Banking service in the study area.
- To analyse the problems of internet banking customers.
- To offer suitable suggestions to promote the Internet banking service of the public and private sector banks.

Research Methodology of the Study

This study is on both the data is collected through a well structured questionnaire to address the research questions and take 60 randoms, but all the questions responses have five options, i.e., Highly satisfied, Satisfied, Neutral, Dissatisfied , Highly Dissatisfied. The relevant secondary data was collected from various journals, magazines, news papers, published information and details on websites and so on.

DATA ANALYSIS AND INTERPRETATIONS

The primary data was collected from the users of Internet banking. Interview schedule was used to collect the data from the internet banking customers of selected public sector banks were State Bank of India, Canara Bank, Indian Bank,Axis Bank and other Banks in Chittoor District of Andhra Pradesh.

GENDER WISE CLASSIFICATION

The gender wise classification of the respondents gives an outline about which category of customers highly prefers the internet banking.

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Table No.4.1
Number of Respondents

Gender	Number Of Responds	Percentage
Male	40	66.60
Female	20	33.40
Total	60	100

Source: Primary Data

Table 4.1 shows that out of the total respondents, a majority (66.60%) of respondents was male and the remaining 33.40% of the respondents were female using internet banking. Therefore, it is concluded that a majority of the male customers prefer internet banking than their females.

AGE WISE CLASSIFICATION

Age is an important demographic variable that not only determines an individual's physical and mental maturity but also depicts life experiences. As the age increases, the learned experience changes the behaviors of individuals. Learning is an action based on experience. Hence, most behavior is learned by individuals. Therefore, it is interesting to note the age - wise distribution of the respondents.

Table No.4.2
Number of Respondents

Age	Number Of Respondents	Percentage
Up to 20 years	18	30.10
21 – 30	29	48.30
Above 50 years	13	21.60
Total	60	100

Source: Primary Data

Table 4.2 from the above table no shows that the majority of the respondents belonged to the age groups 21 - 30 years using internet banking service in the modern world.

MARITAL STATUS

In Indian society, marriage is supposed to be a religious obligation. In the social context, it is the prelude to the family formation, expansion or even bifurcation. After marriage, there is a transition in the status of men and women by change in rights and obligations. More than the conventional roles of parents, today's parents play a crucial role in building up a family; inculcate values for life and so on. Hence, the marital status of the respondents is given in the table.

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Table No.4.3
Marital Status

Marital	Number Of Respondents	Percentage
Married	35	58.3
Un Married	25	41.6
Total	60	100

Source: Primary Data

Table 4.3 shows that out of the total respondents, a majority (58.3%) of respondents was married and the remaining 41.6% of respondents were unmarried. So, it is identified that most of the respondents are married. It is clear from the table married people highly prefer internet banking.

EDUCATIONAL QUALIFICATION

Education is one of the most important traits of the customers because the perception, awareness and behavior of the customers depend largely on his/her educational qualifications. Education plays a vital role for having access to basic internet banking. The level of education of the respondents is portrayed in the below table 4.4.

Table No.4.4
Educational Qualifications

Qualifications	Number Of Respondents	Percentage
SSC	12	20.2
Inter	8	13.3
Graduate	28	46.6
PG	8	13.3
Others	4	6.6
Total	60	100

Source: Primary Data

It reveals that out of the total respondents, 46.6% of the respondents were graduates, 20.2% of the respondents have completed higher secondary level, 13.3% of the respondents were post graduates, again 13.3% of the respondents have completed upto secondary level. 6.6% of the respondents were others. Hence, it is clear that a majority of the respondents are graduates as internet banking requires a little technical knowledge.

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OCCUPATION WISE CLASSIFICATION

Occupation determines the need of using internet banking service. The occupation wise classification of the respondents is given in the table.4.5.

Table No.4.5
Occupation Wise Classification

Occupation	Number Of Respondents	Percentage
Government	3	15.0
Private	20	11.1
Business	4	16.6
Agriculturist	6	10.0
Home Maker	11	20.7
Student	16	26.6
Total	60	100

Source: Primary Data

Table 4.5 shows that out of the total respondents, 26.6% of the respondents were studying, 20.7% of the respondents were homemakers, 16.6% of respondents were businessmen, 15% of the respondents were working as government employees, 11.1% of the respondents were business, and 10.% of the respondents were agriculturists.

Therefore, it is evident from the table that most of the private employees are highly interested in internet banking service as they are well aware of its nuances.

MONTHLY INCOME

Adequate income encourages the customers to opt for internet banking service. The monthly income of the respondents is disclosed in the Table 4.6 shows that out of the total respondents, 51.6% of the respondents had a monthly income of Rs. 10,001 to Rs. 20,000, 43.3% of respondents had a monthly income up to Rs. 10,000, and above Rs. 20,000 respectively.

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Table No.4.6
MONTHLY INCOME

INCOME	Number Of Respondents	Percentage
UP to Rs.10,000	26	43.3
Rs. 10,001-20,000	31	51.6
Above 20,000	3	5.1
Total	60	100

Source: Primary Data

TYPE OF FAMILY

The family background plays an important role in moulding the behavior to any person. The family provides the recognition and security for the individual identity. The living arrangements are very crucial for the socio-economic status of a person. Traditionally, Indian society preferred to live on joint family arrangements. As the economic necessitates improved, people moved towards nuclear families than of joint families. Besides this some of the cultural aspects such as family relationship, increase in style of living have made the family size to shrink. The outline about the type of family of the respondents is given in the table.

Table No.4.7
TYPE OF FAMILY

FAMILY	Number Of Respondents	Percentage
Nuclear Family	46	76.6
Joint family	14	23.3
Total	60	100

Source: Primary Data

Table 4.7 indicates that out of the total respondents, a majority (76.6%) of the respondents belonged to nuclear family and the rest 23.3% of respondents belonged to joint family.

PREFERRED BANK

There are a few reasons behind the choice of bank such as easy convenience, trust worthiness, low cost of transaction and the availability of service. The bank which is preferred by the respondents to maintain their account is shown in the table.

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Table No.4.8
PREFERRED BANK

PREFERRED BANK	Number Of Respondents	Percentage
SBI	11	18.30
Canara Bank	13	1.66
Indian Bank	19	31.60
Union Bank	12	20.11
Axis Bank	2	3.33
Other Bank	3	25.00
Total	60	100

Source: Primary Data

Table 4.8 shows that out of the total respondents, 31.60% of respondents held their account in Indian Bank, 25% of respondents held their account in other Banks, 20.11% of the respondents held their account in Union Bank, 18.30% of the respondents held their account in State Bank of India, 3.33% of respondents held their account in Axis Bank, and 1.66% of the respondents held their account in Canara Bank. Hence, it is clear that a majority of the respondents maintain their accounts in Indian Bank as it offers better quality of service.

SOURCE OF INTRODUCTION

Source of introduction refers to the person who motivates the respondents to open a bank account in a specific bank. The source of motivation of the respondents is unveiled in the table.

Table No.4.9
SOURCE OF INTRODUCTION

Source	Number Of Respondents	Percentage
Friend	27	45.0
Relative	18	30.0
Advertisement	3	5.0
Banker	12	20.0
Total	60	100

Source: Primary Data

Table 4.9 unveils that out of the total respondents, 45% of the respondents were motivated by their friends, 30% of the respondents were motivated by their relatives, 20% of the respondents were motivated by the Banker and 5% of the respondents were motivated by the advertisement to choose the respective banks. Hence, it is clear that most of the respondents were motivated by their relatives to opt for a particular bank.

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FREQUENCY OF USING INTERNET BANKING SERVICE

The frequency of using internet banking varies from one customer to another. How often the respondents are accessing internet banking service is displayed in the table.

Table No.4.10

FREQUENCY OF USING INTERNET BANKING SERVICE

ATM	Number Of Respondents	Percentage
Frequently used	16	26.66
Occasionally	11	18.34
When need arises	33	55.00
TOTAL	60	100

Source: Primary Data

Table: 4.10 shows that out of the total respondents, 55% of the respondents used internet banking service when need arises, 18.34% of the respondents used internet banking service occasionally and the rest 26.66% of the respondents used internet banking service frequently.

SATISFACTION ON INTERNET BANKING SERVICE

The satisfaction of the customers plays a crucial role in the promotion of the service. The customers' satisfaction on internet banking service is described in the below table 4.11

The customers' satisfaction on internet banking is ranked based on the mean score. As per the mean score customers were highly satisfied on a few statements andsatisfied on a few statements. The customers were highly satisfied on internet banking provides 24×7 hours service (61.7%), it curtails the time to stand on queues in the bank branches satisfied and nutral in (35%), it helps to perform the transactions confidentiality in nutral (25%), internet banking highly satisfied (18.3%) internet banking provides up to date information regularly 23.3% in satisfies and highly dissatisfied. It offers high quality service satisfied at (31.66%).

Table No.4.11

SATISFACTION LEVEL ON INTERNET BANKING SERVICE

Statements	HS	S	N	DS	HDS	TOTAL
Internet banking provides 24 X 7 hours service	37 (61.7)	11 (18.8)	5 (8.33)	4 (6.66)	3 (5.5)	60
It curtails the time to stand in queues in the bank Branches	8 (13.33)	21(35.00)	21 (35)	5 (8.33)	5 (8.33)	60
It helps to perform the transactions confidentially	14 (23.3)	14 (23.3)	15(25.00)	13(21.6)	4 (6.66)	60
It provides necessary information to the customers	11(18.3)	15 (2.5)	13 (21.6)	12(20.00)	6 (10.0)	60

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It enhances the financial security	8 (13.3)	11(18.3)	15(2.5)	12(20.0)	14(23.3)	60
It reduces the cost of transaction	14(23.3)	19(1.66)	9(15.9)	10(16.6)	8(1.66)	60
Internet banking provides up–to-date information Regularly	10(16.6)	14(23.3)	15(2.5)	14(23.3)	7(11.6)	60
It performs the transaction at pre-determined time	16(23.6)	17(28.3)	9(15.0)	12(20.0)	6(10.0)	60
It offers high quality service	12(20.00)	19(31.66)	10(16.6)	11(18.3)	8(1.6)	60
Availability of service is faster than traditional banking	17(28.3)	14(23.3)	10(16.6)	7(11.6)	12(20.0)	60
It increases the believability, honesty and trustworthiness of the customers	11(18.3)	17(28.3)	10(16.6)	13(21.6)	9(15.0)	60
12 Internet banking ensures accountability	11(18.3)	13(21.6)	13(21.6)	10(16.6)	3(5.0)	60

(**HS** – Highly satisfied **S**– Satisfied **N**– Neutral **DS** – Dissatisfied **HDS** – Highly Dissatisfied)

The customers were highly satisfied on availability of service is faster than traditional banking (28.3%), and it increases the believability, honesty and trustworthiness of the customers satisfied in (28.3%). It perform the overall internet banking ensures accountability is highly satisfied (18.3%) respectively.

FINDINGS AND SUGGESTIONS

- A majority (66.60%) of the male customers have preferred internet banking than their female counterparts as male is technology.
- 48.3% of the respondents who belonged to the age group of 21 - 30 years make use of internet banking service as they are exposed to technology enabled services.
- A majority (58.3%) of the respondents are married. It is identified that married people mostly prefer internet banking as they have greater responsibility.
- All (100%) the respondents are educated and there is no respondent without formal education.
- It is found out that 26.6% of the respondents are from students background.
- It is understood that 51.6 % of the respondents belong to a monthly income category of Rs. 10,001 - Rs. 20,000.
- A majority (76.6%) of the respondents belong to nuclear family as they need privacy and expect to be independent in all walks of life.
- It is understood that 31.60% of the respondents hold their accounts in Indian Bank as it offers better quality of services in this area.

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SUGGESTIONS

- Banks should take necessary steps to create awareness among rural people about the advantages of internet banking services available in the banks.
- The banks should offer internet banking service in the regional language to attract the customers to enable all the customers to make use of the service irrespective of their education bag round.
- The internet banking system should be enhanced to make the online enquiry and online payment much easier to the customers.
- The bank should not restrict the time to carryout NEFT transaction in care of transferring fund from one bank to another.
- Public sector banks should improve their internet banking services to compare with their private sector counterparts.
- The public sector banks must improve its service quality in terms of communication, responsiveness, reliability and understanding.
- The bank should provide various effective modes for promotional schemes, interaction with the customers, more accuracy in billing, and financial security and privacy in transactions.

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AN OVERVIEW OF NIFTY-50

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ABSTRACT

A stock market index is created by selecting a group of stocks that are representative of the whole market or a segment of the market. NIFTY 50 is the benchmark index of India, reflecting the overall dynamics of an Indian equity market as well as the Indian economy. The NIFTY 50 is a well diversified 50 stock index, which covers all the important sectors of Indian economy and works as a face of Indian economic performance. It is used for a variety of purposes such as benchmarking fund portfolios, index-based derivatives and index funds (options and futures). The objective of this paper is to give insights about what NIFTY 50 is, how it functions, what exactly is an index and benchmark index, what types of stocks are involved in it, what are the measures to calculate market capitalization and how it developed over the years when compared to other stock exchanges,what is SGX NIFTYis andhow is SGX NIFTY is different from Indian NIFTY .

INTRODUCTION

NIFTY 50 Index is an index consisting of 50 blue chip large and liquid stocks listed on the National Stock Exchange of India. Since inception, the NIFTY 50 Index has successfully

become the ‘stock of the nation’, helping investors understand the pulse of Indian capital market. It has lived up to its core purpose of providing afair representation of the Indian equity market focusingon portfolio diversification andliquidity. Over the years, the NIFTY 50 has become one of the most widely used benchmark for exchange traded products on Indian equity market.

II. LITERATURE REVIEW OF

Swati Garg and Y. P. Singh (2013) associated the performance of NIFTY-50 and Index Funds. Five NIFTY-50 and Index Funds tracking the same benchmark indices wereanalysed in the study over a period of three years starting from June 2006 to December 2009. The analysis showed that over long-term investment horizon NIFTY-50 performed better in terms of their imitation strategy, tracking ability and performance effectiveness. However, it was evident from the study that short-term investors face a disadvantage from investing in NIFTY-50.

P.Mishra and G.Singh (2016) attempted to make an intra-class performance evaluation of some Indian Index funds. Graphical interpretations were used along with statistical tools like R-square and tracking error values. Two models of tracking error were test empirically the performance of the selected index funds. Empirical results revealed that out of the selected index funds, SBI NIFTY Index fund outperformed the other six index funds during the period under study. SBI NIFTY Index fund was also able to limit the tracking error to an acceptable limit.

S. Narend (2014) Made a comparative study of the performance of NIFTY-50 and index funds. The study was done empirically since the period of their respective initiation till July 2013. The study used three parameters for the analysis of the performance such as active

returns, tracking error and Jensen's alpha. The analysis showed that NIFTY-50were performing betterwhen compared to the index mutual funds

Falguni Pandya (2016) analysed the index fund and measuring tracking error. The study used descriptive statistics,and proved that NIFTY and banking index-based funds were found to be having lowest tracking error, while Gold NIFTY-50 didn't perform better in terms of mean return whereas, international NIFTY-50was found to be most efficient.

OBJECTIVES OF THE STUDY

1. To know about the NIFTY 50 and their constitution and the types of Sectors involved in NIFTY-50

2. To know about the Index and its methodology.

3. To know about the market capitalization and its calculation method.

4. To know about the SGX NIFTY and how it is different from Indian NIFTY.

NIFTY 50, ITS CONSTITUTION AND TYPES OF SECTORS INVOLVED IN NIFTY-50

Understanding the NIFTY 50

While the NIFTY 50 is now a much relied upon barometer for measuring the performance of Indian stock markets at large, it has been meticulously constructed over time in order to achieve this status. The benchmark index is made up of stocks belonging to 13 sectors in order to achieve diversification. The sectors are as follows:

– Oil and gas

– Consumer goods

– Information technology

– Financial services

– Automobiles

– Construction

– Telecommunication

– Pharmaceuticals

– Power

– Cement products

– Metals

– Fertilizers and Pesticides

– Media and entertainment

The NIFTY 50 functions as an indication of the performance of Indian markets because it is in and itself a small sample representation of the best offerings of the Indian markets; If the stocks in NIFTY 50 are not performing well, it is very likely that the economy at large will not be able to escape the adverse effects that bringingdown the index .

Constitution of NIFTY

To be considered for inclusion in the NIFTY 50, a firm or stock must meet the following criteria:

- The firm should be headquartered in India and should have been listed and traded on the National Stock Exchange (NSE).
- To be included in the NIFTY 50 Index, the firm must be included in the NIFTY 100 index and be accessible for trading in the NSE's futures and options market.
- The business's average free-floating market capitalization should be 1.5 times that of the index's smallest firm.
- The stock should have been traded every day for the previous six months (100 percent trading frequency).

How can a company be entered in NIFTY-50

To enlist in NIFTY, a company has to be listed on NIFTY Index and has to qualify the following criteria:

- The firm must have been enlisted on the National Stock Exchange.
- It needs to be an Indian company.
- The company's shares must be exceedingly liquid.
- The liquidity indicator is the average impact cost. The impact cost can be termed as the trading price of a single share in comparison to the index's influence on a company's market valuation.
- For the succeeding six months, the firm's impact cost should be less than 0.50 per cent. Or it should be less with at least 90% of calculations made on a portfolio of ₹10 crores.
- The frequency of the firm's business should be 100% for six months.
- The Gross Market Capitalization should be free-floating. This GMC should be 1.5 times the size of the index's smallest business.

- Differential Voting Rights or DVR with shares of companies can be eligible for inclusion in the NIFTY 50 Index.

NIFTYINDEX AND ITS METHODOLOGY.

NIFTYIndex

To explore function what NIFTY 50 and what the NIFTY 50 stocks are, one must first understand what exactly an index or a benchmark index is in the its simplest terms, an index is a basket of securities that is created as a representational sample of a certain sector in the market. This representational sample then works as a barometer to test the market performance. It is a statistic that calculates to what extent changes in the stock market. It monitors price changes and market performance. To establish an index, a few stocks are to be chosen from a list that have similar characteristics like company size, industry and total market capitalization.

The value of the stock market index can be calculated by the values of the underlying group of equities. The value of the stock index is influenced by differences in the underlying stock. If the majority of stocks grow in value, so will the index, and vice versa.

Index Methodology

Eligibility Criteria for Selection of Constituent Stocks:

i. Market impact cost is the best measure of the liquidity of a stock. It accurately reflects the costs faced when actually trading an index. For a stock to qualify for possible inclusion into the NIFTY50, it should have traded at an average impact cost of 0.50% or less during thelast six months for 90% of the observations, for a basket size of Rs. 100 Million.

ii. The company should have a listing history of 6 months.

iii. Companies that are allowed to trade in F&O segment alone are eligible to be constituent of the index.

iv. A company which comes out with an IPO will be eligible for inclusion in the index, if it fulfils the normal eligibility criteria forthe index for a 3-month period instead of a 6-month period.

Index Re-Balancing:

Index is re-balanced on semi-annual basis. The cut-off dates are is January 31 and July 31 of each year, i.e. for semi-annual review ofindices, average data for six months ending the cut-off date is considered. Four weeks prior notice is given to market from the date ofchange.

Index Governance:

A professional team manages all NSE indices. There is a three-tier governance structure comprising the Board of Directors of NSEIndices Limited, the Index Advisory Committee (Equity) and the Index Maintenance Sub-Committee.

MARKET CAPITALISZATION AND ITS CALCULATION METHOD

Market Capitalization

Definition: Market capitalization is the aggregate valuation of the company based on its current share price and the total number of outstanding stocks. It is calculated by multiplying the current market price of the company's share with the total outstanding shares of the company.

Description: Market capitalization is one of the most important characteristics that helps the investor determine the returns and the risk in the share. It also helps the investors choose the stock that can meet their risk and diversification criterion**.**

Calculation Method

Market Capitalization = Shares outstanding * Price

Free Float Market Capitalization = Shares outstanding * Price * Investible Weight Factor

Index Value = Current Market Value / Base Market Capital * Base Index Value (1000)

The IWF (Investible Weight Factor) is a factor in the formula above that is used to determine the number of shares available for trading in the market. Because the value of stocks fluctuates daily, as the index is calculated in real-time.

The method above also takes into account changes in the business environment. Stock splits, rights issues, and other similar modifications are examples of these developments. NIFTY maintains the index regularly to ensure its stability and effective operation. This is how NIFTY 50 is calculated.

SGX NIFTY and how it is different from Indian NIFTY.

SGX NIFTY

SGX NIFTY is a derivative of the NIFTY index, which is traded in the Singapore Stock Exchange platform. This trade sets a predetermined price of a share and reduces the future risk of any investments. To make it easy for one to understand, one should keep in mind that like Indian NIFTY trades on the NSE, which is the Indian stock exchange platform, the SGX NIFTY is the futures trade NIFTY in Singapore. In this SGX NIFTY,the price of the share is present, the

buyer and seller have to commit to that pre-decided price in spite of any changes that may take place in the stock market in the future.

As the Singapore Stock Exchange is a leading stock exchange in India, the SGX NIFTY helps to predict and observe the behaviour of the Indian NIFTY and thus has an important role to play in the Indian stock market.

Different between SGX NIFTYand Indian NIFTY

The main difference between the SGX NIFTY and the Indian NIFTY is that the SGX NIFTY is a futures trade platform in Singapore where the prices of stock are predetermined to avoid the future risk, whereas the Indian NIFTY trades only on the Indian stock exchange platform, which is the National Stock Exchange or NSE.

Another important difference is the contract size of the Indian NIFTY and the SGX NIFTY. In an Indian NIFTY a contract between the buyer and seller must have a minimum of 75 shares, which is not required in the SGX NIFTY. This means that SGX NIFTY does not have to include shares, whereas every Indian NIFTY must include shares.

SGX NIFTYattracts a high number of customers and trading activities because it is the most active trading platform in Singapore and the only trading platform that works for sixteen hours a day. This is definitely not the case with the Indian NIFTY, which is a National exchange platform. These characteristics of SGX NIFTY make it more profitable.

Impact of SGX NIFTYon the Indian Market

As already discussed, the SGX NIFTY proves to be helpful in predicting and observing the Indian NIFTY's behaviour. There is also a time difference between the Indian NIFTY and the SGX NIFTY, wherein the Singapore market opens about two and half hours before the Indian

market. This allows investors to keep an eye on the SGX NIFTY to know the fluctuations in the market and observe how well the overall trading process is going. By observing this, the investors get an idea about the Indian market and how does it open either with positive or negative results. Therefore, those who are sceptical about investing in the Indian market, can invest in SGX and keep an eye on the SGX NIFTY to get an idea about the Indian NIFTY and stock exchange platform.

Although this may be a convenient way to judge the Indian market and weigh out 0ne chances, not all results that these investors get are accurate and subject to the various economic factors existing in both the countries as both these countries like India and Singapore have very different economic structures and yet they have different prominent effects on the market behaviour.

Both the Indian NIFTY and SGX NIFTY are equally important as they have some effects on each other's behaviour, and one cannot be talked about without mentioning the other. Everyone who wishes to enter the stock market world and starts trading like an expert need to first know and be familiar with NIFTY and SGX NIFTY terms and many other financial terms commonly used and have important roles to play in the stock market.

CONCLUSION

The NIFTY index is an important pointer of the market, and its movements affect the Indian economy to a great extent. NIFTY is the NSE’s benchmark index (National Stock Exchange). The stock index that calculates the 50 biggest and most liquid stocks on NSE is called NIFTY. These 50 largest firms reflect India’s stock market and economic trends, and they come from a variety of industries. The top 50 largest firms are selected based on the market capitalization as shown above and the top good performing sectors are healthcare and

technology.One must note that SGX NIFTYis highly preferable platform toNIFTY due to the reasons like performing trading for sixteen hours a day, not involving any minimum number of share and the predetermined futures price .

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This certificate is presented to **Prof. M. Venkateswarlu, Head, Department of Commerce, Sri Venkateswara University, Tirupati** for participating / presenting the research paper entitled "**Investigating the Impact of Product Information on Customers' Purchase Intentions in Online Grocery Shopping with Reference to Hyderabad**" in the 4th International Conference on Contemporary Management organized by Department of Management Studies, NPR College of Engineering & Technology, Natham, Dindigul, Tamil Nadu, India on 26th April 2024. (ISBN No. 978-81-864847-2-9)

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PROBLEMS AND PERCEPTIONS OF WEAKER SECTION ENTREPRENEURS IN NELLORE DISTRICT

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***Abstract*- The term "weaker section" refers to a section of the population that is socially, economically, and politically behind the other sections of the population and has been experiencing various forms of inabilities as a result of their backwardness. The Government of India Act, 1935, defines "weaker sections" as class or classes of people who are suffering from educational and economic backwardness, as well as some aspects of social life, due to traditional customs of untouchability, tribal background, tribal way of life, or other backwardness. In India weaker sections encompassing marginalized groups such as Scheduled Castes, Scheduled Tribes, Other Backward Classes, and economically disadvantaged individuals. The research focuses on the objectives of identifying the problems and perceptions of sample entrepreneurs in the Nellore district, particularly those who received financial assistance from the Andhra Pradesh State Finance Corporation (APSFC) between 2022 and 2023. The sample design involves 3658 entrepreneurs from four revenue divisions, with a convenience sampling method adopted for selection. The study spans a ten-year period from 2012-13 to 2021-22, with primary data collected in 2022-23 and secondary data gathered from 2013 to 2022. The problems faced by the sample entrepreneurs are categorized into financial, raw material, marketing, labour, and infrastructural issues. The study also assesses general problems in obtaining assistance from Nellore branch APSFC, highlighting concerns such as delays in loan processing, inadequate sanctions, excessive terms and conditions, high-interest rates, and delays in disbursements. Perceptions of sample entrepreneurs regarding APSFC's activities, sources of information, and opinions about obtaining complete information are analyzed.**

***Keywords*: APSFC, Weaker sections, Disbursement, Perception.**

Introduction

India, with its rich tapestry of cultural diversity and economic dynamism, grapples with the intricate challenge of addressing the needs and aspirations of its weaker sections. The term "weaker sections" encompasses various marginalized groups such as Scheduled Castes (SCs), Scheduled Tribes (STs), Other Backward Classes (OBCs), and economically disadvantaged individuals facing socio-economic vulnerabilities, often due to historical injustices, caste-based discrimination, economic disparities, and lack of access to opportunities.

Historical Perspectives: The roots of the challenges faced by the weaker sections in India can be traced back to historical injustices, deeply embedded in the country's social fabric. The caste system, a centuries-old hierarchical social structure, has perpetuated discrimination and created a stark divide between the privileged and the marginalized. Despite constitutional safeguards and affirmative action measures, the persistent effects of historical oppression continue to hinder the progress of these sections.

Economic Disparities: One of the primary issues faced by weaker sections is economic inequality. Limited access to education, healthcare, and employment opportunities exacerbates their socio-economic vulnerabilities. As a result, a significant portion of the population finds itself trapped in a cycle of poverty, making upward social mobility a distant dream for many.

Educational Challenges: Education, often considered a potent tool for social transformation, remains elusive for many in the weaker sections. Lack of adequate infrastructure, discrimination in educational institutions, and socio-economic constraints contribute to lower enrollment and high dropout rates among these communities. This educational gap perpetuates a cycle of poverty, limiting the potential for overall development.

Caste-Based Discrimination: Despite legal prohibitions, caste-based discrimination continues to persist, affecting the daily lives of those in weaker sections. Social stigmas and prejudices impede their access to basic amenities, healthcare, and even employment opportunities. Addressing these deeply ingrained biases is crucial for fostering an inclusive and equitable society.

Perceptions and Stereotypes: Perceptions surrounding the weaker sections often perpetuate stereotypes, further marginalizing these communities. These preconceived notions hinder their integration into mainstream society and

contribute to the perpetuation of systemic inequalities. Challenging these stereotypes is essential for creating a more just and inclusive society.

Objectives of the study

The main objective of the study is to identify the problems and perceptions of sample entrepreneurs in the study area.

Sample design

The study is to probe into the availability of finance for the weaker sections of entrepreneurs from Nellore branch APSFC in Nellore district. The sample size of the present study includes only the weaker sections of entrepreneurs who got financial assistance from Nellore branch APSFC. The weaker sections of entrepreneurs financed by Nellore branch APSFC during the period 2022 to 2023 have been taken into consideration to collect the required data. Nellore district has been divided into four divisions namely Kandukur, Kavali, Nellore and Atmakur. A total of 3658 entrepreneurs of weaker sections who have taken loan in the above said branch by APSFC have been selected for study in the first stage. The convenience sampling method has been adopted for the selection of the sample respondents as a result of which 15 per cent of weaker sections of entrepreneurs assisted during this period were chosen conveniently for the study. Out of the total 549 sample respondents,129 sample respondents are from Kandukur revenue division,136 sample respondents from Kavali revenue division,175 sample respondents from Nellore revenue division and 109 sample respondents are from Atmakur revenue division. The strength particulars of the sample borrowers of weaker sections entrepreneurs from the four revenue divisions of Nellore branch Andhra Pradesh State Finance Corporation are furnished in the below table 1.

Table No. 1

Sample borrowers of weaker sections of entrepreneurs from four revenue divisions of Nellore branch of Andhra Pradesh State Finance Corporation in Nellore district

Revenue Divisions	**Total number of borrowers in each revenue division**	**Sample number of borrowers in each revenue division (15 Per cent of Total number of borrowers)**
Kandukur	862	129
Kavali	903	136
Nellore	1165	175
Atmakur	728	109
TOTAL	**3658**	**549**

Source: Nellore branch APSFC.

Period of the study

The period of study is for 10 years from 2012-13 to 2021-22. The primary data pertains to the field of study of the weaker sections of entrepreneurs of the four revenue divisions namely Kandukur, Kavali, Nellore and Atmakur in Nellore district and the study was conducted in the year 2022-23. The secondary data were collected during the period from 2013 to 2022.

Problems faced by the sample entrepreneurs

The entrepreneurs of any category or nature of business in the world face different kinds of problems like infrastructure, financial, labour, raw material, marketing and technology, etc., and the degree of severity of the problem varies based on the nature of business, size of business, location of business, form of business organization, etc. Though problems of an entrepreneur of an enterprise can be classified into two categories namely, internal and external problems. Internal problems affect the operating performance of an enterprise to a great extent. The problems are size of the organization and structure, process of production, training of the personnel, scantiness of management etc. External problems result from factors outside the control of entrepreneurs, such as the availability of water, power and other infrastructure facilities required for the smooth management of an enterprise, finance, marketing, etc. In the present research study, the role of Nellore branch APSFC in promoting the Weaker sections entrepreneurs, some of the problems of sample entrepreneurs in the sample district of Nellore have been highlighted to have an understanding about the common problems faced by the entrepreneurs in general in India. The key issues where problems arise in the institution and in the smooth running of entrepreneurs are mobilizing finance, acquiring of raw material, engaging labour, marketing, management, infrastructure facilities, government regulations, technological up-gradation, license, recovery of debts, etc.

Financial Problems of Sample Entrepreneurs

One of the important problems for a business concern is scanty financial resources. Most of the entrepreneurs are suffering from insufficient financial sources. These enterprises are not able to mobilize required finance from different sources because of the small size of the enterprise. The funding agencies arc also imposing number of terms and conditions to provide finance to meet entrepreneurial fixed and working capital requirements. The entrepreneurs have to depend on more than one source and pay heavy investment charges, and the huge rate of interest on loans raised. The other common problems faced by the entrepreneurs are also briefed hereunder. The opinions of the sample entrepreneurs about various aspects of financial problems are depicted in the table no. 2.

Table No. 2-Financial Problems of Sample Entrepreneurs

Problems	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Shortage of long term loans	49	37.98	51	37.50	77	44.00	50	45.88	**227**	**41.34**
Shortage of working capital	42	32.56	44	32.35	52	29.72	26	23.85	**164**	**29.87**
Both of the above	38	29.46	41	30.15	46	26.28	33	30.27	**158**	**28.79**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

The sample entrepreneurs were mainly facing the problem of scarce long-term loans and working capital funds. From the table 2 it is clear that out of 549 sample entrepreneurs, 41.34 per cent were facing the problem of shortage of long-term finance, 29.87 per cent were facing the problem of shortage of working capital and the rest of 28.79 per cent of entrepreneurs were facing shortage of both long-term funds and working capital in the sample district. The shortage of long-term loans and working capital was high in Nellore revenue division when compared to the remaining revenue divisions.

Raw Material Problems of sample entrepreneurs

Majority of the enterprises are facing the problem of production interruptions due to non-availability of raw materials on time. These enterprises have been established in rural and backward areas mainly because of subsidies and incentives offered to them in rural areas. The growth and sustainability of an enterprise depend on the timely supply of raw materials. Sometimes the cost of raw material increases due to short supply and that leads to increase in production cost. The steps initiated by the governments from time to time to supply raw materials at subsidized prices to the entrepreneurs are not supporting the successful functioning of the enterprises and also these enterprises are not following any scientific method of material management to reduce the cost of production. In addition, the problems of transportation, strikes, floods, scarcity and other natural dis-orders affect the supply of raw materials. The table no. 3 reveals the sample entrepreneurs' raw-material problems in the study area i.e., Nellore district.

Table No. 3- Raw Material Problems of sample entrepreneurs

Problems	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Non-availability	27	20.93	25	18.38	29	16.58	24	22.02	**105**	**19.13**
Short supply	22	17.06	24	17.65	31	17.72	18	16.52	**95**	**17.30**
High prices	43	33.33	46	33.83	61	34.85	38	34.86	**188**	**34.24**
Poor quality	12	9.30	14	10.39	19	10.85	10	9.17	**55**	**10.02**
Transportation	25	19.38	27	19.85	35	20.00	19	17.43	**106**	**19.31**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

The table 3 reveals about the sample entrepreneurs' raw-material problems in the study area of Nellore district. It is clear that out of the total 549 sample entrepreneurs 19.13 per cent opined that the non-availability of raw materials was their major problem, 17.30 per cent were facing the problem of shortage of raw materials, 34.24 per cent of entrepreneurs had the problem of high prices, 10.02 per cent faced the problem of low quality of raw materials and 19.31 per cent experienced difficulties in the transportation of goods. Further, it is observed that the high prices are the major problem in the study area.

Labour problems of sample entrepreneurs

Labour is another crucial problem of entrepreneurs in the present-day competitive business environment in India in general and in the sample district of Nellore in particular. Low productivity of labour a persistent problem in the rural and backward areas. Due to job security, the absenteeism, migration and non-availability of skilled labour is a serious problem to enterprises. The labour problem of sample entrepreneurs in various aspects was examined in the sample district of Nellore and the details are presented in the table no. 4.

Table No. 4- Labour problems of sample entrepreneurs

Problems	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Scarcity of skilled labour	36	27.90	38	27.94	58	33.16	33	30.27	**165**	**30.05**
Demand of high salaries and wages	23	17.82	24	17.64	28	16.00	19	17.43	**94**	**17.13**
Irregularity of labour	18	13.98	17	12.40	19	10.85	14	12.89	**68**	**12.38**
Migration of skilled labours	39	30.23	42	30.88	50	28.57	32	29.35	**163**	**29.69**
Strikes	13	10.07	15	11.00	20	11.42	12	10.09	**59**	**10.75**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

It is clear from the table 4 that in Nellore district 30.05 Per cent of enterprises were facing the problem of lack of skilled labour, 17.13 per cent of entrepreneurs faced the problem of demand for high salary and wages, 12.38 per cent were facing difficulty of irregularity of labour, 29.69 per cent faced the problem of migration of skilled labour for better opportunity and 10.75 per cent enterprises faced the problem of strikes out of 549 sample enterprises. The scarcity of skilled labour was the major problem of majority of sample enterprises in the sample divisions of the study.

Marketing problems of the sample entrepreneurs

Problem of marketing is more complicated in the case of enterprises in India. These units are not in a position to face the onslaught of large-scale units, to assess the prevailing market scenario or changes which are taking place such as tastes, likes, dislikes, competition, technology etc. The major problems are lack of market intelligence, poor marketing network, lack of market information, deficiency of worthwhile marketing assistance from government agencies, cut-throat competition, lack of proper marketing channels, poor quality of products, lack of quality control, poor bargaining power, lack of knowledge of marketing, ignorance of potential markets, unfamiliarity with export activities, lack of knowledge of consumer preferences and tastes, lack of proper advising and lack of high quality salesmanship. Details of marketing problems of the sample entrepreneurs in the Nellore district are furnished in the table no. 5.

Table No. 5- Marketing problems of the sample entrepreneurs

Nature of problem	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Competition from other enterprises	41	31.78	48	35.29	66	37.72	36	33.03	**191**	**34.79**
Competition from large scale units	23	17.83	21	15.45	24	13.72	18	16.51	**86**	**15.66**
Slackness demand	11	8.53	10	7.36	17	9.72	12	11.00	**50**	**9.11**
Seasonal demand	17	13.50	16	11.76	19	10.85	16	14.68	**68**	**12.39**
Transport	18	13.95	20	14.70	27	15.42	15	13.77	**80**	**14.57**
Sales promotion	19	14.73	21	15.44	22	12.57	12	11.00	**74**	**13.48**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

The above table 5 shows that in Nellore district, among 549 sample enterprise entrepreneurs, 34.79 per cent of respondent entrepreneurs faced the problem of competition from other enterprises, 15.66 per cent of entrepreneurs

faced severe competition from large enterprises, 9.11 per cent faced the problem of slackness demand, 12.39 per cent were facing the problem of seasonal demand, 14.57 per cent faced problems with regard to transportation and 13.48 per cent were facing difficulty in sales promotion. Further, it is observed from the study that majority of the sample entrepreneurs were facing problems with their peer group members doing business in the same line of activity.

Infrastructural Problems of sample entrepreneurs

The success of any enterprise greatly depends on the availability of all kinds of infrastructure facilities like roads, power, telecommunication, post-office, location, water, warehousing, etc. The micro, small, and medium enterprises are located in rural and backward areas and not able to access all kinds of essential infrastructure facilities. Adequate infrastructure facilities contribute to the physical and financial growth of entrepreneurs. The infrastructural problems of sample entrepreneurs in the Nellore district are presented in the table no. 6.

Table No. 6- Infrastructural Problems of sample entrepreneurs

Problems	**Revenue divisions**								**Total**	
	Kandukur		**Kavali**		**Nellore**		**Atmakur**			
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Power	27	20.93	28	20.58	37	21.14	22	20.18	**114**	**20.76**
Water	9	6.97	11	8.08	18	10.30	8	7.33	**46**	**8.38**
Transport	23	17.82	24	17.64	30	17.14	18	16.51	**95**	**17.30**
Warehousing	21	18.60	22	16.17	28	16.00	17	15.59	**88**	**16.04**
Technology	42	32.55	44	32.35	53	30.28	38	34.86	**177**	**32.24**
Communication	7	5.42	7	5.42	9	5.42	6	5.54	**29**	**5.28**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

It is clear from table 6 that out of 549 sample entrepreneurs, 20.76 per cent of entrepreneurs faced the problem of power shortage and fluctuations, 8.38 per cent were facing the problem of insufficiency of water, 17.30 per cent faced the problem of transportation, 16.04 per cent of entrepreneurs were suffering from lack of warehousing facilities, 32.24 per cent faced the problem of changing technologies and 5.28 per cent of enterprises faced the problem of communication in the study area. The majority of the problems faced were due to lack of technology in the study area.

General problems in obtaining assistance from Nellore branch APSFC

The small-scale entrepreneurs are facing certain difficulties like delay in loan application processing, inadequate sanctions, too many terms and conditions, high rate of interest, delay in disbursements etc., while obtaining financial assistance from the Nellore branch APSFC. General problems in obtaining assistance from Nellore branch APSFC are presented in table no. 7.

Table No. 7- General problems in obtaining assistance from Nellore branch APSFC

Revenue divisions	**Delay in processing of application**	**Inadequate sanctions**	**Too many terms and conditions**	**High rate of interest**	**Delay in disbursements**	**Total**
Kandukur	22	25	26	42	14	**129**
Kavali	26	28	21	46	15	**136**
Nellore	30	29	31	59	26	**175**
Atmakur	19	21	28	29	12	**109**
Total	**97**	**103**	**106**	**176**	**67**	**549**
Chi-square	$\chi 2 = 7.366^{@}$; (p = 0.832) ; df= 12; Not Significant					

Source: Primary Data

It is clear from table 7 that for entrepreneurs high rate of interest was the primary problem followed by delay in processing of application, inadequate sanctions, too many terms and conditions and delay in disbursements. The result of Chi-square test shows the value 7.366 and Sig = 0.000 which is less than 0.05 (at 95% level of confidence) which indicates that there is not significant difference.

Government Regulations

It is a well-known fact that all kinds of enterprises should fulfil the different formalities of the governments during establishment and option of the enterprise. Different Acts are enacted by the Government of India to monitor and regulate the business operations of enterprises. Majority of the entrepreneurs have complained that the government policies towards the entrepreneurs are not flexible and friendly. Entrepreneurs are not happy with the terms of licensing, lending, subsidy and concessions given to them. Furthermore, entrepreneurs in one industrial complex complained that the government did not fulfil its promise to buy their products, especially ambe products at fair prices for industrial production.

Perceptions of sample entrepreneurs

Entrepreneurs and Entrepreneurship have assumed great importance in both developed and developing nations. Entrepreneurship plays a key role in the promotion of capital formation, creation of wealth, exploring opportunities, employment generation, balanced regional development, etc. Capital is one of the important factors of production which promotes entrepreneurship to a greater extent in any country. To procure the required capital to any venture, the entrepreneurs should have the minimum knowledge about the various sources of finance support to an enterprise at all times. The long-term and short-term loans provided by the financial institutions like development banks, corporations, commercial banks, etc., are among the important sources of finance usually provided to any enterprise. The Andhra Pradesh State Financial Corporation is extending financial support for the growth and development of industrial sector in general and enterprises in particular in the state through loans. An in-depth attempt has been made in this study to examine and evaluate the perception of the sample entrepreneurs on Nellore branch APSFC activities like sources of information, opinion about getting complete information, knowledge of the objectives of APSFC, awareness of scheme of assistance and other formalities for getting assistance follow up of action.

Sources of Information

The Andhra Pradesh State Financial Corporation is rendering financial service to all categories of entrepreneurs of the state of Andhra Pradesh through its 13 branches spread over all the districts. The knowledge about the corporation's activities, schemes of assistance, formalities, terms and conditions were essential to entrepreneurs to borrow funds to meet their financial requirements. The customers of the corporation are obtaining information from different sources about the activities of the APSFC to avail its services. The sources of information about entrepreneurial activities of Nellore branch APSFC are presented in table no. 8.

Table No. 8- Sources of information about entrepreneurial activities of Nellore branch APSFC

Sources of Information	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Existing clients	64	49.61	71	52.21	81	46.28	55	50.45	**271**	**49.36**
Official campaigns	23	17.83	25	18.38	29	16.57	21	19.26	**98**	**17.85**
Associates	8	6.20	4	2.96	12	6.85	6	5.50	**30**	**5.46**
Publicity	14	10.85	16	11.75	26	14.85	11	10.09	**67**	**12.21**
Mass media	15	11.63	17	12.50	20	11.45	13	11.93	**65**	**11.84**
Others	5	3.83	3	22.05	7	4.20	3	2.75	**18**	**3.28**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

The table 8 reveals the sources of getting information by the sample entrepreneurs of sample district of Nellore regarding the activities of Andhra Pradesh State Financial Corporation. Out of 549 sample entrepreneurs, nearly 49.36 per cent of entrepreneurs got the information about activities of Nellore branch APSFC from the existing clients, followed by 17.85 per cent of entrepreneurs got information through official campaigns of the corporation, 12.21 per cent of entrepreneurs got it through publicity, 3.28 per cent of entrepreneurs who got information from other sources, 11.84 per cent got it through mass media and 5.46 per cent got information from the associates in APSFC Nellore branch. The same trend of sources of information was observed from the individual sample district entrepreneurs also. The majority of entrepreneurs got the information from the existing clients.

Opinion about getting Complete Information

Obtaining complete information about any task is half of the success of that task. The table no. 9 shows the data regarding obtaining of complete information about the Nellore branch APSFC by sample entrepreneurs.

Table No. 9-Opinion about getting Complete Information

Revenue divisions	Obtained		Not obtained		Total
	No.	%	No.	%	No.
Kandukur	113	89.60	16	12.40	**129**
Kavali	126	92.65	10	7.35	**136**
Nellore	163	93.14	12	6.86	**175**
Atmakur	98	89.91	11	10.09	**109**
TOTAL	**499**	**90.89**	**50**	**9.11**	**549**

Source: Primary Data

The above table 9 reveals that out of the total 549 entrepreneurs, 90.89 per cent of entrepreneurs opined that they obtained complete information while 9.11 per cent of entrepreneurs had not obtained the complete information about the activities of APSFC at the time of applying for financial assistance. Regarding the revenue divisions of sample entrepreneurs, 93.14 per cent of Nellore division sample respondents obtained information and the remaining had not obtained.

CONCLUSION

In conclusion, understanding the problems and perceptions surrounding the weaker sections in India is imperative for fostering sustainable development and social harmony. Tackling historical injustices, addressing economic disparities, ensuring equal access to education, and challenging stereotypes are pivotal steps toward creating a more equitable and inclusive society for all. Financial challenges include a shortage of long-term loans and working capital. Raw material problems involve non-availability, short supply, high prices, poor quality, and transportation issues. Labour problems encompass scarcity of skilled labour, demand for high salaries, irregularity, migration of skilled labour, and strikes. Marketing challenges include competition from other enterprises, seasonal demand, transportation problems, and difficulties in sales promotion. Infrastructural issues involve power shortages, water insufficiency, transportation challenges, lack of warehousing facilities, technological obsolescence, and communication problems. The study also sheds light on the perceptions of sample entrepreneurs regarding the Andhra Pradesh State Financial Corporation (APSFC). While existing clients play a crucial role in disseminating information, the study reveals that a substantial majority of entrepreneurs have obtained complete information about APSFC's activities. However, challenges persist, with high-interest rates and delays in loan processing identified as prominent issues. In essence, the findings underscore the need for comprehensive and targeted interventions to address the intricate challenges faced by weaker sections in India, particularly in the entrepreneurial landscape. This includes policy measures to alleviate financial constraints, improve infrastructure, and foster a more inclusive and supportive environment for entrepreneurs from marginalized communities. Only through such concerted efforts can India truly progress towards a more equitable society.

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AN OVERVIEW OF NIFTY-50

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ABSTRACT

A stock market index is created by selecting a group of stocks that are representative of the whole market or a segment of the market. NIFTY 50 is the benchmark index of India, reflecting the overall dynamics of an Indian equity market as well as the Indian economy. The NIFTY 50 is a well diversified 50 stock index, which covers all the important sectors of Indian economy and works as a face of Indian economic performance. It is used for a variety of purposes such as benchmarking fund portfolios, index-based derivatives and index funds (options and futures). The objective of this paper is to give insights about what NIFTY 50 is, how it functions, what exactly is an index and benchmark index, what types of stocks are involved in it, what are the measures to calculate market capitalization and how it developed over the years when compared to other stock exchanges,what is SGX NIFTYis andhow is SGX NIFTY is different from Indian NIFTY .

INTRODUCTION

NIFTY 50 Index is an index consisting of 50 blue chip large and liquid stocks listed on the National Stock Exchange of India. Since inception, the NIFTY 50 Index has successfully

become the ‘stock of the nation’, helping investors understand the pulse of Indian capital market. It has lived up to its core purpose of providing afair representation of the Indian equity market focusingon portfolio diversification andliquidity. Over the years, the NIFTY 50 has become one of the most widely used benchmark for exchange traded products on Indian equity market.

II. LITERATURE REVIEW OF

Swati Garg and Y. P. Singh (2013) associated the performance of NIFTY-50 and Index Funds. Five NIFTY-50 and Index Funds tracking the same benchmark indices wereanalysed in the study over a period of three years starting from June 2006 to December 2009. The analysis showed that over long-term investment horizon NIFTY-50 performed better in terms of their imitation strategy, tracking ability and performance effectiveness. However, it was evident from the study that short-term investors face a disadvantage from investing in NIFTY-50.

P.Mishra and G.Singh (2016) attempted to make an intra-class performance evaluation of some Indian Index funds. Graphical interpretations were used along with statistical tools like R-square and tracking error values. Two models of tracking error were test empirically the performance of the selected index funds. Empirical results revealed that out of the selected index funds, SBI NIFTY Index fund outperformed the other six index funds during the period under study. SBI NIFTY Index fund was also able to limit the tracking error to an acceptable limit.

S. Narend (2014) Made a comparative study of the performance of NIFTY-50 and index funds. The study was done empirically since the period of their respective initiation till July 2013. The study used three parameters for the analysis of the performance such as active

returns, tracking error and Jensen's alpha. The analysis showed that NIFTY-50were performing betterwhen compared to the index mutual funds

Falguni Pandya (2016) analysed the index fund and measuring tracking error. The study used descriptive statistics,and proved that NIFTY and banking index-based funds were found to be having lowest tracking error, while Gold NIFTY-50 didn't perform better in terms of mean return whereas, international NIFTY-50was found to be most efficient.

OBJECTIVES OF THE STUDY

1. To know about the NIFTY 50 and their constitution and the types of Sectors involved in NIFTY-50

2. To know about the Index and its methodology.

3. To know about the market capitalization and its calculation method.

4. To know about the SGX NIFTY and how it is different from Indian NIFTY.

NIFTY 50, ITS CONSTITUTION AND TYPES OF SECTORS INVOLVED IN NIFTY-50

Understanding the NIFTY 50

While the NIFTY 50 is now a much relied upon barometer for measuring the performance of Indian stock markets at large, it has been meticulously constructed over time in order to achieve this status. The benchmark index is made up of stocks belonging to 13 sectors in order to achieve diversification. The sectors are as follows:

– Oil and gas

– Consumer goods

– Information technology

– Financial services

– Automobiles

– Construction

– Telecommunication

– Pharmaceuticals

– Power

– Cement products

– Metals

– Fertilizers and Pesticides

– Media and entertainment

The NIFTY 50 functions as an indication of the performance of Indian markets because it is in and itself a small sample representation of the best offerings of the Indian markets; If the stocks in NIFTY 50 are not performing well, it is very likely that the economy at large will not be able to escape the adverse effects that bringingdown the index .

Constitution of NIFTY

To be considered for inclusion in the NIFTY 50, a firm or stock must meet the following criteria:

- The firm should be headquartered in India and should have been listed and traded on the National Stock Exchange (NSE).
- To be included in the NIFTY 50 Index, the firm must be included in the NIFTY 100 index and be accessible for trading in the NSE's futures and options market.
- The business's average free-floating market capitalization should be 1.5 times that of the index's smallest firm.
- The stock should have been traded every day for the previous six months (100 percent trading frequency).

How can a company be entered in NIFTY-50

To enlist in NIFTY, a company has to be listed on NIFTY Index and has to qualify the following criteria:

- The firm must have been enlisted on the National Stock Exchange.
- It needs to be an Indian company.
- The company's shares must be exceedingly liquid.
- The liquidity indicator is the average impact cost. The impact cost can be termed as the trading price of a single share in comparison to the index's influence on a company's market valuation.
- For the succeeding six months, the firm's impact cost should be less than 0.50 per cent. Or it should be less with at least 90% of calculations made on a portfolio of ₹10 crores.
- The frequency of the firm's business should be 100% for six months.
- The Gross Market Capitalization should be free-floating. This GMC should be 1.5 times the size of the index's smallest business.

- Differential Voting Rights or DVR with shares of companies can be eligible for inclusion in the NIFTY 50 Index.

NIFTYINDEX AND ITS METHODOLOGY.

NIFTYIndex

To explore function what NIFTY 50 and what the NIFTY 50 stocks are, one must first understand what exactly an index or a benchmark index is in the its simplest terms, an index is a basket of securities that is created as a representational sample of a certain sector in the market. This representational sample then works as a barometer to test the market performance. It is a statistic that calculates to what extent changes in the stock market. It monitors price changes and market performance. To establish an index, a few stocks are to be chosen from a list that have similar characteristics like company size, industry and total market capitalization.

The value of the stock market index can be calculated by the values of the underlying group of equities. The value of the stock index is influenced by differences in the underlying stock. If the majority of stocks grow in value, so will the index, and vice versa.

Index Methodology

Eligibility Criteria for Selection of Constituent Stocks:

i. Market impact cost is the best measure of the liquidity of a stock. It accurately reflects the costs faced when actually trading an index. For a stock to qualify for possible inclusion into the NIFTY50, it should have traded at an average impact cost of 0.50% or less during thelast six months for 90% of the observations, for a basket size of Rs. 100 Million.

ii. The company should have a listing history of 6 months.

iii. Companies that are allowed to trade in F&O segment alone are eligible to be constituent of the index.

iv. A company which comes out with an IPO will be eligible for inclusion in the index, if it fulfils the normal eligibility criteria forthe index for a 3-month period instead of a 6-month period.

Index Re-Balancing:

Index is re-balanced on semi-annual basis. The cut-off dates are is January 31 and July 31 of each year, i.e. for semi-annual review ofindices, average data for six months ending the cut-off date is considered. Four weeks prior notice is given to market from the date ofchange.

Index Governance:

A professional team manages all NSE indices. There is a three-tier governance structure comprising the Board of Directors of NSEIndices Limited, the Index Advisory Committee (Equity) and the Index Maintenance Sub-Committee.

MARKET CAPITALISZATION AND ITS CALCULATION METHOD

Market Capitalization

Definition: Market capitalization is the aggregate valuation of the company based on its current share price and the total number of outstanding stocks. It is calculated by multiplying the current market price of the company's share with the total outstanding shares of the company.

Description: Market capitalization is one of the most important characteristics that helps the investor determine the returns and the risk in the share. It also helps the investors choose the stock that can meet their risk and diversification criterion**.**

Calculation Method

Market Capitalization = Shares outstanding * Price

Free Float Market Capitalization = Shares outstanding * Price * Investible Weight Factor

Index Value = Current Market Value / Base Market Capital * Base Index Value (1000)

The IWF (Investible Weight Factor) is a factor in the formula above that is used to determine the number of shares available for trading in the market. Because the value of stocks fluctuates daily, as the index is calculated in real-time.

The method above also takes into account changes in the business environment. Stock splits, rights issues, and other similar modifications are examples of these developments. NIFTY maintains the index regularly to ensure its stability and effective operation. This is how NIFTY 50 is calculated.

SGX NIFTY and how it is different from Indian NIFTY.

SGX NIFTY

SGX NIFTY is a derivative of the NIFTY index, which is traded in the Singapore Stock Exchange platform. This trade sets a predetermined price of a share and reduces the future risk of any investments. To make it easy for one to understand, one should keep in mind that like Indian NIFTY trades on the NSE, which is the Indian stock exchange platform, the SGX NIFTY is the futures trade NIFTY in Singapore. In this SGX NIFTY,the price of the share is present, the

buyer and seller have to commit to that pre-decided price in spite of any changes that may take place in the stock market in the future.

As the Singapore Stock Exchange is a leading stock exchange in India, the SGX NIFTY helps to predict and observe the behaviour of the Indian NIFTY and thus has an important role to play in the Indian stock market.

Different between SGX NIFTYand Indian NIFTY

The main difference between the SGX NIFTY and the Indian NIFTY is that the SGX NIFTY is a futures trade platform in Singapore where the prices of stock are predetermined to avoid the future risk, whereas the Indian NIFTY trades only on the Indian stock exchange platform, which is the National Stock Exchange or NSE.

Another important difference is the contract size of the Indian NIFTY and the SGX NIFTY. In an Indian NIFTY a contract between the buyer and seller must have a minimum of 75 shares, which is not required in the SGX NIFTY. This means that SGX NIFTY does not have to include shares, whereas every Indian NIFTY must include shares.

SGX NIFTYattracts a high number of customers and trading activities because it is the most active trading platform in Singapore and the only trading platform that works for sixteen hours a day. This is definitely not the case with the Indian NIFTY, which is a National exchange platform. These characteristics of SGX NIFTY make it more profitable.

Impact of SGX NIFTYon the Indian Market

As already discussed, the SGX NIFTY proves to be helpful in predicting and observing the Indian NIFTY's behaviour. There is also a time difference between the Indian NIFTY and the SGX NIFTY, wherein the Singapore market opens about two and half hours before the Indian

market. This allows investors to keep an eye on the SGX NIFTY to know the fluctuations in the market and observe how well the overall trading process is going. By observing this, the investors get an idea about the Indian market and how does it open either with positive or negative results. Therefore, those who are sceptical about investing in the Indian market, can invest in SGX and keep an eye on the SGX NIFTY to get an idea about the Indian NIFTY and stock exchange platform.

Although this may be a convenient way to judge the Indian market and weigh out 0ne chances, not all results that these investors get are accurate and subject to the various economic factors existing in both the countries as both these countries like India and Singapore have very different economic structures and yet they have different prominent effects on the market behaviour.

Both the Indian NIFTY and SGX NIFTY are equally important as they have some effects on each other's behaviour, and one cannot be talked about without mentioning the other. Everyone who wishes to enter the stock market world and starts trading like an expert need to first know and be familiar with NIFTY and SGX NIFTY terms and many other financial terms commonly used and have important roles to play in the stock market.

CONCLUSION

The NIFTY index is an important pointer of the market, and its movements affect the Indian economy to a great extent. NIFTY is the NSE’s benchmark index (National Stock Exchange). The stock index that calculates the 50 biggest and most liquid stocks on NSE is called NIFTY. These 50 largest firms reflect India’s stock market and economic trends, and they come from a variety of industries. The top 50 largest firms are selected based on the market capitalization as shown above and the top good performing sectors are healthcare and

technology.One must note that SGX NIFTYis highly preferable platform toNIFTY due to the reasons like performing trading for sixteen hours a day, not involving any minimum number of share and the predetermined futures price .

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This certificate is presented to **Prof. M. Venkateswarlu, Head, Department of Commerce, Sri Venkateswara University, Tirupati** for participating / presenting the research paper entitled "**Investigating the Impact of Product Information on Customers' Purchase Intentions in Online Grocery Shopping with Reference to Hyderabad**" in the 4th International Conference on Contemporary Management organized by Department of Management Studies, NPR College of Engineering & Technology, Natham, Dindigul, Tamil Nadu, India on 26th April 2024. (ISBN No. 978-81-864847-2-9)

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Accountancy

AWARENESS ON MOBILE COMMERCE: A CASE STUDY AT NAGARI MANDAL OF CHITTOOR DISTRICT IN ANDHRAPRADESH

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ABSTRACT Mobile commerce also known as E-commerce involves using wireless handheld devices like cell phones and tablets to conduct commercial transactions online, including the purchase and sale of goods and services bills, banking services through online. Mobile Commerce is mixture of information and communication technology, mobile technology and internet. The main objective of this paper focus on mobile commerce and e commerce status like that mobile operations, internet usages in india, and Geographical profile of various levels of the respondents, awareness and utilization of different services in Nagari mandalam of chittoor district in Andhra Pradesh.

KEYWORDS : M-Commerce, Geographical profiles and utilization of mobile network services

INTRODUCTION:

Mobile commerce is refers to the buying and selling of goods and services through wireless handhelds devices such as smart phones and tablets. M-Commerce is a form of E-Commerce that enables users to access online shopping platforms without the use of desktop computer. Over time, contents delivery through wireless devices had become faster, more secure. As a result mobile commerce had grown rapidly use specific industries includes the financial and telecommunications, service and retail in information services. Mobile commerce adopted today are hotel booking and reservation, purchasing airline tickets, purchasing movie tickets and restaurant booking and reservation, online shopping through Amazon, Flipkart, Big basket and the list goes on. Booking of the cab through Ola and Uber is prevalent and well appreciated by all in India.

Mobile Commerce

Mobile commerce is a large subset of electronic commerce, a model where firms or individuals conduct business over the internet. As of 2023, nearly 97 percent of the Americans own a cell phone, and 85 percent of the them owned a Smartphone. This is up from 35percent in 2011. Now a day many product and services can transacted via m-commerce, including banking, investing and purchasing books, plane tickets and digital music etc. the rapid growth of mobile commerce has been driven by several factors including increased wireless handheld devices computing power, a proliferation on m-commerce applications, and resolution of security issues.

Mobile commerce adopted today are hotel booking and reservation, purchasing airline tickets, purchasing movie tickets and restaurant booking and reservation, online shopping through Amazon, Flipkart, Big basket and the list goes on. Booking of the cab through Ola and Uber is prevalent and well appreciated by all in India.

Need for the Study

The mobile cellular market is the fastest growing market regarding subscriber numbers and popularity in India. The substantial increase of the mobile users is linked with greater adoption for mobile commerce in India. As the Internet started to proliferate in many parts of the world, the mobile phone penetration also grew rapidly. With the development of wireless and mobile technologies, Mobile Commerce is expected to make a substantial impact on the business. Mobile commerce is quite popular in the developed countries, but in India, it is in a growing stage and yet to take off. At present, Indian users indulge in mobile purchases for high-value transactions such as entertainment services, games, and music downloads. The convergence of the two fastest growing industries- the internet and the mobile communication- has led to the creation of an emerging market for mobile commerce.

Objectives of the Study

The specific objectives of the study are:

- To study the socio-economic and demographic variables among mobile commerce service users in Nagari mandal.
- To identify the level of awareness of mobile commerce service users.
- To examine the use of mobile commerce services.

Research Methodology of the Study

This study is on both the primary data is collected through a well structured questionnaire to address the research questions. The relevant secondary data was collected from various journals, magazines, news papers, published information and details on websites for the study.

Limitations of the Study

- This study is constrained to Nagari Mandal of chittoor District only.
- The behavior of the people belonging to rest of Nagari.
- This study cannot be generalized, due to quick changes in technology, Customer preferences.

Status of M- Commerce & E-commerce In India:

Now a day's mobile commerce has touched in every field of human life. People use internet for various purpose which includes emails, academic, financial and non financial information like that music video games on internet, chatting on online job searching, online banking etc,. India has day by day increasing in the number of internet and mobile commerce users in india.

Table No.1 Mobile Operators in India: Key Statistics

Telecom Operator	Total Subscriber
Airtel	22,92,67,770
VI	13,67,25,060
Reliance Communications	42,87,78,364
BSNL	2,70,66,371

Source: Internet

From the above table No.1 shows that with the growing momentum of wireless revolution and Mobile commerce explosion, it is evident that mobile devices are becoming a critical component of the new digital economy.

Table No.2 Internet penetration: India Vs World

Country	Percentage
America	96.6%
USA	98%
Japan	94%
Brazil	81.3%
China	71.3%

India	47%
France	93%

Source. Published by Statistical Research Department. July 7th 2022

As can be seen from the Table No.2, compared to the developed/ developing markets, the internet penetration in India is insufficient and hence there exist a huge potential. With the introduction of free unlimited internet access, JIO has captured 369 million customers.

From the above table illustrates the growth pattern and development over the period and the impact of the internet and mobile technology. It spells out the mobile internet users in India among urban and rural people in India. Majority of rural Indian people have started using more of internet related services are the basic reasons for the speedy growth of mobile commerce in India.

Data Analysis And Interpretation

The well framed questionnaire is used to bring out the required data regarding customer perception on the impact of mobile commerce. The collected data were analyzed and interpreted for understanding the impact of mobile commerce. The analysis is carried by using descriptive statistics.

Descriptive Analysis

In this study the descriptive analysis is used in exploring the following domains:

- Demographic profile of the respondents
- Level of awareness of mobile commerce
- Usage of mobile commerce services

From the below Table No. 3 describes various demographic profiles of the respondents namely Gender, Age, Educational qualification, marital status Occupation, Monthly income, Family size, Family type and location within Nagari Mandal. The data analysis, the demographic profiles of the respondents are:

I. 55.00% of the respondents are Male, and 45.00% of the respondents are female. ii.15.00% of the respondents belong to less than 20 years age group. One-third of the respondents belong to 21 – 30 years age group (38.75%). Then 32.5% of the respondents belong to 31 – 40 years age group. Only 13.75% of the respondents belong to above 50 years age group. It shows that younger generation is towards mobile commerce.

Table No.3 Demographic Profile of the Respondents

Demographic variables		Frequency	Percentage
Gender	Male	44	55.00
	Female	36	45.00
Age	< 20 years	12	15.00
	21-30years	31	38.75
	31-40 years	26	32.5
	>50 years	11	13.75
Education	School level	13	16.25
	Diploma Level	10	12.5
	Graduate Level	33	41.25
	PG Level	15	18.75
	Others	9	11.25
Marital status	Married	47	58.75
	Unmarried	33	41.25
Occupation	Student	22	27.5
	Housewife	11	13.25
	Self-employed	10	12.50
	Employed	33	41.25
	Retired	4	5.00
Monthly income	<Rs.15,000	25	31.25
	15001- 30,000	36	45.00
	30001- 40,000	16	20.00
	Above 40,000	3	3.75
Family size	2-4 members	26	32.50
	5-6 members	41	51.25
	> 6members	13.	16.25
Family type	Joint family	35	43.75
	Nuclear family	45	56.25
Located in Nagari Mandal	Yes	80	100.00
	No	-	-

Source: Primary Data

iii. Half of the respondents have completed graduation level 41.25%. Almost one-fourth of the respondents are diploma holders 12.5%. 18.75% of them are postgraduates, and 16.25% of them have completed until school level. 11.25% of the respondents have chosen others as their option, which shows that some of the respondents are having other than listed qualification, but also they are able to use mobile commerce. iv. Majority of the respondents are married 58.75% and 41.25% of them are unmarried. v.One third 27.50% of the respondents are students. Nearly 41.25% of the respondents are working in an employees in the organisation, and 12.50% of the respondents are self-employed. 13.75% of them are homemakers, and 5.00% of the respondents are retired. vi. Almost 31.25% of the respondents' monthly income is less than 15000 rupees. 45.00% of their incomes lie between Rs. 15001 –30000 and 20.00% of them earn more than Rs. 30,001-40,000. 3.75% of them earn above Rs.40000. vii. The majority 51.25% of the respondents responded that there are five to six members in their family, 32.50% of their families have two to four members and only 16.25% of them have more than six members in their family. viii. Considering 56.25% they belong to a nuclear family, and 43.75% of the respondents belong to the joint family. ix. 80 respondents 100.00% are from Nagari mandal.

Analyses of level of awareness of mobile commerce namely types of Smartphone, type of connection, the network provided, grocery store, dealer, in respect of the frequency and percentage is given in Table No. 4 below:

Table No.4 Level of Awareness of Mobile Commerce

Particulars		Frequency	Percentage
Type of your Smartphone	Android	62	77.50
	Keypad	8	10.00
	Apple	9	11.25
	Others	1	1.25
Type of Connection	Post paid	20	25.00
	Prepaid	60	75.5
Network provider	Airtel	20	25.00
	BSNL	11	13.75
	IDEA	8	10.00
	JIO	41	51.25
	Others	0	0
Mobile Usage per Month	<Rs.300	20	25.00
	Rs.300-Rs.500	32	40.00
	Rs.500-Rs.700	9	11.25
	Rs.700-Rs.1000	7	8.75
	>Rs.1000	12	15.00

Source: Primary Data

Interpretation:

From the above table No. 4 shows that, i. More than half of the respondents 77.5% have the android type of smart phones, 11.25% of them have apple mobile phones, 10.00% of them have windows (keypad), and 1.25% of them responded that they use other types of operating system. ii. 75.50% of the respondents are using pre-paid, and 25.00% of the respondents are using the post paid connection. iii. Half of the respondents network provider is JIO 51.25%, 25% of the respondents are using Airtel, 13.75% of the respondents are using BSNL, 10.00% of them are using IDEA, networks respectively. More than 60% of the respondents have done their recharge/top up in grocery stores, through a dealer and by internet also. v.

The majority 25.00% of the respondents spend less than Rs.300 per month for mobile. 40.00% of their monthly usage is between Rs.300 – Rs.500. 11.25% of the respondent's usage is between Rs.500 – Rs.700. 8.75% of them have spent Rs.700 to Rs.1000, and only 15.00% of the respondents have spent more than Rs.1,000 for their mobile usage on a monthly basis.

Table No.5 Utilization of Mobile Commerce Services

Usage	Never	Rarely	Some-times	frequently	Always	Total
Internet	4 (5.00)	29 (35.25)	2 (2.5)	9 (11.25)	36 (45.00)	80
Entertainment	20 (25.00)	8 (10.00)	30 (37.5)	15 (18.75)	7 (8.75)	80
Message (Whats App / Hike)	7 (8.75)	11 (13.75)	17 (21.25)	36 (45.00)	9 (11.25)	80

Video Calling (Skype /Viber/IMO)	9 (11.25)	8 (10.00)	57 (71.25)	5 (6.25)	1 (1.25)	80
Shopping (eBay/Amazon / Myntra / Snapdeal)	24 (30.00)	7 (8.75)	23 (28.75)	19 (23.75)	7 (8.75)	80
Navigation (GPS)	39 (48.25)	19 (23.75)	11 (13.75)	7 (8.75)	4 (5.00)	80
VIRTUAL Wallets like paytm/mPass etc.	8 (10.00)	16 (20.00)	29 (36.25)	14 (17.7)	13 (16.25)	80

Source: Primary Data

Interpretation

The maximum mean score is 45% in a, always which is for surfing internet. The next score for utilization of mobile commerce is attained by Entertainment 37.5% in some times, it shows that most of them are using mobile commerce for entertainment purpose. Then they use mobile commerce for the sake of messaging 45.00% in frequently, then video calling 71.25% in some times. The mean of shopping, wallets like Paytm and GPS are below average. Half of the respondents used it for entertainment, internet and messaging. Since the standard deviation is more than one, it shows that there is more deviation in the level of agreement for usage.

Findings and suggestions

Findings

- It is observed that majority (75%) of the respondents have two to four family members. More than half of 56.25% them belong to the nuclear family.
- Students and employed respondents have invariably adopted Mobile commerce.
- Almost 45 % of the respondents monthly income is less than Rupees 30,000.
- It is found that Android type of Smartphone is used most in the market, followed by windows type.
- It is observed that majority of the Nagari mandalam customers are using a pre-paid connection from the service provider.
- During the study period, it is found that more than half 51.25% of the respondents network provider is JIO and about 25% of the respondents are using Airel.
- It is found that Mobile commerce services are utilised mostly for the entertainment purposes like music, cinema ticket booking and travel. This is followed by surfing internet, messaging like WhatsApp and video calling and online chatting etc,.
- It is found that most of the respondents are use of mobile commerce. They use multiple SIM cards and indulge in mobile transactions with the available kind of internet access.
- Majority of the respondents agree that mobile commerce application is very useful for quick search, which infers that they have a wide variety of alternatives during their state of purchase.
- It is observed that 82.20% of the respondents are willing to recommend their family and relatives to use mobile commerce services.

Suggestions

Based on the observations and findings of the study, the following recommendations are made to improve mobile commerce eco-system for the service provider and policy changes are given below:

- Majority of the 85% in Nagari customers are using a pre-paid type of connection and Android type of Smartphone. Any Business promotion shall target prepaid customers in android platform so that the reach is the maximum instantly and bring positive results.
- It is evident from the study that the parameters such as speed, user friendliness, easy to use and compatibility are major influencing factor for the adoption of mobile commerce services.
- What"s App, Navigation and Shopping usages are more in home town. It is recommended to service provider to focus on location based services (e.g. directions for travelling, information about of the nearest store, etc.
- Due to dynamic and ever changing business environment the tele-communication sector in India has to evolve refined model to suit new policy measures and regulatory mechanism which will certainly make customer delight and improve service satisfaction by assessing the periodical survey.

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CUSTOMERS SATISFACTION LEVAL OF INTERNET BANKING SERVICES: A CASE STUDY ON PAKALA MANDAL OF CHITTOOR (Dt.) IN ANDHRA PRADESH

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ABSTRACT:

Now a day's technology has play a key role in modern society. Each and every task in the banking sector is digitalized. From the account opening to money transfer through online mode, eliminating the need for customers to visit banks and wait in long queues. This operation is very easy to customers and banking institutions. Online banking also encourages competition among banks to offer their customers better services and draw in a growing number of customers. To check the level of customer satisfaction among the 60 numbers randomly chosen. Online bill pay, money transfer, any time and any where use, update information, deliver services and save time and energy are directly related to customer satisfaction words internet banking in Pakala mandalam of chittoor district in Andhra Pradesh.

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Key words: Information Technology, Customer satisfaction, Banking sector

INTRODUCTION

Banking is a highly information intensive activity and relies mostly on information technology to acquire, process and deliver the quality information to all the users. Automated delivery of banking products and services to its customers through electronic communication like internet is referred as internet banking. Banks find that to retain their demanding customers, innovation and updation along with the provision of convenient, reliable and expedient services is very important. Today, almost all the Indian banks are trying to differentiate themselves in the competitive industry and align their offerings to the constantly evolving customer needs and developments in technology in everywhere in India. Globalization and deregulations helped banks expand their reach beyond countries which made them more competitive and therefore looking forward offering internet banking services, to maximize profits as well as retain customers. However, this cannot be achieved without high quality service which when satisfied, results in improved customer satisfaction. To make customers' banking more convenient, efficient and effective it is very important to ascertain the customers' perception of overall service quality and their satisfaction with online banking services.

Conceptual frame work:

E-banking refers to banking operations, with which the customers can carry out transaction through internet, which is completely safe and secure. E- banking encourages paperless or cashless transaction in everywhere in india.

Internet Transaction: Banking facility provided the customers through the customers are able to perform a number of monetary& internet using transactions, through the bank websites.

Mobile banking: almost all the banks have designed their mobile applications with which you can perform transactions at your fingertips, which is smart phones, internet, mobile application and banking services in your bank account.

ATM: ATM is not a just a machine with which you can withdraw cash as and when required, bit it also allows you to check your accounts status , deposit funds, transfer funds, change debit card pin, personal identification number

Debit Card: now a day's debit cards used in our day to day life so as to perform end number of transactions. Debit cards are linked to the customer's bank account and so the customer's only needs to swipe the card, in order to make payment at point of sale (POS) outlets, online shopping. ATM withdrawals, in this way the amount is deducted from the customer's account directly.

Credit card: it is just like a debit card, a credit card is also a payment card which the banks issue to the customers on their on their request, after checking their credit score and history. It enables the cardholders to borrow funds up to the pre-approached limit and make a payment. The maximum limit is granted by banks with

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issue the card. The card holder promises to repay the amount within a stipulated time period. Otherwise some charges for the issue of credit card.

Point of Sale (PoS) : PoS system refers to the point, in terms of date, time and place, where the customer makes a payment, using a plastic card for the purchase made or services received.

Electronic Data Interchange (EDI): EDI is a new mode of communicating information between businesses electronically using a standardized format.

Electronic fund transfer: when money is transferred electronically from one bank to another bank. It cover direct debit, direct deposits, wire transfers, RTGS, NEFT,etc,.

OBJECTIVES OF THE STUDY

This research has been carried out with the following objectives.

- To identify the factors influencing the customers to opinion for Internet Banking service in the study area.
- To analyse the problems of internet banking customers.
- To offer suitable suggestions to promote the Internet banking service of the public and private sector banks.

Research Methodology of the Study

This study is on both the data is collected through a well structured questionnaire to address the research questions and take 60 randoms, but all the questions responses have five options, i.e., Highly satisfied, Satisfied, Neutral, Dissatisfied , Highly Dissatisfied. The relevant secondary data was collected from various journals, magazines, news papers, published information and details on websites and so on.

DATA ANALYSIS AND INTERPRETATIONS

The primary data was collected from the users of Internet banking. Interview schedule was used to collect the data from the internet banking customers of selected public sector banks were State Bank of India, Canara Bank, Indian Bank,Axis Bank and other Banks in Chittoor District of Andhra Pradesh.

GENDER WISE CLASSIFICATION

The gender wise classification of the respondents gives an outline about which category of customers highly prefers the internet banking.

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Table No.4.1
Number of Respondents

Gender	Number Of Responds	Percentage
Male	40	66.60
Female	20	33.40
Total	60	100

Source: Primary Data

Table 4.1 shows that out of the total respondents, a majority (66.60%) of respondents was male and the remaining 33.40% of the respondents were female using internet banking. Therefore, it is concluded that a majority of the male customers prefer internet banking than their females.

AGE WISE CLASSIFICATION

Age is an important demographic variable that not only determines an individual's physical and mental maturity but also depicts life experiences. As the age increases, the learned experience changes the behaviors of individuals. Learning is an action based on experience. Hence, most behavior is learned by individuals. Therefore, it is interesting to note the age - wise distribution of the respondents.

Table No.4.2
Number of Respondents

Age	Number Of Respondents	Percentage
Up to 20 years	18	30.10
21 – 30	29	48.30
Above 50 years	13	21.60
Total	60	100

Source: Primary Data

Table 4.2 from the above table no shows that the majority of the respondents belonged to the age groups 21 - 30 years using internet banking service in the modern world.

MARITAL STATUS

In Indian society, marriage is supposed to be a religious obligation. In the social context, it is the prelude to the family formation, expansion or even bifurcation. After marriage, there is a transition in the status of men and women by change in rights and obligations. More than the conventional roles of parents, today's parents play a crucial role in building up a family; inculcate values for life and so on. Hence, the marital status of the respondents is given in the table.

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Table No.4.3
Marital Status

Marital	Number Of Respondents	Percentage
Married	35	58.3
Un Married	25	41.6
Total	60	100

Source: Primary Data

Table 4.3 shows that out of the total respondents, a majority (58.3%) of respondents was married and the remaining 41.6% of respondents were unmarried. So, it is identified that most of the respondents are married. It is clear from the table married people highly prefer internet banking.

EDUCATIONAL QUALIFICATION

Education is one of the most important traits of the customers because the perception, awareness and behavior of the customers depend largely on his/her educational qualifications. Education plays a vital role for having access to basic internet banking. The level of education of the respondents is portrayed in the below table 4.4.

Table No.4.4
Educational Qualifications

Qualifications	Number Of Respondents	Percentage
SSC	12	20.2
Inter	8	13.3
Graduate	28	46.6
PG	8	13.3
Others	4	6.6
Total	60	100

Source: Primary Data

It reveals that out of the total respondents, 46.6% of the respondents were graduates, 20.2% of the respondents have completed higher secondary level, 13.3% of the respondents were post graduates, again 13.3% of the respondents have completed upto secondary level. 6.6% of the respondents were others. Hence, it is clear that a majority of the respondents are graduates as internet banking requires a little technical knowledge.

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OCCUPATION WISE CLASSIFICATION

Occupation determines the need of using internet banking service. The occupation wise classification of the respondents is given in the table.4.5.

Table No.4.5
Occupation Wise Classification

Occupation	Number Of Respondents	Percentage
Government	3	15.0
Private	20	11.1
Business	4	16.6
Agriculturist	6	10.0
Home Maker	11	20.7
Student	16	26.6
Total	60	100

Source: Primary Data

Table 4.5 shows that out of the total respondents, 26.6% of the respondents were studying, 20.7% of the respondents were homemakers, 16.6% of respondents were businessmen, 15% of the respondents were working as government employees, 11.1% of the respondents were business, and 10.% of the respondents were agriculturists.

Therefore, it is evident from the table that most of the private employees are highly interested in internet banking service as they are well aware of its nuances.

MONTHLY INCOME

Adequate income encourages the customers to opt for internet banking service. The monthly income of the respondents is disclosed in the Table 4.6 shows that out of the total respondents, 51.6% of the respondents had a monthly income of Rs. 10,001 to Rs. 20,000, 43.3% of respondents had a monthly income up to Rs. 10,000, and above Rs. 20,000 respectively.

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Table No.4.6
MONTHLY INCOME

INCOME	Number Of Respondents	Percentage
UP to Rs.10,000	26	43.3
Rs. 10,001-20,000	31	51.6
Above 20,000	3	5.1
Total	60	100

Source: Primary Data

TYPE OF FAMILY

The family background plays an important role in moulding the behavior to any person. The family provides the recognition and security for the individual identity. The living arrangements are very crucial for the socio-economic status of a person. Traditionally, Indian society preferred to live on joint family arrangements. As the economic necessitates improved, people moved towards nuclear families than of joint families. Besides this some of the cultural aspects such as family relationship, increase in style of living have made the family size to shrink. The outline about the type of family of the respondents is given in the table.

Table No.4.7
TYPE OF FAMILY

FAMILY	Number Of Respondents	Percentage
Nuclear Family	46	76.6
Joint family	14	23.3
Total	60	100

Source: Primary Data

Table 4.7 indicates that out of the total respondents, a majority (76.6%) of the respondents belonged to nuclear family and the rest 23.3% of respondents belonged to joint family.

PREFERRED BANK

There are a few reasons behind the choice of bank such as easy convenience, trust worthiness, low cost of transaction and the availability of service. The bank which is preferred by the respondents to maintain their account is shown in the table.

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Table No.4.8
PREFERRED BANK

PREFERRED BANK	Number Of Respondents	Percentage
SBI	11	18.30
Canara Bank	13	1.66
Indian Bank	19	31.60
Union Bank	12	20.11
Axis Bank	2	3.33
Other Bank	3	25.00
Total	60	100

Source: Primary Data

Table 4.8 shows that out of the total respondents, 31.60% of respondents held their account in Indian Bank, 25% of respondents held their account in other Banks, 20.11% of the respondents held their account in Union Bank, 18.30% of the respondents held their account in State Bank of India, 3.33% of respondents held their account in Axis Bank, and 1.66% of the respondents held their account in Canara Bank. Hence, it is clear that a majority of the respondents maintain their accounts in Indian Bank as it offers better quality of service.

SOURCE OF INTRODUCTION

Source of introduction refers to the person who motivates the respondents to open a bank account in a specific bank. The source of motivation of the respondents is unveiled in the table.

Table No.4.9
SOURCE OF INTRODUCTION

Source	Number Of Respondents	Percentage
Friend	27	45.0
Relative	18	30.0
Advertisement	3	5.0
Banker	12	20.0
Total	60	100

Source: Primary Data

Table 4.9 unveils that out of the total respondents, 45% of the respondents were motivated by their friends, 30% of the respondents were motivated by their relatives, 20% of the respondents were motivated by the Banker and 5% of the respondents were motivated by the advertisement to choose the respective banks. Hence, it is clear that most of the respondents were motivated by their relatives to opt for a particular bank.

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FREQUENCY OF USING INTERNET BANKING SERVICE

The frequency of using internet banking varies from one customer to another. How often the respondents are accessing internet banking service is displayed in the table.

Table No.4.10

FREQUENCY OF USING INTERNET BANKING SERVICE

ATM	Number Of Respondents	Percentage
Frequently used	16	26.66
Occasionally	11	18.34
When need arises	33	55.00
TOTAL	60	100

Source: Primary Data

Table: 4.10 shows that out of the total respondents, 55% of the respondents used internet banking service when need arises, 18.34% of the respondents used internet banking service occasionally and the rest 26.66% of the respondents used internet banking service frequently.

SATISFACTION ON INTERNET BANKING SERVICE

The satisfaction of the customers plays a crucial role in the promotion of the service. The customers' satisfaction on internet banking service is described in the below table 4.11

The customers' satisfaction on internet banking is ranked based on the mean score. As per the mean score customers were highly satisfied on a few statements andsatisfied on a few statements. The customers were highly satisfied on internet banking provides 24×7 hours service (61.7%), it curtails the time to stand on queues in the bank branches satisfied and nutral in (35%), it helps to perform the transactions confidentiality in nutral (25%), internet banking highly satisfied (18.3%) internet banking provides up to date information regularly 23.3% in satisfies and highly dissatisfied. It offers high quality service satisfied at (31.66%).

Table No.4.11

SATISFACTION LEVEL ON INTERNET BANKING SERVICE

Statements	HS	S	N	DS	HDS	TOTAL
Internet banking provides 24 X 7 hours service	37 (61.7)	11 (18.8)	5 (8.33)	4 (6.66)	3 (5.5)	60
It curtails the time to stand in queues in the bank Branches	8 (13.33)	21(35.00)	21 (35)	5 (8.33)	5 (8.33)	60
It helps to perform the transactions confidentially	14 (23.3)	14 (23.3)	15(25.00)	13(21.6)	4 (6.66)	60
It provides necessary information to the customers	11(18.3)	15 (2.5)	13 (21.6)	12(20.00)	6 (10.0)	60

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It enhances the financial security	8 (13.3)	11(18.3)	15(2.5)	12(20.0)	14(23.3)	60
It reduces the cost of transaction	14(23.3)	19(1.66)	9(15.9)	10(16.6)	8(1.66)	60
Internet banking provides up–to-date information Regularly	10(16.6)	14(23.3)	15(2.5)	14(23.3)	7(11.6)	60
It performs the transaction at pre-determined time	16(23.6)	17(28.3)	9(15.0)	12(20.0)	6(10.0)	60
It offers high quality service	12(20.00)	19(31.66)	10(16.6)	11(18.3)	8(1.6)	60
Availability of service is faster than traditional banking	17(28.3)	14(23.3)	10(16.6)	7(11.6)	12(20.0)	60
It increases the believability, honesty and trustworthiness of the customers	11(18.3)	17(28.3)	10(16.6)	13(21.6)	9(15.0)	60
12 Internet banking ensures accountability	11(18.3)	13(21.6)	13(21.6)	10(16.6)	3(5.0)	60

(**HS** – Highly satisfied **S**– Satisfied **N**– Neutral **DS** – Dissatisfied **HDS** – Highly Dissatisfied)

The customers were highly satisfied on availability of service is faster than traditional banking (28.3%), and it increases the believability, honesty and trustworthiness of the customers satisfied in (28.3%). It perform the overall internet banking ensures accountability is highly satisfied (18.3%) respectively.

FINDINGS AND SUGGESTIONS

- A majority (66.60%) of the male customers have preferred internet banking than their female counterparts as male is technology.
- 48.3% of the respondents who belonged to the age group of 21 - 30 years make use of internet banking service as they are exposed to technology enabled services.
- A majority (58.3%) of the respondents are married. It is identified that married people mostly prefer internet banking as they have greater responsibility.
- All (100%) the respondents are educated and there is no respondent without formal education.
- It is found out that 26.6% of the respondents are from students background.
- It is understood that 51.6 % of the respondents belong to a monthly income category of Rs. 10,001 - Rs. 20,000.
- A majority (76.6%) of the respondents belong to nuclear family as they need privacy and expect to be independent in all walks of life.
- It is understood that 31.60% of the respondents hold their accounts in Indian Bank as it offers better quality of services in this area.

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SUGGESTIONS

- Banks should take necessary steps to create awareness among rural people about the advantages of internet banking services available in the banks.
- The banks should offer internet banking service in the regional language to attract the customers to enable all the customers to make use of the service irrespective of their education bag round.
- The internet banking system should be enhanced to make the online enquiry and online payment much easier to the customers.
- The bank should not restrict the time to carryout NEFT transaction in care of transferring fund from one bank to another.
- Public sector banks should improve their internet banking services to compare with their private sector counterparts.
- The public sector banks must improve its service quality in terms of communication, responsiveness, reliability and understanding.
- The bank should provide various effective modes for promotional schemes, interaction with the customers, more accuracy in billing, and financial security and privacy in transactions.

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PROBLEMS AND PERCEPTIONS OF WEAKER SECTION ENTREPRENEURS IN NELLORE DISTRICT

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***Abstract*- The term "weaker section" refers to a section of the population that is socially, economically, and politically behind the other sections of the population and has been experiencing various forms of inabilities as a result of their backwardness. The Government of India Act, 1935, defines "weaker sections" as class or classes of people who are suffering from educational and economic backwardness, as well as some aspects of social life, due to traditional customs of untouchability, tribal background, tribal way of life, or other backwardness. In India weaker sections encompassing marginalized groups such as Scheduled Castes, Scheduled Tribes, Other Backward Classes, and economically disadvantaged individuals. The research focuses on the objectives of identifying the problems and perceptions of sample entrepreneurs in the Nellore district, particularly those who received financial assistance from the Andhra Pradesh State Finance Corporation (APSFC) between 2022 and 2023. The sample design involves 3658 entrepreneurs from four revenue divisions, with a convenience sampling method adopted for selection. The study spans a ten-year period from 2012-13 to 2021-22, with primary data collected in 2022-23 and secondary data gathered from 2013 to 2022. The problems faced by the sample entrepreneurs are categorized into financial, raw material, marketing, labour, and infrastructural issues. The study also assesses general problems in obtaining assistance from Nellore branch APSFC, highlighting concerns such as delays in loan processing, inadequate sanctions, excessive terms and conditions, high-interest rates, and delays in disbursements. Perceptions of sample entrepreneurs regarding APSFC's activities, sources of information, and opinions about obtaining complete information are analyzed.**

***Keywords*: APSFC, Weaker sections, Disbursement, Perception.**

Introduction

India, with its rich tapestry of cultural diversity and economic dynamism, grapples with the intricate challenge of addressing the needs and aspirations of its weaker sections. The term "weaker sections" encompasses various marginalized groups such as Scheduled Castes (SCs), Scheduled Tribes (STs), Other Backward Classes (OBCs), and economically disadvantaged individuals facing socio-economic vulnerabilities, often due to historical injustices, caste-based discrimination, economic disparities, and lack of access to opportunities.

Historical Perspectives: The roots of the challenges faced by the weaker sections in India can be traced back to historical injustices, deeply embedded in the country's social fabric. The caste system, a centuries-old hierarchical social structure, has perpetuated discrimination and created a stark divide between the privileged and the marginalized. Despite constitutional safeguards and affirmative action measures, the persistent effects of historical oppression continue to hinder the progress of these sections.

Economic Disparities: One of the primary issues faced by weaker sections is economic inequality. Limited access to education, healthcare, and employment opportunities exacerbates their socio-economic vulnerabilities. As a result, a significant portion of the population finds itself trapped in a cycle of poverty, making upward social mobility a distant dream for many.

Educational Challenges: Education, often considered a potent tool for social transformation, remains elusive for many in the weaker sections. Lack of adequate infrastructure, discrimination in educational institutions, and socio-economic constraints contribute to lower enrollment and high dropout rates among these communities. This educational gap perpetuates a cycle of poverty, limiting the potential for overall development.

Caste-Based Discrimination: Despite legal prohibitions, caste-based discrimination continues to persist, affecting the daily lives of those in weaker sections. Social stigmas and prejudices impede their access to basic amenities, healthcare, and even employment opportunities. Addressing these deeply ingrained biases is crucial for fostering an inclusive and equitable society.

Perceptions and Stereotypes: Perceptions surrounding the weaker sections often perpetuate stereotypes, further marginalizing these communities. These preconceived notions hinder their integration into mainstream society and

contribute to the perpetuation of systemic inequalities. Challenging these stereotypes is essential for creating a more just and inclusive society.

Objectives of the study

The main objective of the study is to identify the problems and perceptions of sample entrepreneurs in the study area.

Sample design

The study is to probe into the availability of finance for the weaker sections of entrepreneurs from Nellore branch APSFC in Nellore district. The sample size of the present study includes only the weaker sections of entrepreneurs who got financial assistance from Nellore branch APSFC. The weaker sections of entrepreneurs financed by Nellore branch APSFC during the period 2022 to 2023 have been taken into consideration to collect the required data. Nellore district has been divided into four divisions namely Kandukur, Kavali, Nellore and Atmakur. A total of 3658 entrepreneurs of weaker sections who have taken loan in the above said branch by APSFC have been selected for study in the first stage. The convenience sampling method has been adopted for the selection of the sample respondents as a result of which 15 per cent of weaker sections of entrepreneurs assisted during this period were chosen conveniently for the study. Out of the total 549 sample respondents,129 sample respondents are from Kandukur revenue division,136 sample respondents from Kavali revenue division,175 sample respondents from Nellore revenue division and 109 sample respondents are from Atmakur revenue division. The strength particulars of the sample borrowers of weaker sections entrepreneurs from the four revenue divisions of Nellore branch Andhra Pradesh State Finance Corporation are furnished in the below table 1.

Table No. 1

Sample borrowers of weaker sections of entrepreneurs from four revenue divisions of Nellore branch of Andhra Pradesh State Finance Corporation in Nellore district

Revenue Divisions	**Total number of borrowers in each revenue division**	**Sample number of borrowers in each revenue division (15 Per cent of Total number of borrowers)**
Kandukur	862	129
Kavali	903	136
Nellore	1165	175
Atmakur	728	109
TOTAL	**3658**	**549**

Source: Nellore branch APSFC.

Period of the study

The period of study is for 10 years from 2012-13 to 2021-22. The primary data pertains to the field of study of the weaker sections of entrepreneurs of the four revenue divisions namely Kandukur, Kavali, Nellore and Atmakur in Nellore district and the study was conducted in the year 2022-23. The secondary data were collected during the period from 2013 to 2022.

Problems faced by the sample entrepreneurs

The entrepreneurs of any category or nature of business in the world face different kinds of problems like infrastructure, financial, labour, raw material, marketing and technology, etc., and the degree of severity of the problem varies based on the nature of business, size of business, location of business, form of business organization, etc. Though problems of an entrepreneur of an enterprise can be classified into two categories namely, internal and external problems. Internal problems affect the operating performance of an enterprise to a great extent. The problems are size of the organization and structure, process of production, training of the personnel, scantiness of management etc. External problems result from factors outside the control of entrepreneurs, such as the availability of water, power and other infrastructure facilities required for the smooth management of an enterprise, finance, marketing, etc. In the present research study, the role of Nellore branch APSFC in promoting the Weaker sections entrepreneurs, some of the problems of sample entrepreneurs in the sample district of Nellore have been highlighted to have an understanding about the common problems faced by the entrepreneurs in general in India. The key issues where problems arise in the institution and in the smooth running of entrepreneurs are mobilizing finance, acquiring of raw material, engaging labour, marketing, management, infrastructure facilities, government regulations, technological up-gradation, license, recovery of debts, etc.

Financial Problems of Sample Entrepreneurs

One of the important problems for a business concern is scanty financial resources. Most of the entrepreneurs are suffering from insufficient financial sources. These enterprises are not able to mobilize required finance from different sources because of the small size of the enterprise. The funding agencies arc also imposing number of terms and conditions to provide finance to meet entrepreneurial fixed and working capital requirements. The entrepreneurs have to depend on more than one source and pay heavy investment charges, and the huge rate of interest on loans raised. The other common problems faced by the entrepreneurs are also briefed hereunder. The opinions of the sample entrepreneurs about various aspects of financial problems are depicted in the table no. 2.

Table No. 2-Financial Problems of Sample Entrepreneurs

Problems	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Shortage of long term loans	49	37.98	51	37.50	77	44.00	50	45.88	**227**	**41.34**
Shortage of working capital	42	32.56	44	32.35	52	29.72	26	23.85	**164**	**29.87**
Both of the above	38	29.46	41	30.15	46	26.28	33	30.27	**158**	**28.79**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

The sample entrepreneurs were mainly facing the problem of scarce long-term loans and working capital funds. From the table 2 it is clear that out of 549 sample entrepreneurs, 41.34 per cent were facing the problem of shortage of long-term finance, 29.87 per cent were facing the problem of shortage of working capital and the rest of 28.79 per cent of entrepreneurs were facing shortage of both long-term funds and working capital in the sample district. The shortage of long-term loans and working capital was high in Nellore revenue division when compared to the remaining revenue divisions.

Raw Material Problems of sample entrepreneurs

Majority of the enterprises are facing the problem of production interruptions due to non-availability of raw materials on time. These enterprises have been established in rural and backward areas mainly because of subsidies and incentives offered to them in rural areas. The growth and sustainability of an enterprise depend on the timely supply of raw materials. Sometimes the cost of raw material increases due to short supply and that leads to increase in production cost. The steps initiated by the governments from time to time to supply raw materials at subsidized prices to the entrepreneurs are not supporting the successful functioning of the enterprises and also these enterprises are not following any scientific method of material management to reduce the cost of production. In addition, the problems of transportation, strikes, floods, scarcity and other natural dis-orders affect the supply of raw materials. The table no. 3 reveals the sample entrepreneurs' raw-material problems in the study area i.e., Nellore district.

Table No. 3- Raw Material Problems of sample entrepreneurs

Problems	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Non-availability	27	20.93	25	18.38	29	16.58	24	22.02	**105**	**19.13**
Short supply	22	17.06	24	17.65	31	17.72	18	16.52	**95**	**17.30**
High prices	43	33.33	46	33.83	61	34.85	38	34.86	**188**	**34.24**
Poor quality	12	9.30	14	10.39	19	10.85	10	9.17	**55**	**10.02**
Transportation	25	19.38	27	19.85	35	20.00	19	17.43	**106**	**19.31**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

The table 3 reveals about the sample entrepreneurs' raw-material problems in the study area of Nellore district. It is clear that out of the total 549 sample entrepreneurs 19.13 per cent opined that the non-availability of raw materials was their major problem, 17.30 per cent were facing the problem of shortage of raw materials, 34.24 per cent of entrepreneurs had the problem of high prices, 10.02 per cent faced the problem of low quality of raw materials and 19.31 per cent experienced difficulties in the transportation of goods. Further, it is observed that the high prices are the major problem in the study area.

Labour problems of sample entrepreneurs

Labour is another crucial problem of entrepreneurs in the present-day competitive business environment in India in general and in the sample district of Nellore in particular. Low productivity of labour a persistent problem in the rural and backward areas. Due to job security, the absenteeism, migration and non-availability of skilled labour is a serious problem to enterprises. The labour problem of sample entrepreneurs in various aspects was examined in the sample district of Nellore and the details are presented in the table no. 4.

Table No. 4- Labour problems of sample entrepreneurs

Problems	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Scarcity of skilled labour	36	27.90	38	27.94	58	33.16	33	30.27	**165**	**30.05**
Demand of high salaries and wages	23	17.82	24	17.64	28	16.00	19	17.43	**94**	**17.13**
Irregularity of labour	18	13.98	17	12.40	19	10.85	14	12.89	**68**	**12.38**
Migration of skilled labours	39	30.23	42	30.88	50	28.57	32	29.35	**163**	**29.69**
Strikes	13	10.07	15	11.00	20	11.42	12	10.09	**59**	**10.75**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

It is clear from the table 4 that in Nellore district 30.05 Per cent of enterprises were facing the problem of lack of skilled labour, 17.13 per cent of entrepreneurs faced the problem of demand for high salary and wages, 12.38 per cent were facing difficulty of irregularity of labour, 29.69 per cent faced the problem of migration of skilled labour for better opportunity and 10.75 per cent enterprises faced the problem of strikes out of 549 sample enterprises. The scarcity of skilled labour was the major problem of majority of sample enterprises in the sample divisions of the study.

Marketing problems of the sample entrepreneurs

Problem of marketing is more complicated in the case of enterprises in India. These units are not in a position to face the onslaught of large-scale units, to assess the prevailing market scenario or changes which are taking place such as tastes, likes, dislikes, competition, technology etc. The major problems are lack of market intelligence, poor marketing network, lack of market information, deficiency of worthwhile marketing assistance from government agencies, cut-throat competition, lack of proper marketing channels, poor quality of products, lack of quality control, poor bargaining power, lack of knowledge of marketing, ignorance of potential markets, unfamiliarity with export activities, lack of knowledge of consumer preferences and tastes, lack of proper advising and lack of high quality salesmanship. Details of marketing problems of the sample entrepreneurs in the Nellore district are furnished in the table no. 5.

Table No. 5- Marketing problems of the sample entrepreneurs

Nature of problem	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Competition from other enterprises	41	31.78	48	35.29	66	37.72	36	33.03	**191**	**34.79**
Competition from large scale units	23	17.83	21	15.45	24	13.72	18	16.51	**86**	**15.66**
Slackness demand	11	8.53	10	7.36	17	9.72	12	11.00	**50**	**9.11**
Seasonal demand	17	13.50	16	11.76	19	10.85	16	14.68	**68**	**12.39**
Transport	18	13.95	20	14.70	27	15.42	15	13.77	**80**	**14.57**
Sales promotion	19	14.73	21	15.44	22	12.57	12	11.00	**74**	**13.48**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

The above table 5 shows that in Nellore district, among 549 sample enterprise entrepreneurs, 34.79 per cent of respondent entrepreneurs faced the problem of competition from other enterprises, 15.66 per cent of entrepreneurs

faced severe competition from large enterprises, 9.11 per cent faced the problem of slackness demand, 12.39 per cent were facing the problem of seasonal demand, 14.57 per cent faced problems with regard to transportation and 13.48 per cent were facing difficulty in sales promotion. Further, it is observed from the study that majority of the sample entrepreneurs were facing problems with their peer group members doing business in the same line of activity.

Infrastructural Problems of sample entrepreneurs

The success of any enterprise greatly depends on the availability of all kinds of infrastructure facilities like roads, power, telecommunication, post-office, location, water, warehousing, etc. The micro, small, and medium enterprises are located in rural and backward areas and not able to access all kinds of essential infrastructure facilities. Adequate infrastructure facilities contribute to the physical and financial growth of entrepreneurs. The infrastructural problems of sample entrepreneurs in the Nellore district are presented in the table no. 6.

Table No. 6- Infrastructural Problems of sample entrepreneurs

Problems	**Revenue divisions**								**Total**	
	Kandukur		**Kavali**		**Nellore**		**Atmakur**			
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Power	27	20.93	28	20.58	37	21.14	22	20.18	**114**	**20.76**
Water	9	6.97	11	8.08	18	10.30	8	7.33	**46**	**8.38**
Transport	23	17.82	24	17.64	30	17.14	18	16.51	**95**	**17.30**
Warehousing	21	18.60	22	16.17	28	16.00	17	15.59	**88**	**16.04**
Technology	42	32.55	44	32.35	53	30.28	38	34.86	**177**	**32.24**
Communication	7	5.42	7	5.42	9	5.42	6	5.54	**29**	**5.28**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

It is clear from table 6 that out of 549 sample entrepreneurs, 20.76 per cent of entrepreneurs faced the problem of power shortage and fluctuations, 8.38 per cent were facing the problem of insufficiency of water, 17.30 per cent faced the problem of transportation, 16.04 per cent of entrepreneurs were suffering from lack of warehousing facilities, 32.24 per cent faced the problem of changing technologies and 5.28 per cent of enterprises faced the problem of communication in the study area. The majority of the problems faced were due to lack of technology in the study area.

General problems in obtaining assistance from Nellore branch APSFC

The small-scale entrepreneurs are facing certain difficulties like delay in loan application processing, inadequate sanctions, too many terms and conditions, high rate of interest, delay in disbursements etc., while obtaining financial assistance from the Nellore branch APSFC. General problems in obtaining assistance from Nellore branch APSFC are presented in table no. 7.

Table No. 7- General problems in obtaining assistance from Nellore branch APSFC

Revenue divisions	**Delay in processing of application**	**Inadequate sanctions**	**Too many terms and conditions**	**High rate of interest**	**Delay in disbursements**	**Total**
Kandukur	22	25	26	42	14	**129**
Kavali	26	28	21	46	15	**136**
Nellore	30	29	31	59	26	**175**
Atmakur	19	21	28	29	12	**109**
Total	**97**	**103**	**106**	**176**	**67**	**549**
Chi-square	$\chi 2 = 7.366^{@}$; (p = 0.832) ; df= 12; Not Significant					

Source: Primary Data

It is clear from table 7 that for entrepreneurs high rate of interest was the primary problem followed by delay in processing of application, inadequate sanctions, too many terms and conditions and delay in disbursements. The result of Chi-square test shows the value 7.366 and Sig = 0.000 which is less than 0.05 (at 95% level of confidence) which indicates that there is not significant difference.

Government Regulations

It is a well-known fact that all kinds of enterprises should fulfil the different formalities of the governments during establishment and option of the enterprise. Different Acts are enacted by the Government of India to monitor and regulate the business operations of enterprises. Majority of the entrepreneurs have complained that the government policies towards the entrepreneurs are not flexible and friendly. Entrepreneurs are not happy with the terms of licensing, lending, subsidy and concessions given to them. Furthermore, entrepreneurs in one industrial complex complained that the government did not fulfil its promise to buy their products, especially ambe products at fair prices for industrial production.

Perceptions of sample entrepreneurs

Entrepreneurs and Entrepreneurship have assumed great importance in both developed and developing nations. Entrepreneurship plays a key role in the promotion of capital formation, creation of wealth, exploring opportunities, employment generation, balanced regional development, etc. Capital is one of the important factors of production which promotes entrepreneurship to a greater extent in any country. To procure the required capital to any venture, the entrepreneurs should have the minimum knowledge about the various sources of finance support to an enterprise at all times. The long-term and short-term loans provided by the financial institutions like development banks, corporations, commercial banks, etc., are among the important sources of finance usually provided to any enterprise. The Andhra Pradesh State Financial Corporation is extending financial support for the growth and development of industrial sector in general and enterprises in particular in the state through loans. An in-depth attempt has been made in this study to examine and evaluate the perception of the sample entrepreneurs on Nellore branch APSFC activities like sources of information, opinion about getting complete information, knowledge of the objectives of APSFC, awareness of scheme of assistance and other formalities for getting assistance follow up of action.

Sources of Information

The Andhra Pradesh State Financial Corporation is rendering financial service to all categories of entrepreneurs of the state of Andhra Pradesh through its 13 branches spread over all the districts. The knowledge about the corporation's activities, schemes of assistance, formalities, terms and conditions were essential to entrepreneurs to borrow funds to meet their financial requirements. The customers of the corporation are obtaining information from different sources about the activities of the APSFC to avail its services. The sources of information about entrepreneurial activities of Nellore branch APSFC are presented in table no. 8.

Table No. 8- Sources of information about entrepreneurial activities of Nellore branch APSFC

Sources of Information	Revenue divisions								Total	
	Kandukur		Kavali		Nellore		Atmakur			
	No.	%	No.	%	No.	%	No.	%	No.	%
Existing clients	64	49.61	71	52.21	81	46.28	55	50.45	**271**	**49.36**
Official campaigns	23	17.83	25	18.38	29	16.57	21	19.26	**98**	**17.85**
Associates	8	6.20	4	2.96	12	6.85	6	5.50	**30**	**5.46**
Publicity	14	10.85	16	11.75	26	14.85	11	10.09	**67**	**12.21**
Mass media	15	11.63	17	12.50	20	11.45	13	11.93	**65**	**11.84**
Others	5	3.83	3	22.05	7	4.20	3	2.75	**18**	**3.28**
Total	**129**	**100**	**136**	**100**	**175**	**100**	**109**	**100**	**549**	**100**

Source: Primary Data

The table 8 reveals the sources of getting information by the sample entrepreneurs of sample district of Nellore regarding the activities of Andhra Pradesh State Financial Corporation. Out of 549 sample entrepreneurs, nearly 49.36 per cent of entrepreneurs got the information about activities of Nellore branch APSFC from the existing clients, followed by 17.85 per cent of entrepreneurs got information through official campaigns of the corporation, 12.21 per cent of entrepreneurs got it through publicity, 3.28 per cent of entrepreneurs who got information from other sources, 11.84 per cent got it through mass media and 5.46 per cent got information from the associates in APSFC Nellore branch. The same trend of sources of information was observed from the individual sample district entrepreneurs also. The majority of entrepreneurs got the information from the existing clients.

Opinion about getting Complete Information

Obtaining complete information about any task is half of the success of that task. The table no. 9 shows the data regarding obtaining of complete information about the Nellore branch APSFC by sample entrepreneurs.

Table No. 9-Opinion about getting Complete Information

Revenue divisions	Obtained		Not obtained		Total
	No.	%	No.	%	No.
Kandukur	113	89.60	16	12.40	**129**
Kavali	126	92.65	10	7.35	**136**
Nellore	163	93.14	12	6.86	**175**
Atmakur	98	89.91	11	10.09	**109**
TOTAL	**499**	**90.89**	**50**	**9.11**	**549**

Source: Primary Data

The above table 9 reveals that out of the total 549 entrepreneurs, 90.89 per cent of entrepreneurs opined that they obtained complete information while 9.11 per cent of entrepreneurs had not obtained the complete information about the activities of APSFC at the time of applying for financial assistance. Regarding the revenue divisions of sample entrepreneurs, 93.14 per cent of Nellore division sample respondents obtained information and the remaining had not obtained.

CONCLUSION

In conclusion, understanding the problems and perceptions surrounding the weaker sections in India is imperative for fostering sustainable development and social harmony. Tackling historical injustices, addressing economic disparities, ensuring equal access to education, and challenging stereotypes are pivotal steps toward creating a more equitable and inclusive society for all. Financial challenges include a shortage of long-term loans and working capital. Raw material problems involve non-availability, short supply, high prices, poor quality, and transportation issues. Labour problems encompass scarcity of skilled labour, demand for high salaries, irregularity, migration of skilled labour, and strikes. Marketing challenges include competition from other enterprises, seasonal demand, transportation problems, and difficulties in sales promotion. Infrastructural issues involve power shortages, water insufficiency, transportation challenges, lack of warehousing facilities, technological obsolescence, and communication problems. The study also sheds light on the perceptions of sample entrepreneurs regarding the Andhra Pradesh State Financial Corporation (APSFC). While existing clients play a crucial role in disseminating information, the study reveals that a substantial majority of entrepreneurs have obtained complete information about APSFC's activities. However, challenges persist, with high-interest rates and delays in loan processing identified as prominent issues. In essence, the findings underscore the need for comprehensive and targeted interventions to address the intricate challenges faced by weaker sections in India, particularly in the entrepreneurial landscape. This includes policy measures to alleviate financial constraints, improve infrastructure, and foster a more inclusive and supportive environment for entrepreneurs from marginalized communities. Only through such concerted efforts can India truly progress towards a more equitable society.

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MARKETING STRATEGIES TO OVERCOME THE CHALLENGES FACING THE PHARMACEUTICAL COMPANIES IN INDIA

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Abstract:

This paper analyses and examines the current situation, recent developments, issues and challenges for Pharmaceutical companies in India from the perspective of marketing management. This paper highlights the current position of pharmaceutical companies in the Global pharma markets in order to understand its implications for current market challenges faced by the pharma industry. The challenges faced by pharmaceutical companies in the Indian market with reference to the Marketing function have been examined in this article. The discussion is focused on the marketing mix for pharmaceutical companies comprising the 4Ps, namely, Product, Price, Place and Promotion. This paper suggests a few effective strategies to overcome the challenges faced by the pharmaceutical industry.

Key terms: Product, challenges, marketing, Price, Place and Promotion.

Introduction:

Indian pharmaceutical industry is the 3rd largest in the world by volume and is USD 40 billion in terms of value. India contributes around 3.5% of total drugs and medicines exported globally. India exports pharmaceuticals to more than 200 countries and territories including highly regulated markets such as the USA, The UK, European Union, Canada etc. The Indian Pharma sector has complete ecosystem for development and manufacture of pharmaceuticals. Its Pharma companies possesses the state of the art facilities including highly skilled/technical manpower. Our

countries also has a large number of renowned pharmaceutical educational and research institutes as well as a robust ecosystem of allied industries.

India is the largest provider of generic drugs globally. Access to affordable HIV treatment from India is one of the greatest success stories in medicine. India is one of the biggest suppliers of low-cost vaccines in the world. Because of low price and high quality, Indian medicines are preferred worldwide, thereby rightly naming the country "the pharmacy of the world". The Pharmaceutical sector currently contributes around 1.72% to the country's GDP.

At present a major constituent of Indian exports are low value generic drugs while a large proportion of the demand for patented drugs is met through imports. This is because the Indian Pharmaceutical sector lacks in high value production along with world class pharma R&D. In order to encourage the global and domestic players to enhance their investment and production in these product categories, a well-designed and suitably targeted intervention is required. This would promote the manufacture of specific high value goods such as biopharmaceuticals, complex generic drugs, patented drugs or drugs nearing patent expiry, cell based or gene therapy drugs.

Further, in order to ensure drug security by, unbridled support to the domestic production capability in APIs/KSMs is needed. This would enhance the resilience of the Indian pharmaceutical industry to external shocks. These initiatives improve our ability to achieve the ultimate to objective of affordable healthcare in the country and the target of Health for all by 2030.

History of Pharmaceutical companies in India

Bengal Chemicals and Pharmaceutical Works is the first pharmaceutical company in India. Today, it is one of the five government-owned drug manufacturers that was incorporated on 12th April, 1901. For the next 60 years, most of the drugs in India were imported by multinationals either in fully-formulated or bulk-drug form. The government has actively encouraged the growth of drug manufacturing by Indian companies in the early 1960s, and with the Patents Act in 1970, the Indian an pharma industry emerged stronger. The patent act 1970 deleted the from food and drugs. However, retained the process patents, whose duration was shortened to a period of five to seven years. The absence of patent protection made the Indian market unattractive to the

multinational companies who had dominated the Indian market. As a result, the Indian companies gradually replaced the MNCs. The Indian companies carved a niche in both the Indian and world markets with their expertise in reverse-engineering, in innovative process design for manufacturing drugs at low costs. Although some of the larger companies have taken baby steps towards drug innovation, the industry as a whole has been following this business model until the present.

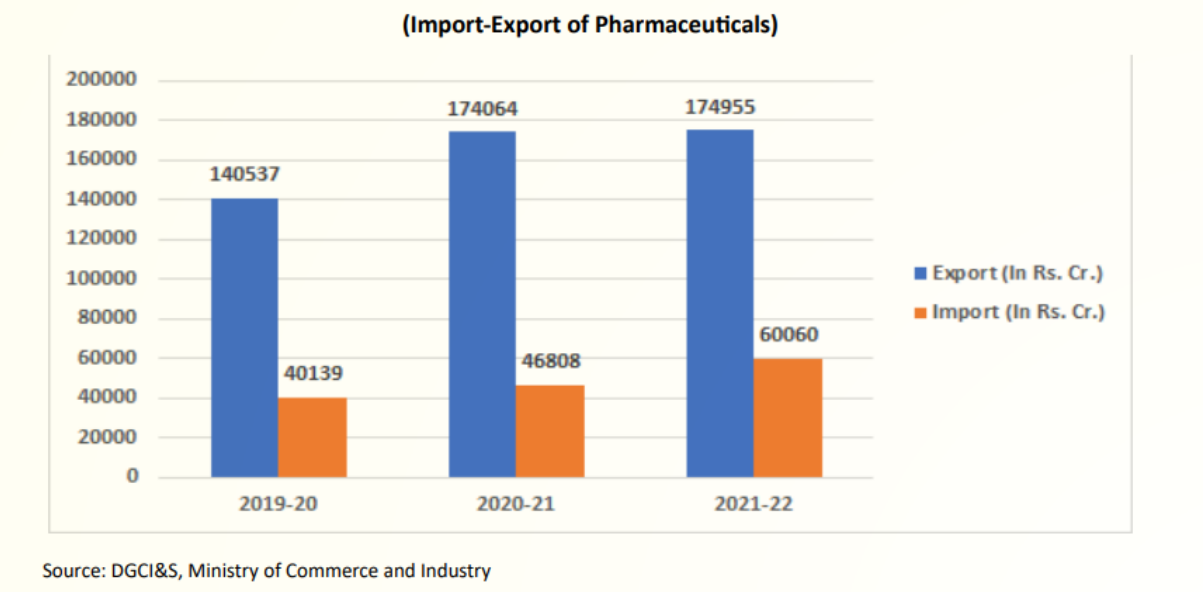
India's pharmaceutical sector is well-known for producing affordable vaccines and generic medications at a third-place global volume in pharmaceutical manufacture. In 2020–21, the industry made up around 1.32% of the Indian economy's gross value added (calculated using constant prices from 2011–2012). For the fiscal year 2021–2022, Pharmaceuticals had a total yearly sale of Rs. 3,44,125 crore (USD 42.34 billion). Generic medications, over-the-counter medications, bulk medications, vaccines, contract research and production, biosimilars, and biologics are some of the main sectors of the Indian pharmaceutical industry. When it comes to the provision of DPT, BCG, and measles vaccinations, India leads the world. About 8% of the worldwide API industry is contributed by 500 API firms. The main source of generic medications is India. It produces over 60,000 distinct generic brands in 60 therapeutic areas, making approximately 20% of the world's generic drug supply. One of the biggest medical achievements is the availability of reasonably priced HIV therapy from India. Indian pharmaceuticals are favored globally due to their affordable prices and superior quality, earning them the title of "pharmacy of the world." The industry has been expanding at a robust pace.

Table shows the sector's yearly turnover trend over the last five years.

Financial Year	Turnover (Rs. in Crore)	Growth Rate
2017-2018	2,26,423	3.03
2018-2019	2,58,534	14.18
2019-2020	2,89,998	12.17
2020-2021	3,28,054	13.12
2021-2022	3,44,125	4.89

Source: Pharmatrac/NPPA/DGCIS, Kolkata

The Indian pharmaceutical business is a major worldwide player, providing millions of people with low-cost, accessible generic medications. The industry provides lower costs without sacrificing quality, as evidenced by the fact that India is home to the greatest number of pharmaceutical facilities outside of the United States that have received approval from the US Food and Drug Administration (USFDA). Additionally, a sizable number of these facilities comply with Good Manufacturing Practices (GMP) regulations set forth by the World Health Organization (WHO) and have also received approval from foreign regulatory bodies. As can be observed from Graph 1A, India's pharmaceutical industry contributes significantly to the nation's international trade and has been steadily producing trade surplus. Pharmaceutical exports totalled Rs. 1,74,955 crore (USD 23.5 billion) in 2021–22, while pharmaceutical imports totalled Rs. 60,060 crore (USD 8.06 billion). As a consequence, there was a trade surplus of Rs. 1,14,895 crore (USD 15.44 billion).



Source: DGCI&S, Ministry of Commerce and Industry

Future growth prospects of Indian Pharmaceuticals:

The pharmaceutical sector has seen significant changes in recent years, putting new demands on payers, providers, and manufacturers. Customers today expect the same variety and convenience from the pharmaceutical sector as they do from other industries. Pharmaceutical marketing aids in raising knowledge of treatments for chronic diseases, which are the major cause

of health-care costs. India is also anticipated to become a pharmaceutical R&D hub in the coming decade, with the Department of Pharmaceuticals preparing a road map for India to become a worldwide player in the industry by 2030.

The Indian Pharmaceutical industry is predictable to grow up to USD 130 billion in value by the end of 20301. In FY22 India had exported pharmaceutical products worth USD 24.62 billion and it has been expected that Indian pharmaceutical exports will reach USD 27 billion in FY 2023. India also has the largest number of manufacturing sites approved by the United States Food and Drug Administration (US FDA) outside of the United States.

Some of the recent developments/investments in the Indian pharmaceutical sector are as follows:

1. In December 2020, Piramal Pharma Solutions announced plans to invest Rs. 235 crore (US$ 32 million) to expand its facility in Michigan, US, with additional capacity and new capabilities for development and manufacturing of active pharmaceutical ingredients (APIs).
2. In November 2020, Indian Immunologicals (IIL) commenced work on Rs. 75 crore (US$ 10.17 million) viral antigen manufacturing facility in Genome Valley, Telangana, that will enhance its vaccine production capacity by 35% by October 2021.
3. In November 2020, the Indian Institute of Technology (IIT) Bombay has stepped up research and development (R&D) amid COVID-19 and researchers are developing products such as a portable sterilization device and germicidal cabinet; wheeled sterilization unit, especially for hospitals; portable and rechargeable car sanitizer; eco-friendly sprays, and alcohol-free and bleach-free sanitizers.
4. In October 2020, six generic drug makers--Dr. Reddy's Laboratories, Zydus Cadila, Glen mark Pharmaceuticals, Torrent Pharmaceuticals, Hetero Drugs and Ackerman Pharma signed a deal with Hidalgo ,a state in Mexico, to establish a large pharmaceutical cluster for production and logistics in Mexico.
5. In October 2020, Aurobindo Pharma acquired MViyeS Pharma Ventures for Rs. 274.22 crore (US$ 37.30 million).

6. In May 2020, Jubilant Generics Ltd entered into a non-exclusive licencing agreement with US-based Gilead Sciences Inc to manufacture and sell the potential COVID-19 drug Remdesivir in 127 countries, including India.
7. Affordable medicines under Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP) achieved record sales turnover of Rs 52 crore (US$ 7.38 million) in the month of April 2020.
8. During December 2019, on moving annual total (MAT) basis, industry growth was at 9.8%, with price growth at 5.3%, new product growth at 2.7%, while volume growth at 2% y-o-y.
9. In October 2019, Telangana Government proposed Hyderabad Pharma City with financial assistance from the Central government of Rs 3,418 crore (US$ 489 million).

Review of Literature:

Saurabh Kumar Saxena[9], (2008), came out with a paper titled as "A Review Of Marketing Strategies Work By Different Pharmaceutical Companies" Provides valuable insights into the supply chain processes and end customer perceptions that determine the formulation of marketing strategies.

Eric Langer, Abhijeet Kelkar (2008), in their paper entitled "Pharmaceutical Distribution in India. Biopharma International", insights the challenges faced by Indian Pharm companies in ensuring the delivery of uncompromised quality in the multilayered distributed system.

P.Parveen, P.Usha, V.Vasu naik, Rajesh Akki (2013), in their paper entitled "Pharmaceutical Distribution in India" this presents the marketing strategies of a pharma company that shifts from Acute-base to chronic therapy base. This study focus on the processes and outcomes of globally distributed pharma companies as well as the drug pricing control order. The DPCO has been a mill stone around the neck of the Indian industry as its severely restricted pharmaceutical companies.

Dr. Pramod Kumar, Dr. Pramod Kumar (2013)," Marketing Mix of Pharmaceutical Industry in India: An Exploration", this paper explores the marketing mix of pharmaceutical

industry in India**.** It provides a crical evaluation of policies and strategies of the pharma companies in the light of the complex interplay of the 4Ps or marketing mix of the pharma companies.

Anil Kalotra (2014), in the paper entitled "Marketing Strategies Of Different Pharmaceutical Companies", has focused on the three stakeholders in the pharma sector that are fundamental to the success of the marketing strategies. The success the marketing strategies in the competitive context is derived from either a cost advantage or a value advantage or ideally from a combination of both. That flows from a synergistic balance amongst the three stakeholders (the firm, its competitors and its customers)

Manvi Aayush Sood (2019), in their paper entitled "Evolution of Indian Pharmaceutical Industry-Overview" The Indian Pharmaceutical Industry has witnessed several fluctuations in its fortunes over the last three to four decades. It is one of the most efficient industry in India it provides employment and health care to the nation. This paper mainly concentrates on the evolution of the industry, its growth and recent trends.

Issues and Challenges faced pharmaceutical companies in India

Several Indian pharmaceutical companies have successfully deployed many standard strategies with a view to target the various customer types. However, the emerging business and customer trends throw up many challenges and opportunities that may improve the profitability. In the pharmaceutical and healthcare industries, a complex web of decision-makers determines the nature of the transaction (prescription) for which direct customer (doctor) of pharmaceutical industry is responsible. However, as the end-user (patient) consumes the product, he/she pays the cost. The appointment of medical representatives for marketing the products to physicians and to convenience the others in the hierarchy of decision makers has been a time-tested tradition.

The industry is still faced with some very serious strategic and operational level issues:

1. Real-time good manufacturing practices and research components are severely lacking in the Indian pharmaceutical business. This has consistently been the main challenge facing the Indian pharmaceutical business. The Pharma businesses should ideally be set up so that they have superior operational capabilities and infrastructure.

2. Indian pharmaceutical businesses are not making enough money since their revenues are essentially much lower than those of their competitors in other nations, like the US. The Indian pharmaceutical sector is thus unable to support its research initiatives.
3. The pharma industry is dependent on China for the supply of raw material for generic medicines production of Active Pharmaceutical Ingredients (API).
4. India needs user friendly government policy for the common man to establish small scale, raw material manufacturing units/ incubators in all states of the country to improve availability of raw materials to manufacture generic drugs at affordable rates.
5. The government and industry should facilitate the pharmacist community to become entrepreneurs and promote incubators' establishment.
6. Raw material produced from small scale units should be properly validated in the testing laboratory of the state to ascertain their quality specifications.
7. There is a need for a functional testing laboratory in every state to hasten the work of raw materials specification.
8. Small scale produces may be re-processed in another industry or via a chain of industry for quality products that can be used for parenteral/tailor-made formulations.
9. Skilled manpower from academic institutions can be achieved through continuing education programmes.

Marketing Mix Strategy for pharmaceutical companies in India

The classical marketing mix consists of four different Ps; product, price, place and promotion (McCarthy 1960). Conceptually, this mix may be adapted and relevant to a most product segments. However, experts are skeptical about its utility and relevance in the case of for marketing of services. Some experts also argue that marketing approach in such cases should not be imitated from Kotlerian Marketing.

In order to outline efficient marketing of services the 7Ps approach were introduced - adding people, physical evidence and process to the traditional mix.

Marketing is an essential function in any business upon which the survival of the business entity is dependent. "There can be no effective corporate strategy that is not marketing oriented, that does not in the end follow this unyielding prescription: The purpose of business is to create

and keep customer" (Theodore Levitt 1960). However, Levitt should also add that businesses must also develop products and services that customers want and at prices they are willing to pay. Marketing may be broadly conceived as the process of making decisions about what products or services to put on the market, who are the potential customers for these goods, how to reach the target markets and induce them to buy; how to price the product or service optionally so as to be make is attractive to the customers; and finally how to provide the goods physically to the ultimate customers. These matters are often expressed as the four Ps of marketing: Product, Price, Promotion and Place.

The four Ps of Pharmaceutical marketing are discussed below.

Product:

Product is an item that is created in an organization to fulfill the demand of the consumers. It can be intangible or tangible – i.e. service or goods.

The Product related decisions encompass the following aspects such as Brand name, Functionality, Product styling, Quality, Safety, Packaging and After-sales service.

The Product related decision fringes on what your customer wants from you. The Product parameters many changes according to its phase of the Product Life Cycle. For instance, during the introduction phase, the company may launch limited versions of the product just to explore adaptability to the customer needs. Similarly, the number of service centers for after-sales service as well as their location may be determined by the geographical spread of its customers**.**

The following are some of the challenges faced by the Pharma sector with respect to 'Product':

The recent COVID-19 Pandemic has highlighted the short comings of the pharma sector in providing the necessary quantities of drugs and other protective items including sanitizers to meet the unexpected surge in the international demand for drugs and accessories to tackle the Pandemic.

1. Demand forecasting and Market Potential
2. Risk management
3. Social Challenges
4. Legal and Regulatory Challenges
5. Distribution Challenges
6. Identifying Customer Pain Points

Price:

Price of the product is the amount that the customer is willing to pay for it. The 'Price' element of the marketing mix is vital for ensuring the economic viability of the Product.

The Major decision elements of 'Price' are pricing strategy (model), retail price, wholesale price, discounts offered, seasonal pricing, bundling pricing, price flexibility and price discrimination.

The decision of price depends on Product Life Cycle. A product during its journey from the Introduction stage to the Decline stage has to modify its Pricing strategies according to the changing market situation.

It gives an advantage to the company as the early adopters buy the product at the very initial stage even at a higher price.

India is recognized lowest priced drug manufacturer and marketer of pharmaceuticals products domestically and internationally. One reason for lower value share is the lower cost of drugs in India ranging from 5% to 50% less as compared to most other countries.

The Pricing Policies of the Indian Pharma sector have to overcome the following challenges. They are:

1. High 'Out of Pocket (OoP) expenditure
2. Pricing of patented drugs
3. Non-Standard drugs

4. Public and government pressure to make drug prices more affordable
5. Inadequate health insurance schemes is an impediment to high-priced drugs.
6. Higher healthcare cost forces the Pharma sector to focus on cost minimization.
7. Unknown value of revenue from each retailer in the territory.

Place:

This P is all about placement and distribution of the product in the market. The place also suggests the Point of Sale of the product. A business has to make sure that the availability of the product should be easy for the customers.

The 'Place' factor comprises of several decision elements such as (i) Distribution channels, (ii) Market coverage, (iii) Inventory, (iv) Warehousing, (v) Order processing and (vi) Transportation.

Market coverage can be intensive, selective or exclusive. For example cigarettes have intensive coverage, while Smartphones selling involves selective coverage in a city. In contrast, luxury products like Mercedes Benz have exclusive coverage.

The decision concerning the 'Place' is determined by the stage in the PLC (Product Life Cycle).

The following are some of the challenges faced by the Pharma sector with respect to 'Place':

1. Storage and Transportation of Temperature sensitive drugs.
2. The availability of adequate transportation facilities could pose a challenge in the delivery of drugs to remotely located destinations.
3. As the decision of the customer (the Patient) to use a particular drug is dependent on the Prescription of the Doctor. Hence, the success of the Distribution channel is dependent on the ability of the Drug manufacture to convince the professional Doctor who is mainly responsible for prescribing the drug. As a result, the Pharma sector faces a stiff competition with respect to cringing the Doctors recommendation for the drug.

4. Absence of transportation on the amount of time invested on profitable and not-so profitable customers and lack of time-share planning towards developing customer base for future and un-tapped markets.
5. Unavailability of go down on storage of cold medicines.

Promotion:

Promotion is comprised of elements like advertising, sales promotion, personal selling, public relation, publicity, etc.

The various phases of PLC give the different meaning of promotion. The advertising activity is extensive at the introduction stage and comes to selective channels in the maturity stage.

Sales promotion also varies at different stages. The budget of the overall advertising also gets affected. At the decline stage, a business dedicates almost nil budget for advertising. It becomes very crucial to work with the advertising or marketing agency that understands the connection of stages of PLC and Promotion.

The following are some of the major challenges faced by the Pharm sector vis-à-vis 'Promotion':

1. Increased competition and unethical practices adopted by some of the propaganda base companies.
2. Low level of customer knowledge (Doctors, Retailers, Wholesalers).
3. Poor customer (both external & internal) acquisition, development and retention strategies.
4. Varying customer perception.
5. The number and the quality of medical representatives
6. High training and re-training costs of sales personnel.
7. Busy doctors giving less time for sales calls.
8. Poor territory knowledge in terms of business value at medical representative level.
9. Unclear value of prescription from each doctor in the list of each sales person.

10. Absence of ideal mechanism of sales forecasting from field sales level, leading to huge deviations

Conclusion:

The Indian pharmaceutical industry has recognized a strong presence in the international generics market by distributing high-quality drugs at measure. The industry has made innovations in processes and formulations and developed itself as are liable, high quality and cost-effective global drug supplier. Currently the industry is worth over USD 38 billion and can hope to grow to USD 120 to 130 billion by 2030 by exploiting on the wonderful opportunities that lie ahead. However the Indian pharma companies can achieve the aspiration of eleven to twelve percent CAGR.

Marketing may be broadly conceived as the process of making decisions about what products or services to put on the market, who are the potential customers for these goods, how to reach the target markets and induce them to buy; how to price the product or service optionally so as to be make is attractive to the customers; and finally how to deliver the goods physically to the ultimate customers. The Indian pharmaceutical companies facing challenges related to the four Ps of marketing: Product, Price, Promotion and Place.

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Research Article

Marketing Challenges And Organizational Performance: An Empirical Investigation With Special To Pharmaceutical Organizations In India

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ABSTRACT

Marketing challenges is a crucial strategic driver for increasing operational performance and maximizing the achievement of organizational objectives, such as improved productivity, improved customer service and enhanced profitability. The age of both market globalization and outsourcing has started, and many companies tend to manage their marketing challenges activities. Most of these organizations understand that marketing challenges needs to be tested for its performance in order to create an effective and efficient marketing. The marketing challenges is the most critical element for companies to boom in pharmaceutical, which needs to be quick, uninterrupted and safe. The competition is fierce because not one or two, but hundreds of pharmaceutical companies are competing for market share, each finding and creating specific strategies for sale and distribution. The present study is an attempt to examine various marketing challenges in the pharmaceutical context. Although there is a lack of literature in this context, the current study critically reviewed the current literature and built a questionnaire with the inputs from leading pharm marketing representatives by identifying the main marketing challenges such as product, price, place, promotion and trying to find the effect of these variables on organizational efficiency. A sample size of 100 employees employed in pharmaceutical departments at different levels of ten leading pharmaceutical organizations in India was taken for a questionnaire survey as a sampling unit. The study found fascinating insights of marketing challenges in pharma, which eventually benefit the marketers to design more effective marketing challenges. Further, the study is confined to Ten Pharma organisations in India which becomes a limitation in generalizing the findings.

Key Words: Marketing Challenges, Operational Performance, Pharmaceutical Organizations

I. INTRODUCTION:

The pharmaceutical sector generates around 2.8 trillion dollars in revenue globally, making it the largest industry in the world. Recent years have witnessed significant changes in the pharmacy sector, putting new demands on payers, providers, and manufacturers. Consumers now expect the pharmaceutical business to provide them with the same options and conveniences as other market segments. The Indian pharmaceutical sector is expected to grow rapidly and steadily over the coming years due to a variety of factors.

The pharmaceutical industry in India stands at the crossroads of opportunity and challenge. With a robust domestic market fueled by a burgeoning population and increasing healthcare awareness, coupled with a strong presence in the global pharmaceutical arena, Indian pharmaceutical companies have made significant strides. However, amidst these achievements lie formidable marketing challenges that require meticulous navigation and strategic acumen to surmount.

At the heart of these challenges lies the regulatory landscape. India's pharmaceutical sector is subject to rigorous regulatory oversight, spanning drug approvals, pricing regulations, and stringent advertising

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guidelines. Navigating this intricate web of regulations demands not only compliance but also agility to adapt to evolving regulatory frameworks. Moreover, with recent regulatory reforms aimed at enhancing drug safety and efficacy, pharmaceutical companies face heightened scrutiny, necessitating robust compliance mechanisms and risk mitigation strategies.

Beyond regulatory hurdles, understanding the dynamics of consumer behavior and healthcare preferences is imperative. India's healthcare landscape is undergoing a paradigm shift, driven by factors such as increasing urbanization, rising disposable incomes, and a growing emphasis on preventive healthcare. Consequently, consumers are becoming more discerning, seeking value-driven healthcare solutions and placing greater emphasis on factors such as brand reputation, efficacy, and affordability. Pharmaceutical marketers must therefore unravel the complexities of consumer behavior, leveraging insights to tailor marketing strategies that resonate with target audiences and drive brand loyalty.

Amidst these shifts, competitive pressures further compound the challenges faced by pharmaceutical companies. The Indian pharmaceutical market is fiercely competitive, characterized by a myriad of domestic players vying for market share alongside multinational giants. Price competitiveness, product differentiation, and market segmentation emerge as pivotal battlegrounds, necessitating continuous innovation and strategic positioning to stay ahead of rivals. Moreover, with the emergence of disruptive technologies and digital platforms, the landscape of competition is evolving rapidly, requiring pharmaceutical marketers to embrace digital transformation and harness data-driven insights to gain a competitive edge.

II. LITERATURE REVIEW:

Giuseppe Festa, Ashutosh Kolte, Maria Rosaria Carli, Matteo Rossi (2022), in their study focussed on annual growth in pharmaceutical, medicinal chemical, and botanical production for healthcare purposes. The country sells generic medications on a big scale, having significant impact in American and European markets. Although the industry's infrastructure and R&D skills have grown, difficulties such as pricing regulation, sector fragmentation, and intellectual property continue to exist. Patents are a major topic of contention in the national industry. Despite India's large population and low per capita income, stronger patent regulations may result in reduced access to medicine for a considerable portion of the population. Affordability of drugs poses a serious challenge in India and South Asia, potentially affecting life and death. The study found a strong economic, business, and commercial outlook for the Indian pharmaceutical industry, notwithstanding certain worries. The sector's main problem is to strike a balance between commercial aspirations for innovative growth and social needs for affordable healthcare.

Abinav Sharma (2020) made an attempt, to study the creation, communication, and provision of value to the target market by healthcare professionals is greatly aided by healthcare marketing. Rather than starting with goods or services, modern marketers start with the customer. Establishing a long-lasting connection holds greater significance than completing a single transaction. Creating a high degree of customer satisfaction should be the goal of a healthcare service provider in order to encourage repeat business from satisfied clients. According to the report, hospitals face a number of difficulties when trying to sell their services, but there are also opportunities in the market that healthcare organizations can take advantage of. With a carefully thought-out marketing strategy, hospitals can maintain their competitive edge and build a long-lasting relationship with patients by providing top-notch care and building a solid reputation.

Priyanka Singh (2013) examined a particular facet of rural marketing that these markets have not been utilized in any way. Its sole objective is to draw attention to the rural markets' increasing significance in the rapidly shifting economic landscape. Due to the wide range of courses that must be taken in rural marketing, particular consideration must be given to the product, its quality, packaging, brand, price, advertisement, personal selling, and distribution channel. The rural marketing strategy must be suitable, fully understanding the dispersed nature of rural consumers and the requirement for a distinct communication mix due to the lower educational attainment and environmental variations. All of this necessitates coordinated and coordinated action from the sector and the government. Even while producers may experience early losses due to high promotion and distribution costs, they shouldn't let this stop them from entering the market because the potential in the rural area is enormous. The country's shifting economic landscape combined with the rural population's increased purchasing power means that the recently established rural markets will undoubtedly pay off handsomely.
Luv Saini and P.K. Agarwal (2023) in their study highlighted a pharmaceutical business would be a smart decision because the industry is growing and has a bright future. The process involves several steps, which present the entrepreneur with a variety of challenges. Materials and information must come from trustworthy and credible sources. This study focuses on the various challenges that come with starting a pharmaceutical business in India. The study is qualitatively descriptive and makes use of secondary data. The results show that registration and licensing, resource requirements, financial concerns, business plan formation, raw material availability, skilled labor, and workforce optimization are the primary barriers to starting a pharmaceutical company in India.

Kalyani Rajput and Dr. Rajesh Kumar Pandey (2022) examined product marketing is a standard practice recognized by the worldwide business community as being essential to organizations seeking to achieve their targeted outcomes. The pharmaceutical industry is one of the most important and widespread industries. Its scope is broad, encompassing anything from over-the-counter (OTC) goods to life-saving medications to medical equipment. So much so that pharmaceutical education is given its own area in medical education as a whole, and the foundation for the production of pharmaceutical products is laid by these excellent educational opportunities. It takes a certain set of abilities to get these medications on the market, which is why pharmaceutical marketing is involved. Pharma marketing is more essential than general product marketing because it falls into the category of necessities and useful goods rather than desired goods, as most people don't plan to purchase medications or medical equipment unless they are prescribed or advised by a healthcare professional. This element presents a significant obstacle for the pharmaceutical marketing industry.

III. METHODOLOGY:

This research study aims to assess the association among important marketing challenges components empirically, namely Product challenges, Price challenges, Place challenges, Promotion challenges and how these critical components influence effective performance, which impacts the organizational performance. The present study framed the following objective of the study to enhance the limited literature available on Marketing challenges in the Pharma context: To study the relationship between marketing effectiveness and organizational Performance in Pharmaceutical organizations in India.

The following Hypotheses were framed for the present study
Ha01: There is a significant relationship between Marketing (4P's) challenges and Organizational Performance.
Ha02: There is a significant relationship between Marketing Effectiveness and Organizational Performance.
Data was collected from both Primary and secondary sources. The primary data was collected by administering a structured questionnaire from the employees working in the selected Pharmaceutical organizational in marketing domain. The secondary data was collected from research articles, journals, company records, and manuals. Measures for the research constructs used in the present study were developed by seeking the help from real time professionals who are working in the Pharma organizations with a framework borrowed and adapted by compiling various standard studies from prior literature. Most of the items were measured using a 5-point Likert scale ranging from "very poor" to "excellent". The antecedents in our research model comprise four constructs. "Product Performance of Marketing challenges" was assessed using six items; "Price Performance of Marketing challenges" was assessed using Five items. Nine items used to capture "Place Performance". "Promotion Performance" was assessed using eight items. Finally, "Marketing Effectiveness Performance" and "Organizational Performance" were assessed by using twelve and eight items respectively. A pilot study with a sample size of 50 responses was conducted before arriving at the final questionnaire. Reliability analysis ***(Cronbach's alpha)*** was applied to check the reliability of items used in initial questionnaire which showed that *Cronbach Alpha ranges from 0.7 to 0.9*(which is quite reliable). Based on reliability analysis and feedback from the Marketing representatives working in Pharma organizations, the final questionnaire was prepared.
The population universe consists of the employees working in India's marketing management wing of the pharmaceutical organization. The present study has limited the scope by restricting the universe as a pharmaceutical organization that only deals with marketing mix challenges. A total of 100 questionnaires were distributed and collected from the employees working in marketing management in pharmaceutical organizations in India.

IV. ANALYSIS

The profile of the respondents includes age, gender, designation, and work experience. The distribution of respondents based on their characteristics is shown in table 1. Analytical aspects of these characteristics are worth noting.

Tabel: 1 Profile of the Respondents

Variables	Categories	Frequency	Per cent
Age of the Respondent	Less than 25 years	24	24.0
	25 – 35 years	56	56.0
	Above 35 years	20	20.0
	Total	100	100.0
Education	Certificate Level	23	23.0
	Diploma Level	7	4.0
	Degree	28	28.0
	Masters	42	42.0
	Total	100	100.0
Qualification	Related to Job	58	58.0

	Unrelated to Job	42	42.0
	Total	100	100.0
Place of Work	City	28	28.0
	Town	38	38.0
	Both	34	34.0
	Total	100	100.0
Experience as Medical Representative	0 – 2 years	25	25.0
	2 – 5 years	44	44.0
	> 5 years	31	31.0
	Total	100	100.0

The final sample (N=100) was respondents are in the age group less than 25 is 24(24%), age group of '25 – 35 years is 56 (56%), 20 respondents are in the age group of 'above 20 years' (20%), Designation wise, the majority of the respondents are at 'Team lead level' (N=56). Twenty respondents are at 'Executive level', and 24 respondents are managers. Similarly, majority of the respondents have experienced are 2-5 five years. 25 respondents have experienced '0-2 years', 31 respondents have experience of 'above 5 years' in the marketing department. As the present study is based on the employees' perception towards marketing challenges practices, having more respondents from team lead level and good experience in marketing departments will make the data collected more authenticate in this survey. Table 2 is designed to exhibit the mean distribution of marketing effectiveness and marketing variables along with organizational performance scale. From the table, it can be noted that the highest mean was observed to the scale 'Product challenges' (M=3.68) and 'Organizational Performance' (M=3.65), whereas low mean was observed to the scales 'Pricing Challenges' (M=3.61) and 'Marketing effectiveness'(M=3.63).

Table:2 MARKETING CHALLENGES AND ORGANIZATIONAL PERFORMANCE

S. No	**Variable**	**Mean**	**S.D.**
1	Product Challenges	3.68	0.676
2	Pricing Challenges	3.61	0.564
3	Place Challenges	3.64	0.689
4	Promotion Challenges	3.67	0.560
5	Marketing Effectiveness	3.63	0.647
6	Organizational Performance	3.65	0.624

The present paper attempts to examine the relationship between marketing effectiveness and organizational performance with two hypotheses. The following deals with hypotheses testing by applying suitable statistical tools. Ha1: There is no significant relationship between selected variables on marketing challenges and Organizational Performance H01: There is a significant relationship between selected variables on marketing challenges and Organizational Performance. The hypothesis is framed to test the statistically significant relationship between marketing effectiveness and organizational performance. To test this hypothesis, linear regression is employed by considering organizational performance as dependent variables and variable of the marketing challenges such as Product challenges, Price challenges, Place (Distribution) challenges, and Plance challenges as independent variables. Table 3a portrays the regression test results, giving that marketing effectiveness variables can explain 71.1% of organizational performance.

Ha01: There is a significant relationship between Marketing (4P's) challenges and Organizational Performance.

Table: 3a **Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.843[a]	**.711**	.699	.35513

Table: 3b **ANOVA[a]**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	29.455	4	7.364	58.387	**0.000[b]**
	Residual	11.981	95	0.126		
	Total	41.436	99			

Table: 3c **Coefficients[a]**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.196	0.266		0-.738	.463
	Product Challenges	0.406	0.079	0.424	5.170	**0.000**
	Pricing Challenges	0.520	0.078	0.453	6.705	**0.000**
	Distribution Challenges	0.095	0.079	0.101	1.202	0.232
	Promotion Challenges	0.030	0.119	0.026	0.248	0.804

From table 3b, it can be inferred from the ANOVA test result that the overall model is significant. Table 3c shows that all the marketing challenges variables significantly influence organizational performance except two variables: product challenges and price challenges. Thus, the null hypothesis (H01) is rejected from the regression analysis test results, and the alternate hypothesis (Ha1) is accepted. H02: There is no significant relationship between marketing effectiveness and Organizational Performance Ha1: There is a significant relationship between Marketing Effectiveness and Organizational Performance. This hypothesis is framed to examine the relationship between marketing challenges and organizational performance. The earlier hypothesis has considered the variables of marketing challenges as independent variables. In this hypothesis, the marketing challenges is regarded as an independent variable and organizational performance as a dependent variable. Linear regression is applied to examine the relationship between the two selected variables. Table 4a shows that 64.1% of organizational performance can be explained by Marketing Effectiveness, which found to be consistent with the previous finding of the present study.

Ha02: There is a significant relationship between Marketing Effectiveness and Organizational Performance.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.783[a]	**0.614**	0.610	.38980

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.637	1	23.637	155.564	**0.000[b]**
	Residual	14.890	98	0.152		
	Total	38.527	99			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.913	0.223		4.089	**0.000**
	MARKETING EFFECTIVENESS	0.755	0.061	0.783	12.473	**0.000**

Table 4b and 4c have given a p-value less than 0.05, which means that there is a statistically significant relationship between marketing effectiveness and organizational performance. Hence, the null hypothesis (H02) is rejected, and an alternative hypothesis (Ha2) is accepted

V. LIMITATIONS

- Any study based on a survey through a predesigned questionnaire suffers from the basic limitation.
- The study is confined to Ten Pharma organisations in India which becomes a limitation in generalizing the facts.
- Non-Probabilistic Sample used in for the survey stands as another limitation of the present study.

VI. CONCLUSION

The study found that organizational performance can be attained by effective marketing management. Marketing challenges can be effective only if designed to meet the various product, price, place and promotion. The study found that product and price are the key issues that significantly impact organizational purpose. The researcher found that the place and promotion are the key issues to address while studying marketing challenges, especially in the pharmaceutical market.

As the study selected marketing segment, product and stock-out situations are unavoidable. But still, efforts should be made to reduce the occurrence of these situations in the future. There are many issues to focus on detail like the product design, accessibility, return policy etc. Hence, further study is recommended to the researchers who shown interest in marketing management.

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IMPACT OF EMPLOYEE RETENTION STRATEGIES ON JOB SATISFACTION OF IT PROFESSIONALS

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ABSTRACT

In the contemporary and dynamic landscape of business, the retention of skilled and experienced software professionals is a critical challenge faced by organizations. High turnover within the software industry not only results in substantial costs but also leads to a loss of productivity and knowledge. To address this challenge, organizations must adopt effective strategies to attract and retain talented software professionals. This research study aims to assess the various employee retention strategies implemented by organizations within the software industry. The study will delve into factors influencing employee retention and evaluate the effectiveness of diverse strategies employed to retain software professionals. Specifically, the research will investigate the impact of organizational culture, work-life balance initiatives, career development opportunities, compensation packages, and employee engagement practices on employee retention. Through a comprehensive analysis, the study seeks to contribute valuable insights that can inform organizations in developing and enhancing their strategies to retain skilled software professionals in the competitive business environment.

Keywords: Employee retention, Productivity, Organizational strategies, Compensation packages, Employee engagement, Human resources.

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1. INTRODUCTION

In the contemporary global business arena, the retention of top-tier talent has emerged as a critical concern for organizations, particularly within the fiercely competitive software industry. With India solidifying its position as a major hub for software development and technology services, companies in this sector face unique challenges in retaining skilled professionals amidst high demand and intense competition [1]. Effective employee retention is pivotal for organizational success, contributing to stability, enhanced productivity, and reduced recruitment and training costs. This study seeks to explore the diverse strategies employed by software companies in India to retain their professionals and evaluate the effectiveness of these strategies in fostering long-term commitment. Given the high demand and competition for skilled professionals in the software industry, organizations deploy a variety of retention strategies to maintain a stable workforce, minimize turnover costs, and cultivate a positive work environment conducive to employee satisfaction and loyalty [2][3]. This paper examines several commonly implemented employee retention strategies in the Indian software industry. It includes many factors such as Competitive Compensation Packages, Career Development Opportunities, Work-Life Balance Initiatives, Recognition and Rewards, Employee Engagement Programs, Transparent Communication, Employee Well-being Initiatives and Strong Leadership and Management [4]. Generally, to attract and retain top talent, companies strive to offer competitive salaries and benefits that align with industry standards, reflecting the value of employees' skills and expertise. Recognizing the motivation driven by growth, organizations invest in employee development, providing clear career paths through training programs, mentorship initiatives, and challenging project opportunities. Acknowledging the importance of balancing work and personal life, software companies often implement flexible schedules, remote work options, and paid time off policies to support work-life integration, reducing burnout and increasing employee loyalty. Fostering a positive work culture involves acknowledging and appreciating contributions through rewards, bonuses, and public appreciation programs, boosting morale and creating a sense of loyalty among employees. Recognizing the link between engagement and retention, software firms implement team-building activities, social events, and employee resource groups to create a supportive work environment that fosters a sense of belonging and camaraderie [5][6]. Open and transparent communication channels build trust and loyalty. Ensuring access to organizational information, regular feedback sessions, and performance reviews provide opportunities for employees to voice concerns and receive constructive feedback. Prioritizing employee well-being involves offering wellness programs, mental health support, and access to fitness facilities, demonstrating a genuine concern for employees' health and building trust and loyalty. Effective leadership and management practices significantly influence retention. Investments in training managers to be supportive, empathetic, and skilled in employee development foster positive relationships, reducing turnover [7]. By examining these strategies, this research paper aims to contribute valuable insights for organizations seeking to enhance their employee retention approaches in the dynamic and competitive landscape of the Indian software industry. The key factors that helps to assess the strategies implemented by Indian software industries for investigating the employee retention strategies in the Indian software industry and the benefits of the employee retention is shown in the following fig.1.



Fig 1: Employee retention in IT industry

II. LITERATURE REVIEW

Employee retention strategies play a crucial role in the contemporary business landscape, particularly within the Information Technology (IT) sector, where attracting and retaining skilled professionals is paramount. This literature review seeks to explore and synthesize existing research on the impact of employee retention strategies on the job satisfaction of IT professionals. Understanding the intricate relationship between retention strategies and job satisfaction is essential for organizations striving to create a positive work environment and retain their valuable IT workforce. Through investigation on the research papers available in the literature reveals the following observations and conclusions.

Rahman, M., Islam, M. A. presented a paper on "Effective Strategies for Employee Retention in the IT Industry"[8]. The presented research work explores, in the ever-evolving landscape of the Information Technology (IT) industry, the retention of skilled professionals stands as a critical imperative for organizational success. This literature review examines several key studies that delve into effective strategies for employee retention within the IT sector. The insights provided by these studies contribute to a comprehensive understanding of the multifaceted approaches organizations employ to reduce turnover, enhance employee satisfaction, and elevate overall organizational performance

Madhavan, A., & Mahadevan, N, presented a paper on “The Impact of Compensation and Benefits on Employee Retention in the IT Sector"[9]. Their research scrutinizes the intricate relationship between compensation and benefits and employee retention within the IT sector. The study underscores the pivotal role of competitive salaries, incentives, and comprehensive benefits packages in attracting and retaining IT professionals. Additionally, it explores the significance of non-monetary rewards, such as flexible work arrangements and career growth opportunities, in bolstering employee retention.

Mehta, P presented a paper on "Employee Retention Strategies and Organizational Performance: A Comprehensive Review with Special Reference to IT Industry"[10]. Mehta's comprehensive review delves into the nexus between employee retention strategies and organizational performance, with a specific focus on the IT industry. The study explores strategies encompassing career development, work-life balance, employee recognition, and leadership development. It provides valuable insights into the positive impact of these strategies on employee commitment, satisfaction, and overall organizational success.

Jain, A., & Kaur, P submitted study on "A Study of Employee Retention Practices and its Effectiveness in IT Sector"[11]. Jain and Kaur's study systematically explores employee retention practices within the IT sector, evaluating their effectiveness. The research meticulously examines factors such as compensation, career growth opportunities, work environment, and employee engagement. It identifies the pivotal role of a positive work culture, supportive leadership, and effective communication in retaining IT professionals.

Singh, A., & Verma, N. presented a paper on “Impact of Work-Life Balance on Employee Retention: A Study in Indian IT Industry"[12]. Singh and Verma's research focuses on the critical impact of work-life balance initiatives on employee retention within the Indian IT industry. The study accentuates the role of flexible work arrangements, family-friendly policies, and employee well-being programs in not only reducing turnover but also enhancing job satisfaction.

Altogether, these studies provide comprehensive understanding of the diverse strategies and practices employed within the IT industry to retain skilled professionals. The insights gathered from these works offer a valuable resource for organizations seeking to refine and implement effective employee retention strategies, thereby fostering a resilient and satisfied IT workforce.

III. RESEARCH METHODOLOGY

To assess the employee retention strategies of software professionals in India, a mixed-methods research approach will be employed. The study will commence with a comprehensive literature review to establish a theoretical foundation and identify existing frameworks and models relevant to employee retention in the software industry. Subsequently, qualitative data will be gathered through semi-structured interviews with HR professionals and software experts to gain insights into the industry's specific context and nuances. The interview data will be thematically analyzed to identify recurring patterns and themes related to effective retention strategies. Additionally, a quantitative survey will be administered to a representative sample of software professionals across different organizations in India. The survey will encompass standardized measures of job satisfaction, perceptions of organizational culture, and the perceived effectiveness of various retention strategies. Statistical analyses, including regression analysis and correlation assessments, will be conducted to determine the relationship between retention strategies and job satisfaction. The combined findings from qualitative and quantitative data will contribute to a holistic understanding of the efficacy of employee retention strategies in the Indian software industry [13] [14] [15].

The survey comprises two sections: The initial part delves into respondents' demographic details, while the subsequent section focuses on gathering insights into their perspectives on the correlation between strategic impact elements and customer perceptions and purchasing behaviors. Using a Likert scale ranging from 1 (strong agreement) to 5 (strong disagreement), respondents rated the claims. Disagreement is denoted by scores of 4 or 5 [16] [17]. Regarding the sample design, a convenience sample was employed, distributing a total of 300 questionnaires, with 240 being fully completed. Upon thorough examination, an impressive 80 percent response rate was achieved. Descriptive statistics indicated a final sample size of 241, comprising both males and females.

IV. CONCEPTUAL FRAMEWORK

The conceptual framework for assessing employee retention strategies among software professionals in India is structured around key dimensions: organizational context, individual factors, and retention strategy effectiveness. The organizational context involves analyzing industry dynamics, examining organizational culture, and evaluating leadership effectiveness. Individual factors encompass demographic variables, job satisfaction, and professional

development needs [18]. The retention strategy effectiveness dimension involves assessing the impact of compensation, career development programs, work-life balance initiatives, and recognition programs on employee retention. The interactions between these dimensions will be explored through qualitative interviews and quantitative surveys.

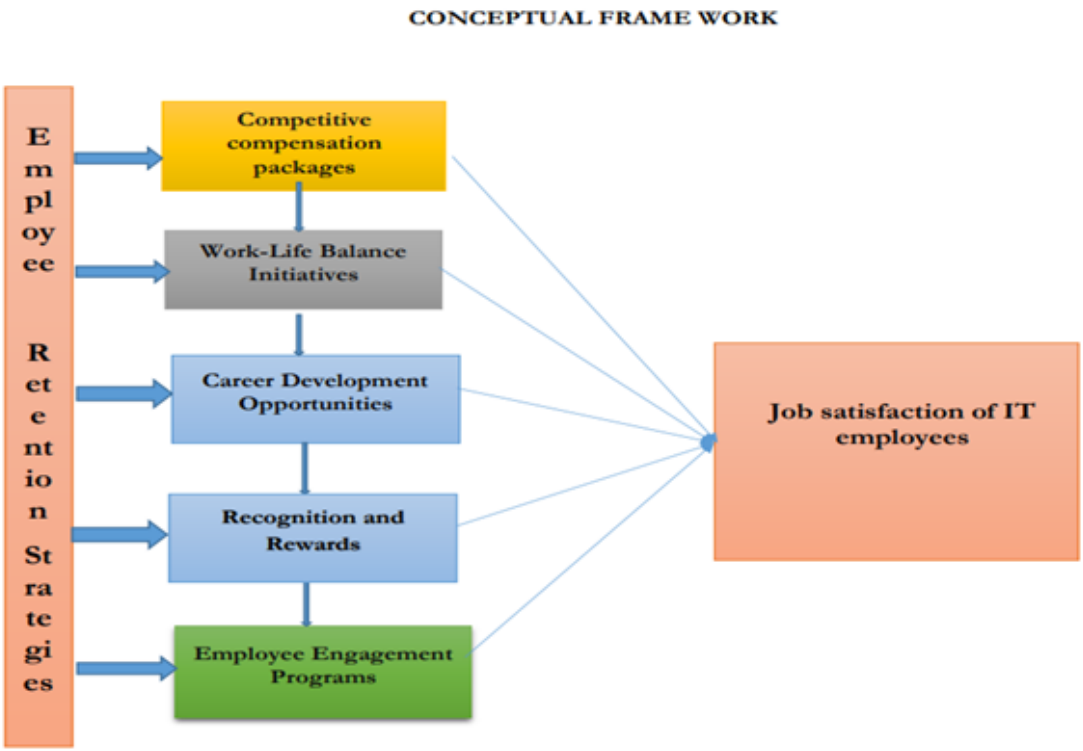


Fig 2: Conceptual frame work

The study aims to delineate the interplay of these factors in the Indian software industry, providing a nuanced understanding of effective retention strategies and their alignment with the unique needs and expectations of software professionals in this dynamic context [19]. The figure 2 revels the concept of the conceptual frame work.

V. OBJECTIVES

The main objective of this paper is to understand the influence of strategies on the job satisfaction of IT employees. The specific objectives of this research study are outlined as follows:

- Evaluate the impact of competitive compensation packages on the job satisfaction of IT employees.
- Analyze the influence of work-life balance initiatives on the job satisfaction of IT employees.
- Assess the impact of career development opportunities on the job satisfaction of IT employees.
- Examine the influence of recognition and rewards on the job satisfaction of IT employees.
- Evaluate the impact of employee engagement programs on the job satisfaction of IT employees.

VI. HYPOTHESIS

Competitive Compensation Packages:

- H0: The impact of Competitive Compensation Packages on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Competitive Compensation Packages on Job satisfaction of IT employees.
- Work-Life Balance Initiatives:
- H0: The impact of Work-Life Balance Initiatives on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Work-Life Balance Initiatives on Job satisfaction of IT employees.
- Career Development Opportunities:
- H0: The impact of Career Development Opportunities on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Career Development Opportunities on Job satisfaction of IT employees.
- Recognition and Rewards:
- H0: The impact of Recognition and Rewards on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Recognition and Rewards on Job satisfaction of IT employees.
- Employee Engagement Programs:
- H0: The impact of Employee Engagement Programs on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Employee Engagement Programs on Job satisfaction of IT employees.

VII. RESULTS & DISCUSSION

To attain the desired outcome of this research work, a systematic research methodology is implemented and the respective outputs were described in this section to conclude the impact of employee retention strategies on job satisfaction of it professionals. In this proposed work, Statistical Package for the Social Sciences SPSS is a software package widely used for statistical analysis in various fields, including management and social sciences. In management, SPSS is often used for tasks such as data analysis, statistical modelling, and reporting. SPSS 22 is a statistical software tool that can be utilized in management for analysing and interpreting data, making informed decisions, and gaining insights into various aspects of organizational processes and behaviour. In this research work SPSS 22 is used to analyse the data. The study under consideration employs exploratory factor analysis to illustrate concept validity and assesses internal consistency using Cronbach's alpha. To identify potential relationships between variables, the study utilizes the regression method. Principal Component Analysis (PCA) is employed in the Exploratory Factor Analysis (EFA) to validate constructs. Referring to Hair et al.'s research in 1998, a factor loading equal to or greater than 0.30 is considered to meet the minimum criterion, followed by factor loadings of 0.40 and 0.50, which are deemed progressively more crucial. This study establishes a termination point at a factor loading of 0.50. The outcomes of the factor analysis are presented in the accompanying table. KMO is a statistic used in management research, particularly in the context of factor analysis, to assess

the adequacy of the data for identifying underlying factors or constructs. The value of KMO, when it is between 0.5 and 1.0, a component analysis is advantageous for the data.

The extent of interdependence among variables is assessed through Bartlett's sphericity test, with researchers measuring the outcome by computing the test's significance level. If the resulting values are significantly small, typically below 0.05, it indicates substantial correlations between the variables. Conversely, a p-value exceeding 0.10 suggests that the data may not be well-suited for factor analysis. The findings affirm the appropriateness of employing factor analysis for the given dataset, as all twenty-one items were validated for the final analysis, with none exhibiting a loading value below 0.5.

Table 1: Results of Exploratory Factor Analysis

Table 1: Results of Exploratory Factor Analysis								
Macro Variable	**Micro Variable**	**Factor loadings**	**KMO Measureof Sample Adequacy (>0.5)**	**Bartlett's Test of Sphericity**		**Items confirmed**	**Items dropped**	**Cum % of loading**
				Chi Square	**Sig. (<.10)**			
Impact of strategies	Competitive compensation packages -1	.907	.574	211.429	.000	3	0	65.843
	Competitive compensation packages - 2	.843						
	Competitive compensation packages -3	.665						
	Work-Life Balance Initiatives-1	.878	.705	355.625	.000	3	0	78.536
	Work-Life Balance Initiatives-2	.857						
	Work-Life Balance Initiatives-3	.922						
	Career Development Opportunities: - 1	.737	.642	309.165	.000	3	0	72.860
	Career Development Opportunities: -2	.901						

Reliability Assessment:

The researchers utilized Cronbach's Alpha calculation to assess the internal consistency and reliability of the questionnaire. Nunally and Bernstein (1994) recommend an alpha value as low as 0.60 for new scales, with acceptability extending to lower values. However, common practice often dictates a requirement for an internally consistent established scale with an alpha value of 0.70 or higher. In this study, the predefined threshold for Cronbach's alpha is established at 0.7.

Table 2: Results of the Reliability Examination

	Independent Variable	Cronbach Alpha
1	Competitive compensation packages	.722
2	Building trust and credibility	.861
3	Career Development Opportunities:	.808
4	Recognition and Rewards	.669
5	Employee Engagement Programs	.946
Over all Reliability of the Questionnaire		.801

Table 2 reveals, the presents Cronbach's alpha values for various independent variables, indicating their internal consistency or reliability within a questionnaire.

1. **Independent Variable:** This column lists the different factors or constructs that were assessed in the questionnaire.
2. **Cronbach Alpha**: Cronbach's alpha is a measure of internal consistency, which assesses how closely related a set of items are as a group. It ranges from 0 to 1, where higher values indicate greater reliability. Competitive compensation packages have a Cronbach alpha of 0.722, suggesting moderate internal consistency. Building trust and credibility has a Cronbach alpha of 0.861, indicating high internal consistency. Career Development Opportunities have a Cronbach alpha of 0.808, indicating a high level of internal consistency. Recognition and Rewards have a Cronbach alpha of 0.669, suggesting moderate internal consistency. Employee Engagement Programs have a Cronbach alpha of 0.946, indicating high internal consistency. The overall reliability of the questionnaire, including all items, has a Cronbach alpha of 0.801, suggesting a good level of internal consistency.

These values provide insights into the reliability of the questionnaire items related to each independent variable, with higher Cronbach alpha values indicating greater reliability.

Table 3: Correlations

	CCP	CDO	R&R	EEP	WLB
Competitive compensation packages(CCP)	1				
Career Development Opportunities: (CDO)	.806**	1			
Recognition and Rewards(R&R))	.755**	.798**	1		
Employee Engagement Programs(EEP)	.757**	.768**	.723**	1	
Work-Life Balance Initiatives(WLB)	.308**	.348**	.343**	.367**	1

Table 3 reveals that the Cronbach's alpha values surpass the acceptable cutoff of 0.7, indicating satisfactory reliability. Specifically, the questionnaire exhibits an overall reliability demonstrated by a Cronbach's alpha value of 0.801.

Moving on to the correlation analysis, the study on independent variables indicates a robust connection among all of them. Each variable demonstrates a significant correlation with the five variables under examination in the "impact of strategies" framework. Notably, all five independent variables within the "impact of strategies" framework exhibit substantial associations with one another (refer to Table 4). The correlation between "Career Development Opportunities" and "Competitive Compensation Packages" is the highest at 0.806, while the least significant relationships are observed between "Building Trust and Credibility" and "Competitive Compensation Packages" at 0.308.

Regression Analysis:

The study utilizes stepwise regression analysis to discern the predictor-criterion relationship between dependent and independent variables. Specifically, the correlation between the impact of retention strategies on job satisfaction was explored.

Results of Hypotheses Testing for Job Satisfaction of IT Employees as Dependent Variable:

Multiple regression models were developed and tested to assess the job satisfaction of IT employees as the dependent variable. The study considered five factors related to the impact of strategies—Competitive Compensation Packages (CCP), Career Development Opportunities (CDO), Recognition and Rewards (R&R), Employee Engagement Programs (EEP), and Work-Life Balance Initiatives (WLB)—as independent variables in the regression models.

Table (4a): Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.863[a]	.744	.743	.355
2	.911[b]	.830	.829	.290
3	.936[c]	.876	.874	.248
4	.955[d]	.912	.910	.210
5	.962[e]	.926	.925	.192

The results of the stepwise regression analysis indicate that, according to Table 4(a), five factors (Competitive Compensation Packages, Career Development Opportunities, Recognition and Rewards, Building Trust and Credibility, Employee Engagement Programs) emerged as significant predictors of "Job satisfaction of IT employees." With an R-square value of 0.934, these five variables collectively explain job satisfaction to the extent of 93.4 percent in the dataset.

a. Dependent Variable: Job satisfaction of IT employees
b. Predictors: (Constant), Career Development Opportunities:
c. Predictors: (Constant), Career Development Opportunities: Employee Engagement Programs
d. Predictors: (Constant), Career Development Opportunities: Employee Engagement Programs,
e. Predictors: (Constant), Career Development Opportunities: Employee Engagement Programs, Recognition and Rewards

Table (4b). ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	87.776	1	87.776	696.150	.000[b]
	Residual	30.135	239	.126		
	Total	117.911	240			
2	Regression	97.885	2	48.943	581.674	.000[c]
	Residual	20.026	238	.084		
	Total	117.911	240			
3	Regression	103.276	3	34.425	557.490	.000[d]
	Residual	14.635	237	.062		
	Total	117.911	240			
4	Regression	107.488	4	26.872	608.429	.000[e]
	Residual	10.423	236	.044		
	Total	117.911	240			
5	Regression	109.232	5	21.846	591.557	.000[f]
	Residual	8.679	235	.037		
	Total	117.911	240			

Moreover, Table 4(b) showcases the ANOVA outcomes for the regression model, affirming validity with a 95 percent confidence level.

Table (4c): Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	.498	.087		5.752	.000
1	Career Development Opportunities:	.800	.030	.863	26.385	.000
2	(Constant)	.517	.071		7.310	.000
	Career Development Opportunities:	.475	.039	.512	12.280	.000
	Employee Engagement Programs	.325	.030	.457	10.961	.000
3	(Constant)	.215	.069		3.124	.002
	Career Development Opportunities:	.440	.033	.475	13.217	.000
	Employee Engagement Programs	.284	.026	.400	11.055	.000
	Building trust and credibility	.183	.020	.231	9.343	.000
4	(Constant)	.156	.058		2.663	.008
	Career Development Opportunities:	.262	.034	.283	7.811	.000
	Employee Engagement Programs	.224	.023	.316	9.928	.000
	Building trust and credibility	.171	.017	.216	10.310	.000
	Recognition and Rewards	.271	.028	.328	9.765	.000
5	(Constant)	.074	.055		1.358	.176
	Career Development Opportunities:	.185	.033	.199	5.655	.000
	Employee Engagement Programs	.191	.021	.268	8.965	.000
	Building trust and credibility	.168	.015	.212	11.045	.000
	Recognition and Rewards	.250	.026	.302	9.758	.000
	Competitive compensation packages	.173	.025	.191	6.873	.000

a. Dependent Variable: Job satisfaction of IT employees

A brief scrutiny of the corresponding coefficients in Table 4(c) discloses beta values for the factors— "Competitive Compensation Packages (CCP), Career Development Opportunities (CDO), Recognition and Rewards (R&R), Employee Engagement Programs (EEP), Work-Life Balance Initiatives (WLB)"—as 0.129, 0.221, 0.215, 0.265, and 0.195, respectively. These findings strongly underscore the significance of these factors in influencing job satisfaction among employees.

Table 5: Test Results for Hypotheses

Hypothesis	Independent Variables	Dependent Variables	R-Square	Beta Coefficient	t-value	Sig Value
H1	Competitive compensation packages (CCP)	Job satisfaction of IT employees	0.129	3.593	0.076	Accepted
H2	Career Development Opportunities (CDO)	Job satisfaction of IT employees	0.221	7.437	0.000	Accepted
H3	Recognition and Rewards (R&R)	Job satisfaction of IT employees	0.215	11.793	0.003	Accepted
H4	Employee Engagement Programs (EEP)	Job satisfaction of IT employees	0.265	8.771	0.012	Accepted
H5	Work-Life Balance Initiatives (WLB)	Job satisfaction of IT employees	0.195	7.379	0.017	Accepted

The table 5 presents the findings of a research study examining the relationship between various factors and the job satisfaction of IT employees. The study hypothesized that factors such as competitive compensation packages, career development opportunities, recognition and rewards, employee engagement programs, and work-life balance initiatives influence job satisfaction in the IT sector. The results indicate that all hypotheses were supported, as evidenced by the statistically significant relationships between the independent variables and job satisfaction. Specifically, career development opportunities, recognition and rewards, employee engagement programs, and work-life balance initiatives showed particularly strong associations with job satisfaction, as indicated by their higher beta coefficients, t-values, and lower significance values. These findings suggest that organizations seeking to enhance job satisfaction among IT employees should prioritize initiatives related to career development, recognition, engagement, and work-life balance. Overall, the study highlights the importance of considering various organizational factors in understanding and promoting job satisfaction within the IT industry. The research findings support the hypotheses with numerical evidence and are summarized as follows. Competitive compensation packages (CCP): The relationship with job satisfaction has a beta coefficient of 0.129, a t-value of 3.593, and a significance value of 0.076.Career Development Opportunities (CDO): The association with job satisfaction is stronger with a beta coefficient of 0.221, a t-value of 7.437, and a significance value of 0.000.Recognition and Rewards (R&R): This factor has a beta coefficient of 0.215, a t-value of

11.793, and a significance value of 0.003, indicating a significant impact on job satisfaction. Employee Engagement Programs (EEP): The relationship with job satisfaction is notable, with a beta coefficient of 0.265, a t-value of 8.771, and a significance value of 0. 012.Work-Life Balance Initiatives (WLB): This factor shows a beta coefficient of 0.195, a t-value of 7.379, and a significance value of 0.017, indicating a statistically significant relationship with job satisfaction.

These numerical values provide quantitative evidence supporting the conclusion that career development opportunities, recognition and rewards, employee engagement programs, and work-life balance initiatives have significant associations with job satisfaction among IT employees.

VIII. RECOMMENDATIONS & SUGGESTIONS

Based on the extensive research conducted on employee retention strategies and their impact on job satisfaction of IT professionals, the primary recommendations and suggestions are listed below.

1. **Tailor Compensation Packages**: Customize compensation packages to align with industry standards and the unique skills and expertise of IT professionals.
2. **Invest in Career Development**: Prioritize investments in training programs, mentorship initiatives, and challenging project opportunities to support career growth and advancement.
3. **Promote Work-Life Balance**: Implement flexible work arrangements, remote work options, and paid time off policies to support work-life integration and reduce burnout.
4. **Enhance Recognition and Rewards**: Recognize and reward outstanding performance through bonuses, incentives, and public appreciation programs to boost morale and loyalty.
5. **Strengthen Employee Engagement**: Foster a supportive work environment through team-building activities, social events, and employee resource groups to promote engagement and camaraderie.
6. **Facilitate Transparent Communication**: Establish open channels of communication between management and employees to address concerns and provide feedback effectively.
7. **Prioritize Employee Well-being**: Offer wellness programs, mental health support, and access to fitness facilities to demonstrate genuine concern for employee health and well-being.
8. **Develop Leadership Skills**: Invest in training managers to be supportive, empathetic, and skilled in employee development to foster positive relationships and reduce turnover.
9. **Promote Diversity and Inclusion**: Create a diverse and inclusive workplace culture where all employees feel valued and respected.
10. **Regularly Review HR Policies**: Continuously review and update HR policies to ensure they meet the evolving needs and expectations of IT professionals and the organization.
11. **Encourage Cross-Functional Collaboration**: Facilitate collaboration between IT teams and other departments to promote innovation and problem-solving.
12. **Implement Mentorship Programs**: Pair junior IT professionals with experienced mentors to facilitate knowledge transfer and career development.
13. **Offer Performance-Based Incentives**: Tie rewards and incentives directly to individual and team performance to motivate IT professionals and drive results.

14. **Provide Leadership Opportunities**: Identify and groom future leaders within the IT department by offering leadership training and opportunities for advancement.
15. **Support Continuous Learning**: Encourage IT professionals to attend workshops, conferences, and training programs to stay updated with the latest technologies and trends.
16. **Create a Positive Work Culture**: Foster a culture of trust, collaboration, and appreciation to enhance job satisfaction and employee retention.
17. **Promote Flexibility**: Allow IT professionals to have autonomy over their work schedules and environments to accommodate personal preferences and obligations.
18. **Encourage Innovation:** Create avenues for IT professionals to contribute ideas and solutions to drive innovation within the organization.
19. **Provide Clear Expectations**: Communicate clear goals, expectations, and performance metrics to ensure alignment and accountability.
20. **Seek Feedback and Iterate**: Regularly solicit feedback from IT professionals and adapt retention strategies based on their input and changing needs.

These recommendations aim to help organizations in the IT industry develop and enhance their employee retention strategies to foster job satisfaction and create a conducive work environment for their valuable IT workforce.

Altogether, the recommendations and suggestions outlined provide a comprehensive framework for organizations within the IT industry to enhance their employee retention strategies and promote job satisfaction among their workforce. By implementing tailored compensation packages, investing in career development, promoting work-life balance, and fostering a supportive work culture, organizations can create an environment where IT professionals feel valued, motivated, and engaged. Additionally, prioritizing transparent communication, recognizing and rewarding performance, and supporting employee well-being are essential components of effective retention strategies. By continuously reviewing and updating HR policies, promoting diversity and inclusion, and encouraging innovation, organizations can adapt to the evolving needs and expectations of their workforce while staying competitive in the dynamic IT landscape.

Ultimately, by incorporating these recommendations into their retention strategies, organizations can cultivate a dedicated and loyal IT workforce, driving organizational success, growth, and innovation. As the IT industry continues to evolve, organizations must prioritize employee satisfaction and retention to remain competitive and thrive in the ever-changing market.

IX. CONCLUSION

Research on employee retention strategies within the software industry consistently emphasizes the robust correlation between these strategies and job satisfaction. The software industry, renowned for its competitiveness and high demand for skilled professionals, grapples with substantial challenges in retaining its workforce. Nevertheless, organizations can overcome these challenges by deploying effective retention strategies, thereby establishing a positive work environment conducive to job satisfaction, heightened employee commitment, and increased loyalty. Numerous studies have pinpointed key employee retention strategies integral to fostering job satisfaction in the software industry. These encompass competitive compensation packages, career development opportunities, work-life balance initiatives, recognition and rewards, employee engagement programs, transparent communication, employee well-being initiatives, and robust leadership and management practices. Research findings underscore the critical importance of offering competitive salaries and benefits in

attracting and retaining software professionals. Furthermore, providing avenues for career development, such as training programs and clear career paths, proves instrumental in promoting job satisfaction by enabling skill enhancement and career progression within the organization. In the demanding landscape of the software industry, work-life balance initiatives, including flexible work schedules and remote work options, emerge as pivotal contributors to job satisfaction, facilitating a healthy integration of work and personal life. Recognition and rewards programs significantly contribute to job satisfaction by acknowledging employee contributions and nurturing a positive work culture. Engagement programs, transparent communication channels, and employee well-being initiatives collectively play a substantial role in cultivating a supportive and fulfilling work environment, thereby enhancing job satisfaction. Finally, strong leadership and management practices that prioritize employee development and support further contribute to job satisfaction and employee retention. In summation, the literature review unequivocally supports the conclusion that the implementation of effective employee retention strategies in the software industry leads to heightened job satisfaction among software professionals. By addressing key influencers of job satisfaction, organizations can cultivate a dedicated and loyal workforce, ultimately bolstering the company's success and growth.

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COMPREHENSIVE EVALUATION OF THE DIGITAL INDIA PROGRAMME TO ADDRESS PAIN POINTS IN INDIA'S DIGITAL TRANSFORMATION

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ABSTRACT

The Digital India Programme represents a transformative vision aimed at reshaping India's digital landscape to promote widespread digital inclusion and socio-economic development. Despite significant advancements in digital banking, e-governance, and rural development, the programme faces numerous challenges, especially in rural areas. These challenges include inadequate digital literacy, poor infrastructure, socio-economic disparities, and cybersecurity threats, which hinder the effective adoption of digital financial services. Studies highlight these impediments and underscore the need for interventions to ensure equitable distribution of digital benefits. This comprehensive evaluation identifies pain points associated with the programme's implementation and suggests measures to enhance its efficacy. This study discusses key issues such as network and infrastructure limitations, digital literacy gaps, socio-cultural resistance, economic barriers, insufficient customer support, and slow regulatory responses. The findings emphasize the importance of strategic investments, regulatory support, and community engagement to overcome these challenges and achieve the programme's full potential.

Keywords: Digital India, digital literacy, rural development, e-governance, cybersecurity.

1. INTRODUCTION

The Digital India Programme represents a transformative vision to fundamentally reshape India's digital landscape, promoting widespread digital inclusion and enhancing socio-economic development. However, the programme's implementation has encountered significant challenges, especially in rural areas where barriers such as inadequate digital literacy, poor infrastructure, and socio-economic disparities persist. Literature reviews, including studies from the Thane District, reveal that these challenges hinder the effective adoption of digital financial services, underscoring the need for interventions to ensure equitable distribution of digitalization benefits. Despite notable advancements in digital banking and e-governance, cybersecurity threats and the need for regulatory frameworks remain pressing issues. The programme's impact on rural development is evident through improved access to information, education, healthcare, and government schemes, yet

obstacles like unreliable internet connectivity and resistance to change within governmental bodies persist. Furthermore, digital initiatives in education and healthcare, such as telemedicine and mobile health applications, highlight both the potential and the hurdles of digital transformation, with infrastructural deficiencies and digital illiteracy posing significant barriers. The role of the Digital India Programme in fostering entrepreneurship and growth in MSMEs is also notable, though limited digital skills, access to finance, and infrastructural constraints need to be addressed through supportive policies and capacity-building initiatives. This comprehensive evaluation aims to identify the pain points associated with the Digital India Programme's implementation and suggests measures to enhance its efficacy. The study employs a descriptive research design, drawing on secondary data from journal articles, books, and electronic sources. Key issues discussed include network and infrastructure limitations, digital literacy gaps, socio-cultural resistance, economic barriers, insufficient customer support, and slow regulatory responses.

2. LITERATURE REVIEW:

The Digital India Programme has made significant strides in fostering digital inclusion and enhancing financial literacy among marginalized communities, yet it faces considerable challenges, particularly in rural areas. Studies, such as the one conducted in Thane District, highlight several barriers to the effective adoption of digital financial services, including a lack of digital literacy, inadequate infrastructure, and socio-economic challenges. These impediments hinder the programme's goal of creating a digitally empowered society. While the initiative has made headway in promoting digital inclusion, there is a clear need for interventions to address these challenges and ensure the equitable distribution of digitalization benefits. Furthermore, the transformative impact on the Indian banking sector through the Digital India Programme has been profound, with digital banking services like mobile and internet banking reshaping traditional models. This transformation has enhanced efficiency, customer experience, and broadened financial inclusion, especially in rural areas, though cybersecurity threats and the need for regulatory frameworks remain pertinent challenges.

The role of the Digital India Programme in enhancing e-governance and its socio-economic impact on rural communities underscores its broad influence across various sectors. The integration of digital technologies into government-led operations has improved transparency, efficiency, and citizen engagement, as evidenced by successful initiatives like the Digital Locker system and online grievance redressal mechanisms. However, persistent hurdles such as the digital divide and resistance to change within governmental bodies need addressing. In rural India, digital initiatives have facilitated access to information, education, healthcare, and government schemes, contributing significantly to rural development. Despite these positive outcomes, challenges such as inadequate internet connectivity and lack of awareness about digital services continue to pose obstacles. Sustained efforts are required to bridge these gaps and ensure inclusive digital growth, highlighting the importance of strategic investments in infrastructure and comprehensive digital literacy campaigns.

The Digital India Programme's impact on education, healthcare, and entrepreneurship further illustrates its transformative potential and the accompanying challenges. Digital education initiatives hold promise for transforming education by making learning more accessible and interactive, though infrastructural deficiencies

and digital illiteracy among students and teachers pose significant barriers. Similarly, digital health initiatives like telemedicine and mobile health applications have improved healthcare access, particularly in underserved areas, but issues related to data privacy and the digital divide persist. The programme has also spurred entrepreneurship and growth in MSMEs by creating new business opportunities and expanding market access. However, limited digital skills, access to finance, and infrastructural constraints remain challenges that need to be addressed through supportive policies and capacity-building initiatives. Overall, the Digital India Programme has made commendable progress, but achieving its full potential requires addressing these challenges through strategic investments, regulatory support, and community engagement.

3. OBJECTIVES AND RESEARCH METHODOLOGY:

Objectives:

1. To study the pain points associated with the implementation of Digital India Programme.
2. To suggest, based on the findings, various measures to the Government of India to advance the Digital India Programme.

Research Design: Used a descriptive research design.

Data Sources:

The researcher collected secondary data from journal articles, write-ups from books and electronic sources.

Discussion:

Network and infrastructure issues result in fewer digital payments, as unreliable connectivity disrupts transactions and undermines trust in digital financial systems. The limited digital infrastructure in these regions exacerbates the problem, with many rural areas lacking essential facilities like reliable internet and digital devices, thus hindering access to digital services. Poor internet connectivity further restricts the use of online platforms for education, healthcare, and government services, isolating rural populations from digital advancements. Additionally, the dependence on an unreliable power supply for digital devices poses a major challenge. Frequent power outages and unstable electricity supply disrupt the functioning of digital services, making it difficult for rural communities to maintain consistent digital connectivity.

Many rural individuals lack the basic skills to navigate and utilize digital platforms, which limits their ability to benefit from digital initiatives. The limited outreach of digital literacy campaigns exacerbates this issue, as many such efforts fail to reach remote and underserved communities, leaving a substantial portion of the rural population without essential digital knowledge. Furthermore, a lack of awareness about digital financial services leads to underutilization of digital payment systems, online banking, and other financial technologies that could enhance economic efficiency and inclusivity. Additionally, insufficient training and capacity-building programs for rural users mean that even those who have access to digital technologies struggle to keep pace with rapidly evolving digital environments.

Resistance to adopting new digital technologies in rural areas where traditional methods are preferred. This reluctance is compounded by a lack of trust in digital financial transactions, with fears of security breaches and

digital fraud discouraging engagement with online financial services. Cybersecurity concerns and the fear of fraud further deter users, as potential risks associated with cyber threats and scams create apprehension about the safety of digital transactions. Socio-cultural barriers also play a crucial role, as deeply entrenched norms and practices in rural communities foster suspicion and skepticism towards digital adoption. These socio-cultural attitudes, along with a lack of digital literacy, reinforce distrust and resistance.

High costs of digital devices and internet access create significant barriers for rural and economically disadvantaged populations, preventing them from fully participating in the digital economy. Many individuals and families in these areas cannot afford the initial investment in smartphones, computers, or consistent internet connectivity, which are essential for accessing digital services. Furthermore, limited access to financial resources for digital investments exacerbates this problem. Without sufficient financial support or affordable financing options, rural users are unable to invest in the necessary infrastructure to benefit from digital advancements.

Insufficient customer support for digital services significantly in rural and remote areas where users often require assistance to navigate new technologies. The limited availability of localized digital content and services further exacerbates this issue, as many digital platforms fail to cater to the specific needs and preferences of diverse regional populations. This gap in service availability prevents users from fully benefiting from digital initiatives designed to improve their daily lives. Additionally, the lack of multilingual support on digital platforms creates a barrier for non-English speaking users, making it difficult for them to access and utilize digital services effectively. This language barrier particularly affects rural users, who may be more comfortable with regional languages.

Many rural populations remain excluded from formal financial systems. This exclusion is exacerbated by ineffective digital payment systems in rural areas, where poor connectivity and inadequate infrastructure hinder seamless transactions. Consequently, the slow adoption of digital payment systems by small businesses further restricts the economic benefits of digitalization, as these enterprises struggle to transition from cash-based operations to digital platforms. Moreover, there is a dependency on intermediaries for digital transactions, which increases costs and reduces trust among users. These intermediaries often charge fees for facilitating transactions, making digital payments less attractive for both consumers and small businesses.

Slow regulatory responses to emerging digital challenges hinder the program's ability to adapt and evolve in a rapidly changing technological landscape, leaving gaps in legal and operational frameworks necessary for effective digital governance. Limited collaboration between the private and public sectors further exacerbates these issues, as the lack of coordinated efforts and shared goals between these entities stifles innovation and the effective implementation of digital initiatives. Additionally, limited financial incentives for digital adoption discourage businesses and individuals from transitioning to digital platforms, slowing the overall progress of the programme.

Verification challenges often stem from inconsistencies and inaccuracies in digital identity databases, leading to difficulties in authenticating users and accessing services. This undermines trust in digital systems and discourages their use. Additionally, the lack of seamless integration between digital services and existing government schemes hampers the efficiency and effectiveness of digital initiatives. Without cohesive integration, beneficiaries face obstacles in leveraging digital platforms to access various welfare and support programs.

The Digital India Programme faces significant challenges in achieving its goals due to the digital exclusion of elderly and less-educated populations. These groups often lack the necessary digital skills and familiarity with technology, which prevents them from fully participating in and benefiting from digital initiatives. The elderly, in particular, may find it difficult to adapt to new digital tools and platforms, leading to their marginalization in an increasingly digital society. Individuals with lower levels of education may struggle to understand and use digital services, further exacerbating the digital divide.

To address the challenges faced by the Digital India Programme, the Indian government needs to implement a comprehensive and integrated approach that leverages existing capacities while fostering innovation and collaboration. Enhancing network and infrastructure is paramount; thus, investments in expanding reliable internet connectivity and robust digital infrastructure, particularly in rural areas, must be prioritized. This could include initiatives such as deploying satellite internet services and strengthening the power supply to ensure consistent digital connectivity. Simultaneously, expanding digital literacy campaigns is essential to equip rural populations with the skills needed to navigate digital platforms. Tailored training programs, supported by localized and multilingual content, can bridge the knowledge gap and foster greater digital inclusion. To build trust and overcome resistance to digital adoption, the government should enhance cybersecurity measures, provide extensive awareness campaigns about the safety and benefits of digital transactions, and establish customer support networks. Encouragingly, subsidies and financial incentives for purchasing digital devices and internet access can alleviate economic barriers, enabling wider participation in the digital economy. Additionally, fostering public-private partnerships can drive innovation and resource-sharing, expediting the development and deployment of digital solutions tailored to diverse regional needs. Improving the regulatory framework to adapt swiftly to emerging digital challenges will ensure legal and operational coherence, enhancing the program's effectiveness. Furthermore, streamlining digital identity verification processes and integrating digital services with existing government schemes can bolster trust and efficiency in accessing welfare programs. To specifically address the needs of elderly and less-educated populations, targeted outreach and simplified digital interfaces can make digital services more accessible and user-friendly.

4. CONCLUSION

The Digital India Programme faces significant challenges that hinder its effectiveness, particularly in rural areas where network and infrastructure issues disrupt digital payments, education, healthcare, and government services. Limited digital literacy, resistance to adopting new technologies, and cybersecurity concerns further exacerbate these issues, creating a significant digital divide. High costs of digital devices and internet access, insufficient customer support, and verification challenges add to the complexity, preventing

many from fully benefiting from digital initiatives. To address these challenges, a comprehensive and integrated approach is essential. Prioritizing investments in reliable internet connectivity, expanding digital literacy campaigns, enhancing cybersecurity measures, and providing financial incentives can foster greater digital inclusion. Public-private partnerships and improved regulatory frameworks can drive innovation and adaptability, while tailored outreach programs can make digital services more accessible to elderly and less-educated populations. By adopting this holistic strategy, the Indian government can advance the Digital India Programme, ensuring inclusive participation in the digital revolution.

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MARKETING STRATEGIES TO OVERCOME THE CHALLENGES FACING THE PHARMACEUTICAL COMPANIES IN INDIA

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Abstract:

This paper analyses and examines the current situation, recent developments, issues and challenges for Pharmaceutical companies in India from the perspective of marketing management. This paper highlights the current position of pharmaceutical companies in the Global pharma markets in order to understand its implications for current market challenges faced by the pharma industry. The challenges faced by pharmaceutical companies in the Indian market with reference to the Marketing function have been examined in this article. The discussion is focused on the marketing mix for pharmaceutical companies comprising the 4Ps, namely, Product, Price, Place and Promotion. This paper suggests a few effective strategies to overcome the challenges faced by the pharmaceutical industry.

Key terms: Product, challenges, marketing, Price, Place and Promotion.

Introduction:

Indian pharmaceutical industry is the 3rd largest in the world by volume and is USD 40 billion in terms of value. India contributes around 3.5% of total drugs and medicines exported globally. India exports pharmaceuticals to more than 200 countries and territories including highly regulated markets such as the USA, The UK, European Union, Canada etc. The Indian Pharma sector has complete ecosystem for development and manufacture of pharmaceuticals. Its Pharma companies possesses the state of the art facilities including highly skilled/technical manpower. Our

countries also has a large number of renowned pharmaceutical educational and research institutes as well as a robust ecosystem of allied industries.

India is the largest provider of generic drugs globally. Access to affordable HIV treatment from India is one of the greatest success stories in medicine. India is one of the biggest suppliers of low-cost vaccines in the world. Because of low price and high quality, Indian medicines are preferred worldwide, thereby rightly naming the country "the pharmacy of the world". The Pharmaceutical sector currently contributes around 1.72% to the country's GDP.

At present a major constituent of Indian exports are low value generic drugs while a large proportion of the demand for patented drugs is met through imports. This is because the Indian Pharmaceutical sector lacks in high value production along with world class pharma R&D. In order to encourage the global and domestic players to enhance their investment and production in these product categories, a well-designed and suitably targeted intervention is required. This would promote the manufacture of specific high value goods such as biopharmaceuticals, complex generic drugs, patented drugs or drugs nearing patent expiry, cell based or gene therapy drugs.

Further, in order to ensure drug security by, unbridled support to the domestic production capability in APIs/KSMs is needed. This would enhance the resilience of the Indian pharmaceutical industry to external shocks. These initiatives improve our ability to achieve the ultimate to objective of affordable healthcare in the country and the target of Health for all by 2030.

History of Pharmaceutical companies in India

Bengal Chemicals and Pharmaceutical Works is the first pharmaceutical company in India. Today, it is one of the five government-owned drug manufacturers that was incorporated on 12th April, 1901. For the next 60 years, most of the drugs in India were imported by multinationals either in fully-formulated or bulk-drug form. The government has actively encouraged the growth of drug manufacturing by Indian companies in the early 1960s, and with the Patents Act in 1970, the Indian an pharma industry emerged stronger. The patent act 1970 deleted the from food and drugs. However, retained the process patents, whose duration was shortened to a period of five to seven years. The absence of patent protection made the Indian market unattractive to the

multinational companies who had dominated the Indian market. As a result, the Indian companies gradually replaced the MNCs. The Indian companies carved a niche in both the Indian and world markets with their expertise in reverse-engineering, in innovative process design for manufacturing drugs at low costs. Although some of the larger companies have taken baby steps towards drug innovation, the industry as a whole has been following this business model until the present.

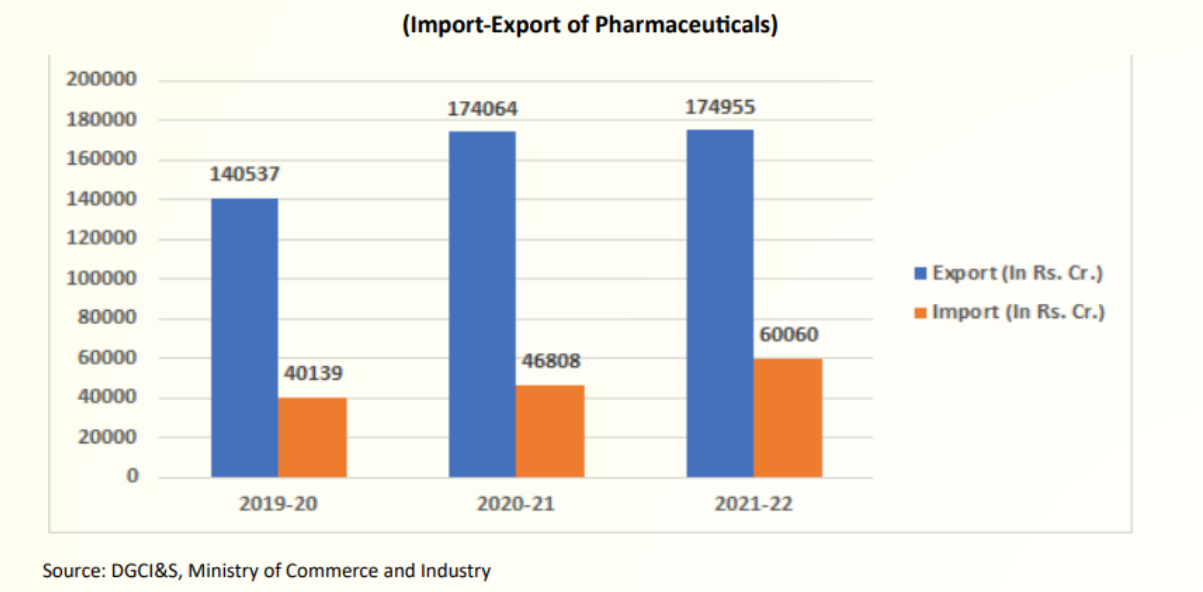
India's pharmaceutical sector is well-known for producing affordable vaccines and generic medications at a third-place global volume in pharmaceutical manufacture. In 2020–21, the industry made up around 1.32% of the Indian economy's gross value added (calculated using constant prices from 2011–2012). For the fiscal year 2021–2022, Pharmaceuticals had a total yearly sale of Rs. 3,44,125 crore (USD 42.34 billion). Generic medications, over-the-counter medications, bulk medications, vaccines, contract research and production, biosimilars, and biologics are some of the main sectors of the Indian pharmaceutical industry. When it comes to the provision of DPT, BCG, and measles vaccinations, India leads the world. About 8% of the worldwide API industry is contributed by 500 API firms. The main source of generic medications is India. It produces over 60,000 distinct generic brands in 60 therapeutic areas, making approximately 20% of the world's generic drug supply. One of the biggest medical achievements is the availability of reasonably priced HIV therapy from India. Indian pharmaceuticals are favored globally due to their affordable prices and superior quality, earning them the title of "pharmacy of the world." The industry has been expanding at a robust pace.

Table shows the sector's yearly turnover trend over the last five years.

Financial Year	Turnover (Rs. in Crore)	Growth Rate
2017-2018	2,26,423	3.03
2018-2019	2,58,534	14.18
2019-2020	2,89,998	12.17
2020-2021	3,28,054	13.12
2021-2022	3,44,125	4.89

Source: Pharmatrac/NPPA/DGCIS, Kolkata

The Indian pharmaceutical business is a major worldwide player, providing millions of people with low-cost, accessible generic medications. The industry provides lower costs without sacrificing quality, as evidenced by the fact that India is home to the greatest number of pharmaceutical facilities outside of the United States that have received approval from the US Food and Drug Administration (USFDA). Additionally, a sizable number of these facilities comply with Good Manufacturing Practices (GMP) regulations set forth by the World Health Organization (WHO) and have also received approval from foreign regulatory bodies. As can be observed from Graph 1A, India's pharmaceutical industry contributes significantly to the nation's international trade and has been steadily producing trade surplus. Pharmaceutical exports totalled Rs. 1,74,955 crore (USD 23.5 billion) in 2021–22, while pharmaceutical imports totalled Rs. 60,060 crore (USD 8.06 billion). As a consequence, there was a trade surplus of Rs. 1,14,895 crore (USD 15.44 billion).



Source: DGCI&S, Ministry of Commerce and Industry

Future growth prospects of Indian Pharmaceuticals:

The pharmaceutical sector has seen significant changes in recent years, putting new demands on payers, providers, and manufacturers. Customers today expect the same variety and convenience from the pharmaceutical sector as they do from other industries. Pharmaceutical marketing aids in raising knowledge of treatments for chronic diseases, which are the major cause

of health-care costs. India is also anticipated to become a pharmaceutical R&D hub in the coming decade, with the Department of Pharmaceuticals preparing a road map for India to become a worldwide player in the industry by 2030.

The Indian Pharmaceutical industry is predictable to grow up to USD 130 billion in value by the end of 20301. In FY22 India had exported pharmaceutical products worth USD 24.62 billion and it has been expected that Indian pharmaceutical exports will reach USD 27 billion in FY 2023. India also has the largest number of manufacturing sites approved by the United States Food and Drug Administration (US FDA) outside of the United States.

Some of the recent developments/investments in the Indian pharmaceutical sector are as follows:

1. In December 2020, Piramal Pharma Solutions announced plans to invest Rs. 235 crore (US$ 32 million) to expand its facility in Michigan, US, with additional capacity and new capabilities for development and manufacturing of active pharmaceutical ingredients (APIs).
2. In November 2020, Indian Immunologicals (IIL) commenced work on Rs. 75 crore (US$ 10.17 million) viral antigen manufacturing facility in Genome Valley, Telangana, that will enhance its vaccine production capacity by 35% by October 2021.
3. In November 2020, the Indian Institute of Technology (IIT) Bombay has stepped up research and development (R&D) amid COVID-19 and researchers are developing products such as a portable sterilization device and germicidal cabinet; wheeled sterilization unit, especially for hospitals; portable and rechargeable car sanitizer; eco-friendly sprays, and alcohol-free and bleach-free sanitizers.
4. In October 2020, six generic drug makers--Dr. Reddy's Laboratories, Zydus Cadila, Glen mark Pharmaceuticals, Torrent Pharmaceuticals, Hetero Drugs and Ackerman Pharma signed a deal with Hidalgo ,a state in Mexico, to establish a large pharmaceutical cluster for production and logistics in Mexico.
5. In October 2020, Aurobindo Pharma acquired MViyeS Pharma Ventures for Rs. 274.22 crore (US$ 37.30 million).

6. In May 2020, Jubilant Generics Ltd entered into a non-exclusive licencing agreement with US-based Gilead Sciences Inc to manufacture and sell the potential COVID-19 drug Remdesivir in 127 countries, including India.
7. Affordable medicines under Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP) achieved record sales turnover of Rs 52 crore (US$ 7.38 million) in the month of April 2020.
8. During December 2019, on moving annual total (MAT) basis, industry growth was at 9.8%, with price growth at 5.3%, new product growth at 2.7%, while volume growth at 2% y-o-y.
9. In October 2019, Telangana Government proposed Hyderabad Pharma City with financial assistance from the Central government of Rs 3,418 crore (US$ 489 million).

Review of Literature:

Saurabh Kumar Saxena[9], (2008), came out with a paper titled as "A Review Of Marketing Strategies Work By Different Pharmaceutical Companies" Provides valuable insights into the supply chain processes and end customer perceptions that determine the formulation of marketing strategies.

Eric Langer, Abhijeet Kelkar (2008), in their paper entitled "Pharmaceutical Distribution in India. Biopharma International", insights the challenges faced by Indian Pharm companies in ensuring the delivery of uncompromised quality in the multilayered distributed system.

P.Parveen, P.Usha, V.Vasu naik, Rajesh Akki (2013), in their paper entitled "Pharmaceutical Distribution in India" this presents the marketing strategies of a pharma company that shifts from Acute-base to chronic therapy base. This study focus on the processes and outcomes of globally distributed pharma companies as well as the drug pricing control order. The DPCO has been a mill stone around the neck of the Indian industry as its severely restricted pharmaceutical companies.

Dr. Pramod Kumar, Dr. Pramod Kumar (2013)," Marketing Mix of Pharmaceutical Industry in India: An Exploration", this paper explores the marketing mix of pharmaceutical

industry in India**.** It provides a crical evaluation of policies and strategies of the pharma companies in the light of the complex interplay of the 4Ps or marketing mix of the pharma companies.

Anil Kalotra (2014), in the paper entitled "Marketing Strategies Of Different Pharmaceutical Companies", has focused on the three stakeholders in the pharma sector that are fundamental to the success of the marketing strategies. The success the marketing strategies in the competitive context is derived from either a cost advantage or a value advantage or ideally from a combination of both. That flows from a synergistic balance amongst the three stakeholders (the firm, its competitors and its customers)

Manvi Aayush Sood (2019), in their paper entitled "Evolution of Indian Pharmaceutical Industry-Overview" The Indian Pharmaceutical Industry has witnessed several fluctuations in its fortunes over the last three to four decades. It is one of the most efficient industry in India it provides employment and health care to the nation. This paper mainly concentrates on the evolution of the industry, its growth and recent trends.

Issues and Challenges faced pharmaceutical companies in India

Several Indian pharmaceutical companies have successfully deployed many standard strategies with a view to target the various customer types. However, the emerging business and customer trends throw up many challenges and opportunities that may improve the profitability. In the pharmaceutical and healthcare industries, a complex web of decision-makers determines the nature of the transaction (prescription) for which direct customer (doctor) of pharmaceutical industry is responsible. However, as the end-user (patient) consumes the product, he/she pays the cost. The appointment of medical representatives for marketing the products to physicians and to convenience the others in the hierarchy of decision makers has been a time-tested tradition.

The industry is still faced with some very serious strategic and operational level issues:

1. Real-time good manufacturing practices and research components are severely lacking in the Indian pharmaceutical business. This has consistently been the main challenge facing the Indian pharmaceutical business. The Pharma businesses should ideally be set up so that they have superior operational capabilities and infrastructure.

2. Indian pharmaceutical businesses are not making enough money since their revenues are essentially much lower than those of their competitors in other nations, like the US. The Indian pharmaceutical sector is thus unable to support its research initiatives.
3. The pharma industry is dependent on China for the supply of raw material for generic medicines production of Active Pharmaceutical Ingredients (API).
4. India needs user friendly government policy for the common man to establish small scale, raw material manufacturing units/ incubators in all states of the country to improve availability of raw materials to manufacture generic drugs at affordable rates.
5. The government and industry should facilitate the pharmacist community to become entrepreneurs and promote incubators' establishment.
6. Raw material produced from small scale units should be properly validated in the testing laboratory of the state to ascertain their quality specifications.
7. There is a need for a functional testing laboratory in every state to hasten the work of raw materials specification.
8. Small scale produces may be re-processed in another industry or via a chain of industry for quality products that can be used for parenteral/tailor-made formulations.
9. Skilled manpower from academic institutions can be achieved through continuing education programmes.

Marketing Mix Strategy for pharmaceutical companies in India

The classical marketing mix consists of four different Ps; product, price, place and promotion (McCarthy 1960). Conceptually, this mix may be adapted and relevant to a most product segments. However, experts are skeptical about its utility and relevance in the case of for marketing of services. Some experts also argue that marketing approach in such cases should not be imitated from Kotlerian Marketing.

In order to outline efficient marketing of services the 7Ps approach were introduced - adding people, physical evidence and process to the traditional mix.

Marketing is an essential function in any business upon which the survival of the business entity is dependent. "There can be no effective corporate strategy that is not marketing oriented, that does not in the end follow this unyielding prescription: The purpose of business is to create

and keep customer" (Theodore Levitt 1960). However, Levitt should also add that businesses must also develop products and services that customers want and at prices they are willing to pay. Marketing may be broadly conceived as the process of making decisions about what products or services to put on the market, who are the potential customers for these goods, how to reach the target markets and induce them to buy; how to price the product or service optionally so as to be make is attractive to the customers; and finally how to provide the goods physically to the ultimate customers. These matters are often expressed as the four Ps of marketing: Product, Price, Promotion and Place.

The four Ps of Pharmaceutical marketing are discussed below.

Product:

Product is an item that is created in an organization to fulfill the demand of the consumers. It can be intangible or tangible – i.e. service or goods.

The Product related decisions encompass the following aspects such as Brand name, Functionality, Product styling, Quality, Safety, Packaging and After-sales service.

The Product related decision fringes on what your customer wants from you. The Product parameters many changes according to its phase of the Product Life Cycle. For instance, during the introduction phase, the company may launch limited versions of the product just to explore adaptability to the customer needs. Similarly, the number of service centers for after-sales service as well as their location may be determined by the geographical spread of its customers**.**

The following are some of the challenges faced by the Pharma sector with respect to 'Product':

The recent COVID-19 Pandemic has highlighted the short comings of the pharma sector in providing the necessary quantities of drugs and other protective items including sanitizers to meet the unexpected surge in the international demand for drugs and accessories to tackle the Pandemic.

1. Demand forecasting and Market Potential
2. Risk management
3. Social Challenges
4. Legal and Regulatory Challenges
5. Distribution Challenges
6. Identifying Customer Pain Points

Price:

Price of the product is the amount that the customer is willing to pay for it. The 'Price' element of the marketing mix is vital for ensuring the economic viability of the Product.

The Major decision elements of 'Price' are pricing strategy (model), retail price, wholesale price, discounts offered, seasonal pricing, bundling pricing, price flexibility and price discrimination.

The decision of price depends on Product Life Cycle. A product during its journey from the Introduction stage to the Decline stage has to modify its Pricing strategies according to the changing market situation.

It gives an advantage to the company as the early adopters buy the product at the very initial stage even at a higher price.

India is recognized lowest priced drug manufacturer and marketer of pharmaceuticals products domestically and internationally. One reason for lower value share is the lower cost of drugs in India ranging from 5% to 50% less as compared to most other countries.

The Pricing Policies of the Indian Pharma sector have to overcome the following challenges. They are:

1. High 'Out of Pocket (OoP) expenditure
2. Pricing of patented drugs
3. Non-Standard drugs

4. Public and government pressure to make drug prices more affordable
5. Inadequate health insurance schemes is an impediment to high-priced drugs.
6. Higher healthcare cost forces the Pharma sector to focus on cost minimization.
7. Unknown value of revenue from each retailer in the territory.

Place:

This P is all about placement and distribution of the product in the market. The place also suggests the Point of Sale of the product. A business has to make sure that the availability of the product should be easy for the customers.

The 'Place' factor comprises of several decision elements such as (i) Distribution channels, (ii) Market coverage, (iii) Inventory, (iv) Warehousing, (v) Order processing and (vi) Transportation.

Market coverage can be intensive, selective or exclusive. For example cigarettes have intensive coverage, while Smartphones selling involves selective coverage in a city. In contrast, luxury products like Mercedes Benz have exclusive coverage.

The decision concerning the 'Place' is determined by the stage in the PLC (Product Life Cycle).

The following are some of the challenges faced by the Pharma sector with respect to 'Place':

1. Storage and Transportation of Temperature sensitive drugs.
2. The availability of adequate transportation facilities could pose a challenge in the delivery of drugs to remotely located destinations.
3. As the decision of the customer (the Patient) to use a particular drug is dependent on the Prescription of the Doctor. Hence, the success of the Distribution channel is dependent on the ability of the Drug manufacture to convince the professional Doctor who is mainly responsible for prescribing the drug. As a result, the Pharma sector faces a stiff competition with respect to cringing the Doctors recommendation for the drug.

4. Absence of transportation on the amount of time invested on profitable and not-so profitable customers and lack of time-share planning towards developing customer base for future and un-tapped markets.
5. Unavailability of go down on storage of cold medicines.

Promotion:

Promotion is comprised of elements like advertising, sales promotion, personal selling, public relation, publicity, etc.

The various phases of PLC give the different meaning of promotion. The advertising activity is extensive at the introduction stage and comes to selective channels in the maturity stage.

Sales promotion also varies at different stages. The budget of the overall advertising also gets affected. At the decline stage, a business dedicates almost nil budget for advertising. It becomes very crucial to work with the advertising or marketing agency that understands the connection of stages of PLC and Promotion.

The following are some of the major challenges faced by the Pharm sector vis-à-vis 'Promotion':

1. Increased competition and unethical practices adopted by some of the propaganda base companies.
2. Low level of customer knowledge (Doctors, Retailers, Wholesalers).
3. Poor customer (both external & internal) acquisition, development and retention strategies.
4. Varying customer perception.
5. The number and the quality of medical representatives
6. High training and re-training costs of sales personnel.
7. Busy doctors giving less time for sales calls.
8. Poor territory knowledge in terms of business value at medical representative level.
9. Unclear value of prescription from each doctor in the list of each sales person.

10. Absence of ideal mechanism of sales forecasting from field sales level, leading to huge deviations

Conclusion:

The Indian pharmaceutical industry has recognized a strong presence in the international generics market by distributing high-quality drugs at measure. The industry has made innovations in processes and formulations and developed itself as are liable, high quality and cost-effective global drug supplier. Currently the industry is worth over USD 38 billion and can hope to grow to USD 120 to 130 billion by 2030 by exploiting on the wonderful opportunities that lie ahead. However the Indian pharma companies can achieve the aspiration of eleven to twelve percent CAGR.

Marketing may be broadly conceived as the process of making decisions about what products or services to put on the market, who are the potential customers for these goods, how to reach the target markets and induce them to buy; how to price the product or service optionally so as to be make is attractive to the customers; and finally how to deliver the goods physically to the ultimate customers. The Indian pharmaceutical companies facing challenges related to the four Ps of marketing: Product, Price, Promotion and Place.

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Research Article

Marketing Challenges And Organizational Performance: An Empirical Investigation With Special To Pharmaceutical Organizations In India

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ABSTRACT

Marketing challenges is a crucial strategic driver for increasing operational performance and maximizing the achievement of organizational objectives, such as improved productivity, improved customer service and enhanced profitability. The age of both market globalization and outsourcing has started, and many companies tend to manage their marketing challenges activities. Most of these organizations understand that marketing challenges needs to be tested for its performance in order to create an effective and efficient marketing. The marketing challenges is the most critical element for companies to boom in pharmaceutical, which needs to be quick, uninterrupted and safe. The competition is fierce because not one or two, but hundreds of pharmaceutical companies are competing for market share, each finding and creating specific strategies for sale and distribution. The present study is an attempt to examine various marketing challenges in the pharmaceutical context. Although there is a lack of literature in this context, the current study critically reviewed the current literature and built a questionnaire with the inputs from leading pharm marketing representatives by identifying the main marketing challenges such as product, price, place, promotion and trying to find the effect of these variables on organizational efficiency. A sample size of 100 employees employed in pharmaceutical departments at different levels of ten leading pharmaceutical organizations in India was taken for a questionnaire survey as a sampling unit. The study found fascinating insights of marketing challenges in pharma, which eventually benefit the marketers to design more effective marketing challenges. Further, the study is confined to Ten Pharma organisations in India which becomes a limitation in generalizing the findings.

Key Words: Marketing Challenges, Operational Performance, Pharmaceutical Organizations

I. INTRODUCTION:

The pharmaceutical sector generates around 2.8 trillion dollars in revenue globally, making it the largest industry in the world. Recent years have witnessed significant changes in the pharmacy sector, putting new demands on payers, providers, and manufacturers. Consumers now expect the pharmaceutical business to provide them with the same options and conveniences as other market segments. The Indian pharmaceutical sector is expected to grow rapidly and steadily over the coming years due to a variety of factors.

The pharmaceutical industry in India stands at the crossroads of opportunity and challenge. With a robust domestic market fueled by a burgeoning population and increasing healthcare awareness, coupled with a strong presence in the global pharmaceutical arena, Indian pharmaceutical companies have made significant strides. However, amidst these achievements lie formidable marketing challenges that require meticulous navigation and strategic acumen to surmount.

At the heart of these challenges lies the regulatory landscape. India's pharmaceutical sector is subject to rigorous regulatory oversight, spanning drug approvals, pricing regulations, and stringent advertising

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guidelines. Navigating this intricate web of regulations demands not only compliance but also agility to adapt to evolving regulatory frameworks. Moreover, with recent regulatory reforms aimed at enhancing drug safety and efficacy, pharmaceutical companies face heightened scrutiny, necessitating robust compliance mechanisms and risk mitigation strategies.

Beyond regulatory hurdles, understanding the dynamics of consumer behavior and healthcare preferences is imperative. India's healthcare landscape is undergoing a paradigm shift, driven by factors such as increasing urbanization, rising disposable incomes, and a growing emphasis on preventive healthcare. Consequently, consumers are becoming more discerning, seeking value-driven healthcare solutions and placing greater emphasis on factors such as brand reputation, efficacy, and affordability. Pharmaceutical marketers must therefore unravel the complexities of consumer behavior, leveraging insights to tailor marketing strategies that resonate with target audiences and drive brand loyalty.

Amidst these shifts, competitive pressures further compound the challenges faced by pharmaceutical companies. The Indian pharmaceutical market is fiercely competitive, characterized by a myriad of domestic players vying for market share alongside multinational giants. Price competitiveness, product differentiation, and market segmentation emerge as pivotal battlegrounds, necessitating continuous innovation and strategic positioning to stay ahead of rivals. Moreover, with the emergence of disruptive technologies and digital platforms, the landscape of competition is evolving rapidly, requiring pharmaceutical marketers to embrace digital transformation and harness data-driven insights to gain a competitive edge.

II. LITERATURE REVIEW:

Giuseppe Festa, Ashutosh Kolte, Maria Rosaria Carli, Matteo Rossi (2022), in their study focussed on annual growth in pharmaceutical, medicinal chemical, and botanical production for healthcare purposes. The country sells generic medications on a big scale, having significant impact in American and European markets. Although the industry's infrastructure and R&D skills have grown, difficulties such as pricing regulation, sector fragmentation, and intellectual property continue to exist. Patents are a major topic of contention in the national industry. Despite India's large population and low per capita income, stronger patent regulations may result in reduced access to medicine for a considerable portion of the population. Affordability of drugs poses a serious challenge in India and South Asia, potentially affecting life and death. The study found a strong economic, business, and commercial outlook for the Indian pharmaceutical industry, notwithstanding certain worries. The sector's main problem is to strike a balance between commercial aspirations for innovative growth and social needs for affordable healthcare.

Abinav Sharma (2020) made an attempt, to study the creation, communication, and provision of value to the target market by healthcare professionals is greatly aided by healthcare marketing. Rather than starting with goods or services, modern marketers start with the customer. Establishing a long-lasting connection holds greater significance than completing a single transaction. Creating a high degree of customer satisfaction should be the goal of a healthcare service provider in order to encourage repeat business from satisfied clients. According to the report, hospitals face a number of difficulties when trying to sell their services, but there are also opportunities in the market that healthcare organizations can take advantage of. With a carefully thought-out marketing strategy, hospitals can maintain their competitive edge and build a long-lasting relationship with patients by providing top-notch care and building a solid reputation.

Priyanka Singh (2013) examined a particular facet of rural marketing that these markets have not been utilized in any way. Its sole objective is to draw attention to the rural markets' increasing significance in the rapidly shifting economic landscape. Due to the wide range of courses that must be taken in rural marketing, particular consideration must be given to the product, its quality, packaging, brand, price, advertisement, personal selling, and distribution channel. The rural marketing strategy must be suitable, fully understanding the dispersed nature of rural consumers and the requirement for a distinct communication mix due to the lower educational attainment and environmental variations. All of this necessitates coordinated and coordinated action from the sector and the government. Even while producers may experience early losses due to high promotion and distribution costs, they shouldn't let this stop them from entering the market because the potential in the rural area is enormous. The country's shifting economic landscape combined with the rural population's increased purchasing power means that the recently established rural markets will undoubtedly pay off handsomely.
Luv Saini and P.K. Agarwal (2023) in their study highlighted a pharmaceutical business would be a smart decision because the industry is growing and has a bright future. The process involves several steps, which present the entrepreneur with a variety of challenges. Materials and information must come from trustworthy and credible sources. This study focuses on the various challenges that come with starting a pharmaceutical business in India. The study is qualitatively descriptive and makes use of secondary data. The results show that registration and licensing, resource requirements, financial concerns, business plan formation, raw material availability, skilled labor, and workforce optimization are the primary barriers to starting a pharmaceutical company in India.

Kalyani Rajput and Dr. Rajesh Kumar Pandey (2022) examined product marketing is a standard practice recognized by the worldwide business community as being essential to organizations seeking to achieve their targeted outcomes. The pharmaceutical industry is one of the most important and widespread industries. Its scope is broad, encompassing anything from over-the-counter (OTC) goods to life-saving medications to medical equipment. So much so that pharmaceutical education is given its own area in medical education as a whole, and the foundation for the production of pharmaceutical products is laid by these excellent educational opportunities. It takes a certain set of abilities to get these medications on the market, which is why pharmaceutical marketing is involved. Pharma marketing is more essential than general product marketing because it falls into the category of necessities and useful goods rather than desired goods, as most people don't plan to purchase medications or medical equipment unless they are prescribed or advised by a healthcare professional. This element presents a significant obstacle for the pharmaceutical marketing industry.

III. METHODOLOGY:

This research study aims to assess the association among important marketing challenges components empirically, namely Product challenges, Price challenges, Place challenges, Promotion challenges and how these critical components influence effective performance, which impacts the organizational performance. The present study framed the following objective of the study to enhance the limited literature available on Marketing challenges in the Pharma context: To study the relationship between marketing effectiveness and organizational Performance in Pharmaceutical organizations in India.

The following Hypotheses were framed for the present study
Ha01: There is a significant relationship between Marketing (4P's) challenges and Organizational Performance.
Ha02: There is a significant relationship between Marketing Effectiveness and Organizational Performance.
Data was collected from both Primary and secondary sources. The primary data was collected by administering a structured questionnaire from the employees working in the selected Pharmaceutical organizational in marketing domain. The secondary data was collected from research articles, journals, company records, and manuals. Measures for the research constructs used in the present study were developed by seeking the help from real time professionals who are working in the Pharma organizations with a framework borrowed and adapted by compiling various standard studies from prior literature. Most of the items were measured using a 5-point Likert scale ranging from "very poor" to "excellent". The antecedents in our research model comprise four constructs. "Product Performance of Marketing challenges" was assessed using six items; "Price Performance of Marketing challenges" was assessed using Five items. Nine items used to capture "Place Performance". "Promotion Performance" was assessed using eight items. Finally, "Marketing Effectiveness Performance" and "Organizational Performance" were assessed by using twelve and eight items respectively. A pilot study with a sample size of 50 responses was conducted before arriving at the final questionnaire. Reliability analysis ***(Cronbach's alpha)*** was applied to check the reliability of items used in initial questionnaire which showed that *Cronbach Alpha ranges from 0.7 to 0.9*(which is quite reliable). Based on reliability analysis and feedback from the Marketing representatives working in Pharma organizations, the final questionnaire was prepared.
The population universe consists of the employees working in India's marketing management wing of the pharmaceutical organization. The present study has limited the scope by restricting the universe as a pharmaceutical organization that only deals with marketing mix challenges. A total of 100 questionnaires were distributed and collected from the employees working in marketing management in pharmaceutical organizations in India.

IV. ANALYSIS

The profile of the respondents includes age, gender, designation, and work experience. The distribution of respondents based on their characteristics is shown in table 1. Analytical aspects of these characteristics are worth noting.

Tabel: 1 Profile of the Respondents

Variables	Categories	Frequency	Per cent
Age of the Respondent	Less than 25 years	24	24.0
	25 – 35 years	56	56.0
	Above 35 years	20	20.0
	Total	100	100.0
Education	Certificate Level	23	23.0
	Diploma Level	7	4.0
	Degree	28	28.0
	Masters	42	42.0
	Total	100	100.0
Qualification	Related to Job	58	58.0

	Unrelated to Job	42	42.0
	Total	100	100.0
Place of Work	City	28	28.0
	Town	38	38.0
	Both	34	34.0
	Total	100	100.0
Experience as Medical Representative	0 – 2 years	25	25.0
	2 – 5 years	44	44.0
	> 5 years	31	31.0
	Total	100	100.0

The final sample (N=100) was respondents are in the age group less than 25 is 24(24%), age group of '25 – 35 years is 56 (56%), 20 respondents are in the age group of 'above 20 years' (20%), Designation wise, the majority of the respondents are at 'Team lead level' (N=56). Twenty respondents are at 'Executive level', and 24 respondents are managers. Similarly, majority of the respondents have experienced are 2-5 five years. 25 respondents have experienced '0-2 years', 31 respondents have experience of 'above 5 years' in the marketing department. As the present study is based on the employees' perception towards marketing challenges practices, having more respondents from team lead level and good experience in marketing departments will make the data collected more authenticate in this survey. Table 2 is designed to exhibit the mean distribution of marketing effectiveness and marketing variables along with organizational performance scale. From the table, it can be noted that the highest mean was observed to the scale 'Product challenges' (M=3.68) and 'Organizational Performance' (M=3.65), whereas low mean was observed to the scales 'Pricing Challenges' (M=3.61) and 'Marketing effectiveness'(M=3.63).

Table:2 MARKETING CHALLENGES AND ORGANIZATIONAL PERFORMANCE

S. No	**Variable**	**Mean**	**S.D.**
1	Product Challenges	3.68	0.676
2	Pricing Challenges	3.61	0.564
3	Place Challenges	3.64	0.689
4	Promotion Challenges	3.67	0.560
5	Marketing Effectiveness	3.63	0.647
6	Organizational Performance	3.65	0.624

The present paper attempts to examine the relationship between marketing effectiveness and organizational performance with two hypotheses. The following deals with hypotheses testing by applying suitable statistical tools. Ha1: There is no significant relationship between selected variables on marketing challenges and Organizational Performance H01: There is a significant relationship between selected variables on marketing challenges and Organizational Performance. The hypothesis is framed to test the statistically significant relationship between marketing effectiveness and organizational performance. To test this hypothesis, linear regression is employed by considering organizational performance as dependent variables and variable of the marketing challenges such as Product challenges, Price challenges, Place (Distribution) challenges, and Plance challenges as independent variables. Table 3a portrays the regression test results, giving that marketing effectiveness variables can explain 71.1% of organizational performance.

Ha01: There is a significant relationship between Marketing (4P's) challenges and Organizational Performance.

Table: 3a **Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.843[a]	**.711**	.699	.35513

Table: 3b **ANOVA[a]**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	29.455	4	7.364	58.387	**0.000[b]**
	Residual	11.981	95	0.126		
	Total	41.436	99			

Table: 3c **Coefficients[a]**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.196	0.266		0-.738	.463
	Product Challenges	0.406	0.079	0.424	5.170	**0.000**
	Pricing Challenges	0.520	0.078	0.453	6.705	**0.000**
	Distribution Challenges	0.095	0.079	0.101	1.202	0.232
	Promotion Challenges	0.030	0.119	0.026	0.248	0.804

From table 3b, it can be inferred from the ANOVA test result that the overall model is significant. Table 3c shows that all the marketing challenges variables significantly influence organizational performance except two variables: product challenges and price challenges. Thus, the null hypothesis (H01) is rejected from the regression analysis test results, and the alternate hypothesis (Ha1) is accepted. H02: There is no significant relationship between marketing effectiveness and Organizational Performance Ha1: There is a significant relationship between Marketing Effectiveness and Organizational Performance. This hypothesis is framed to examine the relationship between marketing challenges and organizational performance. The earlier hypothesis has considered the variables of marketing challenges as independent variables. In this hypothesis, the marketing challenges is regarded as an independent variable and organizational performance as a dependent variable. Linear regression is applied to examine the relationship between the two selected variables. Table 4a shows that 64.1% of organizational performance can be explained by Marketing Effectiveness, which found to be consistent with the previous finding of the present study.

Ha02: There is a significant relationship between Marketing Effectiveness and Organizational Performance.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.783[a]	**0.614**	0.610	.38980

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.637	1	23.637	155.564	**0.000[b]**
	Residual	14.890	98	0.152		
	Total	38.527	99			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.913	0.223		4.089	**0.000**
	MARKETING EFFECTIVENESS	0.755	0.061	0.783	12.473	**0.000**

Table 4b and 4c have given a p-value less than 0.05, which means that there is a statistically significant relationship between marketing effectiveness and organizational performance. Hence, the null hypothesis (H02) is rejected, and an alternative hypothesis (Ha2) is accepted

V. LIMITATIONS

- Any study based on a survey through a predesigned questionnaire suffers from the basic limitation.
- The study is confined to Ten Pharma organisations in India which becomes a limitation in generalizing the facts.
- Non-Probabilistic Sample used in for the survey stands as another limitation of the present study.

VI. CONCLUSION

The study found that organizational performance can be attained by effective marketing management. Marketing challenges can be effective only if designed to meet the various product, price, place and promotion. The study found that product and price are the key issues that significantly impact organizational purpose. The researcher found that the place and promotion are the key issues to address while studying marketing challenges, especially in the pharmaceutical market.

As the study selected marketing segment, product and stock-out situations are unavoidable. But still, efforts should be made to reduce the occurrence of these situations in the future. There are many issues to focus on detail like the product design, accessibility, return policy etc. Hence, further study is recommended to the researchers who shown interest in marketing management.

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IMPACT OF EMPLOYEE RETENTION STRATEGIES ON JOB SATISFACTION OF IT PROFESSIONALS

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ABSTRACT

In the contemporary and dynamic landscape of business, the retention of skilled and experienced software professionals is a critical challenge faced by organizations. High turnover within the software industry not only results in substantial costs but also leads to a loss of productivity and knowledge. To address this challenge, organizations must adopt effective strategies to attract and retain talented software professionals. This research study aims to assess the various employee retention strategies implemented by organizations within the software industry. The study will delve into factors influencing employee retention and evaluate the effectiveness of diverse strategies employed to retain software professionals. Specifically, the research will investigate the impact of organizational culture, work-life balance initiatives, career development opportunities, compensation packages, and employee engagement practices on employee retention. Through a comprehensive analysis, the study seeks to contribute valuable insights that can inform organizations in developing and enhancing their strategies to retain skilled software professionals in the competitive business environment.

Keywords: Employee retention, Productivity, Organizational strategies, Compensation packages, Employee engagement, Human resources.

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1. INTRODUCTION

In the contemporary global business arena, the retention of top-tier talent has emerged as a critical concern for organizations, particularly within the fiercely competitive software industry. With India solidifying its position as a major hub for software development and technology services, companies in this sector face unique challenges in retaining skilled professionals amidst high demand and intense competition [1]. Effective employee retention is pivotal for organizational success, contributing to stability, enhanced productivity, and reduced recruitment and training costs. This study seeks to explore the diverse strategies employed by software companies in India to retain their professionals and evaluate the effectiveness of these strategies in fostering long-term commitment. Given the high demand and competition for skilled professionals in the software industry, organizations deploy a variety of retention strategies to maintain a stable workforce, minimize turnover costs, and cultivate a positive work environment conducive to employee satisfaction and loyalty [2][3]. This paper examines several commonly implemented employee retention strategies in the Indian software industry. It includes many factors such as Competitive Compensation Packages, Career Development Opportunities, Work-Life Balance Initiatives, Recognition and Rewards, Employee Engagement Programs, Transparent Communication, Employee Well-being Initiatives and Strong Leadership and Management [4]. Generally, to attract and retain top talent, companies strive to offer competitive salaries and benefits that align with industry standards, reflecting the value of employees' skills and expertise. Recognizing the motivation driven by growth, organizations invest in employee development, providing clear career paths through training programs, mentorship initiatives, and challenging project opportunities. Acknowledging the importance of balancing work and personal life, software companies often implement flexible schedules, remote work options, and paid time off policies to support work-life integration, reducing burnout and increasing employee loyalty. Fostering a positive work culture involves acknowledging and appreciating contributions through rewards, bonuses, and public appreciation programs, boosting morale and creating a sense of loyalty among employees. Recognizing the link between engagement and retention, software firms implement team-building activities, social events, and employee resource groups to create a supportive work environment that fosters a sense of belonging and camaraderie [5][6]. Open and transparent communication channels build trust and loyalty. Ensuring access to organizational information, regular feedback sessions, and performance reviews provide opportunities for employees to voice concerns and receive constructive feedback. Prioritizing employee well-being involves offering wellness programs, mental health support, and access to fitness facilities, demonstrating a genuine concern for employees' health and building trust and loyalty. Effective leadership and management practices significantly influence retention. Investments in training managers to be supportive, empathetic, and skilled in employee development foster positive relationships, reducing turnover [7]. By examining these strategies, this research paper aims to contribute valuable insights for organizations seeking to enhance their employee retention approaches in the dynamic and competitive landscape of the Indian software industry. The key factors that helps to assess the strategies implemented by Indian software industries for investigating the employee retention strategies in the Indian software industry and the benefits of the employee retention is shown in the following fig.1.



Fig 1: Employee retention in IT industry

II. LITERATURE REVIEW

Employee retention strategies play a crucial role in the contemporary business landscape, particularly within the Information Technology (IT) sector, where attracting and retaining skilled professionals is paramount. This literature review seeks to explore and synthesize existing research on the impact of employee retention strategies on the job satisfaction of IT professionals. Understanding the intricate relationship between retention strategies and job satisfaction is essential for organizations striving to create a positive work environment and retain their valuable IT workforce. Through investigation on the research papers available in the literature reveals the following observations and conclusions.

Rahman, M., Islam, M. A. presented a paper on "Effective Strategies for Employee Retention in the IT Industry"[8]. The presented research work explores, in the ever-evolving landscape of the Information Technology (IT) industry, the retention of skilled professionals stands as a critical imperative for organizational success. This literature review examines several key studies that delve into effective strategies for employee retention within the IT sector. The insights provided by these studies contribute to a comprehensive understanding of the multifaceted approaches organizations employ to reduce turnover, enhance employee satisfaction, and elevate overall organizational performance

Madhavan, A., & Mahadevan, N, presented a paper on “The Impact of Compensation and Benefits on Employee Retention in the IT Sector"[9]. Their research scrutinizes the intricate relationship between compensation and benefits and employee retention within the IT sector. The study underscores the pivotal role of competitive salaries, incentives, and comprehensive benefits packages in attracting and retaining IT professionals. Additionally, it explores the significance of non-monetary rewards, such as flexible work arrangements and career growth opportunities, in bolstering employee retention.

Mehta, P presented a paper on "Employee Retention Strategies and Organizational Performance: A Comprehensive Review with Special Reference to IT Industry"[10]. Mehta's comprehensive review delves into the nexus between employee retention strategies and organizational performance, with a specific focus on the IT industry. The study explores strategies encompassing career development, work-life balance, employee recognition, and leadership development. It provides valuable insights into the positive impact of these strategies on employee commitment, satisfaction, and overall organizational success.

Jain, A., & Kaur, P submitted study on "A Study of Employee Retention Practices and its Effectiveness in IT Sector"[11]. Jain and Kaur's study systematically explores employee retention practices within the IT sector, evaluating their effectiveness. The research meticulously examines factors such as compensation, career growth opportunities, work environment, and employee engagement. It identifies the pivotal role of a positive work culture, supportive leadership, and effective communication in retaining IT professionals.

Singh, A., & Verma, N. presented a paper on “Impact of Work-Life Balance on Employee Retention: A Study in Indian IT Industry"[12]. Singh and Verma's research focuses on the critical impact of work-life balance initiatives on employee retention within the Indian IT industry. The study accentuates the role of flexible work arrangements, family-friendly policies, and employee well-being programs in not only reducing turnover but also enhancing job satisfaction.

Altogether, these studies provide comprehensive understanding of the diverse strategies and practices employed within the IT industry to retain skilled professionals. The insights gathered from these works offer a valuable resource for organizations seeking to refine and implement effective employee retention strategies, thereby fostering a resilient and satisfied IT workforce.

III. RESEARCH METHODOLOGY

To assess the employee retention strategies of software professionals in India, a mixed-methods research approach will be employed. The study will commence with a comprehensive literature review to establish a theoretical foundation and identify existing frameworks and models relevant to employee retention in the software industry. Subsequently, qualitative data will be gathered through semi-structured interviews with HR professionals and software experts to gain insights into the industry's specific context and nuances. The interview data will be thematically analyzed to identify recurring patterns and themes related to effective retention strategies. Additionally, a quantitative survey will be administered to a representative sample of software professionals across different organizations in India. The survey will encompass standardized measures of job satisfaction, perceptions of organizational culture, and the perceived effectiveness of various retention strategies. Statistical analyses, including regression analysis and correlation assessments, will be conducted to determine the relationship between retention strategies and job satisfaction. The combined findings from qualitative and quantitative data will contribute to a holistic understanding of the efficacy of employee retention strategies in the Indian software industry [13] [14] [15].

The survey comprises two sections: The initial part delves into respondents' demographic details, while the subsequent section focuses on gathering insights into their perspectives on the correlation between strategic impact elements and customer perceptions and purchasing behaviors. Using a Likert scale ranging from 1 (strong agreement) to 5 (strong disagreement), respondents rated the claims. Disagreement is denoted by scores of 4 or 5 [16] [17]. Regarding the sample design, a convenience sample was employed, distributing a total of 300 questionnaires, with 240 being fully completed. Upon thorough examination, an impressive 80 percent response rate was achieved. Descriptive statistics indicated a final sample size of 241, comprising both males and females.

IV. CONCEPTUAL FRAMEWORK

The conceptual framework for assessing employee retention strategies among software professionals in India is structured around key dimensions: organizational context, individual factors, and retention strategy effectiveness. The organizational context involves analyzing industry dynamics, examining organizational culture, and evaluating leadership effectiveness. Individual factors encompass demographic variables, job satisfaction, and professional

development needs [18]. The retention strategy effectiveness dimension involves assessing the impact of compensation, career development programs, work-life balance initiatives, and recognition programs on employee retention. The interactions between these dimensions will be explored through qualitative interviews and quantitative surveys.

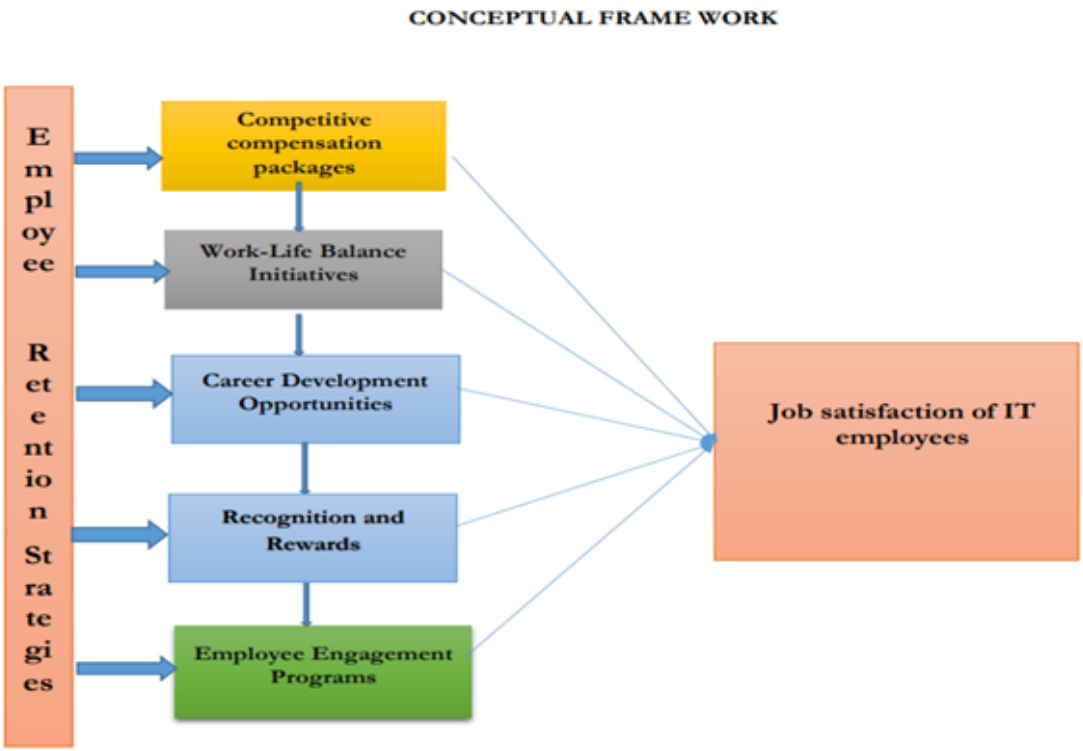


Fig 2: Conceptual frame work

The study aims to delineate the interplay of these factors in the Indian software industry, providing a nuanced understanding of effective retention strategies and their alignment with the unique needs and expectations of software professionals in this dynamic context [19]. The figure 2 revels the concept of the conceptual frame work.

V. OBJECTIVES

The main objective of this paper is to understand the influence of strategies on the job satisfaction of IT employees. The specific objectives of this research study are outlined as follows:

- Evaluate the impact of competitive compensation packages on the job satisfaction of IT employees.
- Analyze the influence of work-life balance initiatives on the job satisfaction of IT employees.
- Assess the impact of career development opportunities on the job satisfaction of IT employees.
- Examine the influence of recognition and rewards on the job satisfaction of IT employees.
- Evaluate the impact of employee engagement programs on the job satisfaction of IT employees.

VI. HYPOTHESIS

Competitive Compensation Packages:

- H0: The impact of Competitive Compensation Packages on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Competitive Compensation Packages on Job satisfaction of IT employees.
- Work-Life Balance Initiatives:
- H0: The impact of Work-Life Balance Initiatives on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Work-Life Balance Initiatives on Job satisfaction of IT employees.
- Career Development Opportunities:
- H0: The impact of Career Development Opportunities on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Career Development Opportunities on Job satisfaction of IT employees.
- Recognition and Rewards:
- H0: The impact of Recognition and Rewards on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Recognition and Rewards on Job satisfaction of IT employees.
- Employee Engagement Programs:
- H0: The impact of Employee Engagement Programs on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Employee Engagement Programs on Job satisfaction of IT employees.

VII. RESULTS & DISCUSSION

To attain the desired outcome of this research work, a systematic research methodology is implemented and the respective outputs were described in this section to conclude the impact of employee retention strategies on job satisfaction of it professionals. In this proposed work, Statistical Package for the Social Sciences SPSS is a software package widely used for statistical analysis in various fields, including management and social sciences. In management, SPSS is often used for tasks such as data analysis, statistical modelling, and reporting. SPSS 22 is a statistical software tool that can be utilized in management for analysing and interpreting data, making informed decisions, and gaining insights into various aspects of organizational processes and behaviour. In this research work SPSS 22 is used to analyse the data. The study under consideration employs exploratory factor analysis to illustrate concept validity and assesses internal consistency using Cronbach's alpha. To identify potential relationships between variables, the study utilizes the regression method. Principal Component Analysis (PCA) is employed in the Exploratory Factor Analysis (EFA) to validate constructs. Referring to Hair et al.'s research in 1998, a factor loading equal to or greater than 0.30 is considered to meet the minimum criterion, followed by factor loadings of 0.40 and 0.50, which are deemed progressively more crucial. This study establishes a termination point at a factor loading of 0.50. The outcomes of the factor analysis are presented in the accompanying table. KMO is a statistic used in management research, particularly in the context of factor analysis, to assess

the adequacy of the data for identifying underlying factors or constructs. The value of KMO, when it is between 0.5 and 1.0, a component analysis is advantageous for the data.

The extent of interdependence among variables is assessed through Bartlett's sphericity test, with researchers measuring the outcome by computing the test's significance level. If the resulting values are significantly small, typically below 0.05, it indicates substantial correlations between the variables. Conversely, a p-value exceeding 0.10 suggests that the data may not be well-suited for factor analysis. The findings affirm the appropriateness of employing factor analysis for the given dataset, as all twenty-one items were validated for the final analysis, with none exhibiting a loading value below 0.5.

Table 1: Results of Exploratory Factor Analysis

Table 1: Results of Exploratory Factor Analysis								
Macro Variable	**Micro Variable**	**Factor loadings**	**KMO Measureof Sample Adequacy (>0.5)**	**Bartlett's Test of Sphericity**		**Items confirmed**	**Items dropped**	**Cum % of loading**
				Chi Square	**Sig. (<.10)**			
Impact of strategies	Competitive compensation packages -1	.907	.574	211.429	.000	3	0	65.843
	Competitive compensation packages - 2	.843						
	Competitive compensation packages -3	.665						
	Work-Life Balance Initiatives-1	.878	.705	355.625	.000	3	0	78.536
	Work-Life Balance Initiatives-2	.857						
	Work-Life Balance Initiatives-3	.922						
	Career Development Opportunities: - 1	.737	.642	309.165	.000	3	0	72.860
	Career Development Opportunities: -2	.901						

Reliability Assessment:

The researchers utilized Cronbach's Alpha calculation to assess the internal consistency and reliability of the questionnaire. Nunally and Bernstein (1994) recommend an alpha value as low as 0.60 for new scales, with acceptability extending to lower values. However, common practice often dictates a requirement for an internally consistent established scale with an alpha value of 0.70 or higher. In this study, the predefined threshold for Cronbach's alpha is established at 0.7.

Table 2: Results of the Reliability Examination

	Independent Variable	Cronbach Alpha
1	Competitive compensation packages	.722
2	Building trust and credibility	.861
3	Career Development Opportunities:	.808
4	Recognition and Rewards	.669
5	Employee Engagement Programs	.946
Over all Reliability of the Questionnaire		.801

Table 2 reveals, the presents Cronbach's alpha values for various independent variables, indicating their internal consistency or reliability within a questionnaire.

1. **Independent Variable:** This column lists the different factors or constructs that were assessed in the questionnaire.
2. **Cronbach Alpha**: Cronbach's alpha is a measure of internal consistency, which assesses how closely related a set of items are as a group. It ranges from 0 to 1, where higher values indicate greater reliability. Competitive compensation packages have a Cronbach alpha of 0.722, suggesting moderate internal consistency. Building trust and credibility has a Cronbach alpha of 0.861, indicating high internal consistency. Career Development Opportunities have a Cronbach alpha of 0.808, indicating a high level of internal consistency. Recognition and Rewards have a Cronbach alpha of 0.669, suggesting moderate internal consistency. Employee Engagement Programs have a Cronbach alpha of 0.946, indicating high internal consistency. The overall reliability of the questionnaire, including all items, has a Cronbach alpha of 0.801, suggesting a good level of internal consistency.

These values provide insights into the reliability of the questionnaire items related to each independent variable, with higher Cronbach alpha values indicating greater reliability.

Table 3: Correlations

	CCP	CDO	R&R	EEP	WLB
Competitive compensation packages(CCP)	1				
Career Development Opportunities: (CDO)	.806**	1			
Recognition and Rewards(R&R))	.755**	.798**	1		
Employee Engagement Programs(EEP)	.757**	.768**	.723**	1	
Work-Life Balance Initiatives(WLB)	.308**	.348**	.343**	.367**	1

Table 3 reveals that the Cronbach's alpha values surpass the acceptable cutoff of 0.7, indicating satisfactory reliability. Specifically, the questionnaire exhibits an overall reliability demonstrated by a Cronbach's alpha value of 0.801.

Moving on to the correlation analysis, the study on independent variables indicates a robust connection among all of them. Each variable demonstrates a significant correlation with the five variables under examination in the "impact of strategies" framework. Notably, all five independent variables within the "impact of strategies" framework exhibit substantial associations with one another (refer to Table 4). The correlation between "Career Development Opportunities" and "Competitive Compensation Packages" is the highest at 0.806, while the least significant relationships are observed between "Building Trust and Credibility" and "Competitive Compensation Packages" at 0.308.

Regression Analysis:

The study utilizes stepwise regression analysis to discern the predictor-criterion relationship between dependent and independent variables. Specifically, the correlation between the impact of retention strategies on job satisfaction was explored.

Results of Hypotheses Testing for Job Satisfaction of IT Employees as Dependent Variable:

Multiple regression models were developed and tested to assess the job satisfaction of IT employees as the dependent variable. The study considered five factors related to the impact of strategies—Competitive Compensation Packages (CCP), Career Development Opportunities (CDO), Recognition and Rewards (R&R), Employee Engagement Programs (EEP), and Work-Life Balance Initiatives (WLB)—as independent variables in the regression models.

Table (4a): Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.863[a]	.744	.743	.355
2	.911[b]	.830	.829	.290
3	.936[c]	.876	.874	.248
4	.955[d]	.912	.910	.210
5	.962[e]	.926	.925	.192

The results of the stepwise regression analysis indicate that, according to Table 4(a), five factors (Competitive Compensation Packages, Career Development Opportunities, Recognition and Rewards, Building Trust and Credibility, Employee Engagement Programs) emerged as significant predictors of "Job satisfaction of IT employees." With an R-square value of 0.934, these five variables collectively explain job satisfaction to the extent of 93.4 percent in the dataset.

a. Dependent Variable: Job satisfaction of IT employees
b. Predictors: (Constant), Career Development Opportunities:
c. Predictors: (Constant), Career Development Opportunities: Employee Engagement Programs
d. Predictors: (Constant), Career Development Opportunities: Employee Engagement Programs,
e. Predictors: (Constant), Career Development Opportunities: Employee Engagement Programs, Recognition and Rewards

Table (4b). ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	87.776	1	87.776	696.150	.000[b]
	Residual	30.135	239	.126		
	Total	117.911	240			
2	Regression	97.885	2	48.943	581.674	.000[c]
	Residual	20.026	238	.084		
	Total	117.911	240			
3	Regression	103.276	3	34.425	557.490	.000[d]
	Residual	14.635	237	.062		
	Total	117.911	240			
4	Regression	107.488	4	26.872	608.429	.000[e]
	Residual	10.423	236	.044		
	Total	117.911	240			
5	Regression	109.232	5	21.846	591.557	.000[f]
	Residual	8.679	235	.037		
	Total	117.911	240			

Moreover, Table 4(b) showcases the ANOVA outcomes for the regression model, affirming validity with a 95 percent confidence level.

Table (4c): Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	.498	.087		5.752	.000
1	Career Development Opportunities:	.800	.030	.863	26.385	.000
2	(Constant)	.517	.071		7.310	.000
	Career Development Opportunities:	.475	.039	.512	12.280	.000
	Employee Engagement Programs	.325	.030	.457	10.961	.000
3	(Constant)	.215	.069		3.124	.002
	Career Development Opportunities:	.440	.033	.475	13.217	.000
	Employee Engagement Programs	.284	.026	.400	11.055	.000
	Building trust and credibility	.183	.020	.231	9.343	.000
4	(Constant)	.156	.058		2.663	.008
	Career Development Opportunities:	.262	.034	.283	7.811	.000
	Employee Engagement Programs	.224	.023	.316	9.928	.000
	Building trust and credibility	.171	.017	.216	10.310	.000
	Recognition and Rewards	.271	.028	.328	9.765	.000
5	(Constant)	.074	.055		1.358	.176
	Career Development Opportunities:	.185	.033	.199	5.655	.000
	Employee Engagement Programs	.191	.021	.268	8.965	.000
	Building trust and credibility	.168	.015	.212	11.045	.000
	Recognition and Rewards	.250	.026	.302	9.758	.000
	Competitive compensation packages	.173	.025	.191	6.873	.000

a. Dependent Variable: Job satisfaction of IT employees

A brief scrutiny of the corresponding coefficients in Table 4(c) discloses beta values for the factors— "Competitive Compensation Packages (CCP), Career Development Opportunities (CDO), Recognition and Rewards (R&R), Employee Engagement Programs (EEP), Work-Life Balance Initiatives (WLB)"—as 0.129, 0.221, 0.215, 0.265, and 0.195, respectively. These findings strongly underscore the significance of these factors in influencing job satisfaction among employees.

Table 5: Test Results for Hypotheses

Hypothesis	Independent Variables	Dependent Variables	R-Square	Beta Coefficient	t-value	Sig Value
H1	Competitive compensation packages (CCP)	Job satisfaction of IT employees	0.129	3.593	0.076	Accepted
H2	Career Development Opportunities (CDO)	Job satisfaction of IT employees	0.221	7.437	0.000	Accepted
H3	Recognition and Rewards (R&R)	Job satisfaction of IT employees	0.215	11.793	0.003	Accepted
H4	Employee Engagement Programs (EEP)	Job satisfaction of IT employees	0.265	8.771	0.012	Accepted
H5	Work-Life Balance Initiatives (WLB)	Job satisfaction of IT employees	0.195	7.379	0.017	Accepted

The table 5 presents the findings of a research study examining the relationship between various factors and the job satisfaction of IT employees. The study hypothesized that factors such as competitive compensation packages, career development opportunities, recognition and rewards, employee engagement programs, and work-life balance initiatives influence job satisfaction in the IT sector. The results indicate that all hypotheses were supported, as evidenced by the statistically significant relationships between the independent variables and job satisfaction. Specifically, career development opportunities, recognition and rewards, employee engagement programs, and work-life balance initiatives showed particularly strong associations with job satisfaction, as indicated by their higher beta coefficients, t-values, and lower significance values. These findings suggest that organizations seeking to enhance job satisfaction among IT employees should prioritize initiatives related to career development, recognition, engagement, and work-life balance. Overall, the study highlights the importance of considering various organizational factors in understanding and promoting job satisfaction within the IT industry. The research findings support the hypotheses with numerical evidence and are summarized as follows. Competitive compensation packages (CCP): The relationship with job satisfaction has a beta coefficient of 0.129, a t-value of 3.593, and a significance value of 0.076.Career Development Opportunities (CDO): The association with job satisfaction is stronger with a beta coefficient of 0.221, a t-value of 7.437, and a significance value of 0.000.Recognition and Rewards (R&R): This factor has a beta coefficient of 0.215, a t-value of

11.793, and a significance value of 0.003, indicating a significant impact on job satisfaction. Employee Engagement Programs (EEP): The relationship with job satisfaction is notable, with a beta coefficient of 0.265, a t-value of 8.771, and a significance value of 0. 012.Work-Life Balance Initiatives (WLB): This factor shows a beta coefficient of 0.195, a t-value of 7.379, and a significance value of 0.017, indicating a statistically significant relationship with job satisfaction.

These numerical values provide quantitative evidence supporting the conclusion that career development opportunities, recognition and rewards, employee engagement programs, and work-life balance initiatives have significant associations with job satisfaction among IT employees.

VIII. RECOMMENDATIONS & SUGGESTIONS

Based on the extensive research conducted on employee retention strategies and their impact on job satisfaction of IT professionals, the primary recommendations and suggestions are listed below.

1. **Tailor Compensation Packages**: Customize compensation packages to align with industry standards and the unique skills and expertise of IT professionals.
2. **Invest in Career Development**: Prioritize investments in training programs, mentorship initiatives, and challenging project opportunities to support career growth and advancement.
3. **Promote Work-Life Balance**: Implement flexible work arrangements, remote work options, and paid time off policies to support work-life integration and reduce burnout.
4. **Enhance Recognition and Rewards**: Recognize and reward outstanding performance through bonuses, incentives, and public appreciation programs to boost morale and loyalty.
5. **Strengthen Employee Engagement**: Foster a supportive work environment through team-building activities, social events, and employee resource groups to promote engagement and camaraderie.
6. **Facilitate Transparent Communication**: Establish open channels of communication between management and employees to address concerns and provide feedback effectively.
7. **Prioritize Employee Well-being**: Offer wellness programs, mental health support, and access to fitness facilities to demonstrate genuine concern for employee health and well-being.
8. **Develop Leadership Skills**: Invest in training managers to be supportive, empathetic, and skilled in employee development to foster positive relationships and reduce turnover.
9. **Promote Diversity and Inclusion**: Create a diverse and inclusive workplace culture where all employees feel valued and respected.
10. **Regularly Review HR Policies**: Continuously review and update HR policies to ensure they meet the evolving needs and expectations of IT professionals and the organization.
11. **Encourage Cross-Functional Collaboration**: Facilitate collaboration between IT teams and other departments to promote innovation and problem-solving.
12. **Implement Mentorship Programs**: Pair junior IT professionals with experienced mentors to facilitate knowledge transfer and career development.
13. **Offer Performance-Based Incentives**: Tie rewards and incentives directly to individual and team performance to motivate IT professionals and drive results.

14. **Provide Leadership Opportunities**: Identify and groom future leaders within the IT department by offering leadership training and opportunities for advancement.
15. **Support Continuous Learning**: Encourage IT professionals to attend workshops, conferences, and training programs to stay updated with the latest technologies and trends.
16. **Create a Positive Work Culture**: Foster a culture of trust, collaboration, and appreciation to enhance job satisfaction and employee retention.
17. **Promote Flexibility**: Allow IT professionals to have autonomy over their work schedules and environments to accommodate personal preferences and obligations.
18. **Encourage Innovation:** Create avenues for IT professionals to contribute ideas and solutions to drive innovation within the organization.
19. **Provide Clear Expectations**: Communicate clear goals, expectations, and performance metrics to ensure alignment and accountability.
20. **Seek Feedback and Iterate**: Regularly solicit feedback from IT professionals and adapt retention strategies based on their input and changing needs.

These recommendations aim to help organizations in the IT industry develop and enhance their employee retention strategies to foster job satisfaction and create a conducive work environment for their valuable IT workforce.

Altogether, the recommendations and suggestions outlined provide a comprehensive framework for organizations within the IT industry to enhance their employee retention strategies and promote job satisfaction among their workforce. By implementing tailored compensation packages, investing in career development, promoting work-life balance, and fostering a supportive work culture, organizations can create an environment where IT professionals feel valued, motivated, and engaged. Additionally, prioritizing transparent communication, recognizing and rewarding performance, and supporting employee well-being are essential components of effective retention strategies. By continuously reviewing and updating HR policies, promoting diversity and inclusion, and encouraging innovation, organizations can adapt to the evolving needs and expectations of their workforce while staying competitive in the dynamic IT landscape.

Ultimately, by incorporating these recommendations into their retention strategies, organizations can cultivate a dedicated and loyal IT workforce, driving organizational success, growth, and innovation. As the IT industry continues to evolve, organizations must prioritize employee satisfaction and retention to remain competitive and thrive in the ever-changing market.

IX. CONCLUSION

Research on employee retention strategies within the software industry consistently emphasizes the robust correlation between these strategies and job satisfaction. The software industry, renowned for its competitiveness and high demand for skilled professionals, grapples with substantial challenges in retaining its workforce. Nevertheless, organizations can overcome these challenges by deploying effective retention strategies, thereby establishing a positive work environment conducive to job satisfaction, heightened employee commitment, and increased loyalty. Numerous studies have pinpointed key employee retention strategies integral to fostering job satisfaction in the software industry. These encompass competitive compensation packages, career development opportunities, work-life balance initiatives, recognition and rewards, employee engagement programs, transparent communication, employee well-being initiatives, and robust leadership and management practices. Research findings underscore the critical importance of offering competitive salaries and benefits in

attracting and retaining software professionals. Furthermore, providing avenues for career development, such as training programs and clear career paths, proves instrumental in promoting job satisfaction by enabling skill enhancement and career progression within the organization. In the demanding landscape of the software industry, work-life balance initiatives, including flexible work schedules and remote work options, emerge as pivotal contributors to job satisfaction, facilitating a healthy integration of work and personal life. Recognition and rewards programs significantly contribute to job satisfaction by acknowledging employee contributions and nurturing a positive work culture. Engagement programs, transparent communication channels, and employee well-being initiatives collectively play a substantial role in cultivating a supportive and fulfilling work environment, thereby enhancing job satisfaction. Finally, strong leadership and management practices that prioritize employee development and support further contribute to job satisfaction and employee retention. In summation, the literature review unequivocally supports the conclusion that the implementation of effective employee retention strategies in the software industry leads to heightened job satisfaction among software professionals. By addressing key influencers of job satisfaction, organizations can cultivate a dedicated and loyal workforce, ultimately bolstering the company's success and growth.

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COMPREHENSIVE EVALUATION OF THE DIGITAL INDIA PROGRAMME TO ADDRESS PAIN POINTS IN INDIA'S DIGITAL TRANSFORMATION

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ABSTRACT

The Digital India Programme represents a transformative vision aimed at reshaping India's digital landscape to promote widespread digital inclusion and socio-economic development. Despite significant advancements in digital banking, e-governance, and rural development, the programme faces numerous challenges, especially in rural areas. These challenges include inadequate digital literacy, poor infrastructure, socio-economic disparities, and cybersecurity threats, which hinder the effective adoption of digital financial services. Studies highlight these impediments and underscore the need for interventions to ensure equitable distribution of digital benefits. This comprehensive evaluation identifies pain points associated with the programme's implementation and suggests measures to enhance its efficacy. This study discusses key issues such as network and infrastructure limitations, digital literacy gaps, socio-cultural resistance, economic barriers, insufficient customer support, and slow regulatory responses. The findings emphasize the importance of strategic investments, regulatory support, and community engagement to overcome these challenges and achieve the programme's full potential.

Keywords: Digital India, digital literacy, rural development, e-governance, cybersecurity.

1. INTRODUCTION

The Digital India Programme represents a transformative vision to fundamentally reshape India's digital landscape, promoting widespread digital inclusion and enhancing socio-economic development. However, the programme's implementation has encountered significant challenges, especially in rural areas where barriers such as inadequate digital literacy, poor infrastructure, and socio-economic disparities persist. Literature reviews, including studies from the Thane District, reveal that these challenges hinder the effective adoption of digital financial services, underscoring the need for interventions to ensure equitable distribution of digitalization benefits. Despite notable advancements in digital banking and e-governance, cybersecurity threats and the need for regulatory frameworks remain pressing issues. The programme's impact on rural development is evident through improved access to information, education, healthcare, and government schemes, yet

obstacles like unreliable internet connectivity and resistance to change within governmental bodies persist. Furthermore, digital initiatives in education and healthcare, such as telemedicine and mobile health applications, highlight both the potential and the hurdles of digital transformation, with infrastructural deficiencies and digital illiteracy posing significant barriers. The role of the Digital India Programme in fostering entrepreneurship and growth in MSMEs is also notable, though limited digital skills, access to finance, and infrastructural constraints need to be addressed through supportive policies and capacity-building initiatives. This comprehensive evaluation aims to identify the pain points associated with the Digital India Programme's implementation and suggests measures to enhance its efficacy. The study employs a descriptive research design, drawing on secondary data from journal articles, books, and electronic sources. Key issues discussed include network and infrastructure limitations, digital literacy gaps, socio-cultural resistance, economic barriers, insufficient customer support, and slow regulatory responses.

2. LITERATURE REVIEW:

The Digital India Programme has made significant strides in fostering digital inclusion and enhancing financial literacy among marginalized communities, yet it faces considerable challenges, particularly in rural areas. Studies, such as the one conducted in Thane District, highlight several barriers to the effective adoption of digital financial services, including a lack of digital literacy, inadequate infrastructure, and socio-economic challenges. These impediments hinder the programme's goal of creating a digitally empowered society. While the initiative has made headway in promoting digital inclusion, there is a clear need for interventions to address these challenges and ensure the equitable distribution of digitalization benefits. Furthermore, the transformative impact on the Indian banking sector through the Digital India Programme has been profound, with digital banking services like mobile and internet banking reshaping traditional models. This transformation has enhanced efficiency, customer experience, and broadened financial inclusion, especially in rural areas, though cybersecurity threats and the need for regulatory frameworks remain pertinent challenges.

The role of the Digital India Programme in enhancing e-governance and its socio-economic impact on rural communities underscores its broad influence across various sectors. The integration of digital technologies into government-led operations has improved transparency, efficiency, and citizen engagement, as evidenced by successful initiatives like the Digital Locker system and online grievance redressal mechanisms. However, persistent hurdles such as the digital divide and resistance to change within governmental bodies need addressing. In rural India, digital initiatives have facilitated access to information, education, healthcare, and government schemes, contributing significantly to rural development. Despite these positive outcomes, challenges such as inadequate internet connectivity and lack of awareness about digital services continue to pose obstacles. Sustained efforts are required to bridge these gaps and ensure inclusive digital growth, highlighting the importance of strategic investments in infrastructure and comprehensive digital literacy campaigns.

The Digital India Programme's impact on education, healthcare, and entrepreneurship further illustrates its transformative potential and the accompanying challenges. Digital education initiatives hold promise for transforming education by making learning more accessible and interactive, though infrastructural deficiencies

and digital illiteracy among students and teachers pose significant barriers. Similarly, digital health initiatives like telemedicine and mobile health applications have improved healthcare access, particularly in underserved areas, but issues related to data privacy and the digital divide persist. The programme has also spurred entrepreneurship and growth in MSMEs by creating new business opportunities and expanding market access. However, limited digital skills, access to finance, and infrastructural constraints remain challenges that need to be addressed through supportive policies and capacity-building initiatives. Overall, the Digital India Programme has made commendable progress, but achieving its full potential requires addressing these challenges through strategic investments, regulatory support, and community engagement.

3. OBJECTIVES AND RESEARCH METHODOLOGY:

Objectives:

1. To study the pain points associated with the implementation of Digital India Programme.
2. To suggest, based on the findings, various measures to the Government of India to advance the Digital India Programme.

Research Design: Used a descriptive research design.

Data Sources:

The researcher collected secondary data from journal articles, write-ups from books and electronic sources.

Discussion:

Network and infrastructure issues result in fewer digital payments, as unreliable connectivity disrupts transactions and undermines trust in digital financial systems. The limited digital infrastructure in these regions exacerbates the problem, with many rural areas lacking essential facilities like reliable internet and digital devices, thus hindering access to digital services. Poor internet connectivity further restricts the use of online platforms for education, healthcare, and government services, isolating rural populations from digital advancements. Additionally, the dependence on an unreliable power supply for digital devices poses a major challenge. Frequent power outages and unstable electricity supply disrupt the functioning of digital services, making it difficult for rural communities to maintain consistent digital connectivity.

Many rural individuals lack the basic skills to navigate and utilize digital platforms, which limits their ability to benefit from digital initiatives. The limited outreach of digital literacy campaigns exacerbates this issue, as many such efforts fail to reach remote and underserved communities, leaving a substantial portion of the rural population without essential digital knowledge. Furthermore, a lack of awareness about digital financial services leads to underutilization of digital payment systems, online banking, and other financial technologies that could enhance economic efficiency and inclusivity. Additionally, insufficient training and capacity-building programs for rural users mean that even those who have access to digital technologies struggle to keep pace with rapidly evolving digital environments.

Resistance to adopting new digital technologies in rural areas where traditional methods are preferred. This reluctance is compounded by a lack of trust in digital financial transactions, with fears of security breaches and

digital fraud discouraging engagement with online financial services. Cybersecurity concerns and the fear of fraud further deter users, as potential risks associated with cyber threats and scams create apprehension about the safety of digital transactions. Socio-cultural barriers also play a crucial role, as deeply entrenched norms and practices in rural communities foster suspicion and skepticism towards digital adoption. These socio-cultural attitudes, along with a lack of digital literacy, reinforce distrust and resistance.

High costs of digital devices and internet access create significant barriers for rural and economically disadvantaged populations, preventing them from fully participating in the digital economy. Many individuals and families in these areas cannot afford the initial investment in smartphones, computers, or consistent internet connectivity, which are essential for accessing digital services. Furthermore, limited access to financial resources for digital investments exacerbates this problem. Without sufficient financial support or affordable financing options, rural users are unable to invest in the necessary infrastructure to benefit from digital advancements.

Insufficient customer support for digital services significantly in rural and remote areas where users often require assistance to navigate new technologies. The limited availability of localized digital content and services further exacerbates this issue, as many digital platforms fail to cater to the specific needs and preferences of diverse regional populations. This gap in service availability prevents users from fully benefiting from digital initiatives designed to improve their daily lives. Additionally, the lack of multilingual support on digital platforms creates a barrier for non-English speaking users, making it difficult for them to access and utilize digital services effectively. This language barrier particularly affects rural users, who may be more comfortable with regional languages.

Many rural populations remain excluded from formal financial systems. This exclusion is exacerbated by ineffective digital payment systems in rural areas, where poor connectivity and inadequate infrastructure hinder seamless transactions. Consequently, the slow adoption of digital payment systems by small businesses further restricts the economic benefits of digitalization, as these enterprises struggle to transition from cash-based operations to digital platforms. Moreover, there is a dependency on intermediaries for digital transactions, which increases costs and reduces trust among users. These intermediaries often charge fees for facilitating transactions, making digital payments less attractive for both consumers and small businesses.

Slow regulatory responses to emerging digital challenges hinder the program's ability to adapt and evolve in a rapidly changing technological landscape, leaving gaps in legal and operational frameworks necessary for effective digital governance. Limited collaboration between the private and public sectors further exacerbates these issues, as the lack of coordinated efforts and shared goals between these entities stifles innovation and the effective implementation of digital initiatives. Additionally, limited financial incentives for digital adoption discourage businesses and individuals from transitioning to digital platforms, slowing the overall progress of the programme.

Verification challenges often stem from inconsistencies and inaccuracies in digital identity databases, leading to difficulties in authenticating users and accessing services. This undermines trust in digital systems and discourages their use. Additionally, the lack of seamless integration between digital services and existing government schemes hampers the efficiency and effectiveness of digital initiatives. Without cohesive integration, beneficiaries face obstacles in leveraging digital platforms to access various welfare and support programs.

The Digital India Programme faces significant challenges in achieving its goals due to the digital exclusion of elderly and less-educated populations. These groups often lack the necessary digital skills and familiarity with technology, which prevents them from fully participating in and benefiting from digital initiatives. The elderly, in particular, may find it difficult to adapt to new digital tools and platforms, leading to their marginalization in an increasingly digital society. Individuals with lower levels of education may struggle to understand and use digital services, further exacerbating the digital divide.

To address the challenges faced by the Digital India Programme, the Indian government needs to implement a comprehensive and integrated approach that leverages existing capacities while fostering innovation and collaboration. Enhancing network and infrastructure is paramount; thus, investments in expanding reliable internet connectivity and robust digital infrastructure, particularly in rural areas, must be prioritized. This could include initiatives such as deploying satellite internet services and strengthening the power supply to ensure consistent digital connectivity. Simultaneously, expanding digital literacy campaigns is essential to equip rural populations with the skills needed to navigate digital platforms. Tailored training programs, supported by localized and multilingual content, can bridge the knowledge gap and foster greater digital inclusion. To build trust and overcome resistance to digital adoption, the government should enhance cybersecurity measures, provide extensive awareness campaigns about the safety and benefits of digital transactions, and establish customer support networks. Encouragingly, subsidies and financial incentives for purchasing digital devices and internet access can alleviate economic barriers, enabling wider participation in the digital economy. Additionally, fostering public-private partnerships can drive innovation and resource-sharing, expediting the development and deployment of digital solutions tailored to diverse regional needs. Improving the regulatory framework to adapt swiftly to emerging digital challenges will ensure legal and operational coherence, enhancing the program's effectiveness. Furthermore, streamlining digital identity verification processes and integrating digital services with existing government schemes can bolster trust and efficiency in accessing welfare programs. To specifically address the needs of elderly and less-educated populations, targeted outreach and simplified digital interfaces can make digital services more accessible and user-friendly.

4. CONCLUSION

The Digital India Programme faces significant challenges that hinder its effectiveness, particularly in rural areas where network and infrastructure issues disrupt digital payments, education, healthcare, and government services. Limited digital literacy, resistance to adopting new technologies, and cybersecurity concerns further exacerbate these issues, creating a significant digital divide. High costs of digital devices and internet access, insufficient customer support, and verification challenges add to the complexity, preventing

many from fully benefiting from digital initiatives. To address these challenges, a comprehensive and integrated approach is essential. Prioritizing investments in reliable internet connectivity, expanding digital literacy campaigns, enhancing cybersecurity measures, and providing financial incentives can foster greater digital inclusion. Public-private partnerships and improved regulatory frameworks can drive innovation and adaptability, while tailored outreach programs can make digital services more accessible to elderly and less-educated populations. By adopting this holistic strategy, the Indian government can advance the Digital India Programme, ensuring inclusive participation in the digital revolution.

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Allure of the 'Indo-Pacific' and dynamics of regional cooperation after COVID-19

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Abstract

The security relations have changed globally in reaction to the ongoing political developments on the world stage, particularly in the light of China's rapid economic development and military modernization. The exceptional growth of China and its claims of entire South China Sea is an alarming development for the US, Japan, Australia and India as well as regional actors in the Indo-Pacific region. The broad geopolitical changes brought about by China's rise prodded the US, India, Japan and Australia to devote their time and precious few resources to boost Indo-Pacific alliances. Major Powers have reached a new level of collaboration and have strengthened their contacts in the areas of security, business, humanitarian aid and public health as a result of the swift geoeconomic and geostrategic changes in the Indo-Pacific. In order to help the region's nations recover from the Covid-19 pandemic faster and to promote environmentally sustainable development and a better future, this paper focuses on the Quad and India's cooperative posture in the Indo-Pacific.

Keywords: Indo-Pacific, Quad, India and Quad, Humanitarian assistance, HADR and AUKUS

Indo-Pacific Initiation

In the post-Cold War era, new robust economic states have emerged in the world. In the current situation, Asian nations are growing, and the Indian Ocean is quickly emerging as a region with enormous economic and human resource potential. The massive oil and gas reserves in the Middle East and North Africa are transported through this vital route. The surge of China started attempting to alter the status quo and started to displace the leading developed countries in the Indo-Pacific region. In the beginning of 21st century the major powers evinced keen

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SHANGHAI COOPERATION ORGANISATION (SCO) AND INDIA'S ROLE IN ITS REGIONAL DEVELOPMENT AND STABILITY

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ABSTRACT

Multilateral regional organisations were founded all over the world in the decades that followed the Second World War and the Cold War. Building confidence mechanisms, regional economic integration, trade, and multilateral agreements are all activities that regional organisations are getting more and more involved in. Furthermore, they are paying more attention to matters like general notions of security, terrorism, drug trafficking, human trafficking, and more human rights, and energy and environmental concerns. The precarious conditions erupted after the disintegration of the USSR, encouraged Russia, China and the newly formed Central Asian countries to join hands for a strong regional cooperation. Thus, the Shanghai Cooperation Organisation (SCO) was founded in 2001 with an aim to enhance political, economic cooperation and evolve strategy to fight against terrorism in the Eurasian region. This paper will focus on the evolution of SCO's multilateral cooperation and engagement of member countries in economic, political, energy security and strategic areas under the regional governance.

KEYWORDS: ***SCO, China, Terrorism, RATS, India and SCO***

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GENESIS AND GROWTH OF THE SCO

The Shanghai Cooperation Organisation (SCO), a young regional group with one and half decades, has swiftly forged ahead from mere political to significant economic, strategic and cultural institution. Since inception, the

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Social Science

INDIA-ASEAN NAVAL COOPERATION: AN IMPORTANT STRATEGY

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KEYWORDS :

India holds a primary interest in the Freedom of Navigation through the South China Sea. It also has an economic interest in exploring hydrocarbon resources in the area. But how effective are India's role as the balancing actor that the ASEAN nations seek?

Maritime cooperation is one of the important aspects of the India-ASEAN strategic partnership. The ongoing territorial disputes among some of the ASEAN nations and China in the South China Sea is challenging the regions peace and tranquillity. India holds a primary interest in the Freedom of Navigation (FON) through the South China Sea. It also has an economic interest in exploring hydrocarbon resources in the area with ONGC Videsh Ltd. (OVL) the global arm of the Indian petroleum company, Oil and Natural Gas Ltd. (ONGC) operating in two oil blocks in Vietnam. China's increasingly assertive navy make it necessary for New Delhi to maintain its stakes and safeguard its interests in the region. This in turn will require continued naval engagement with the littorals. India can be a key player in maintaining peace and security in the region and for that New Delhi must further strengthen its maritime cooperation with the Association for the South East Asian Nations, despite China's disapproval. As India looks to strengthening its ties with members of the Association for Southeast Asian nations (ASEAN), this article looks at India's naval cooperation with ASEAN countries and evaluates India's role as the balancing actor that the ASEAN nations seek.

China's growing assertiveness

The SCS is an important trade route and a major Sea Lane of Communication (SLOC)with six nations (China, Taiwan, the Philippines, Vietnam, Brunei and Malaysia) competing over territorial rights in the region. China, the most assertive in its claims, considers the entire SCS in a U shaped line as its territory.

Beijing's claims go well into the Exclusive Economic Zone (EEZ) of the other disputing nations. China's vigorous pursuance of its territorial claims concern the international community as this affects a major SLOC. China even protests India's oil exploration with Vietnam in Block 128 despite the block falling within Vietnam's EEZ. Beijing nevertheless went ahead and put the block up for bidding to international companies ignoring the fact that it is already being operated by India. The China Philippines row in 2012 over the Scarborough Shoal incident is another instance where China displayed its assertive behaviour.

While Beijing strongly opposes internationalisation of the issue and suggests that the disputes be resolved bilaterally, countries like Vietnam and the Philippines do not want to be seated alone against Beijing at the negotiating table. Hence, the countries seek extra regional powers to balance the situation.

India-ASEAN naval cooperation

India's naval cooperation with the Southeast Asian nations is an important dimension of the "Look East Policy", launched in the early 1990's. India ASEAN relations have improved incrementally in recent years with India becoming the ASEAN Sectoral Dialogue Partner in 1992, and a full Dialogue Partner as well as a member of the ASEAN Regional Forum (ARF) in 1996. In December 2012, India and ASEAN celebrated 20 years of dialogue partnership and 10 years of Summit level partnership. Today India ASEAN relations stand at an elevated echelon of a strategic partnership.

The Indian Navy has been carrying out joint exercises and military drills with the navies of the Southeast Asian nations for a long period of time. India has enhanced its naval cooperation with the ASEAN nations and seek to further strengthen its defence cooperation with the countries. However, China is wary of New Delhi's growing closeness to its ASEAN neighbours and perceives this as a strategy to counter balance a rising China. Such concerns are fuelled due to countries such as Vietnam and the Philippines, who are seeking extra regional powers to maintain their presence and encourage their engagements in the region.

It must be noted that India's naval cooperation with the ASEAN nations date back to the early 1990's. Although India and its ASEAN counterparts may not have yet realised the full potential of their naval cooperation, there has been incremental progress on this front over the years. The table below lists out the current exercises between the Indian Navy and the navies of the ASEAN nations.

The need for Indian presence is set to shoot up.

Indian presence in the region has not been fuelled solely by the recent ongoing maritime disputes. Indian presence in the South China Sea dates back to early 2000 with India's overseas naval deployment to the area as well as in the form of SIMBEX.

India has regularly deployed its vessels from its Eastern Fleet to Southeast Asia and the SCS. New Delhi has deployed its vessels for Presence-cum-Surveillance missions in the Malacca Strait, Sunda Strait and the South China Sea during May 2003 .

India also sent its aircraft carrier INS Viraat on Southeast Asia deployments to mark its presence and build its ties with the ASEAN navies complemented with high level visits on the defence front between India and the ASEAN nations. In 2003 Singapore's Defence Minister, visited India and signed an agreement on defence cooperationII . A bilateral agreement for the conduct of joint military training and exercises between the two countries was signed in 2007. New Delhi held its first India Vietnam security dialogue in 2003 and signed a Memorandum of Understanding (MoU) on defence cooperation in 2009. India also participated in a security dialogue with the Philippines in 2003III and institutionalized the Joint Defence Cooperation Committee in 2012.

Additionally, the Indian Navy frequently visits major ports in Singapore, Thailand, Vietnam, the Philippines, Cambodia and Indonesia while deployed to the SCS and Southeast Asia. The 2012 Commemorative Summit also saw the Indian Naval Ship Sudarshini embarking on a commemorative ship expedition to ASEAN countries from 15 September 2012 to 25 March 2013. The expedition retraced the sea routes linking India with South East Asia, covering most of the modern and ancient ports in the ASEAN countries. The expedition was conceptualized to demonstrate India's historical proximity with its ASEAN neighbours and to commemorate the longstanding ASEAN-India maritime and trade relationship.

Defence diplomacy

Naval goodwill visits are an important element of defence diplomacy. Defence engagements are crucial to build and maintain trust and contribute toward conflict prevention and resolution. In this, India and ASEAN share common ground wherein both parties seek to maintain peace and security in the region. This was reflected by the Vision statement adopted at the India-ASEAN commemorative Summit 2012, which underlines the importance of maritime security. "We are committed to strengthening cooperation to ensure maritime security and freedom of navigation, and safety of sea lanes of communication for unfettered movement of trade in accordance with international law,

including UNCLOS" stated the Vision Statement, highlighting the main concerns in the SCS namely freedom of navigation and the need to adhere to international rules and norms.

ASEAN nations have welcomed Indian presence in the region and wish to see India pursue its engagements. Both sides have realised the importance of India ASEAN cooperation. Indian Prime Minister Manmohan Singh underlining the need to further strengthen ties remarked in May 2013 that "...ASEAN countries are our strategic partners and there are enormous opportunities of expanding trade ties, expanding investment relations, expanding maritime cooperation, expanding the scope of trade and investment. And now we have reached a stage where large-scale flow of trade and investment is becoming a reality..." When Beijing put up Block 128 for bidding to international companies, Vietnam was enraged and protested vigorously. Vietnam then requested OVL to stay put in the block and promised more data and help to successfully drill the oil block. India had earlier decided that it may vacate the oil block due to unsuccessful drilling but reconsidered its decision. In January 2013, Vietnamese Deputy Prime Minister Mr. Vu Van Ninh invited "Indian companies to continue to invest and enter into Vietnam".

The stabilising factor

The ongoing maritime disputes in the SCS are a major concern for the ASEAN nations. It has created a rift within ASEAN as the nations are divided on how to resolve the disputes. Countries like Singapore and Vietnam believe that India can play a positive role in the regions peace and stability. India is concerned over the maritime disputes and their implications. The maritime disputes and the safety of sea lanes are discussed in all major forums between India and ASEAN for whether it is the India ASEAN Summit, or the Delhi Dialogue. What is yet to be seen if India can be the balancing actor that the region seeks.

New Delhi's presence in the area is not a strategy to counter China but rather a necessity to safeguard its interests from an increasingly assertive Beijing. India looks to increase its engagements with ASEAN nations and in turn, the Southeast Asian nations seek its presence in stabilising the region. Although there is a concerted effort for an increased cooperation on maritime security, New Delhi must be careful not to let China intimidate this collaboration. Keeping in mind the rapidly changing geo political dynamics in Asia, and India's vision of enhanced cooperation, it would be beneficial for India to remain in the area and protect its interests. New Delhi must continue to engage and cooperate with the ASEAN countries to realise its desired level of strategic partnership. This in turn would involve deepening naval cooperation with the key countries of ASEAN and major powers sharing India's interest in defending the principle of Freedom of Navigation and maintaining peace and stability. New Delhi must find the political will to be the stabilising factor that its ASEAN friends seek.

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INDIA-ASEAN DEFENCE COOPERATION

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KEYWORDS :

India's defence strategy towards Southeast Asia can be understood in terms of two broad sets of strategic objectives that together drive India's relationships in the region. These include its ambitions to be the predominant power in the Ocean and a broader objective to assume a greater strategic role in Southeast Asia and the Pacific. India's aspirations to increase its defence presence in the region are broadly consistent with the perspectives of many ASEAN states, which mostly see India as a positive factor in the Southeast Asian balance of power. But India is yet to demonstrate itself as a useful and consistent security partner for much of the region. India is hindered by a lack of strategic focus and planning that is consistent with many of its strategic relationships

New Delhi sees several strategic imperatives to be the predominant power in the Indian Ocean, which includes the huge bay comprised of the Bay of Bengal and Andaman Sea. For India, the northeast represents a key defensive space against potential threats that may emanate from or through the Southeast Asian archipelago. The ability to control the sea lines of communication that cross the Bay of Bengal and Andaman Sea and enter the Pacific Ocean through the Malacca Strait would also pro-vide India with considerable strategic leverage in dealing with rival powers. The area also has numerous immediate security issues that may either directly threaten India's interests or otherwise require it to act as a regional maritime security provider, including piracy and smuggling, maritime terrorism, the activities of separatist movements in Sri Lanka, Myanmar, Thailand, and India, and territorial disputes over offshore energy resources.India's second set of strategic objectives in Southeast Asia stems from its desire to expand its strategic role in Southeast Asia and further into the Pacific. India is driven by an imperative to balance China's growing influence in Southeast Asia as well as its aspirations to expand its own strategic space. India has been relatively successful in recent years in expanding its influence in Southeast Asia in a cooperative and relatively benign manner. It has little choice but to proceed in that way. India's lack of strength compared with other major powers, particularly China, means it must remain flexible and discreet in its engagement with Southeast Asia with the expectation that its relative power will grow in coming decades.

Despite these imperatives, India does not yet have a clearly articulated strategy for its defense engagement with Southeast Asia. New Delhi has made it clear that closer defence relations with Southeast Asia is a key part of its Look East policy through which India has sought to develop a comprehensive economic, political, and security relationship with the region. At a diplomatic level, India has engaged in regional security groupings such as the ASEAN Regional Forum, the Shangri-La Dialogue and the ASEAN Defence Ministers + 8 meetings, as well as establishing regular bilateral dialogues at Defence Minister level with key states such as Singapore, Vietnam, Indonesia, Malaysia, and Thailand. New Delhi has frequently allowed the Indian Navy to lead the way in building military-to-military relationships. This has involved developing a naval presence where it could through regular exercises, coordinated patrols and ship visits. The Indian Navy has also sought to emphasize its role as a leading provider of public goods to the region, including in areas such as piracy, smuggling, maritime terrorism, and humanitarian and disaster relief. Through these means, India is seeking its gradual acceptance over time as a benign power and a preferred security partner to ASEAN, if one having a somewhat undefined role.

Although India is a strong supporter of ASEAN as a regional organization, the lack of a regional defence policy among ASEAN states means that most engagement takes place at a bilateral level. India's initial focus in expanding its influence into Southeast Asia has been on Singapore, which historically recognized India as being a natural security provider to the region. India has also had a political alliance with Vietnam stemming from the Cold War era, but which has been revived in recent years. But India will need to make considerable investments of resources and political will to develop other partners in the region, some of which have been more hesitant in recognizing India's regional security role.

India's Leading Maritime Security Role in the Indian Ocean The starting point in any discussion of India's defence strategy in Southeast Asia is India's leading maritime security role in the Indian Ocean. Key ASEAN states such as Indonesia, Malaysia, Thailand, Singapore, and Myanmar lie on or near these waters. India's role in this area is a function of its geographic advantages, its relative capabilities and its perceived strategic imperatives. India has dominated the northeast Indian Ocean since at least 1971, when the separation of Bangladesh from Pakistan removed any challenge to its position from any potential rival. India's successful naval blockade of Bangladesh severely inhibited Pakistan's ability to defend the territory and was an important reminder of the strategic consequences of control over the Bay of Bengal/Andaman Sea.

In recent years, India has been reinforcing its capabilities in the Indian Ocean. Much of India's naval modernization program over the last decade has focused on improving its capabilities. There has been an effective "rebalancing" of the proportion of defence resources committed to the India's eastern waters, reflecting relatively reduced conventional maritime threat perceptions in relation to Pakistan and relatively increased threat perceptions in relation to China. This rebalancing includes the planned construction of a major new base for the Eastern Fleet south of Visakhapatnam on India's east coast, with capacity for two aircraft carriers and nuclear submarines, among other things.

India dominant strategic position in the Indian Ocean is underpinned by its possession of the Andaman and Nicobar islands, which run north-south through the Andaman Sea near the western end of the Malacca Strait. As K. M. Panikkar once commented, the Andaman and Nicobar Islands potentially give India strategic bases "which if fully utilised in coordination with air power can convert the Bay of Bengal into a secure area."2 These islands also form a natural base for India to project power into the Malacca Strait and beyond into the South China Sea. They also have the poten-tial to dominate the Malacca Strait and have been described by a Chinese naval writer as constituting a "metal chain" that could lock the western end of the Malacca Strait tight.

Beginning in the mid-1990s, India developed extensive military facilities in the Andaman and Nicobar Islands, including port facilities to service elements of the Eastern Fleet and air bases for surveillance and strike aircraft. The operational radius of aircraft based in, or staging through, the Andaman's encompasses the Malacca Strait and large portions of the South China Sea. Under a plan announced in 2010, there will be a major development of military infrastructure, including runway upgrades and the development of port infrastructure for use by major vessels. In addition, there will be a permanent deployment of UAVs and an expansion of the 3,500-strong army brigade to divisional strength.5 In July 2012, the Indian Navy opened a new forward air base on Great Nicobar, at the northern end of the Malacca Strait, which will be used primarily for maritime surveillance. However, the Indian Air Force has not yet permanently deployed frontline strike aircraft in the islands.

Over the last two decades, the Indian Navy has played a leading role in developing cooperative security relationships with several ASEAN states bordering the Bay of Bengal/Andaman Sea, including through conducting joint naval patrols, bilateral exercises, and hosting the biennial MILAN "gathering" of regional navies at Port Blair in the Andaman Islands. The absence of the United States and China from the MILAN meetings is a none-too-subtle reminder of India's assertion of regional leadership. As the same time, the Indian Navy has made considerable efforts to prove itself the leading provider of public goods to the region, providing maritime security in areas such as piracy, smuggling, refugees, terrorism and separatism. The Indian Navy has also demonstrated its capabilities to provide humanitarian assistance and disaster relief to several ASEAN states, including following the 2004 Tsunami, which affected much of the northeast Indian Ocean, the 2007 Cyclone Sidr in Bangladesh, and 2008 Cyclone Nargis in Myanmar. All of these initiatives help legitimize India's naval presence in the region.

India's Maritime Security Ambitions in the Malacca Strait

A focal point of India's maritime security ambitions in the northeast Indian Ocean is its ambitions in the Malacca Strait, which is identified by the Indian Navy as part of its "primary area of interest." The Malacca Strait is the primary route for sea traffic between the Indian and Pacific Oceans and one of the world's busiest waterways, including a projected 140,000 ship movements per annum by 2020. Around one third of global trade and the bulk of energy supplies from the Middle East to East Asia transit it. An ability to exert negative control over the Strait would be significant for India's strategic role in Southeast Asia, and indeed the entire Indian Ocean. Some claim that for India the Strait represents a rough counterpart to the strategic importance of the Panama Canal to the United States.8 Kaplan describes the Strait as being as strategically significant in coming decades as was the Fulda Gap during the Cold War.

India's defense facilities in the Andaman and Nicobar Islands provide it with considerable measure of potential control over the western approaches to the Malacca Strait. Over the last decade India has also sought to develop an active security role—either direct or indirect—inside the Strait. At the turn of this century there were considerable concerns about piracy and the potential for maritime ter-rorists to block use of the Strait. In 2002, following an unsolicited request from the United States, India provided naval escorts for high-value commercial traffic through the Strait as part of the US-led Operation Enduring Freedom. India's participation in the operation was supported by Singapore (which hosted Indian naval vessels), and India is believed to have consulted Malaysia and Indonesia as well as the Philippines and Australia on the initiative. As the Chairman of the U.S. Joint Chiefs of Staff, General Pace, commented in 2006, the United States was "very comfortable with the fact that India has offered its assistance" in providing security in the Strait.

Most ASEAN states now see India's defence presence in the Indian Ocean in relatively benign terms and regard India as a net security provider. This contrasts with a degree of unease felt in the region during the 1980s about India's ambitious naval modernization plans and what was seen to be its opaque intentions. Regional perspectives about India also contrast sharply with perspectives on China's naval build up in the South China Sea, which is now seen as a major destabilizing factor in the region. But India's ambitions in the Malacca Strait are seen somewhat differently from its presence in the Bay of Bengal/Andaman Sea and there seems little prospect at the moment that all the littoral states will agree to giving India a direct security role in the Strait. Among other things, there are few immediate security threats (such as piracy and maritime terrorism) to be addressed and any Indian naval presence in the Strait would likely be regarded as highly provocative by China. But if the security environ-ment changes and littoral states come under increased pressure to take action on Strait security they may allow India to participate in Strait security on their terms. Any secu-rity role for India would be a significant, not only with respect to the Malacca Strait, but also in legitimizing India's claims to be a benign security provider to the region as a whole.

India's Defence Engagement with Southeast Asia

India's second set of strategic objectives in Southeast Asia relate to its broader ambitions to expand its political and security role in the region. India is driven not only by an imperative to balance China's growing influence in Southeast Asia but also by its aspirations to expand its own strategic space into the region as part of its own growing economic and military power. Several Southeast Asian states are encouraging India to play a greater role in the region as a useful balance to China.

The United States is also encouraging India to assume a greater role in the Southeast Asian balance of power, including through developing its defence relationships with U.S. allies and friends in the region. Washington is also actively promoting the idea of the "Indo-Pacific" as a single security region, which justifies India playing a greater political and defence role in East Asia/Pacific. In the longer term this includes poten-tially assuming a direct security role in the Malacca Strait and the South China Sea. The United States hopes that India might become an important political partner in East Asia, which can help bolster its efforts to temper China's strategic ambitions.

The majority of ASEAN states have, to a greater or lesser degree, welcomed an increased regional role for India, including in maritime security. Many now see India as potentially playing an important role in the regional balance of power through helping to ensure a balanced distribution of power in the region, alongside other key extra-regional

powers such as the United States, China, Japan and Australia. Singapore, in particular, has consistently welcomed and encouraged a balanced role for external security providers on the basis that competition between major regional powers "must be squarely confronted and cannot be wished away."Singapore's conception of a "balance of power" involves a multipolar balance that provides freedom to smaller states. As the Prime Minister Lee Hsien Loong has argued, Singapore's concept of a balance of power "depends on the competing interests of several big powers in the region, rather than on linking the nation's fortunes to one overbearing power. The big powers can keep one another in check, and will prevent any one of them from dominating the entire region, and so allow small states to survive in the interstices between them."

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HOW BALOCHISTAN BECAME A PART OF PAKISTAN – A HISTORICAL PERSPECTIVE

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INTRODUCTION:

Baluchistan consists of the south west of Pakistan. In the west it borders with Afghanistan and Iran and in the south, it has the Arabian Sea. It accounts for nearly half the land mass of Pakistan and only 3.6% of its total population. The province is immensely rich in natural resources, including oil, gas, copper and gold. Despite these huge deposits of mineral wealth, the area is one of the poorest regions of Pakistan. A vast majority of its population lives in deplorable housing conditions where they don't have access to electricity or clean drinking water. Before the partition of India and Pakistan, Balochistan consisted of four princely states under the British Raj. These were Kalat, Lasbela, Kharan and Makran. Two of these provinces, Lasbela and Kharan, were fiduciary states placed under Khan of Kalat's rule by the British, as was Makran which was a district of Kalat. Three months before the formation of Pakistan, Muhammed Ali Jinnah had negotiated the freedom of Baluchistan under Kalat from the British. Discussions were made about Kalat's relationship with Pakistan as it was formed. This ensued a series of meetings between the Viceroy, as the Crown's Representative, Jinnah and the Khan of Kalat. This resulted in a communique on August 11, 1947, which stated that: a. The Government of Pakistan recognizes Kalat as an independent sovereign state in treaty relations with the British Government with a status different from that of Indian States. b. Legal opinion will be sought as to whether or not agreements of leases will be inherited by the Pakistan Government. c. Meanwhile, a Standstill Agreement has been made between Pakistan and Kalat. d.

Role of Women in Tourism Sector

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There is no denying the fact that women in India have made a considerable progress in almost seven decades of Independence, but they still have to struggle against many handicaps and social evils in the male-dominated society. Many evil and masculine forces still prevail in the modern Indian society that resists the forward march of its women folk. It is ironical that a country, which has recently acclaimed the status of the first Asian country to accomplish its Mars mission in the maiden attempt, is positioned at the 29th rank among 146 countries across the globe on the basis of Gender Inequality Index. There has been amelioration in the position of women, but their true empowerment is still awaited.

Swami Vivekananda, one of the greatest sons of India, quoted that, “There is no chance for the welfare of the world unless the condition of women is improved, It is not possible for a bird to fly on only one wing.” Therefore, the inclusion of ‘Women Empowerment’ as one of the prime goals in the eight Millennium Development Goals underscores the relevance of this fact. Thus, in order to achieve the status of a developed country, India needs to transform its colossal women force into an effective human resource and this is possible only through the empowerment of women.

Causes for the conflict in Baluchistan

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Background:

The landscape of Baluchistan is comprised of an area over half a million square kilometers in the southeastern part of the Iran plateau, south of the central deserts and the Helmand river. The Baluchs are the main ethnic group in the province, followed by Pashtuns. The majority of the inhabitants are Sunni Muslims. A small number of Shia's and Hindus also reside in the province. The province is divided between three countries: Afghanistan, Pakistan and Iran. The largest part of Baluchistan belongs to Pakistan. In spite of the natural resources in the Baluchistan province including chromites, fluorite, marble, gold, gas, iron and petroleum which are of prominent importance , it has remained one of the poorest provinces in Pakistan. The province has been marginalized throughout history. The history of the conflict in the province goes back to the independence of Pakistan in 1947. The first conflict arose in 1948, when Kalat, a part of the current Baluchistan, chose independence. This was followed by further conflict in 1958-59 and 1963-69. These conflicts were about the One Unit policy and military bases in Baluchistan. In 1973-79 President Bhutto dismissed the provincial government of Baluchistan, which led to an armed insurgency and revolt. From 2005 to now, there have been several issues driving the protracted conflict in the province such as the attack on General Shujaat Zamir, Inspector of the Frontier Corps of Pakistan and his deputy in Baluchistan Province in 2005, killing of the 79 year old Baluch political leader Nawab Akbar Khan Bugti in 2006, detention of the two leaders of the Baluch movement in 2009, and the announcement of the Council for Independent Baluchistan by Mir Suliman Dawood the Khan of Kalat in late 2009. The Islamic Republic of Pakistan has accused the army of Baluchistan of engaging in violent incidents.

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Tourism Sector:

The hospitality sector is linked to the tourism sector. The sector that employs millions of Indians started bouncing back after the first wave, but the second wave of covid was back for the devastation! The tourism sector contributes nearly 7% to India's annual GDP. It comprises hotels, homestays, motels and more. The restrictions due to the second wave have crippled the tourism sector, which was already struggling to recover from the initial loss suffered by the businesses in 2020.

Aviation and Travel sector:

Aviation and other sector establishments faced a massive struggle during the second wave of the pandemic. The larger travel sector is also taking a hit as people are scared to step out of their homes. For airlines and the broader travel sector, its recovery will depend on whether people in future will opt for such services. At present, the outlook for the aviation and broader travel sector does not look good.

Automobile sector:

The automobile sector is expected to remain under pressure in the near term due to the covid-19 situation in India.

Real Estate and Construction sector:

The real estate and construction activities have started facing a disruption during the second wave as a large number of migrant workers have left the urban areas. The situation has not been grave as of 2020 for this sector.

Fiscal Deficit:

The Covid-19 pandemic has not affected our fiscal deficit and disinvestment target much. In this year's union budget, Finance minister Nirmala Sitharaman announced a fiscal deficit target of 6.8% for 2021 to 2022. India's fiscal deficit for 2020-21 zoomed to 9.5% of GDP as against 3.5% projected earlier. Our finance minister has promised to achieve a fiscal deficit of 4.5% of GDP by 2025-26 by increasing the steaming tax revenues through increased tax compliance as well as asset monetization over the years. According to the medium-term fiscal policy statement that the government had presented in February 2020, the fiscal deficit for 2021-22 and 2022-23 was at 3.3% and 3.1% respectively.

The impact of the lockdowns and restrictions:

The extents to which localised lockdowns and restrictions have been imposed in the past have impacted the economic recovery timeliness. There is a scope for sustained fiscal stimulus going throughout the year. To some extent, if credit is made available to businesses at low-interest rates, then monetary stimulus is also possible. The second wave has pushed back India's fragile economic recovery. Rising inequality and strained household balance sheets have constrained the recovery. From growing only 4% in 2019-20 to contracting 7-8% in 2020-21 to staring at another low economic growth recovery in 2021, India has been virtually stopped in all its tracks. Therefore, fiscal policy must lend a generous helping hand to lead vulnerable businesses and households towards economic recovery.

What is the path to recovery?

If the outbreak worsens over time, or if the case numbers are very high, this would elevate the risk to India's economic and fiscal recovery. The Indian economy should resume its recovery once the covid waves recede and the Indian economy will continue to grow at a faster pace than its peers at similar levels of per capita income around the world. On the downside, there will be less vigorous recoveries in the government revenues and severe downside scenarios may entail additional fiscal spending. Commodities and the automobile sector are severely affected by the initial stream of infections and associated lockdown measures. It recovered strongly in the second half of 2021.

The recovery in the global economy has made it unlikely that a sharp price decline like 2020 will happen again. The pent up demand in the automobile sector will likely drive a strong recovery when curbs are relaxed as was seen in 2020. The second wave of covid-19 has challenged an otherwise strong recovery for Indian Infrastructure. As consumers strive to maximize their utility, they will maintain earning due to regulated returns, fixed tariffs and quick recovery in demand. Airports are most at risk with international traffic recovery likely delayed by another year. This may impede a strong domestic recovery if the government increases the severity and scope of restrictions on mobility. A strong recovery is needed after a crushing 2020. As the outbreak grew worse the state governments have applied re-

strictive lockdown measures that halted the budding economic recovery in tracks.

Downgrades are a warning not to take economic recovery for granted. The slow pace of vaccinations is likely to be a burden on India's economic recovery. The Indian recovery has been vigorous across many sectors particularly in the last quarter of fiscal 2021. Halts to domestic air traffic and subdued international travel have dismantled recovery for airports. The covid wave has hit small and medium-size enterprises particularly hard. It has delayed recovery in banks' asset quality. Mobility has been down to 50-60% of the normal levels. Therefore, people are staying home more and spending less. Recovery will take hold later this year. India's budding economic recovery throughout March solidified government revenues.

Power Sector: The Indian power sector will generate huge revenues and it would track the recovery of the GDP of India.

Airports: The second wave has threatened India's air recovery traffic. The domestic passenger traffic has decreased by 75% of the pre-covid levels. The traffic recovery in the worst-case scenario could be 10% lower than what is predicted. Weaker traffic hits the cash flows of the airports. There will be a sharp recovery in road traffic after a short disruption. The commercial vehicle traffic will see better resilience as it supports logistics and essential services.

Ports: A modest recovery will be witnessed by import volumes. Fertilizers and containers will increase at a greater pace than crude and coal segments.

Operating cash flows will recover most infrastructure and utilities such as water, sewage, dams and natural gas segments. Credit loss will remain high in the fiscal year 2022 at 2.2% of the total loans before it recovers to 1.8% in 2023. India's strong economic recovery and the steps taken by the central governments and the state government to mitigate the effects of the economic crisis have lessened the burden on the banks. Additionally, banks have raised capitals to strengthen their balance sheets. This will smoothen the hit from covid related losses. The weak consumption accompanied by large scale job losses and the salary cuts in the formal sector may hit the banking sector's loans and 'credit card' loans. This is accompanied by lower recovery rates in the bank's non-performing assets. That could lead to a rise in weaker loans.

If we have to move towards sustained and real economic growth against v-shaped, k-shaped or w-shaped paths, the states and the centre need to work towards a cooperative strategy through their "cooperative federalism" scheme to increase the vaccination drive.

In 2020, the government chose life over livelihoods. By choosing to protect the former, the covid 1.0 was delayed in September and its intensity was much lower than predicted. By January 2021, the government had declared victory over covid-19. The first threat to economic recovery is the regional cases which are resulting in further extension of lockdowns and hence they are limiting the pace of economic recovery. The second threat is the vaccination rates arising from the vaccine supply. Without inoculating a major portion of our labour force, there is a threat that viruses will disrupt our real economy. It is apparent from the worldwide cases of Covid-19.

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Indians in Indonesia: A Study

Dr. G. Vijay Kumar Reddy

It must be a touch of magic that has drawn Indians to Indonesia for two millennia. Indians have historically made the journey to Indonesia - a name derived from the Latin Indus, meaning "India", and the Greek Nesos, meaning "island", in search of economic opportunities, to find sources of livelihood and success for themselves and their families.

The abundant friendly faces and easy smiles have captivated Indian migrants for centuries and even today, ask any Indian expatriate: they would like to grow roots in Indonesia. If they move to any other part of the world, they yearn to come back. It is like coming home, because after all, Indonesia is a cultural Godchild of India. The underlying philosophical concepts introduced since the 5th century by the Brahman priests have had a profound effect in shaping every facet of Indonesian society.

At present, individuals of Indian descent are found in nearly all sizeable towns of the Indonesian archipelago, from Banda Aceh at the northern end of the island of Sumatra to Jayapura in Irian Jaya, near the eastern boundary of the republic. However the Indian population is concentrated in Medan, Jakarta, Bandung and Surabaya. The Indians here form a continuum between two extremes. Between short term visitors with their homes in India at one extreme; and Indonesians of Indian descent who do not identify themselves as being Indian in any way, at the other extreme.

The Indian community of Indonesia is generally well-to-do. They have assimilated well, have cordial relationship with the local community as well as close connections with government officials and politicians. In the 20th century, Indian enterprise was characterized by the traders of Sindhi and Punjabi origin, who migrated and settled in Indonesia. They setup prominent businesses in textiles, garments, entertainment, sports goods, chemicals and general trading. The garment trade is still largely controlled by them in Indonesia.

The first Indian migrants came primarily from Gujarat in India during the first Christian era. This followed the introduction of the Sanskrit language which led to the development of the Kawi language and script. Early trade relations were established between India and the islands of Sumatra, called 'Swarna Dwipa' or "the island of gold," and 'Java Dwipa' or "the rice island". The influx of Indian settlers continued till the 16th century and this period is historically referred to as the Hindu-Indonesian period.

Indian culture and customs were introduced and soon colored the entire fabric of Indonesian society from government, military, literature, music and dances, architecture, and religious practices and rituals. The Hindu literary works known as Vedas and the "Mahabharata" and "Ramayana" epics gained popularity and continue to be an integral part of present day Indonesia.

The modern aspect of the relationship between the two countries grew out of their respective struggles for independence and through personal friendship between the leaders of the new nations - Sukarno, Mohammad Hatta, Sutan Sjahrir and Jawaharlal Nehru. "Today, India and Indonesia share a common commitment to democracy, pluralism and unity in diversity and at the same time face similar challenges and opportunities" said Indian President Pratibha Patil, during her last visit to Indonesia.

The recent global financial crisis has further put a spotlight on the tremendous inherent potential of the two nations. These growing economic powerhouses are being variously clubbed together. New areas of cooperation are being discussed and there is a renewed entrepreneurial effort by businessmen of both countries to capitalize on the burgeoning opportunities. The new Indian migrant to Indonesia is no longer ethno-centric but opportunistic and individualistic, investing in the shared bilateral dream. The sense of the local ethnic Indian Indonesian too has changed from a rigid network to a more flexible and social community due to increased acceptance and points of interaction. There is also a focus on community development and philanthropy, with a genuine feeling of oneness.

It is now that Indians in Indonesia, people who belong to many different regional and linguistic groups, castes, religions, and traditions are developing, with greater confidence, a sense of Indian identity, unity and sense of pride. They are indeed

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living up to their host country's official national motto Bhinneka Tunggal Ika - a unity that draws strength from diversity.

Although a predominantly Muslim region now, Java, home of Jakarta and the most densely populated of Indonesia's islands, has a long Hindu history. Figures from Hindu mythology continue to have a popular resonance here. Garishly painted advertisements on public buses, for example, market an energy drink called Kuku Bima Ener-G. The name is a reference to the mighty Pandava, Bhima (in fact the father of Gatotkatcha) also of Mahabharata fame. Kuku Bima Energ-G is, however, not to be confused with Kuku Bima, a traditional medicinal potion with benefits for "men's health." It transpires that in one of the Javanese versions of the Mahabharata, Bhima draws the irrigation lines of Java's rice fields with his fingernail. This is the allusion in the name Kuku Bima: a vitality drink!

Java's classical Hindu history means that living in Jakarta can feel like having wandered onto the set of a Mahabharata TV serial. People pepper ordinary conversation with words like "manushya" (man) and "karena" (because). The explanation lies in the fact that Sanskrit forms the basis for a substantial part of the vocabulary of Bahasa Indonesia, the national language.

Indians have been living in Indonesia for centuries, from the time of the Sri Vijaya and Majaphit Empire, both of which were Hindu and heavily influenced by the subcontinent. Indians were later brought to Indonesia by the Dutch in the 19th century as indentured labourers to work on plantations located around Medan in Sumatra. While the majority of these came from South India, a significant number also came from the north. The Medan Indians included Hindus, Muslims and Sikhs. They have now been in Indonesia for over four generations, and hold Indonesian passports. While local statistics continue to suggest that there are some 400 PIOs in Sumatra, the vast majority are now completely assimilated in Indonesian society, though some elements of the Tamil, Sikh and Bihari Communities still maintain their cultural traditions.

The Indian Diaspora also includes several thousand Sindhi families who constitute the second wave of Indian immigrants who made Indonesia their home in the first half of the 20th century. The Sindhi community is mainly engaged in trading and commerce. Among these communities, Tamils and to a lesser extent Sikhs were primarily engaged in agriculture, while Sindhis and Punjabis mainly established themselves in the textile trade and the sports business.

Tamils have lived in Indonesia since the 1930s; though predominantly in Medan, Tamil business men have set up various enterprises. Waves of expatriates speaking Tamil language have set up home in Indonesia. Indonesia Tamil Manram, a social organisation is very active In Jakarta. The organisation is also involved in welfare activities. Indonesian Tamil Manram also teaches the Tamil language to children with Tamil as their mother tongue, conducts interesting programs involving Tamil language and culture, distributes Tamil literature and books to children, organizes Tamil debates, dramas, dance and music programs for local talent, and brings reputable artists from India in the fields of dance, music, drama, and other cultural fields.

Many feel that India is becoming culturally individualistic and aggressive which stands in contrast to Indonesia. The latter is more collaborative in nature. "In Indonesia, the collaborative attitude actually flows from Hindu-Buddhist tradition, but the fear is that two may collide one day because of Make in India campaign," says Amol.

Life for an expat or person of an Indian origin is almost like a rhythm. "We follow every festival. We celebrate them together. Outside India, we are Indians first," says Shanti, an expat who lives in Jakarta. The religious festivals for Indians outside become cultural festivals, a glue which binds them over parochial difference of caste, language and religion. The other side, the majority too is religious and religious space is being contested between conservatives and people who want tolerant Islam.

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The evolution of Islamic Terrorism

Dr.G.Vijay Kumar Reddy

Definition of Terrorism

"The unlawful use of — or threatened use of — force or violence against individuals or property to coerce or intimidate governments or societies, often to achieve political, religious, or ideological objectives."

— U.S. Department of Defense publication

In the wake of the Sept. 11, 2001 terrorist attacks on the U.S., the threat of militant Islamic terrorism -- rooted in the Middle East and South Asia -- has taken center stage. While these extremely violent religious extremists represent a minority view, their threat is real. As pointed out by RAND's Bruce Hoffman, in 1980 two out of 64 groups were categorized as largely religious in motivation; in 1995 almost half of the identified groups, 26 out of 56, were classified as religiously motivated; the majority of these espoused Islam as their guiding force.

To better understand the roots and threat of militant Islam, here's a closer look at how modern terrorism has evolved in the Middle East and South Asia.

The Dawn of modern International Terrorism

The colonial era, failed post-colonial attempts at state formation, and the creation of Israel engendered a series of Marxist and anti-Western transformations and movements throughout the Arab and Islamic world. The growth of these nationalist and revolutionary movements, along with their view that terrorism could be effective in reaching political goals, generated the first phase of modern international terrorism.

In the late 1960s Palestinian secular movements such as Al Fatah and the Popular Front for the Liberation of Palestine (PFLP) began to target civilians outside the immediate arena of conflict. Following Israel's 1967 defeat of Arab forces, Palestinian leaders realized that the Arab world was unable to militarily confront Israel. At the same time, lessons drawn from revolutionary movements in Latin America, North Africa, Southeast Asia as well as during the Jewish struggle against Britain in Palestine, saw the Palestinians move away from classic guerrilla, typically rural-based, warfare toward urban terrorism. Radical Palestinians took advantage of modern communication and transportation systems to internationalize their struggle. They launched a series of hijackings, kidnappings, bombings, and shootings, culminating in the kidnapping and subsequent deaths of Israeli athletes during the 1972 Munich Olympic games.

These Palestinian groups became a model for numerous secular militants, and offered lessons for subsequent ethnic and religious movements. Palestinians created an extensive transnational extremist network -- tied into which were various state sponsors such as the Soviet Union, certain Arab states, as well as traditional criminal organizations. By the end of the 1970s, the Palestinian secular network was a major channel for the spread of terrorist techniques worldwide.

Key Radical Palestinian Groups

Popular Front for the Liberation of Palestine (PFLP): The PFLP, one of the original members of the PLO, [1] is a Marxist-Leninist group founded in 1967 by George Habash. The group was against the 1993 Declaration of Principles; participation in the PLO was also suspended. Participated in meetings with Arafat's Fatah party and PLO representatives in 1999 to discuss national unity but continues to oppose negotiations with Israel. Committed numerous international terrorist attacks during the 1970s, has allegedly been involved in attacks against Israel since the beginning of the second intifadah in September 2000. Syria has been a key source of safe haven and limited logistical support.

Front for the Liberation of Palestine-General Command (PFLP-GC): This group, led by Ahmed Jibril, split from the PFLP in 1968, wanting to focus more on terrorist than political action; violently opposed to the PLO and is closely tied to Syria and Iran. The PFLP-GC conducted multiple attacks in Europe and the Middle East during the 1970s and

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1980s. Unique in that it conducted cross-border operations against Israel using unusual means, including hot-air balloons and motorized hang gliders. Currently focused on small-scale attacks in Israel, the West Bank, and Gaza Strip.

Abu Nidal Organization (ANO): Anti-Western and anti-Israel international terrorist organization led by Sabri al-Banna; left the PLO in 1974. Organizational structure composed of various functional committees, including political, military, and financial. The ANO has carried out terrorist attacks in 20 countries, killing or injuring almost 900 persons. Targets have included the United States, the United Kingdom, France, Israel, moderate Palestinians, the PLO, and various Arab countries. Major attacks included the Rome and Vienna airports in December 1985, the Neve Shalom synagogue in Istanbul and the Pan Am flight 73 hijacking in Karachi in September 1986, and the City of Poros day-excursion ship attack in Greece in July 1988. Suspected of assassinating PLO deputy chief Abu Iyad and PLO security chief Abu Hul in Tunis in January 1991. ANO assassinated a Jordanian diplomat in Lebanon in January 1994. Has not attacked Western targets since the late 1980s. Al-Banna relocated to Iraq in December 1998, where the group maintains a presence. Financial problems and internal disorganization have reduced the group's capabilities; activities shut down in Libya and Egypt in 1999.

While these secular Palestinians dominated the scene during the 1970s, religious movements also grew. The failure of Arab nationalism in the 1967 war resulted in the strengthening of both progressive and extremist Islamic movements. In the Middle East, Islamic movements increasingly came into opposition with secular nationalism, providing an alternative source of social welfare and education in the vacuum left by the lack of government-led development -- a key example is The Muslim Brotherhood. Islamic groups were supported by anti-nationalist conservative regimes, such as Saudi Arabia, to counter the expansion of nationalist ideology. Yet political Islam, [2] more open to progressive change, was seen as a threat to conservative Arab regimes and thus support for more fundamentalist -- and extremist -- groups occurred to combat both nationalist and political Islamist movements.

Meanwhile, in Iran, a turn to revolutionary Shia Islam under the leadership of Ayatollah Khomeini further eroded the power and legitimacy of the U.S.-backed authoritarian Pahlevi regime, setting the stage for the Shah's downfall.

1979 - 1991: The Afghan Jihad and State Sponsors of Terrorism

The year 1979 was a turning point in international terrorism. Throughout the Arab world and the West, the Iranian Islamic revolution sparked fears of a wave of revolutionary Shia Islam. Meanwhile, the Soviet invasion of Afghanistan and the subsequent anti-Soviet mujahedeen war, lasting from 1979 to 1989, stimulated the rise and expansion of terrorist groups. Indeed, the growth of a post-jihad pool of well-trained, battle-hardened militants is a key trend in contemporary international terrorism and insurgency-related violence. Volunteers from various parts of the Islamic world fought in Afghanistan, supported by conservative countries such as Saudi Arabia. In Yemen, for instance, the Riyadh-backed Islamic Front was established to provide financial, logistical, and training support for Yemeni volunteers. So called "Arab-Afghans" have -- and are -- using their experience to support local insurgencies in North Africa, Kashmir, Chechnya, China, Bosnia, and the Philippines.

In the West, attention was focused on state sponsorship, specifically the Iranian-backed and Syrian-supported Hezbollah; state sponsors' use of secular Palestinian groups was also of concern. [3] Hezbollah pioneered the use of suicide bombers in the Middle East, and was linked to the 1983 bombing and subsequent deaths of 241 U.S. marines in Beirut, Lebanon, as well as multiple kidnappings of U.S. and Western civilians and government officials. Hezbollah remains a key trainer of secular, Shia, and Sunni movements. As revealed during the investigation into the 1988 bombing of Pan Am Flight 103, Libyan intelligence officers were allegedly involved with the Palestinian Front for the Liberation of Palestine -- General Command (PFLP-GC). Iraq and Syria were heavily involved in supporting various terrorist groups, with Baghdad using the Abu Nidal Organization on several occasions. State sponsors used terrorist groups to attack Israeli as well as Western interests, in addition to domestic and regional opponents. It should be noted that the American policy of listing state sponsors was heavily politicized, and did not include several countries -- both allies and opponents of Washington -- that, under U.S. government definitions, were guilty of supporting or using terrorism.

Key Radical Religious Groups

Hezbollah: Radical Shia group formed in 1982 in Lebanon. Strongly anti-Western and anti-Israeli. Closely allied with, and often directed by, Iran but may have conducted operations that were not approved by Tehran. Known or suspected to have been involved in numerous anti-U.S. terrorist attacks, including the suicide truck bombing of the U.S. Embassy and U.S. Marine barracks in Beirut in October 1983 and the U.S. Embassy annex in Beirut in September 1984. Elements of the group were responsible for the kidnapping and detention of U.S. and other Western hostages in Lebanon. The group also attacked the Israeli Embassy in Argentina in 1992 and is a suspect in the 1994 bombing of the Israeli cultural center in Buenos Aires. Operates in the Bekaa Valley, the southern suburbs of Beirut, and southern Lebanon. Has established cells in Europe, Africa, South America, North America, and Asia. Receives substantial amounts of financial, training, weapons, explosives, political, diplomatic, and organizational aid from Iran and Syria.

Egyptian Islamic Jihad (EIJ - Al-Jihad, Jihad Group, Islamic Jihad): Egyptian group active since the late 1970s. The EIJ is apparently split into two factions: one led by Ayman al-Zawahiri - who currently is in Afghanistan and is a key leader in the Usama bin Laden (UBL) network - and the Vanguards of Conquest (Talaa' al-Fateh) led by Ahmad Husayn Agiza. Abbud al-Zumar, leader of the original Jihad, is imprisoned in Egypt and recently joined the group's jailed spiritual leader, Shaykh Umar Abd al-Rahman, in a call for a "peaceful front." The group's traditional goal is the overthrow of the Egyptian Government and creation of an Islamic state. Given its involvement with UBL, EIJ is likely increasingly willing to target U.S. interests. The group has threatened to strike the U.S. for its jailing of Shaykh al-Rahman and the arrests of EIJ cadres in Albania, Azerbaijan, and the United Kingdom..

Palestinian Islamic Jihad (PIJ): The PIJ, emerging from radical Gazan Palestinians in the 1970s, is apparently a series of loosely affiliated factions rather than a cohesive group. The PIJ focus is the destruction of Israel and the creation of a Palestinian Islamic state. Due to Washington's support of Israel, the PIJ has threatened to strike American targets; the PIJ has not "specifically" conducted attacks against U.S. interests; Arab regimes deemed as un-Islamic are also threatened. The group has stated its willingness to hit American targets in Jordan. PIJ cadres reportedly receive funding from Tehran and logistical support from Syria.

Islamic Resistance Movement (HAMAS): Emerging from the Muslim Brotherhood during the first Palestinian intifadah (1987), HAMAS has become the primary anti-Israeli religious opposition in the occupied territories. The group is mainly known for its use of suicide bombers and is loosely organized, with centers of strength in Gaza and certain areas in the West Bank. HAMAS, while condemning American policies favoring Israel, has not targeted the U.S. directly.

Al-Gamaat Al-Islamiyya (IG - the Islamic Group, al-Gama'at, Islamic Gama'at, Egyptian al-Gama'at al-Islamiyya, GI): The IG, begun in the 1970s, is the largest of the Egyptian militant groups. Its core goal is the overthrow of the Cairo regime and creation of an Islamic state. The IG appears to be a more loosely organized entity than the EIJ, and maintains a globally present external wing. IG leadership signed Usama Bin Ladin's February 1998 anti-U.S. fatwa but has denied supporting UBL. Shaykh Umar Abd al-Rahman is al-Gama'at's spiritual leader, and thus the U.S. has been threatened with attack. From 1993 until the cease-fire, al-Gama'a launched attacks on tourists in Egypt, most notably the attack in November 1997 at Luxor that killed 58 foreign tourists. Also claimed responsibility for the attempt in June 1995 to assassinate Egyptian President Hosni Mubarak in Addis Ababa, Ethiopia. Has a worldwide presence, including Sudan, the United Kingdom, Afghanistan, Austria, and Yemen. The Egyptian Government believes that Iran, Bin Ladin, and Afghan militant groups support the organization.

1990 - 2001: The Globalization of Terror

The disintegration of post-Cold War states, and the Cold War legacy of a world awash in advanced conventional weapons and know-how, has assisted the proliferation of terrorism worldwide. Vacuums of stability created by conflict and absence of governance in areas such as the Balkans, Afghanistan, Colombia, and certain African countries offer ready made areas for terrorist training and recruitment activity, while smuggling and drug trafficking routes are often exploited by terrorists to support operations worldwide. With the increasing ease of transnational transportation and communication, the continued willingness of states such as Iran and Iraq to provide support, and dehumanizing ideologies that

enable mass casualty attacks, the lethal potential of terrorist violence has reached new heights.

The region of Afghanistan -- it is not a country in the conventional sense -- has, particularly since the 1989 Soviet withdrawal, emerged as a terrorist training ground. Pakistan, struggling to balance its needs for political-economic reform with a domestic religious agenda, provides assistance to terrorist groups both in Afghanistan and Kashmir while acting as a further transit area between the Middle East and South Asia.

Since their emergence in 1994, the Pakistani-supported Taliban militia in Afghanistan has assumed several characteristics traditionally associated with state-sponsors of terrorism, providing logistical support, travel documentation, and training facilities. Although radical groups such as the Egyptian Islamic Jihad, Osama bin Laden's Al Qaeda, and Kashmiri militants were in Afghanistan prior to the Taliban, the spread of Taliban control has seen Afghan-based terrorism evolve into a relatively coordinated, widespread activity focused on sustaining and developing terrorist capabilities. Since the mid-1990s, Pakistani-backed terrorist groups fighting in Kashmir have increasingly used training camps inside Taliban-controlled areas. At the same time, members of these groups, as well as thousands of youths from Pakistan's Northwest Frontier Province (NWFP), have fought with the Taliban against opposition forces. This activity has seen the rise of extremism in parts of Pakistan neighboring Afghanistan, further complicating the ability of Islamabad to exert control over militants. Moreover, the intermixing of Pakistani movements with the Taliban and their Arab-Afghan allies has seen ties between these groups strengthen.

Since 1989 the increasing willingness of religious extremists to strike targets outside immediate country or regional areas underscores the global nature of contemporary terrorism. The 1993 bombing of the World Trade Center, and the Sept. 11, 2001, attacks on the World Trade Center and Pentagon, are representative of this trend.

Key Groups in the New Phase of Militant Islamic Terrorism

Al-Qaeda (The Base): Established by Usama Bin Ladin (UBL) circa 1990, Al Qaeda aims to coordinate a transnational mujahideen network; stated goal is to "reestablish the Muslim State" throughout the world via the overthrow of corrupt regimes in the Islamic world and the removal of foreign presence - primarily American and Israeli - from the Middle East. UBL has issued three anti-U.S. fatwas encouraging Muslims to take up arms against Washington's "imperialism." Al Qaeda provides financial, manpower, transportation, and training support to extremists worldwide. In February 1998 bin Ladin issued a statement under the banner of "The World Islamic Front for Jihad Against The Jews and Crusaders," saying it was the duty of all Muslims to kill U.S. citizens, civilian or military, and their allies. Allegedly orchestrated the bombings of the U.S. Embassies in Nairobi, Kenya and Dar Es Salaam, Tanzania, on August 7, 1998. Claims to have been involved in the 1993 killing of U.S. servicemen in Somalia and the December 1992 bombings against U.S. troops in Aden, Yemen. Al Qaeda serves as the core of a loose umbrella organization that includes members of many Sunni Islamic extremist groups, including factions of the Egyptian Islamic Jihad (EIJ), the Gama'at al-Islamiyya (IG), and the Harakat ul-Mujahidin (HUM). The group is a prime suspect in the Sept. 11 attacks as well as the U.S.S Cole bombing.

Armed Islamic Group (GIA): Having initiated terrorist activities in 1992 following Algiers refusal to accept a democratically elected Islamist government, the GIA has conducted multiple mass killings of civilians and assassinations of Algerian leaders. While present in areas such as Yemen, the GIA reportedly does not target the U.S. directly. However, it is possible that GIA splinter movements or personnel may become involved in anti-U.S. action.

Aden-Abyan Islamic Army (AAIA): The Aden-Abyan Islamic Army is allegedly affiliated to the Yemeni Islamic Jihad and has been implicated in acts of violence with the stated goal to "hoist the banner of al-Jihad, and fight secularism in Yemen and the Arab countries." Aden-Abyan Islamic Army leader Zein al-Abideen al-Mehdar was executed for participating in the December 1998 kidnapping of 16 Western tourists. Four of the hostages were killed and another 13 hostages were freed when Yemeni security forces attacked the place where the hostages were being held. In March 1999 the group warned the U.S. and British ambassadors in Yemen to leave immediately.

Harakat ul-Mujahidin (HUM): Formerly part of the Harakat al-Ansar (HUA), the Pakistani-based HUM operates primarily in Kashmir. Long-time leader of the group, Fazlur Rehman Khalil, in mid-February stepped down; the popular Kashmiri commander

and second-in-command, Farooq Kashmiri, assumed the reigns. Khalil, who has been linked to Bin Ladin and signed his fatwa in February 1998 calling for attacks on U.S. and Western interests, assumed the position of HUM Secretary General. The HUM is linked to the militant group al-Faran that kidnapped five Western tourists in Kashmir in July 1995; one was killed in August 1995 and the other four reportedly were killed in December of the same year. Supporters are mostly Pakistanis and Kashmiris and also include Afghans and Arab veterans of the Afghan war. The HUM trains its militants in Afghanistan and Pakistan.

Jaish-e-Mohammed (Army of Mohammed): The Pakistan-based Jaish-e-Mohammed (JEM) has greatly expanded since Maulana Masood Azhar, a former ultra-fundamentalist Harakat ul-Ansar (HUA) leader, formed the group in February 2000. The group's aim is to unite Kashmir with Pakistan. It is politically aligned with the radical, pro-Taliban, political party, Jamiat-i Ulema-i Islam (JUI-F). The JEM maintains training camps in Afghanistan. Most of the JEM's cadre and material resources have been drawn from the militant groups Harakat ul-Jihad al-Islami (HUJI) and the Harakat ul-Mujahedin (HUM). The JEM has close ties to Afghan Arabs and the Taliban. Usama Bin Ladin is suspected of giving funding to the JEM. Group by this name claimed responsibility for the USS Cole attack.

Lashkar-i-Taiba (LT) (Army of the Righteous): The LT is the armed wing of the Pakistan-based religious organization, Markaz-ud-Dawa-wal-Irshad (MDI)--a Sunni anti-U.S. missionary organization formed in 1989. One of the three largest and best-trained groups fighting in Kashmir against India, it is not connected to a political party. The LT leader is MDI chief, Professor Hafiz Mohammed Saeed. Almost all LT cadres are foreigners--mostly Pakistanis from seminaries across the country and Afghan veterans of the Afghan wars. The LT trains its militants in mobile training camps across Pakistan-administered Kashmir and Afghanistan.

What produces terrorists and what conditions allow them to multiply in number and power in the Muslim world? While many studies point to the important role public opinion plays in creating an environment in which terrorist groups can flourish, relatively few works have explored survey data to measure support for terrorism among general publics.

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BILATERAL RELATIONS TO EXPORT AND IMPORT POWER BETWEEN INDIA AND CHINA

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ABSTRACT

The economic relations and international trade have assumed a considerable significance because of the key role they play in accelerating the pace of development and growth. The subject has since occupied Centre stage in the wake of recent worldwide economic development and growth. The successful conclusion of the prolonged GATT (General Agreement on Tariffs and Trade) at WTO (World Trade Organization) in 1995, multilateral trade negotiations and the thrust on globalization in the Third World has created unprecedented developments, which have exercised a profound impact on international trade. The Globalization, economic liberalization, structural reforms, and global integration have become a common phenomenon in the developing countries in recent years. In their efforts to activate international competitiveness in exports and to integrate their economies in the global economy, developing nations have started liberalizing their trade regimes and opening their markets for foreign competition. India's total trade with China in 2021 was worth $125.7 billion. The sharp uptick in imports on a large base has pushed India's trade deficit with China to a record high $69.4 billion in 2021, up from $45.9 billion in 2020 and $56.8 billion in 2019. Some of India's key imports from China include smartphones, components for smartphones and automobiles, telecom equipment, plastic and metallic goods, active pharmaceutical ingredients (APIs), and other chemicals. Experts have noted that players in the Indian electronic goods space are still largely focused on the assembly of products and did not have much discretion in sourcing of components. India's exports to China grew to $28.1 billion in calendar year 2021, up 34.9 per cent from exports worth $20.9 billion in 2020, which was impacted by Covid-19 related restrictions, according to Chinese government data. India's exports to China in 20201 were 56.5 per cent higher than exports in 2019, which was not impacted by the pandemic. Raw material exports constitute a significant portion of India's outbound trade with China with iron ore, organic

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The Impact of Covid-19 on Indian Economy

Dr.V.Ramesh Babu

As per the official data released by the ministry of statistics and program implementation, the Indian economy contracted by 7.3% in the April-June of 2021 year. This is the worst decline ever observed since the ministry had started compiling GDP stats quarterly in 1996. In 2020, an estimated 10 million migrant workers returned to their native places after the imposition of the lockdown. But what was surprising was the fact that neither the state government nor the central government had any data regarding the migrant workers who lost their jobs and their lives during the lockdown.

The government extended their help to migrant workers who returned to their native places during the second wave of the corona, apart from just setting up a digital-centralized database system. The second wave of Covid-19 has brutally exposed and worsened existing vulnerabilities in the Indian economy. India's $2.9 trillion economy remains shuttered during the lockdown period, except for some essential services and activities. As shops, eateries, factories, transport services, business establishments were shuttered, the lockdown had a devastating impact on slowing down the economy. The informal sectors of the economy have been worst hit by the global epidemic. India's GDP contraction during April-June could well be above 8% if the informal sectors are considered. Private consumption and investments are the two biggest engines of India's economic growth. All the major sectors of the economy were badly hit except agriculture. The Indian economy was facing headwinds much before the arrival of the second wave. Coupled with the humanitarian crisis and silent treatment of the government, the covid-19 has exposed and worsened existing inequalities in the Indian economy. The contraction of the economy would continue in the next 4 quarters and a recession is inevitable. Everyone agrees that the Indian economy is heading for its full-year contraction. The surveys conducted by the Centre for Monitoring Indian Economy shows a steep rise in unemployment rates, in the range of 7.9% to 12% during the April-June quarter of 2021. The economy is having a knock-on effect with MSMEs shutting their businesses. Millions of jobs have been lost permanently and have dampened consumption. The government should be ready to spend billions of dollars to fight the health crisis and fast-track the economic recovery from the covid-19 instigated recession. The most effective way out of this emergency is that the government should inject billions of dollars into the economy.

The GDP growth had crashed 23.9% in response to the centre's no notice lockdown. India's GDP shrank 7.3% in 2020-21. This was the worst performance of the Indian economy in any year since independence. As of now, India's GDP growth rate is likely to be below 10 per cent.

The Controller General of Accounts Data for the centre's fiscal collection indicates a gross-tax revenue (GTR) of rupees 20 lakh crore and the net tax revenue of rupees 14 lakh crore for 2020-21. The tax revenue growth will be 12 per cent, which would mean the projected gross and the net tax revenues for 2020-21 would be rupees 22.7 lakh crore and 15.8 lakh crore respectively.

This suggests some additional net tax revenues to the centre amounting to rupees 0.35 lakh crores as compared to the budget magnitudes. The main expected shortfall may still be in the non-tax revenues and the non-debt capital receipts. If we look down in the past, the growth rate for the non-tax revenues and non-debt capital receipts have been volatile, but if we add them together, they average to a little lower than 15% during the five years preceding 2020-21.

How have different sectors been affected due to Covid-19?

Hospitality Sector:

As many states have imposed localised lockdowns, the hospitality sector is facing a repeat of 2020. The hospitality sector includes many businesses like restaurants, beds and breakfast, pubs, bars, nightclubs and more. The sector that has contributed to a large portion of India's annual GDP has been hit hard by restrictions and curfews imposed by the states.

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ECONOMIC CO-OPERETION BETWEEN INDIA AND JAPAN

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ABSTRACT

The economic relations between India and Japan have vast potential for growth given the obvious complementarities that exist between the two Asian economies. Japan's interest in India is increasing due to variety of reasons including India's huge and growing market and its resources, especially the human resources. The signing of the historic India-Japan comprehensive economic partnership agreement (CEPA) and its implementation from august 2011 is expected to further accelerate growth of trade, economic and commercial relation between the two countries. India-Japan economic cooperation has also grown over the past few years Japan currently holds the position of India's 4th largest investor. In the financial year 2015-16 India and Japan bilateral trade stood at US$14513 millions along with a cumulative figure of US$ 19.43 billion of Japanese foreign investment into India over the time period from 2000 to December 2015. The two countries can also be seen engaging in crucial economic initiative figure including 2011 joint CE+PA. Which seeks to eliminate around 94% of the tariff between Japan and India within 10 years Japan and India committed to working together to promote peace stability and prosperity through economic growth and development in the Indo Pacific including Africa enhancing connectivity through quality infrastructure and capacity building of our partner.

KEYWORDS: Co-Operetion, India, Japan, Economic

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Exports and Imports between India and Japan: A Study

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Abstract

While on one hand, the Japanese open market has not seen growing in the product zones of India's interest, Indian business bits and pieces are opposite problems in market place right to use. Indian business would, consequently, have the option of taking part in this process of investment generated trade. The other route of admittance of India's export sectors into Japan will require language proficiency, transferring a simplified framework for market access and continuous trade elevation efforts on the part of businesses and the Government. The Government will, therefore, run exceptional programmes for trade promotion in Japan in identified segments such as textiles, garments, information technology services, pharmaceuticals, leather products and agro handled products. India and Japan was bilateral trade in 2018-19 was neighbouring to US$ 18 billion. Exports from Japan to India throughout this old-fashioned be situated US$ 12.77 billion and imports be located US$ 4.86 billion. Japan's exports to India stood 2.48 per cent of India's entire imports and India's exports to Japan be situated 1.47 per cent of India's total exports. India's primary transport crossways to Japan are petroleum foodstuffs, chemicals, fundamentals, complexes, non-metallic mineral squander, fish and fish arrangements, metalliferous ores and disagreement, sartorial and equipment, iron and steel products, textile yarn, materials and equipment . India's top three imports from Japan in 2010-11 had been sustained the same in 2018-19. These be made up of nuclear-powered reactors, boilers, equipment and mechanical utilisations electrical machinery, iron and steel. In 2010-11 these three import groups reported for from place to place 55 per cent of India's imports their share in 2018-19 fell to 48 per cent. A noteworthy strengthening in the imports of copper and its apprenticeships from Japan was experimental in 2018-19 - from 0.3 per cent in 2010-11 to 2.87 per cent in 2018-19.

India-China Political and Economic Relations: An Overview

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Abstract

India and China are not mere societies they are civilizations. We do not know exactly when and how they started exchanging their cultural elements, but we do know that they grew in parallel and shared their cultural traits since the beginning of human history and this tradition of sharing has continued ever since. Even before the advent of Buddhism, the Shang-Zhou civilization and the ancient Vedic civilization in 1500-1000 B.C. showed some evidence of conceptual and linguistic exchanges. For instance,"wumingzhi" (nameless finger) in Chinese is called "anamika" (nameless) in Sanskrit and in Pali. Similarly, some ancient Indian literature mentions "chinas" referring to the Chinese people. Higher political level contacts were revived by the visit of the then External Affairs Minister, A.B. Vajpayee in February 1979. The Chinese Foreign Minister Huang Hua paid a return visit to India in June, 1981. Prime Minister Rajiv Gandhi visited China in December 1988. During this visit, both sides agreed to develop and expand bilateral relations in all fields. It was also agreed to establish a Joint Working Group (JWG) - to seek fair, reasonable and mutually acceptable solutions on the boundary question - and a Joint Economic Group (JEG). From the Chinese side, Premier Li Peng visited India in December 1991. Prime Minister Narasimha Rao visited China in September 1993. India and China shared deep cultural norms, primarily through Buddhism, which shaped both societies. India's famous Nobel Laureate, Rabindranath Tagore, took a leading role in the modern cultural exchange between India and China. Chinese philosopher Hu Shih once said that India conquered China culturally for 20 centuries without ever sending a soldier across its border, which symbolizes the rich history of cultural ties between the two civilizations.China was one of the co-sponsors of the UN resolution designating June 21 as the International Day of Yoga.The two countries have established pairs of sister cities and provinces. Examples are Fujian Province, Tamil Nadu State, Quanzhou City, and Chennai City.India-China bilateral trade which was as low as US$ 2.92 billion in 2000 reached US$ 41.85 billion in 2008, making China India's largest trading partner in goods. By 2015, as per DGC&IS provisional data India-China bilateral trade stood

AN OVERVIEW OF DIGITAL BANKING SYSTEM IN INDIA

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ABSTRACT

Digital India Program was launched by Prime Minister Narendra Modi on July1, 2015. In the opening speech of this program he has been mentioned his dream from digital India i.e. for driving innovation, knowledge is strength and empowers the people, access of information knows no barrier, government is open and governance is transparent, technology ensures the citizen government interface is morally upright, governmental services are easy and efficiently available to citizens on mobile devices, government productivity engaged with people through social media, superiority education reaches the most inaccessible corners driven by digital learning, excellence health care percolates right up to remotest region powered by e health care, formers are empowered with real-time information to the connected with global market, mobile enable emergency services ensures personal security, cyber security is integral part of national security, mobile and E-banking ensures financial exclusion, ecommerce drive entrepreneurship , world looks to India for next big idea. Digital India attracted more than 4 lakh crore investments and generated more than eighteen lakh job opportunists at its launch. Second highest import category in India is electronics goods in country. This truth is hard to understand because India has largest number of IT professional and very large MSME (Micro, small and Medium) scoter still it has not developed its capabilities to manufacture in this sector. The Government has been made the strategy with a vision to make net zero import of this category. "The digital India and making in India programme is a flagship programme of the government of India with a hallucination to transform India into a digitally empowered society and knowledge economy" The ATM is the most well-known device in India, Automatic Teller Machine (ATM) the ATM is the most famous device in India, which enables customers to pull back their money 24 hours every day, 7 days per week.

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Original Research Paper

Management

INDIA-ASEAN DEFENCE COOPERATION

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KEYWORDS :

India's defence strategy towards Southeast Asia can be understood in terms of two broad sets of strategic objectives that together drive India's relationships in the region. These include its ambitions to be the predominant power in the Ocean and a broader objective to assume a greater strategic role in Southeast Asia and the Pacific. India's aspirations to increase its defence presence in the region are broadly consistent with the perspectives of many ASEAN states, which mostly see India as a positive factor in the Southeast Asian balance of power. But India is yet to demonstrate itself as a useful and consistent security partner for much of the region. India is hindered by a lack of strategic focus and planning that is consistent with many of its strategic relationships

New Delhi sees several strategic imperatives to be the predominant power in the Indian Ocean, which includes the huge bay comprised of the Bay of Bengal and Andaman Sea. For India, the northeast represents a key defensive space against potential threats that may emanate from or through the Southeast Asian archipelago. The ability to control the sea lines of communication that cross the Bay of Bengal and Andaman Sea and enter the Pacific Ocean through the Malacca Strait would also pro-vide India with considerable strategic leverage in dealing with rival powers. The area also has numerous immediate security issues that may either directly threaten India's interests or otherwise require it to act as a regional maritime security provider, including piracy and smuggling, maritime terrorism, the activities of separatist movements in Sri Lanka, Myanmar, Thailand, and India, and territorial disputes over offshore energy resources.India's second set of strategic objectives in Southeast Asia stems from its desire to expand its strategic role in Southeast Asia and further into the Pacific. India is driven by an imperative to balance China's growing influence in Southeast Asia as well as its aspirations to expand its own strategic space. India has been relatively successful in recent years in expanding its influence in Southeast Asia in a cooperative and relatively benign manner. It has little choice but to proceed in that way. India's lack of strength compared with other major powers, particularly China, means it must remain flexible and discreet in its engagement with Southeast Asia with the expectation that its relative power will grow in coming decades.

Despite these imperatives, India does not yet have a clearly articulated strategy for its defense engagement with Southeast Asia. New Delhi has made it clear that closer defence relations with Southeast Asia is a key part of its Look East policy through which India has sought to develop a comprehensive economic, political, and security relationship with the region. At a diplomatic level, India has engaged in regional security groupings such as the ASEAN Regional Forum, the Shangri-La Dialogue and the ASEAN Defence Ministers + 8 meetings, as well as establishing regular bilateral dialogues at Defence Minister level with key states such as Singapore, Vietnam, Indonesia, Malaysia, and Thailand. New Delhi has frequently allowed the Indian Navy to lead the way in building military-to-military relationships. This has involved developing a naval presence where it could through regular exercises, coordinated patrols and ship visits. The Indian Navy has also sought to emphasize its role as a leading provider of public goods to the region, including in areas such as piracy, smuggling, maritime terrorism, and humanitarian and disaster relief. Through these means, India is seeking its gradual acceptance over time as a benign power and a preferred security partner to ASEAN, if one having a somewhat undefined role.

Although India is a strong supporter of ASEAN as a regional organization, the lack of a regional defence policy among ASEAN states means that most engagement takes place at a bilateral level. India's initial focus in expanding its influence into Southeast Asia has been on Singapore, which historically recognized India as being a natural security provider to the region. India has also had a political alliance with Vietnam stemming from the Cold War era, but which has been revived in recent years. But India will need to make considerable investments of resources and political will to develop other partners in the region, some of which have been more hesitant in recognizing India's regional security role.

India's Leading Maritime Security Role in the Indian Ocean The starting point in any discussion of India's defence strategy in Southeast Asia is India's leading maritime security role in the Indian Ocean. Key ASEAN states such as Indonesia, Malaysia, Thailand, Singapore, and Myanmar lie on or near these waters. India's role in this area is a function of its geographic advantages, its relative capabilities and its perceived strategic imperatives. India has dominated the northeast Indian Ocean since at least 1971, when the separation of Bangladesh from Pakistan removed any challenge to its position from any potential rival. India's successful naval blockade of Bangladesh severely inhibited Pakistan's ability to defend the territory and was an important reminder of the strategic consequences of control over the Bay of Bengal/Andaman Sea.

In recent years, India has been reinforcing its capabilities in the Indian Ocean. Much of India's naval modernization program over the last decade has focused on improving its capabilities. There has been an effective "rebalancing" of the proportion of defence resources committed to the India's eastern waters, reflecting relatively reduced conventional maritime threat perceptions in relation to Pakistan and relatively increased threat perceptions in relation to China. This rebalancing includes the planned construction of a major new base for the Eastern Fleet south of Visakhapatnam on India's east coast, with capacity for two aircraft carriers and nuclear submarines, among other things.

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Original Research Paper

Education

CAMBODIA-FLOATING VILLAGE KAMPONG SEAM REAP

Dr. M. Padmaja Associate Professor, CSEAPS, S.V.University, Tirupati.

KEYWORDS :

Lord Venkateswara is known has Kaliyugavaryukuntam situated in TirumalaTirupatiAndhraPradesh India. It was constructed and developed by Krishna devarayalu andSalvanarasimharayalu. Lord Vishnu temple at Angkor watSiem reap is the largest temple, with area 500 akers in Cambodia. I went to Cambodia on December 2022 and visited Angkor wat at that time I visited Kampong floating Village. As an Anthropologist I surprised a lot how people are living in this village in the floating water.

The village consist houses, schools, temples, health centers what not it consists of each and everything else. The flora and fauna covered with greenary and the trees remain in the floating water with their fixed roots the areas is abundant with dogs and pigs few birdsand aquatic creatures.

The people come from the various countries visit the floating village. Watch Sun rise and Sun set. The sun set which we see can feel the excitement because the Sun is sinking into the sky . I asked people who live there how they constructed wooden houses remain safely in the water. They answered isthat isthe pine wood they used for construction of houses. Stay secure and this is the Characteristic of pine wood of Sieam Reap. At first when we want enter into big boat they pay 60 dollars and after reaching the point there is a wooden hotel later a small boat intelugu we know it as theppa, and we should pay 15 dollars each person.

The larger boat is moved by 12 years age boy persons and smaller boat is moved by Kampong women and they singing a song "Row row a boat" and their names are similar to Indian culture like Savithrie, Sakunthalai.

This is anexcellent examples this how Indian culture is diffusedsocial, culturally and religiously. First we have to remember Suryvarma and Jayavarma. who constructed Angkor wat at Cambodia and diffused Indian culture in Cambodian Khmers life.

Fishing:

The people livelihood is fishing in kampong village. with making fishing nets and catching fish and trading it. They live 15 feets space for wood pillars at base and then they construct houses in the first floor. The ground base is used for boat parking as we used for vehicles parking such as cars, two wheelers and bicycles . Tonal Sop is 16,000 square kilometers and nine meters deep during rainy season. In the dry season, that shrinks to 2,700 sq km and between 1 - 2 meters deep.

Because the water levels differ so drastically in dry and rainy season, fishing families who make their living on the lake began living in floating villages which move with the changing water levels Tonal Sop is one of the world's biggest inland fisheries. The annual income of households on the lake is under $500.A few years ago, in New York Times published a sad outlook for Tonal Sop lake, reciting the issues the floating villages of Tonal Sop face due to climate change and longer periods of droughts.

The ecosystem in the lake is changing, the catch of the fishermen is declining, and it is likely that the floating villages won't be able to sustain themselves in the future.



Sun Rise And Sun Set

Life in Kampong:

Row a boat is hard task and women row a boat to the lake and as we read in tale and moral stories. After reaching the point they pick lotus flowers from the running boat and present the flowers to us. This is an excitement feeling for us running in the boat in water and keeping stick in a hand into water. With all these emotional feelings one side with fear and other side with daring the excitement experiences and Pleasure. What a beautifully trip kampong floating village and experiencing the peoples livelihood in the floating village those who planning to Cambodia don't miss it. The floating markets of Bangkok with their colorful produce on adorable wooden boats floating through the city's canals. Most of Cambodia's floating villages are based on Lake Tonal Sop. Though this is the largest freshwater lake in South East Asia, this unique body of water changes drastically in size throughout the year. In the rainy season between June and October, the lake is massive, flooded with water from the Mekong River. In the dry season, from November to May, the lake shrinks to such a degree that its flow reverses to deposit water back into the Mekong



Participation In Field Work At Kampong Villlage In Cambodia

Life in a floating village means that every errand must be run by boat. Dropping the kids off at school or heading off to play

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SELF HELP GROUPS AND MICROFINANCE: A STUDY ON LIVELIHOOD AND EMPOERMENT OF THE PULLA YERUKULA TRIBE IN SPSR NELLORE DISTRICT OF ANDHRA PRADESH

[1]Dr. Bhargavanath. Valluru, [2]Dr. M. Padmaja

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Abstract: Self Help Groups (SHGs). Its participation has been tremendous changes in women livelihood and style of poor women and has empowered them at various levels not only as individuals but also as members of the family members of the community and the society as whole. They come together for the purpose of solving their common problems through self-help and mutual help. The more attractive scheme with less effort is "Self Help Group" (SHGs). It is a tool to remove poverty and improve the women entrepreneurship and financial support in India. The main objective of this paper Impact of Self Help Groups on Women Livelihood and Empowerment in Nellore, Gudur, Sydapuram, Nayudupeta, and Sullurpeta Mandals/villeges in Nellore District of Andhra Pradesh. In the present study, an attempt has been made to analyze the structure, conduct and performance of Pulla Yerukula descriptive tribal women by administering research design. STs, especially the Pulla Yerukula are the major population living in the project area.in collaboration with line departments Community development aimed at uplifting the downtrodden tribal community by undertaking various livelihood and empowerment activities through bank linkage. The main objective of this paper is the randomly collected basic data from 150 members of self-help groups who make a living from baskets weaving (Buttalu, Thattalu, Gampalu) products and seasonal business, from five Mandals/villages in the Nellore district of Andhra Pradesh. The study used primary data and secondary data for analysis according to the research paper set out in the result and findings of the study.

Keywords: Self Help Groups (SHGs), SHG Participation, Changing livelihood, Empowerment, Pulla Yerukula.

1. INTRODUCTION

When we think about tribal women, they are more backward and their social and economic empowerment issues are even more complicated. Microfinance alone cannot alleviate poverty. It needs a holistic approach to improve their employability status. This includes improved skill levels, attention to entrepreneurial aspect, market availability, problems, new technology etc. In this regard, the role of the Self-Help Group (SHG) is very important. The Government of India

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Original Research Paper

Law

MYNAMAR-MILITARY POWER- VIOLENCE

Dr. M. Padmaja

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KEYWORDS :

The old Burma is named as Myanmar and the capital city is Rangoon now replaced by the name Yagoon. Mynamar is peopled predominantly by Mongoloid groups composed of at least three major ethnic strains. These are : (1) the Tibeto-Burman people, Burmans, Kachins, Chins and sub-groups who speak the same basic language with variation and who form the great majority of the total population: (2) the Shan-Tai peoples, Shans, Karens, and their sub-groups who speak related languages and dialects-these two strains represent about eight percent each of the population, or sixteen who speak a as single group; (3) The Mons and sub-groups above men-common language with variations. The sub-groups above mentioned represent triable and other groupings who have acquired names as a result of tribal distinctions, dialect varoations, and identification in terms of hill or plains location. **(Helen G Trager)**

The present paper is based on secondary data . the paper focus its attention on Violence against women, Children, Rohingyas and the power of military in Myanmar. United states and some states at global level rising their hands for uplipment Burma peace and security.

Women and Gender Issues

There is no discrimination against the girl-child in Myanmar. The Myanmar National committee for Women's Affairs (MNCWA) held the First and Second National Women's Conference, in November, 1988 and June 2001 respectively. At the First Conference, the National plan of Action for Advancement of Women was discussed and adopted. At he second conference, the works implemented by the state/ Division Working Committees for Women's Affairs, at the grass-roots levels were reviewed, the constrains encountered were discussed and the future Plan of Actions recommended. In Myanmar 50.3% of the total population are women. Thus the women outnumber the men. The status of Myanmar women has alweys been high since the days of the Myanmar Kings. They enjoy equal rights as men. The legal system of Myanmar provides equal rights to women and men in the area of business and commerce. With regard to women in the profession, women outnumber men in the field of education and nursing, while 50% of women are doctors. There is a Myanmar saying: When a daughter is born parents usally say, "Assurance of an additional dish on the dining table". In Myanmar family, the husband and wife share equal household responsibilities. (Dr. M.Padmaja)

When the United Nations began its annual campaign to end violence against women 30 years ago, no one had Myanmar on their radar. But in recent years, Myanmar's military has escalated its use of sexual and gender-based violence to terrorize women and girls — most infamously against ethnic minorities, notably the Rohingya. Confronted by these atrocities, the international community has issued widespread demands for accountability and justice that have yet to come to fruition.

With reports of sexual and gender-based violence piling up in the [illegible] violence should pay particular attention to Myanmar — and the United States is in the perfect position to lead the way.

Since Myanmar's military seized control in a coup last February, women have emerged as symbols of defiance and as key leaders of resistance efforts. Generation Z women in particular have assumed prominent roles on the front lines of the civil disobedience movement. However, this has also put them at great risk. Since the coup, the junta has arrested more than a thousand women, many of whom have been held in interrogation camps in unknown locations and subjected to severe abuse.

Within months of the coup, evidence of this abuse began to pour in, as more and more women reported experiences of sexual assault at the hands of the military. Khin Lay, director of the Triangle Women Organization in Myanmar, says that women are most vulnerable when held alone during interrogation, enabling the police and military to act without wilnesses. **(Kathleen kuehnast Ph.D; Gabriela sagun)**

Violence against Children

Myanmar's military, known as the Tatmadaw, remains locked in an armed struggle with its own people, but the crisis barely reached the surface at last week's United Nations General Assembly meetings in New York. Officials from the United States and Malaysia met on the sidelines with representatives from Myanmar's National Unity Government, a cabinet formed by elected lawmakers ousted when the military seized power in February 2021. The United Nations has delayed responding to the junta's request for a seat; Myanmar's current representative at the United Nations, Kyaw Moe Tun, remains loyal to the overthrown government.

As diplomacy sputters, violence in Myanmar is spiraling. At least 11 children were killed on Sept. 16 when military helicopters fired on a school in Sagaing region, a resistance stronghold. The killing of students was shocking, but extreme violence has come to characterize the junta. The military allegedly rampaged through a village in Kachin State, burning down homes and killing civilians. These attacks followed a trend: The monitoring group Data for Myanmar said the military has torched more than 28,000 civilian homes since the coup, and August was the worst month on record.

Junta leader Min Aung Hlaing has had ample opportunity to make minor concessions to the international community, such as allowing a meeting with detained civilian leader Aung San Suu Kyi, that would have allowed him to reenter the fold without fundamentally threatening the military's power. At every turn, the regime has instead chosen the path least conducive to compromise. The July executions took place against a backdrop of global outcry, including from authoritarian Cambodian Prime Minister Hun Sen, who currently chaired the Association of Southeast Asian Nations. But like most of the junta's decisions since the coup, the killings were intended for a [illegible]

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Damaraju Pundarikakshudu's Dramas and its Impact on Freedom Movement in Andhra

- *Dr. V. Thimmappa,* Academic Consultant, Centre for Southeast Asia and Pacific Studies, Sri Venkateswara University- Tirupati.

Introduction :

Even a stony heart should melt if you see his play! After hearing his songs we have to jump in the freedom struggle with heroism! Damaraju Pundarikakshudu, a rare Telugu writer, who made the letters as a weapon, The English government, which was unable to restrain him despite banning his writings. In the days when the independence movement was in full swing, The British rulers considered writing and performing movement plays as an act of treason. Pundarikaksha was the warrior who put those threats under the palm of his hand. Pundarikaksha was jailed twice for creating opposition to the government with political dramas. The main reason why he became known as the first writer of national dramas in the country was *'Swarajya Sopanam'*.

The patriotic songs, anecdotes, burrakathas written by Pundarikakshu were not only appreciated by celebrities and scholars, but also penetrated the mouths of the average Indians and fostered nationalism in them. The drama 'Panchala Parabhavam' written by Pundarikakshu was a sensation at that time, incorporating the atrocity of Jallianwala Bagh in the story of Mahabharata'. The main objective of this paper is to understand how his Plays were played an important role to mobilize the common people into the main stream of freedom struggle. Through this article an analysis is made to highlight the core concept of the selected plays of Damaraju Pundarikashudu.

About the Author :

Damaraju was born on 6th July 1896 in Patibandla village of Pedkurapadu Mandal of Guntur (present Palnadu) district. His mother Rangamamba and Father Gopalakishnaiah, he studied schooling in Nuzivedu, later Damaraju went Guntur for Intermediate and completed BA and BL (Law) in Madras[1]. While studying on the one hand, on the other hand he sharpened his literature by criticizing the British tyranny and awakening people towards the national movement. Damaraju inspired from great National leaders like Gandhi, Tilak, Dadbai Nouroji and others. He started writings against the British atrocities. He wrote 9 Plays and 6 stories in 1921 he wrote a Drama i.e., *"Swarajya Sopanam"*[2] that was banned by the British Government.

The government not only banned the plays written by him but seized the copies and burnt them. During the national movement, he suffered from long-term illness as his lungs were damaged due to police baton charge[3]. Pundarikaksha was jailed twice for creating opposition to the government with political dramas. The main reason why he became known as the first writer of national dramas in the country was 'Swarajya Sopanam'. It is remarkable that the play was banned by the British government and published in 1961 after independence. As a Lawyer he fought for the rights of victims. Damaraju was died in 1975[4].

Let us start our analysis with some of the

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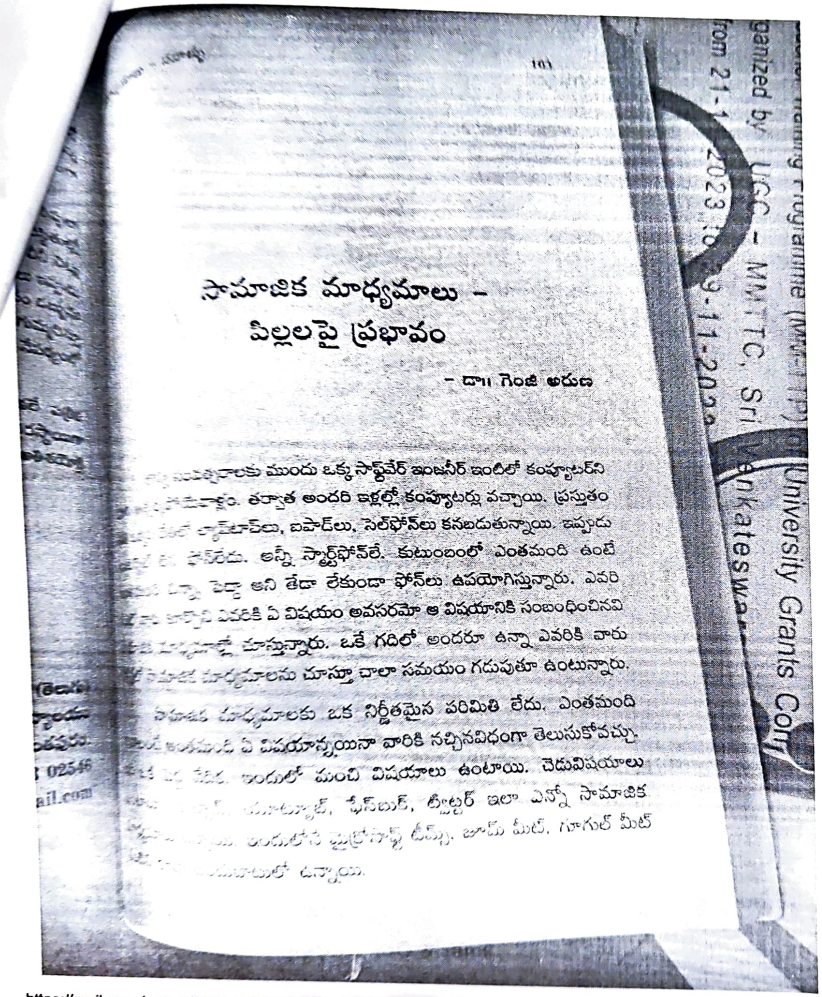
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సామాజిక మాధ్యమాలు - పిల్లలపై ప్రభావం

– డా॥ గెంజి అరుణ

...సాంకేతికాలకు ముందు ఒక్క సాఫ్ట్‌వేర్ ఇంజనీర్ ఇంటిలో కంప్యూటర్‌ని ...చూసేవాళ్ళం. తర్వాత అందరి ఇళ్లల్లో కంప్యూటర్లు వచ్చాయి. ప్రస్తుతం ...ఇంట్లో ల్యాప్‌టాప్‌లు, ఐపాడ్‌లు, సెల్‌ఫోన్‌లు కనబడుతున్నాయి. ఇప్పుడు ...ఫోన్‌లేదు. అన్నీ స్మార్ట్‌ఫోన్‌లే. కుటుంబంలో ఎంతమంది ఉంటే ...అన్నా పెద్ద అని తేడా లేకుండా ఫోన్‌లు ఉపయోగిస్తున్నారు. ఎవరి ...కార్యాని వివరికి ఏ విషయం అవసరమో ఆ విషయానికి సంబంధించినవి ...మాత్రమే చూస్తున్నారు. ఒకే గదిలో అందరూ ఉన్నా ఎవరికి వారు ...సామాజిక మాధ్యమాలను చూస్తూ చాలా సమయం గడుపుతూ ఉంటున్నారు.

...సామాజిక మాధ్యమాలకు ఒక నిర్దిష్టమైన పరిమితి లేదు. ఎంతమంది ...ఉపయోగిస్తున్నారు ఏ విషయాన్నయినా వారికి నచ్చినవిధంగా తెలుసుకోవచ్చు. ...ఇంటర్నెట్ ద్వారా ఇంటిలో మంచి విషయాలు ఉంటాయి. చెడువిషయాలు ...ఫేస్‌బుక్, ట్విట్టర్ ఇలా ఎన్నో సామాజిక ...ఇంటర్నెట్ ద్వారా ఇంటిలో ఉన్నాయి. ...ఫ్లిప్‌కార్ట్, ఫేస్‌బుక్, ట్విట్టర్ ఇలా ఎన్నో సామాజిక ...ఇంటర్నెట్ ద్వారా ఇంటిలో ఉన్నాయి. ...ఫ్లిప్‌కార్ట్, ఫేస్‌బుక్, ట్విట్టర్ ఇలా ఎన్నో సామాజిక ...ఇంటర్నెట్ ద్వారా ఇంటిలో ఉన్నాయి.

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1.శ్రీరాముని రథోత్సవం: మట్టి బుడిగీల ప్రయోజనాలు



ఆచార్య గెంజి అరుణ
శాఖాధ్యక్షులు, విదేశీ భాషలు & భాషాశాస్త్రవిభాగం
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వ్యాససంగ్రహం:

సంస్కృతి, సంప్రదాయాలకు, ఆచారవ్యవహారాలకు పుట్టినిల్లు మన భారతదేశం. సంస్కృతి సంప్రదాయాలను మన పండగలు ఉత్సవాలు తిరునాళ్లు తెలియజేస్తాయి. ఈ వ్యాసంలో విషయాలు క్షేత్రపర్యటన చేసి సేకరించివి, పూర్వపరిశోధనల్లోని పాందుపరిచినవి. జానపదవిజ్ఞానాన్ని ఐదు భాగాలుగా విభజించగా, అందులోని సాంఘికజానపద ఆచారాలు, జానపదవస్తుసంస్కృతి కిందకు ప్రస్తుత పరిశోధనాంశం చేరుతుంది. శ్రీరామనవమి పండుగకు తిరుపతిలోని శ్రీకోదండరామస్వామి ఆలయంలో జరిగే రథోత్సవాన్ని తిరుపతిలో నివసించే వారు భక్తిశ్రద్ధలతో ఏ విధంగా జరుపుకుంటారనే విషయాలను క్షేత్రపర్యటనలో సేకరించిన అంశాలపై పరిశోధనాత్మక విశ్లేషణలు ఈ వ్యాసంలో ఉన్నాయి. ఉత్సవంనాడు అమ్మబడే ప్రత్యేకమైన మట్టిపాత్రలు, వాటితోపాటు పిల్లలు ఆడుకునే బుడిగీలకు సంబంధించిన విషయాలు, ప్రయోజనాలు మొదలైన అంశాలను చర్చించడం ఈ వ్యాసం ప్రధాన ఉద్దేశం. మన సంస్కృతిసంప్రదాయాలు, ఆచారవ్యవహారాలు మరుగున పడిపోకుండా,వారసత్వంగా భావితరాలకు అందించాలనే ఆశయంతో ఈ పరిశోధనవ్యాసం రూపుదిద్దుకుంది.

Keywords: సంస్కృతి, సంప్రదాయం, వారసత్వం, ఆచార వ్యవహారాలు, రథోత్సవం, భక్తిశ్రద్ధలు మట్టి బుడిగీలు, ఉత్సాహం, పానకం, విసనకర్రలు. మానసిక పరిపక్వత.

1.ఉపోద్ఘాతం:

సంస్కృతి సంప్రదాయాలకు నిలువెత్తు నిదర్శనం పండుగలు. పండుగ అంటేనే ఆనందం, సంతోషం, ఉత్సాహం, భక్తి భావం, శ్రద్ధా అన్నీ కలగలిపి ఉంటాయి.పూర్వ పరిశోధకులు జానపద విజ్ఞానాన్ని ఐదు భాగాలు విభజించారు. అవి జానపదసాహిత్యం, సాంఘిక జానపద ఆచారాలు, వస్తు సంస్కృతి, జానపద కళలు, జానపదుల భాష .అందులో సాంఘిక జానపద ఆచారాలలో జానపద సాంఘిక ఆచారాలు ఒక భాగం. ఈ భాగంలో మనిషి పుట్టుక నుంచి చావు వరకు జరిగే కార్యక్రమాలు,నమ్మకాలు మూఢ విశ్వాసాలు,పండుగలు జాతరలు రాగా ఆటలు, వినోదాలు మరో భాగంగా ఉన్నాయి.



(క్షేత్ర పర్యటనలో భాగంగా కోదండ రామాలయం ముందు వ్యాసకర్త)

"తరతరాలుగా జన సమూహంలో నిలిచి ఉన్న నమ్మకాలు సంప్రదాయాలు క్రియ రూపాన్ని దాల్చగా పండగలు ఏర్పడ్డాయి." (ఆంధ్రుల జానపద విజ్ఞానం, పుట: 296)

పండుగకు పర్యాయపదాలుగా ఉత్సవాలు, తిరునాళ్లు, జాతరలను చెప్పుకోవచ్చు.

హిందువుల పండుగలలో శ్రీరామనవమి పండుగ ఒకటి. హిందువులు పూజించే వైష్ణవ దేవుళ్లలో శ్రీరామచంద్రుడు ఒకరు. చైత్ర శుద్ధ నవమి నాడు వచ్చే ఈ పండుగకు ముందుగా తిరుపతిలోని శ్రీ కోదండ రామస్వామి ఆలయంలో స్వామివారికి బ్రహ్మోత్సవాలు జరుగుతాయి. బ్రహ్మోత్సవాలలో రథోత్సవం అతి ముఖ్యమైనది. ఈ రథోత్సవాన్ని తిరుపతి వాసులంతా చాలా పవిత్రంగా, ముఖ్యంగా జరుపుకుంటారు.

"తెలుగు వారి పండుగలను ఒక్కొక్కసారి ప్రత్యేకంగా వివరించడం కష్టం ఉత్సవాలు, ఊరేగింపులు, జాతరలు కూడా ఒక విధంగా పండుగలే. నోములు వ్రతాలు పండుగలు కావని ఎవరనగలరు? అయినా మనం వాడుకునే పదాలను బట్టి వీటిలోనే కొన్నింటిని పండుగలని, కొన్నింటిని ఉత్సవాలని పిలవడం జరుగుతున్నది".

(ఆంధ్రుల జానపద విజ్ఞానం, పుట: 299).

కోదండ రామస్వామి తేరు అంటే ఒక పెద్ద పండగలాగా ఉంటుంది. అంగరంగ వైభవంగా రథోత్సవం జరుగుతుంది.



(కోదండరాముని రథోత్సవం)

2. ప్రాంతవిధానం:

రాముల వారి రథోత్సవం రోజున అందరూ నిద్రలేచి తల స్నానాలు గావించుకుని పరమ పవిత్రంగా రాముల వారిని రథం పైన దర్శించుకోవడానికి ఎంతో ఉత్సాహంగా ఆలయానికి వెళ్తారు. రాములవారి రథాన్ని లాగడానికి ఎంతో ఉత్సాహపడుతారు. ఒకరికొకరు సహాయ సహకారాలతో అందరు కలిసి రాముల వారి రథాన్ని మాడ వీధుల్లో ఊరేగింపుగా లాగుతారు. ఇసుక వేస్తే రాలనంత జనం స్వామివారిని దర్శించుకుంటారు. రథం లాగడానికి అడా మగా చిన్న పెద్ద అని తేడా లేకుండా ప్రతిఒక్కరూ రథాన్ని లాగుతారు.రథం లాగడం వారి పూర్వ జన్మ సుకృతంగా భావిస్తారు. రథం లాగేటప్పుడు రథంపైన ఉప్పు మిరియాలను భక్తులు చల్లుతారు. మిరియాలు చల్లడం వల్ల శరీరంపై వచ్చే "పులిపిర్లు పోతాయని నమ్ముతారు. అలాగే రథంపై చల్లిన మిరియాలను ఏరుకొని తింటే రోగాలు పోతాయని నమ్ముతారు". (జి. సరస్వతి,(70), కేశవయాని గుంట, తిరుపతి).

భక్తి పారవశ్యంతో గోవిందా! గోవిందా! అని నామ స్మరణ చేస్తూ అలాగే జై శ్రీ రామా, జై శ్రీరామా అని అంటూ భక్తులు రథాన్ని ఉత్సాహంగా లాగడం చేస్తారు. రథం లాగడం కూడా భక్తిలో ఒక భాగమే. రథం లాగే భక్తులు సంతోషంతో పులకించి పోతారు. ఏదో ఒక విధంగా స్వామివారికి సేవ చేసుకోవడం భక్తులు వారి భాగ్యంగా భావిస్తారు.రథం లాగి పూర్తయి యదాస్థానానికి రథం చేరిన తర్వాత భక్తులు హారతులు ఇచ్చి కొబ్బరికాయలు కొడతారు.యథాస్థానానికి చేరిన తర్వాత ప్రజల సందర్శనార్థం సీతా లక్ష్మణ సమేత రాముల వారిని రథం పైనే చాలా సేపు ఉంచడం జరుగుతుంది.

రథంపై స్వామి వారిని దర్శించుకోడానికి స్నేహితులతో చుట్టాలతో కలిసి వెళ్ళడం జరుగుతుంది.

3. దానధర్మాలు చేయడం:

ఏదో ఒక విధంగా స్వామివారి సేవకు పాత్రులు కావాలని భక్తులకు కోరికగా ఉంటుంది. అందులో భాగంగానే అనేక రకాలైన దానధర్మాలు చేస్తారు రాముల వారి రథోత్సవం నాడు కూడా కింది విధంగా దానధర్మాలు చేస్తారు.

3.1. పానకం:

శ్రీరాముడి రథోత్సవం రోజున మాడ వీధుల్లో వచ్చిన భక్తులకు పానకం పంచుతారు.పానకం పంచడం కూడా స్వామివారి సేవలో ఒక భాగంగా భావిస్తారు. వేసవికాలం అప్పుడే ప్రారంభం అవుతూ ఉంటుంది. కాబట్టి చలువ చేయడానికి, దాహార్తిని తీర్చడానికి అక్కడి స్థానికులు ఉత్సవానికి వచ్చే భక్తులకు పానకం పంచే ఆచారం ఉంది. భక్తులందరూ పానకాన్ని దేవుడి ప్రసాదంగా భావించి భక్తి పూర్వకంగా స్వీకరిస్తారు.

> **"పానకం పంచే ఆచారం పూర్వ కాలం నుంచి వస్తున్నది.నీటిలో బెల్లాన్ని వేసి కరిగించి అందులో నిమ్మకాయ రసం, యాలుకల పొడి కలిపి పానకం తయారు చేస్తారు"** (వీరమ్మ. డి. (67), అనంత వీధి, తిరుపతి).

3.2 విసనకర్రలు పంచడం:

"రథోత్సవం నాడు కొంతమంది భక్తులు విసనకర్రలు పంచేవారు. వేసవి కాలంలో వేడికి విసురు కోవడానికి విసనకర్రలను పంచేవారు" (కే. రాజయ్య (65), పరసాలపీఠి, తిరుపతి).

వెదురుతో చేసిన విసన కర్రలను పంచేవారు. ఇప్పుడు విసనకర్రతో విసురుకునేవారు చాలా తక్కువ. కరెంట్ పోతే బయట గాలికి కూర్చొనే వారే తక్కువ. అప్పటి కాలంలో బయట చల్ల గాలికి సాయం వేళల్లో మధ్యాహ్న వేళలో చెట్ల కింద కూర్చొని మాట్లాడుకుంటూ గాలికోసం విసన కర్రలతో విసురుకునే వాళ్ళు. ఇప్పుడు విసనకర్రలు కనబడటమే చాలా అరుదుగా ఉంది. కొంతమంది పిల్లలకు విసనకర్ర అంటే ఏమిటో కూడా తెలియని పరిస్థితి. వెదురుతో కాకుండా తర్వాత ప్లాస్టిక్ విసనకర్రలు వచ్చాయి. పూర్వ కాలం సీలింగ్ ఫ్యాన్స్ లేని కాలంలో ప్రతి ఇంట్లో నూ విసన కర్రలు ఉండేవి. ఈ విసనకర్రలు పూర్వం శుభకార్యాలలో కూడా విసురుకోవడానికి ఇచ్చేవారు.

3.3 అంగళ్లు పెట్టడం:

ఉత్సవాలు, తిరునాళ్లు, జాతరలకు అంగళ్లు పెట్టడం ఒక ఆనవాయితీగా వస్తోంది.

"ఇంతకు ముందు ప్రసిద్ధ పుణ్యక్షేత్రాలలో జాతరలు జరిగేవి. లక్షలాది ప్రజలు ఒక్క చోట చేరేవారు తర్వాత తర్వాత ఇవి ఒక్కొక్క పల్లెకు ప్రత్యేకమైన పండుగలుగా మారిపోయాయి. దేవుడు కొంత ప్రభావశాలి అనుకుంటే ఒక్క దినం జాతర రెండు దినాలకు మూడు దినాలకు వ్యాపిస్తుంది. దీనితోబాటు కేవలం ధార్మిక వాతావరణం కాక జన సమూహానికి తగ్గట్టుగా వ్యాపార కార్యకలాపాలు కూడా ప్రారంభమవుతాయి. జాతర ఉత్సవాలు అనగానే బొమ్మలు అమ్మేవాళ్లు, తిండి దినుసులు అమ్మేవాళ్లు, వినోద కార్య కలాపాలతో డబ్బు చేసుకునేవారు, బొమ్మలు ఆడించేవారు, రంకుల రాట్నాల వారు అందరూ తయారవుతారు" (ఆంధ్రుల జానపద విజ్ఞానం, పుట:316)

ఉత్సవాలకు వచ్చిన ప్రతి ఒక్కరూ వారికి కావాల్సిన వస్తువులను అక్కడ తీసుకోవడం జరుగుతుంది. తినుబండారాలు ఇంటికి కావాల్సిన వస్తువులు, ఆట వస్తువులు వంటివి కనబడతాయి. రోడ్డుకి ఇరు వైపులా కళ్లు మిరుమిట్లు గొలిపేలాగా తాత్కాలిక అంగళ్లను పెడతారు.ప్రతి ఒక్కరూ ఏదో ఒక వస్తువును కొనడం ఒక ఆచారంగా సంప్రదాయంగా వస్తోంది.



(మట్టి పాత్రల అమ్మకం)

3.4 తినుబండారాలు:

రాముల వారి ఉత్సవంలో అనేక రకాలైన తిరు బండారాలు దర్శనమిస్తాయి. అందులో పీచు మిఠాయిలు, కమర కట్ట, ఢిల్లీ పాకు, తీపి బూందీ, కారా బూందీ, తీపి మురుకులు, బొరుగులు, నిమ్మకాయ సోడా, అల్లం బర్ఫీ, కొబ్బరి బర్ఫీలు, లడ్డులు వంటి తినుబండారాలు దర్శనమిస్తాయి. వచ్చిన భక్తులు సరదాగా వాటిని కనుక్కొని తింటారు.

3.4 ఇంటికి కావాల్సిన వస్తువులు:

ఇంటికి కావాల్సిన వస్తువులన్నీ జానపద వస్తు సంస్కృతి కిందకు వస్తాయి. ఉత్సవాలు తిరునాళ్లలో ఇంటికి కావాల్సిన వస్తువులు అనేకం కనిపిస్తాయి ఎందుకంటే భక్తులు ఆ చోటకు వచ్చినప్పుడు వాటిని చూసి కొనుక్కోవడానికి అవకాశం ఉంటుంది.ఇంటికి కావాల్సిన వస్తువుల్లో గరిటెలు, పాత్రలు. గిన్నెలు,తట్టలు రకరకాల బుట్టలు చీపుర, చేట వంటివి కొనుక్కుంటారు.

3.5 మట్టి పాత్రలు కొనడం:

రాముల వారి రథోత్సవం సమయంలో ఎక్కువగా కుండలు అమ్ముతారు. ఇప్పుడు అది చాలా తక్కువగా కనిపిస్తోంది. ఒకప్పుడు రాముల వారి రథోత్సవానికి వచ్చి కుండలను కొనుక్కోవడం తప్పనిసరిగా ఉండేది.

> **"మాకు రాముల వారి రథోత్సవం అంటే చాలా సరదాగా ఉండేది. ఎందుకంటే ప్రతి సంవత్సరం రథోత్సవం నాడు ఇప్పుడు రామకృష్ణ పుష్కరిణి ఉన్న ప్రాంతంలో అప్పుడు మట్టి పాత్రలను అమ్మేవారు. మేము కుండలు కొనుక్కోవడానికి వెళ్ళేవాళ్ళం.ఎందుకంటే పుష్కరిణికి దగ్గర లో కుమ్మర వీధి ఉంది. దీన్నే కుమ్మరతోపు అని అంటారు. అక్కడ తయారు చేసే మట్టి పాత్రలను రథోత్సవం నాడు తీసుకొని వచ్చి విశేషంగా అమ్మేవారు.**

వేసవి కాలం కనుక అప్పటి కాలంలోఆ ప్రాంతమంతా మట్టికుండలు కొనుక్కోవడానికి జనం కిటకిటలాడేవారు.మట్టికుండలతో పాటు మట్టి పాత్రలు, కూజాలు మూకుళ్లు వంటివాటితో పాటుగా పిల్లలు ఆడుకునేందుకు మట్టి బుడిగీలు అమ్మేవారు. రామకృష్ణ పుష్కరిణి ప్రాంతం కాస్త ఎత్తుగా ఉంటుంది. అప్పట్లో పుష్కరిణి చుట్టుపక్కలంతా మట్టితోనే దారి ఉండేది. ఎత్తుగా ఉన్న ఆ ప్రాంతానికి నడుచుకుంటూ వెళ్లడానికి చాలా ఉత్సాహాన్ని కనబరిచేవాళ్ళం." (జి. ఎల్లమ్మ (72), నెహ్రూ వీధి, తిరుపతి).

ప్రస్తుతం ఆ ప్రాంతమంతా పుష్కరిణి ఉద్యానవనంతో చుట్టుపక్కల రవాణా సౌకర్యంతో ప్రజలకు ఉపయోగపడుతోంది. ఆధునిక కాలం లో కుండల వినియోగం చాలా తగ్గింది. ఎందుకంటే ఫ్రిజ్‌లు ఆ స్థానంలో చోటు చేసుకున్నాయి. అందువల్ల కుండలను వాడడం తగ్గింది. కానీ ఆరోగ్యానికి కుండ నీళ్లు మంచిది. ప్రస్తుతం మళ్లీ చల్ల నీటికోసం కుండలను, వాడుకోవడానికి మట్టి పాత్రలను ఉపయోగించడం క్రమక్రమంగా పెరుగుతూ ఉంది.



(క్షేత్ర పర్యటనలో విషయ సేకరణ చేస్తున్న వ్యాసకర్త)

3.6. ఆట వస్తువులు:

ఉత్సవాలు, తిరునాళ్ళు, జాతరలు అలాంటి సమయాల్లో పిల్లల ఆట వస్తువులు ఎక్కువగా కనబడతాయి. అలాగే కోదండ రామస్వామి రథోత్సవం రోజున కూడా పిల్లల ఆట వస్తువులు అనేకం అమ్మడం జరుగుతుంది. ఈ ఉత్సవాలకు పెద్దలతో పాటు పిల్లలు కూడా వస్తారు. కాబట్టి ఆట వస్తువులను విరివిగా కొంటారు. బుడగలు, గోళీకాయలు వామన గుంటలాడే పెట్టే, పాచికలు, పరమపదసోపాన పటం,కోలాటం కర్రలు, రింగు బాలు, అనేక రకాల బంతులు చెక్కతోనూ, ప్లాస్టిక్ తో చేసిన అనేక బొమ్మలు, చెక్క బుడిగీలు మట్టి బుడిగీలు ఒకటేంటి అనేక రకాలు కనబడతాయి. వీటినన్నింటిని పిల్లలు సంతోషంగా కొనుక్కుంటారు. రాముల వారి రథోత్సవం నాడు మట్టి బుడిగీలు ప్రత్యేకంగా కనబడతాయి. మట్టి బుడిగీలలో చిన్న చిన్న కుండలు, అన్నం చేసుకునే పాత్రలు, చిన్న నీళ్లు తాగే లోటాలు, వాటి పైకి మూతలు వండుకోడానికి పొయ్యి, రోలు,

చిన్నారులు, సానరాయి వంటి పాత్రలన్నీ దర్శనమిస్తాయి. ఆడపిల్లలు మట్టి బుడిగీలు కొనుక్కోవడానికి చాలా ఉత్సాహపడుతారు. వాటితో ఆడుకోవడానికి చాలా ఇష్టపడతారు. ఆడపిల్లలు మట్టి బుడిగీలతో కింది విధంగా ఆడుకుంటారు.

4. బుడిగీలతో ఆటలు:

ఆడపిల్లలు వంట పనుల్లో తల్లిని అనుకరిస్తారు. తల్లి చేసే పనులను చూసి వారు వంట నేర్చుకుంటారు చిన్న వయసులోనే సరదాగా వంట చేయాలనే ఉత్సాహం పిల్లలో ఉంటుంది. పిల్లలు ఆడుకునే బుడిగిలాటలో ముందుగా బుడిగీలన్నింటిని కడిగి ఆరబెట్టుకుంటారు. పిల్లలు అందరూ ఒకచోట చేరి ఇంటి ఇంటి చుట్టూ ఉన్న చెట్ల నుంచి రాలిన పుల్లలను ఏరు కొంటారు. ఒక చోట తెచ్చుకున్న మట్టి పొయ్యిని పెట్టి వెలిగించి అన్నప్రసాదం వండుతారు. ముందుగా. ఇంటిలో నుంచి కాస్త బియ్యం,కొంచెం బెల్లం తీసుకుని వస్తారు. తెచ్చిన కుండలో బియ్యాన్ని నానబెట్టి మరొక కుండని పొయ్యిపై పెట్టి అందులో కాస్త నీటిని పోసి ఎసరు పెట్టి అది కాగిన తర్వాత బియ్యం కడిగి యసర్లో వేస్తారు. బియ్యం ఉడికిన తర్వాత బెల్లం వేసి కలుపుతారు. బియ్యం ఉడికిందా లేదా అని చూడటానికి అందరం పోటీ పడతారు. బెల్లం వేసి బాగా కలిపి అందులో కాస్త నెయ్యి వేస్తారు. బియ్యం ఉడికే వరకు మంట ఆరిపోకుండా చూసుకుంటూ పొయ్యి లో సన్నని పుల్లలను వేస్తూ ఉంటారు. అందర పొయ్యి చుట్టూ కూర్చుని సరదాగా మాట్లాడుకుంటూ పని చేసుకుంటారు. అందరు పొయ్యి చుట్టూ కూర్చొని ప్రసాదం వండడం పిల్లలకు చాలా ఉత్సాహంగా ఉంటుంది .ప్రసాదం తయారైన తర్వాత దాన్ని అందరూ కూర్చొని పంచుకొని తింటారు. ఇంటిలో ఉన్న పెద్ద వాళ్ళకు కూడా ప్రసాదాన్ని పెడతారు. వాళ్ళు పిల్లలు వండిన ప్రసాదాన్ని తిని చాలా బాగుంది అని అంటారు. ఆ మాటకు పిల్లలు చాలా పొంగిపోతారు. తెచ్చుకున్న చిన్నచిన్న కుండల్లో నీళ్లు పోసి కాసేపు ఉంచి అవి చల్లబడ్డాక సరదాగా వాటిని తాగి ఆ చల్లదనానికి సంతోషపడతారు. అలాగే నిమ్మకాయలు తెచ్చుకొని వాటిలోని రసాన్ని పిండి చల్లని నీటిలో కలిపి అందులో కాస్త చక్కెరను వేసి నిమ్మరసాన్ని తయారు చేసి తాగుతారు.ఇలాంటి చిన్న చిన్న ఆనందాలే పిల్లలకి చాలా సంతోషాన్ని కలుగజేస్తాయి. విధంగా పిల్లలు మట్టి బుడిగీలతో ఆటలను ఆడుకుంటారు.

5. ప్రయోజనాలు:

మన సంస్కృతిలో అనేక రకాలైన సాంఘిక సాంస్కృతిక అంశాలు చోటుచేసుకొని ఉన్నాయి. వీటి వల్ల మనకు అనేక ప్రయోజనాలు కలుగుతాయి. రామువారి గుడికి వెళ్ళడంఅక్కడ భక్తులు చేసే సేవ చేసే దానాలు వంటివాటితో పాటు అక్కడ మట్టి బుడిగీలు కొనుక్కోవడం వంటి విషయాలు మనకు కనబడుతున్నాయి. ఈ విషయాలను గనుక పరిశీలిస్తే అనేక రకాలైన ప్రయోజనాలు మనకు మన భావితరాలకు ఉపయోగపడతాయి.

5.1 భక్తి భావం పెరుగుతుంది:

ఉత్సవాలు, తిరునాళ్లు మన సంస్కృతిలో ఒక భాగం. ఉత్స వాలకు, తిరునాళ్లకు వెళ్లడం వల్ల మనలో భక్తిభావం పెరుగుతుంది. ఆ ప్రదేశాలకు తీసుకుని వెళ్లడం వల్ల పిల్లలకు సంస్కృతి వారసత్వం తెలుసుకునే అవకాశం కలుగుతుంది.

5.2 ఐకమత్యం:

ఐకమత్యమే మహాభాగ్యం. కలిసి కట్టుగా ఉంటే ఏ పనైనా చేయవచ్చు. అందరూ కలిసి ఆనందంగా ఒక చోటకు వెళ్లడం అక్కడ స్వామివారి సేవ చేసుకోవడం వంటి పనుల వల్ల అది చూసి పిల్లలు కూడా నేర్చుకుంటారు. అదే విధంగా పిల్లలు అందరూ కలిసి ఆడుకోవడం వల్ల ఐకమత్యం పెరుగుతుంది ఒకరి ఆలోచనలు ఒకరు పంచుకోవడానికి అవకాశం కలుగుతుంది. పిల్లలు అందరూ కలిసి ఆడుకోవడం వల్ల ఐకమత్యం కలుగుతుంది. వారి మధ్య స్నేహ భావం పెరగడానికి అవకాశం కలుగుతుంది.

5.3. మానసిక పరిపక్వత:

పిల్లలందరూ కలిసి ఆడుకోవడం వల్ల మానసికంగా వారిలో ఎదుగుదల బాగా ఉంటుంది. ఒకరినొకరు అర్థం చేసుకునే స్వభావాన్ని కలిగి ఉంటారు. ఇప్పటి కాలంలో వేసవి సెలవులు వచ్చినా పిల్లలు ఆడుకోవడానికి అంతగా ఆసక్తి చూపడం లేదు. ఆధునిక సాంకేతిక పరిజ్ఞానం మన అరచేతిలో వైకుంఠంలాఉంది. సెల్‌ఫోన్లు లాప్ టాప్‌లో ఇంటర్నెట్ వల్ల పిల్లల్లో ఎదుటి వారితో కలిసే మాట్లాడే విధానంపోతోంది వాటికి పిల్లలు అలవాటు పడిపోయి బయటకు వచ్చి ఆడుకునే పరిస్థితి ప్రస్తుతం చాలా తక్కువనే చెప్పవచ్చు. ఆడుకోవడానికి పిల్లలకు తల్లిదండ్రులే ఉత్సాహం కల్పించాలి. శారీరక శ్రమతో మానసిక పరిపక్వత బాగా పెరుగుతుంది. ఆధునిక సాంకేతిక పరిజ్ఞానం అవసరమే కానీ విపరీతమైన సాంకేతిక పరిజ్ఞానం ముప్పు కి దారితీస్తుంది.

5.4 ఆలోచన శక్తి పెరగడం:

ఆడుకోవడం వల్ల పిల్లల్లో ఆలోచనాశక్తి పెరుగుతుంది. అంటే వంటకు కావాల్సిన వస్తువులు ఏమి కావాలి వంట ఎలా చేయాలి, ఎలా చేస్తే వంట రుచిగా వస్తుంది అనే ఆలోచనలు పిల్లలు చేసినట్లు అన్ని ఆలోచనలు చేసే శక్తి పిల్లలకు కలుగుతుంది.

5.5 ఉత్సాహం కల్పించడం:

చేసిన పనిని మెచ్చుకోవడం వల్ల పిల్లల్లో మంచి ఉత్సాహం కలుగుతుంది. ఇక్కడ ప్రసాదం చేసి పెద్దలకు పెట్టడంతో వారు మెచ్చుకోవడంతో పిల్లల్లో ఎంతో సంతోషం కలిగింది. అలాగే పెద్దలతో పాటు పిల్లలు కూడా అనేక ప్రదేశాలకు తీసుకుని వెళ్లి వారిలో భక్తిభావాన్ని పెంపొందించి అటువైపుగా వెళ్లడానికి వారిలో

అవకాశాన్ని కల్పించాలి. అలా చేయడం వల్ల పిల్లలు ఇంకా మంచి మంచి పనులు చేయడానికి అవకాశం కలుగుతుంది.

5.6 సాంత ప్రణాళిక:

ఆటలు ఆడుకొనేటప్పుడు వేసుకునే ప్రణాళిక వారి జీవితంలో కూడా ఉపయోగపడుతుంది. చదువుకొనేటప్పుడు, చదువు తర్వాత జీవితాన్ని ఎలా మలచుకోవాలో కూడా ఆటలు నేర్పుతాయి.

5.7 ఓపిక, సహనం:

అమ్మానాన్నలే సహన వంతులు, ఓపికస్తులు అనే ఒక నానుడి. ఈ ఓపిక సహనం పిల్లలు చిన్నప్పటి నుంచే వారి ఆటలు ద్వారా నేర్చుకుంటారు. ఓపికగా వారి ఆటలో వంట చేసేటప్పుడు పుల్లలు ఏరుకోవడం, అంచనా కూర్చొని గుంపుగా మంట ఆరిపోకుండా వంట చేయడం అన్నం ఉడికేంత వరకు ఓపికగా ఉండటం వంటివన్నీ అవి వారే చేయగలరు.

5.8. వ్యాయామం కలగటం:

బుడిగేలాటలో పిల్లలు రక రకాలైన పనులు చేస్తూ ఉంటారు. వంగటం, లేవటం, కూర్చోవటం, నడవడం వంటి పనులను చేస్తుంటారు. దీనివల్ల వారికి తెలియకుండానే మంచి వ్యాయామం కలుగుతుంది.

6. ముగింపు:

- మన సంస్కృతి సంప్రదాయాల పట్ల పిల్లలకు అవగాహన కలిగేటట్లు చేయాలి.
- భక్తి భావం పెంపొందుతుంది
- విషయ పరిజ్ఞానం కలుగుతుంది.
- పిల్లల ఆటలకు పాఠశాలల్లో అలాగే ఇంట్లోనూ సమయాన్ని కేటాయించాలి.
- పిల్లల్లో ఆలోచనా శక్తి, సృజనాత్మక శక్తి పెరుగుతుంది. చురుకుగా ఉంటారు.

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గమనిక: ఈ పత్రికలోని వ్యాసాలలో అభిప్రాయాలు రచయితల వ్యక్తిగతమైనవి.
వాటికి సంపాదకులు గానీ, పబ్లిషర్స్ గానీ ఎలాంటి బాధ్యత వహించరు.

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21वीं शती की भारतीय दलित कहानियों में वैषम्य

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हिन्दी साहित्य में कई दलित कहानियाँ लिखी जा चुकी हैं। इनमें वैषम्य की जाँच पड़ताल करना पूर्ण, न्यायसंगत न होगा फिर भी 21वीं शती की भारतीयकहानियों में जिन बिन्दुओं पर भिन्नता स्पष्ट नजर आती है उनकी चर्चा करने का प्रयास किया है ।

1. अभिव्यक्तिगत वैषम्य
2. दलित महिला के दो अभिशाप
3. स्त्री शोषण व अपमान

अभिव्यक्ति वैषम्य

दलित कहानियों में अभिव्यक्ति की सहजता को अपनाया गया है। अपने सुख–दुःख आदि को बहुत ही हृदयस्पर्शी तरीके से बहुत ही सादगी से, किसी भी प्रकार की कलात्मकता के वगैर जस का तस अभिव्यक्त किया है । कहानीकारों के सभी क्रियाकलाप 'स्व' से शुरू होकर 'हम' अर्थात् कि समष्टि भाव में बदल जाते हैं। 'स्वयं' की वेदना से प्रारंभ हुआ, दलित रुदन धीरे–धीरे 'हम' के रुदन में अर्थात् कि दलित समाज के रुदन में बदल जाता है। यदि पुरुष व महिला दलित कहानीकारों के अभिव्यक्तिगत वैषम्य की बात करें तो, दोनों में कुछ भिन्नतायें जरूर नजर आती है । पुरुष दलित कहानियाँ स्वयं एवं दलित समाज केन्द्रित है जबकि महिला दलित कहानियाँ स्वयं एवं अपने परिवार केन्द्रित अधिक रही है । जहाँ दलित कहानीकार खुद को और अपने समाज को अधिक अभिव्यक्त करता हैवहीं महिला कहानीकार खुद के महिला जीवन को और अपने परिवार को प्रमुखतादेती है ।

दलित कहानीकारों ने अपने भावों को सशक्त बनाने के लिए जैसा जिया और अनुभव किया वैसा ही सशब्द अपनी कहानियों में चित्रित किया है। जिसके लिए उन्होंने कई स्थानों पर गाली–गलौच व अश्लील शब्दों का भी प्रयोग किया है। ऐसे अनेक उदाहरण पुरुष कहानीकारों की कहानियों में देने को मिलते हैं। जबकि दलित महिला कहानीकार अपनी कहानियाँ में ऐसे अश्लील शब्दों का प्रयोग नही करती है। ऐसा नहीं है कि पति द्वारा दी गई यातनाओं, प्रताड़नाओं, मारपीट को झेलते समय पति के मुँह से गाली–गलौच न हुआ हो किन्तु, महिला कहानीकारों ने उन गाली–गलौच के शब्दों का प्रयोग अपनी कहानियाँ में नहीं किया है। "कहा था और अब कह रहा हूँ नहीं मिलेगी। ये पैसे शहर में जाके दिखाना। दो पैसे हो गये जेब में तो सारी दुनिया को सिर पे बिठाया लिया है। ये शहर नहीं गाँव है यहाँ चूहड़े चमारों को मेरी दुकान पर तो दाय नहीं मिलने वाली कहीं और जाते पियो।" यहां पर दलित जाति के लोगों को उनकी जाति पर गाली दी जाती है। चमार और चूहड़े जैसे खराब शब्दों से अपमानित किया जाता है। 'बैल की खाल' कहानी में जब काले और भूरे समय पर नहीं पहुँचते तो बिरिज मोहन उन्हें गाली देने लगता है– "कहाँ मर गये थे.... तड़के में ढूंढ–ढूंढ के गोड्डे टूट गए हैं और अब आ रहे हो। इसे बैल को कौन उठावेगा तुम्हारा बाप।'

ओमप्रकाश वाल्मीकि की कहानी 'यह अंत नहीं' में भी दलितों को अपमानित होते देखा जा सकता है "भंगी चमारों की यह हिम्मत ..... क्यूं बे बसना मुझे प्रधान इसलिए बनाया था। और इतना उन सभी को बता देना दरोगा से लेकर एस. पी. तक सभी अपनी जात के हैं ।"

दलितों के साथ गाली–गलौच के शब्दों का प्रयोग जिस तरह कहानियों में देखा गया है वैसे ही हिन्दी दलित आत्मकथाकारों की आत्मकथा में भी देखा जा सकता है। 'जूठन' आत्मकथा में ओमप्रकाश वाल्मीकि ने बताया है कि स्कूल में बालक ओमप्रकाश से हैडमास्टर कालीराम दो दिनों तक स्कूल का मैदान साफ करवाता है। तीसरे दिन ओमप्रकाश चुपचाप क्लासरूम में जाकर बैठ जाता है। उसी समय हैडमास्टर कालीराम की दहाड़ सुनाई पड़ती है "अबे ओ चूहड़े के मादरचोद कहाँ घुस गया.... अपनी माँ..... ?" लेखक सूरजपाल अपनी पत्नी के साथ पैदल चलकर अपने गाँव जा रहे थे। रास्ते में पत्नी विमला को प्यास लगने पर सवर्ण के कुएँ पर जाते हैं। पत्नी विमला ओक बनाकर जैसे ही पानी पीने के लिए एक कदम आगे बढ़ती है उसी समय दाँत पीसते हुए बूढ़ा जमींदार बोला "अरे भंगनिया नेक पीछे के हट के पानी पी, यह शहर ना है गाँव है। मारे लठिया के कमर तोड़ दई जाएगी । मैंचो भंगिया और चमट्टा के शहर में जा के नये नये लत्ता (कपड़े) पहर (पहन) के गाँव में आ जात है, कुछ पता न चलतु कि जे भंगिया के हैं कि नाय ।" 'शिकंजे का दर्द' आत्मकथा में सुशीला टाकभौरे अपने पति के द्वारा की जानेवाली मारपीट के संदर्भ में लिखती हैं– "घर में झगड़ा होता, मारने–पीटने की और मेरे रोने चिल्लाने की आवाज ऊँची सुनाई देती। पड़ोसियों को ये बातें सुनाई न दें, इसके लिए वे रेडियो की आवाजऊँची कर देते थे।" इस प्रकार भारतीय दलित कहानियों में ही नहीं बल्कि अन्य विधाओं में भी दलितों के साथ गाली–गलौच जैसी भाषा का उपयोग किया जाता है।

मराठी दलित कहानियों के संदर्भ में यह कहा जा सकता है कि ये सारी कहानियाँ आम दलित जनता की भाषा में कहीं गयी है। इसमें ज्यादातर पात्र अशिक्षित मजबूर और दबे हुए वर्ग के प्रतिनिधि होने के कारण इनकी भाषा में औपचारिकता कम है। दलितों की भाषा तो अपने जीवन संग्राम की भाषा है, उनके साहित्य में यही भाषा तो अभिव्यक्त होती है। उसमें अधिक रूप से बोली के शब्दों का प्रयोग होता है । यह आश्चर्य की बात नहीं है क्योंकि ये कहानियाँ

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बंजारा लोक साहित्य का संक्षिप्त इतिहास

Authored By

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Associate Professor, Dept. of Hindi, S.V. University- Tirupati-517502, Andhra Pradesh

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21वीं शती की भारतीय दलित कहानियों में वैषम्य

Dr. Narayana, Associate Professor, Dept. of Hindi, S.V. University- Tirupati-517502, Andhra Pradesh

हिन्दी साहित्य में कई दलित कहानियाँ लिखी जा चुकी हैं। इनमें वैषम्य की जाँच पड़ताल करना पूर्ण, न्यायसंगत न होगा फिर भी 21वीं शती की भारतीयकहानियों में जिन बिन्दुओं पर भिन्नता स्पष्ट नजर आती है उनकी चर्चा करने का प्रयास किया है ।

1. अभिव्यक्तिगत वैषम्य
2. दलित महिला के दो अभिशाप
3. स्त्री शोषण व अपमान

अभिव्यक्ति वैषम्य

दलित कहानियों में अभिव्यक्ति की सहजता को अपनाया गया है। अपने सुख–दुःख आदि को बहुत ही हृदयस्पर्शी तरीके से बहुत ही सादगी से, किसी भी प्रकार की कलात्मकता के वगैर जस का तस अभिव्यक्त किया है । कहानीकारों के सभी क्रियाकलाप 'स्व' से शुरू होकर 'हम' अर्थात् कि समष्टि भाव में बदल जाते हैं। 'स्वयं' की वेदना से प्रारंभ हुआ, दलित रुदन धीरे–धीरे 'हम' के रुदन में अर्थात् कि दलित समाज के रुदन में बदल जाता है। यदि पुरुष व महिला दलित कहानीकारों के अभिव्यक्तिगत वैषम्य की बात करें तो, दोनों में कुछ भिन्नतायें जरूर नजर आती है । पुरुष दलित कहानियाँ स्वयं एवं दलित समाज केन्द्रित है जबकि महिला दलित कहानियाँ स्वयं एवं अपने परिवार केन्द्रित अधिक रही है । जहाँ दलित कहानीकार खुद को और अपने समाज को अधिक अभिव्यक्त करता हैवहीं महिला कहानीकार खुद के महिला जीवन को और अपने परिवार को प्रमुखतादेती है ।

दलित कहानीकारों ने अपने भावों को सशक्त बनाने के लिए जैसा जिया और अनुभव किया वैसा ही सशब्द अपनी कहानियों में चित्रित किया है। जिसके लिए उन्होंने कई स्थानों पर गाली–गलौच व अश्लील शब्दों का भी प्रयोग किया है। ऐसे अनेक उदाहरण पुरुष कहानीकारों की कहानियों में देने को मिलते हैं। जबकि दलित महिला कहानीकार अपनी कहानियाँ में ऐसे अश्लील शब्दों का प्रयोग नहीं करती है। ऐसा नहीं है कि पति द्वारा दी गई यातनाओं, प्रताड़नाओं, मारपीट को झेलते समय पति के मुँह से गाली–गलौच न हुआ हो किन्तु, महिला कहानीकारों ने उन गाली–गलौच के शब्दों का प्रयोग अपनी कहानियाँ में नहीं किया है। "कहा था और अब कह रहा हूँ नहीं मिलेगी। ये पैसे शहर में जाके दिखाना। दो पैसे हो गये जेब में तो सारी दुनिया को सिर पे बिठाया लिया है। ये शहर नहीं गाँव है यहाँ चूहड़े चमारों को मेरी दुकान पर तो दाय नहीं मिलने वाली कहीं और जाते पियो।" यहां पर दलित जाति के लोगों को उनकी जाति पर गाली दी जाती है। चमार और चूहड़े जैसे खराब शब्दों से अपमानित किया जाता है। 'बैल की खाल' कहानी में जब काले और भूरे समय पर नहीं पहुँचते तो बिरिज मोहन उन्हें गाली देने लगता है– "कहाँ मर गये थे.... तड़के में ढूंढ–ढूंढ के गोड्डे टूट गए हैं और अब आ रहे हो। इसे बैल को कौन उठावेगा तुम्हारा बाप।' ओमप्रकाश वाल्मीकि की कहानी 'यह अंत नहीं' में भी दलितों को अपमानित होते देखा जा सकता है "भंगी चमारों की यह हिम्मत ..... क्यूं बे बसना मुझे प्रधान इसलिए बनाया था। और इतना उन सभी को बता देना दरोगा से लेकर एस. पी. तक सभी अपनी जात के हैं ।"

दलितों के साथ गाली–गलौच के शब्दों का प्रयोग जिस तरह कहानियों में देखा गया है वैसे ही हिन्दी दलित आत्मकथाकारों की आत्मकथा में भी देखा जा सकता है। 'जूठन' आत्मकथा में ओमप्रकाश वाल्मीकि ने बताया है कि स्कूल में बालक ओमप्रकाश से हैडमास्टर कालीराम दो दिनों तक स्कूल का मैदान साफ करवाता है। तीसरे दिन ओमप्रकाश चुपचाप क्लासरूम में जाकर बैठ जाता है। उसी समय हैडमास्टर कालीराम की दहाड़ सुनाई पड़ती है "अबे ओ चूहड़े के मादरचोद कहाँ घुस गया.... अपनी माँ..... ?" लेखक सूरजपाल अपनी पत्नी के साथ पैदल चलकर अपने गाँव जा रहे थे। रास्ते में पत्नी विमला को प्यास लगने पर सवर्ण के कुएँ पर जाते हैं। पत्नी विमला ओक बनाकर जैसे ही पानी पीने के लिए एक कदम आगे बढ़ती है उसी समय दाँत पीसते हुए बूढ़ा जमींदार बोला "अरे भंगनिया नेक पीछे के हट के पानी पी, यह शहर ना है गाँव है। मारे लठिया के कमर तोड़ दई जाएगी । मैंचो भंगिया और चमट्टा के शहर में जा के नये नये लत्ता (कपड़े) पहर (पहन) के गाँव में आ जात है, कुछ पता न चलतु कि जे भंगिया के हैं कि नाय ।" 'शिकंजे का दर्द' आत्मकथा में सुशीला टाकभौरे अपने पति के द्वारा की जानेवाली मारपीट के संदर्भ में लिखती हैं– "घर में झगड़ा होता, मारने–पीटने की और मेरे रोने चिल्लाने की आवाज ऊँची सुनाई देती। पड़ोसियों को ये बातें सुनाई न दें, इसके लिए वे रेडियो की आवाजऊँची कर देते थे।" इस प्रकार भारतीय दलित कहानियों में ही नहीं बल्कि अन्य विधाओं में भी दलितों के साथ गाली–गलौच जैसी भाषा का उपयोग किया जाता है।

मराठी दलित कहानियों के संदर्भ में यह कहा जा सकता है कि ये सारी कहानियाँ आम दलित जनता की भाषा में कहीं गयी है। इसमें ज्यादातर पात्र अशिक्षित मजबूर और दबे हुए वर्ग के प्रतिनिधि होने के कारण इनकी भाषा में औपचारिकता कम है। दलितों की भाषा तो अपने जीवन संग्राम की भाषा है, उनके साहित्य में यही भाषा तो अभिव्यक्त होती है। उसमें अधिक रूप से बोली के शब्दों का प्रयोग होता है । यह आश्चर्य की बात नहीं है क्योंकि ये कहानियाँ

अंक-1, वर्ष-1

मार्च-2024

शोध प्रयाण

(वार्षिक शोध पत्रिका)



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FARMER'S SUICIDES IN RAYALASEEMA REGION, ANDHRA PRADESH, INDIA

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ABSTRACT

Rayalaseema is a geographic region in the Indian state of Andhra Pradesh. It comprises four southern districts of the State, from prior to the districts reorganization in 2022, namely Kurnool, Anantapur, YSR Kadapa and Chittoor. The wide variations in agricultural output that have occurred throughout human history testify to the fact that farming is an economic activity dependent on the vagaries of weather. As a sequel, climatic variations significantly impact the livelihood of millions and particularly poor and vulnerable people. The performance of agricultural sector in Rayalaseema region has great impact on people living on dry land agriculture. Owing to vagaries of monsoon, cost of fertilizers, low yield, low prices for output are making the farmers to go for suicide. The present paper elicits the number of people made suicide in Rayalaseema and their causes thereof.

INTRODUCTION

Rayalaseema is a geographic region in the Indian state of Andhra Pradesh. The Rayalaseema region is the land once ruled by the 'Rayas' of the famous Vijayanagara Empire. The name has become popular after Sri Krishnadevaraya, the great king who ruled Rayalaseema as part of his kingdom from 1509 to 1530 AD. It was also poetically called as 'Rayalaseema is Rathanalaseema' (area of precious stones)[1]. Also, it is an economically backward region of Andhra Pradesh when compared to coastal Andhra. This is a typically dry tract of AP, situated in an unfavourable zone and has been declared as famine zone of south India[2]. Rayalaseema region lies between 12° 30' N and 16° 30' N latitudes and 76° 30' E to 79° 55' E longitudes. It includes the four southern districts of Anantapur, Chittoor, YSR Kadapa and Kurnool (covering an area of 67, 298 Sq kms (42 % of state area)). Anantapur revenue district is the largest district with an area of (19130) square kms, followed by Chittoor (15151), YSR Kadapa (15359) and Kurnool (17658), the total numbers of Mandals of all the four districts are 234. The particulars of the district wise, area wise population, density and sex ration of Rayalaseema districts are furnished (Table 1) and location map of the area indicate Figure 1.

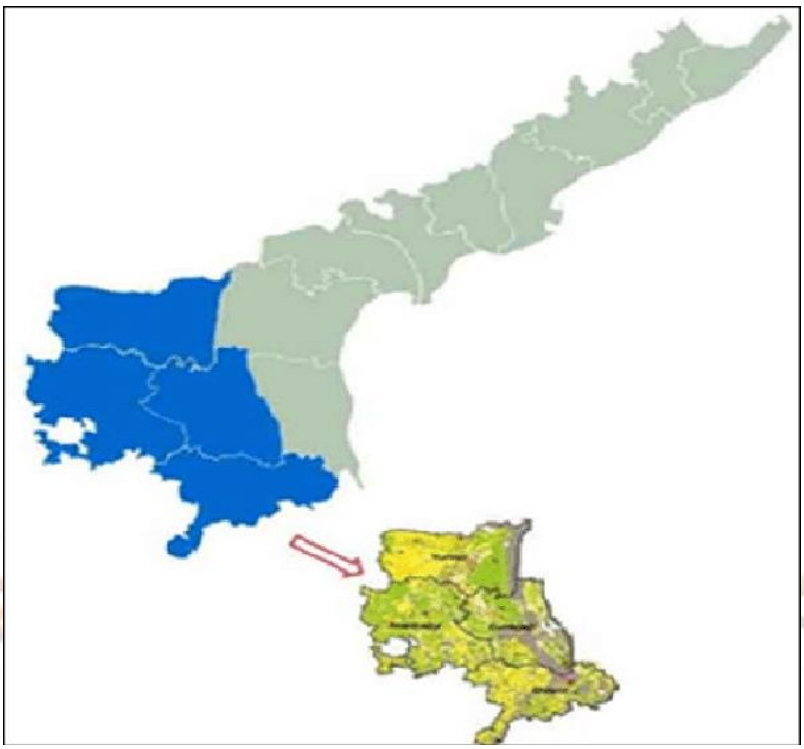


Fig.1 Map of Rayalaseema

Table 1
Population, density and sex ration of Rayalaseema (As per 2011 Census)

Sl. No.	Name of the District	Area (Sq Km)	Population	Population Density (per Sq Km)	Sex ratio (Per thousand Males)
1	Anantapur	19130	4081148	213	977
2	Chittoor	15151	4174064	275	977
3	YSR Kadapa	15359	2882469	188	985
4	Kurnool	17658	4053463	229	988

Source: Hand book of statistics Anantapur, Chittoor, YSR Kadapa and Kurnool (2015-16)[3]

GENERAL LAND USE PATTERN

The land use pattern is significant not only just in agricultural dominated and over populated developing regions, but also throughout the globe because of its relationship with different human phenomena. Its importance also increased during the population pressure and decreasing human and land ratio, increasing demand for food and raw materials they require for optimal use of land in an integrated manner has assumed greater relevance. Land use is any kind of stable or cyclic human being intervention on the environment to satisfy human needs and the land use capability or land suitability is the potential capability of giving tract and to support different types of land utilization under given cultural and socioeconomic conditions (**Vink A.P.A., 1975**).[4]

Classification of Land use pattern

Land use classifications are the systematic arrangement of land on the basis of certain related characteristics, mainly to identify and understand their basic utilities intelligently and effectively. The land use pattern indicates the spatio-temporal sequence of field under different uses. It too indicates that net

available land for cultivation, which is an significant factor since it is the foundation for agricultural planning (Arsud, 2000).[5]

The classification and major categories of Land use pattern is as follows:

1. Forest land
2. Barren and uncultivable land
3. Land put to non-agricultural uses
4. Cultivable waste land
5. Permanent pastures and other grazing Land
6. Land under miscellaneous tree crops and groves not 'included in net sown'
7. Current fallow land
8. Other fallow land
9. Net area sown
10. Total cropped area
11. Area sown more than once
12. Land under fish and prawn culture.

The above land use classifications have been taken on all the provinces leading to comparability in land use pattern (Veerannachari, 2015).[6] Some land is for a particular use depending mostly on the physical characteristics of land to its suitability for a particular usage is concerned.

Land utilisation Pattern in Rayalaseema region

The total geographical area of Rayalaseema region is about 4484200 (in hectares) and forests occupied 1108968 (in hec) in the year 2013-2014. Out of these the total area under Barren and uncultivable land is 519441 (in hec), followed by the area under Land put to non- agricultural uses is 532789 (in hec), Cultivable waste 146181 (in hec), Permanent pastures and other grazing is 48196 (in hec), Land under miscellaneous tree crops & groves not 'included in net sown' is 52370 (in hec), Current fallows is 386349 (in hec), Other fallow lands is 453359 (in hec), Net area sown is 2604981 (in hec), Total cropped area is 2894749 (in hec), Area sown more than once is 292494 (in hec) and Fish & Prawn culture is 1184 (in hec). There is change in photographic, soil types, rainfall and geology all these factors played important part in setting the agricultural practices. The categories include any land classified as a forest legal enactment. The land use of the Rayalaseema region (in hectares) for various aspects is furnished in the Table 2.

Table 2
Land Utilisation Pattern in Rayalaseema region 2013-14 (Area in Hectares)

Sl. No.	Land use Category	Name of the District				Total
		Anantapur	Chittoor	YSR Kadapa	Kurnool	
1	Total geographical area	1913000	151500	653900	1765800	4484200
2	Forests	196978	452018	119303	340669	1108968
3	Barren & Uncultivable land	166425	152700	73003	127313	519441
4	Land put to non-agricultural uses	150140	157312	77678	147659	532789
5	Cultivable waste	48533	46097	4243	47308	146181

6	Permanent pastures & other grazing	5848	33540	5231	3577	48196
7	Land under miscellaneous tree crops & groves not 'included in net sown	9416	30561	10535	1858	52370
8	Current fallows	86502	120944	64058	114845	386349
9	Other fallow land	209067	150207	23150	70935	453359
10	Net area sown	1038980	371717	276630	917654	2604981
11	Total cropped area	1106371	417066	372619	998693	2894749
12	Area sown more than once	67381	45349	95989	83775	292494
13	Fish & Prawn culture	1111	4	69	0	1184
Total		**4999752**	**2129015**	**1776408**	**4620086**	**13525261**

Source: Chief Planning Officer, Anantapur, Chittoor, YSR Kadapa and Kurnool (2013-14)[7]

Out of the entire area of Rayalaseema region, in Anantapur district the total geographical area is 1913000 lakh hectares and followed by the Chittoor total area is 1515100 lakh hectares, YSR Kadapa total geographical area is 653900 lakh hectares and the total geographical area covered by Kurnool is 1765800 lakh hectares. In Anantapur district 196978 he of the total land area is covered by the Forest. Chittoor district has 452018 (hec) of Forests. YSR Kadapa district has 119303 (hec) of the Forests in the total land area. In Kurnool district 340669 (hec) is under Forest area.

Barren and uncultivable lands are rocky outcrops of hills, plateaus, mountains etc., and this land put up under no conceivable circumstances be brought under farming. Merely a very high cost a little proportion may be classified as unproductive waste. This area occupies in Anantapur district is 166425 (hec), Chittoor district has 452018 (hec), YSR Kadapa district has 73003 (hec) and Kurnool district has 127313 (hec). The concentration of land under land put to non-agricultural uses is high in Chittoor which amounts to 157312 (hec). In Anantapur district about 150140 (hec) and Kurnool districts about 147659 (hec) lands under this category of land use, about 77678 (hec) of the total lands put to non-agricultural use of the YSR Kadapa district. The cultivable waste land is high in Anantapur district that is 48533 (hec), then Kurnool district has 47308. Chittoor district has 46097 (hec) and Kadapa district has 4243(hec) under cultivable waste. The entire acres under permanent pastures and other grazing land in Anantapur district is 5848 (hec), high in Chittoor district is approximately 33540 (hec). In YSR Kadapa district it is about 5231 (hec) of the total land. In Kurnool district, an area of about 3577 (hec) of land is found under permanent pastures and other grazing lands.

The land under miscellaneous tree crops & groves (not included in net sown), the Anantapur district posses 9416 (hec), the Chittoor district has 30561(hec), the YSR Kadapa district posses 10535 (hec) and the Kurnool district has 1858 (hec) of the land under miscellaneous tree crops and groves. The current fallow land is high in Chittoor district followed by Kurnool, Anantapur and YSR Kadapa. The absorption of other fallow land is high in Anantapur that is 209067 (hec) and Chittoor district has 150207 (hec), followed by Kurnool and Kadapa districts. The total land under net area sown high in Anantapur is about 1038980 (hec), then Kurnool district has 917654 (hec), followed by Chittoor and Kadapa districts. The total land under

cropped area high in Anantapur district is about 1106371 (hec), followed by the Kurnool, Chittoor and Kadapa districts. The land under sown more than once is high in Kadapa district. The concentration of Fish & Prawn culture is high in Anantapur district, normal in YSR Kadapa district, fewer amounts in Chittoor and Kurnool districts.

The land competence of the Rayalaseema region has been turned out taking positive variables like cropped area, total irrigated area and net area sown. In the Rayalaseema region, out of the total geographical area, majority of the land is under total cropped area followed by net area sown, forest cover, area sown more than once, land under non-agricultural use, other fallow lands, fallow land and under cultivable waste land etc. The maximum land use is found in Anantapur and Kurnool districts. The dispersion of soil under forest is uneven in the Rayalaseema region. The land under Fish and Prawn culture is very minuscule amount. For any regional improvement, the planners must learn the spatial form of land use pattern for forthcoming developmental activities to be held at local stage and regional level. Expansion of agricultural land with the assistance of technology may cause considerable changes in land use.

HISTORICAL STUDY OF FARMER'S SUICIDES INRAYALASEEMA

India is an agrarian country with around 60% of its people directly or indirectly depends upon agriculture. Agriculture in India is often attributed as gambling with monsoons because of its almost exclusive dependency on precipitation from monsoons. The failure of these monsoons leading to a series of droughts, lack of remunerative prices, exploitation by middlemen, all of which have led to a series of suicides committed by farmers across India**.** Farmers in India became the centre of considerable concern in the 1990s. Official reports initially denied the farmer suicides but as more and more information came to light, the government began to accept that farmers in India were under considerable stress. On suicide figures, there was much debate since the issue was so emotive.

More than 17,500 farmers a year killed themselves between 2002 and 2006, according to experts who have analyzed government statistics. Others traced the increase in farmer suicides to the early 1990s. It was said that a comprehensive all India study is still awaited, that most suicides occurred in states of Andhra Pradesh, Maharashtra, Karnataka, Kerala and Punjab. The situation was grim enough to force at least the Maharashtra government to set up a dedicated office to deal with farmers' distress. The agrarian crisis has its roots in the collapse of the rural economy. The centrality of basic livelihood security concerns is missing in most government policies. A systems approach is missing in dealing with the problems of farmers' distress. There is no coordination among various government departments dealing with the different components of the agrarian crisis. Unemployment is on the rise. The minimum support price mechanism is not operating for most commodities. At every level of the livelihood security system, there is a tendency to make profit out of poverty.

CAUSES OF FARMERS SUICIDE

Farmer's suicide is a major issue and it should be dealt with seriousness. Many farmers' lives are at stake because of this. The reasons why farmers commit suicide are varied and the methods they use to end their lives are different. Various reasons that could make the farmers in India take this ghastly step of ending their lives. The main reasons behind farmer's suicide could be lack of money, financial problems, carrying the burden of debt, extreme crop failure due to natural calamities etc.

Increased Costs

From seeds to fertilizers, from tools to big equipment, everything has become extremely expensive for the farmers to buy and grow crops. On top of it the livestock industry also needs a good amount of expense to look after the animals, their health, their food, their hygiene and so much more. All these increased costs may affect the purchasing value for the farmers which could lead in low production or low output.

The Debt

When the costs for equipment and other facilities increase, farmers may not have a choice but get a loan. Again, when the income is low due to the low production, then naturally paying off the interest and the loan amount is going to be challenge. The burden of increasing interest and low income to pay it off can be a lot to bear. Suicides due to inability to pay off the loans are high in farmers and the biggest cause that leads then to this path of taking their own life.

Loss of Family's Support

Loss of support from peers or family members could also be one of the major reasons for farmers' suicide. When we say 'support' it is not just financial support, but also emotional and mental support, which is equally important. When families of farmers go one step ahead and create an empathetic support for them, then the feeling of being understood or knowing that they aren't alone or they can fight and find ways out of the problem can help them to take a step back from think about suicide.

Lack of Awareness

If farmers are educated frequently about the loan facilities, subsidies, new ways of farming and much more than their problem-solving skills may develop and they may think of different ways to look at a problem and find different solution other than suicide. The main reasons include monsoon failure, climate change, high debt burdens, government policies, mental health, personal issues and family problems among the reasons of farmers' suicides.

The surge in input costs

A major cause of the farmers' suicides in India has been the increasing burden on the farmers due to inflated prices of agricultural inputs. The culmination of these factors is seen in the **overall increase in the cost of cultivation**, for wheat, the cost at present is three times than it was in 2005.

Cost of chemicals and seeds

Be it the fertilizers, crop protection chemicals or even the seeds for cultivation, farming has become expensive for the already indebted farmers.

Costs of Agricultural equipment

The input costs, moreover, aren't limited to the basic raw materials. Using agricultural equipment and machinery like tractors, submersible pumps etc adds to the already surging costs. Besides, these secondary inputs have themselves become less affordable for the small and marginal farmers.

Labour costs

Likewise, hiring labourers and animals is getting costlier too. While this may reflect an improvement in the socio-economic status of the labourers, driven primarily by MGNERGA and hike in minimum basic income, this has not gone too well with boosting the agriculture sector.

Distressed due to loans

The NCRB data points out that in 2474 suicides out of the studied 3000 farmer suicides in 2015 the victims had unpaid loans from local banks. This is clear enough an indication for drawing correlations between the two. Whether or not the banks had been harassing them, however, is a long-drawn debate and needs more specific empirical evidence. Moreover, a shift away from usual trend also revealed that of the loans taken by these farmers, only 9.8% were loans from money-lenders. Thus the pressure or muscle-power of money-lenders could be far from being a major driving force, as is otherwise perceived. Another source of strong linkages between farmer suicides and indebtedness is reflected from the spread of the two. While Maharashtra had 1293 suicides for indebtedness, Karnataka had 946. Note that both these states saw one of the highest incidences of farmer suicides as well as indebtedness.

Lack of direct integration with the market

Although initiatives like the National Agricultural Market and contract farming are helping integrate the farmers' produce directly with the market, cutting the role of intermediaries, the reality is still lagging behind.

Lack of awareness

The digital divide, as well as the literacy gap, has made the marginal and small farmers particularly vulnerable due to their inability to utilise the positives of government policies. This is reflected in the continued unsustainable cropping practices – like cultivating sugarcane in water-deficit regions.

Water crisis

The concentration of these suicides in the water-deficit regions of states like Maharashtra, Karnataka is a manifestation of how the water crisis and thereby failure to meet production demands have intensified the menace. This is particularly true in the backdrop of continued failed monsoons.

Interstate water disputes

What has added to the already prevalent crisis is the unwillingness to cater to each other's water needs amongst the states. A case in point is the recently resurfaced Kaveri dispute that saw Karnataka and Tamil Nadu battle out water shortage both in and outside the tribunal even to the extent of non-compliance with the tribunal award.

Climate change

The climate change has acted as the last nail in the coffin by resulting in furthering of the uncertainties associated with the already uncertain monsoon system and hence agricultural production. While incidents like flash floods have led to crop losses, deferred monsoons have seen production shortfall year-in and year-out.

Loan waivers instead of restructuring, re-investment measures

Our approach of handling farmer indebtedness and hence farmer suicides has been appeasement politics like the recent move by the UP government to waive off Rs 36000 crore worth of loans. Surprisingly this comes at a time when agricultural yield is expected to be better in the wake of a good monsoon. In essence, the factors sum up to crop failure, unsustainable production and subsequent farmer indebtedness leading to failure of strengthening the economic state of the farmer as the driving force behind these suicides.

FARMERS'S SUICIDES IN RAYALASEEMA REGION

The district wise and year wise number of suicides by farmers in Rayalaseema during 2004 - 2014 are presented in Table 3.

Table 3
Year-wise Farmers' Suicides in Rayalaseema

Sl. No.	Name of the District	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	Ananthapur	72	70	69	90	86	47	45	67	40	31	41	51	908
2	Chittoor	39	22	24	24	17	10	3	7	3	0	0	3	163
3	YSR Kadapa	21	17	9	26	20	11	4	8	2	1	0	6	131
4	Kurnool	76	62	75	85	75	71	42	44	26	3	1	4	610
	Total	208	171	177	225	198	139	94	126	71	35	42	64	1712

CV:1. Chittoor 0.97 2. Ananthapur 2.71 3. YSR Kadapa 1.57 4. Kurnool 2.34 Andhra Pradesh 2.04
Source: Commissionerate of Agriculture, Govt. of Andhra Pradesh, Amaravathi[8]

As per the data collected from newspapers and from the list prepared by Andhra Pradesh Rythu Sangam (before bifurcation) during the five year period i.e. October 1997 to September 2002, a total of 877 suicides by farmers were reported in the state. In 1998 a maximum of 353 farmers committed suicide. During 1990-99, 59 farmers and in 2000, 82 farmers committed suicide. Again in 2001 there was a steep rise in suicides, the number reaching 200. The year 2012 also saw a spate of suicides. By the end of August 2002, 112 cases were reported. Later the figure rose to 218 by the end of November (**Prajasakthi, November 21st, 2002**)[9]. Of the total of 877 suicides, Coastal Andhra and Rayalaseema Regions accounted for around 13 percent each. Moreover in Ananthapur district 70 cases and 59 cases in Guntur district were reported.

Intensity of Farmers' Suicides in the Rayalaseema

District-wise Details of Farmers

The district-wise details of farmers' suicides in the state (2015-16) are presented in table 4.

Table 4

District-wise details of farmers' suicide in the state (July, 2015 to June, 2016) – AP[9]

Sl. No.	Name of the district	No. of farmers' suicide	% to state total	No. of farmers' suicide per lakh hectare of Net Sown Area = (no. of farmers' suicides x 100,000) / net sown area in ha)	No. of farmers' suicide per lakh hectare of Gross cropped area = (no. of farmers' suicides x 100,000) / gross cropped area in ha)	No. of farmers' suicide per lakh farming farmers = (no. of farmers' suicides x 100,000) / no. of farmers)
1	Ananthapur	27	34.18	3.18	2.93	3.71
2	Chittoor	2	2.53	0.54	0.47	0.30
3	YSR Kadapa	9	11.39	2.65	2.27	2.04
4	Kurnool	1	1.27	0.12	0.11	0.16
	Total	39	100	1.30	1.05	1.04

Source:Commissionerate of Agriculture, Govt. of Andhra Pradesh[9]

During 2015-16 the cases of suicides reported are 39. Of them 34.18 percent are reported from Ananthapur district. Moreover the number of Farmers' suicides per lakh hectare of net sown area is reported as 1.30, and the number of farmers' suicides per lakh hectare of gross cropped area is reported as 1.05 in the state. On the other hand the numbers of farmers' suicides per lakh farming families are reported as 1.04 in the state. Observing across the districts the number of farmers' suicides per lakh hectare of net sown area are reported to be 3.18 in Ananthapur district. Similarly the numbers of farmers' suicides per lakh hectare of gross cropped area are estimated to be 2.93 in Ananthapur district. Moreover the numbers of farmers suicides per lakh farming farmers are observed to be 3.71 in Ananthapur. Observing across the districts of the state the suicides per lakh farming farmers varied from 0.16 is Kurnool district to 3.71 in Ananthapur district.

Month-wise Farmers' Suicides

The details of month-wise farmers' suicides in the state (2015-16) are presented in table 5.

Table 5
Month-wise farmers' suicide in Rayalaseema

Sl. No.	Month	No. of Farmers' Suicides	Percent to total number of farmers' suicides
1	July 15	8	10.13
2	August 15	9	11.39
3	September 15	11	13.92
4	October 15	15	18.99
5	November 15	9	11.39
6	December 15	9	11.39
7	January 16	3	3.80
8	February 16	8	10.13
9	March 16	2	2.53
10	April 16	5	6.33
11	May 16	0	0.00
12	June 16	0	0.00
Total		79	100.00

Source: Commissionerate of Agriculture, Govt. of Andhra Pradesh[10]

It can be observed from the table that comparatively higher percentage of suicides was taken place in September and October months of 2015. Similar percentage of suicides was reported in August, November and December months of 2015. Moreover 10.13 percent of suicides are reported in both July 2015 and February, 2016. No suicide cases were reported in May and June months of 2016. Observing across the months the percentage of suicide cases varied from 18.99 percent in October 2015 to 2.53 percent in March 2016.

CONCLUSION

Rayalaseema is a landlocked region with an expanse of 67,298 Sq Km accounting for 42% of the total geographical area of Andhra Pradesh. Rayalaseema region is the still neglected and economically backward region. The cropping pattern also varies with the effect of temperature, soil and other irrigation facilities. In the Rayalaseema region, out of the total geographical area, majority of the land is under total cropped area followed by net area sown, forest cover, area sown more than once, land under non-agricultural use, other fallow lands, fallow land and under cultivable waste land etc. The maximum land use is found in Anantapur and Kurnool districts. There is change in photographic, soil types, rainfall and geology all these factors played important part in setting the agricultural practices. Agriculture is often attributed as gambling with monsoons because of its almost exclusive dependency on precipitation from monsoons. The failure of these monsoons leading to a series of droughts, lack of remunerative prices, exploitation by middlemen, all of which have led to a series of suicides. The suicides per lakh farming farmers varied from 0.16 is Kurnool district to 3.71 in Ananthapur district. The percentage of suicide cases varied from 18.99 per cent in October 2015 to 2.53 per cent in March 2016. In long-term preventive policies, the main cause of drought is inadequacy of irrigation, a plan for development of scarcity prone areas should ensure maximum increase and in addition, following tube well and lift irrigation schemes to enhance the farmers to sustain.

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Farmers Suicides in Andhra Pradesh, India

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ABSTRACT

Andhra Pradesh is called as rice bowl of India. The deltas formed by the most important rivers of the Godavari and the Krishna make up the central part of the plains, an area of fertile alluvial soil. Thus, agriculture plays an immensely important role not only in the economy but also for achieving the food security for the state and also for the country. Andhra Pradesh is one of the leading rice-growing states in the country and is a major producer of India's tobacco. The main challenges of agriculture are, growing water scarcity, degrading natural resources like land and decreasing per capita availability of land and water resources. The large number of suicides by farmers is perhaps the most distressing phenomenon observed in Andhra Pradesh over the last decade. The main reasons behind farmer's suicide could be lack of money, financial problems, carrying the burden of debt, extreme crop failure due to natural calamities etc. The paper presents the number of farmer's suicides, distribution in different districts and reasons thereof in Andhra Pradesh.

Keywords: Farmers, Suicides, Reasons, Andhra Pradesh

INTRODUCTION

Andhra Pradesh State is "the bejewelled rice bowl of India". Agriculture plays an important role in the livelihoods of people as 63 per cent of the population in Andhra Pradesh lives in rural areas and depends on agriculture and related livelihood opportunities. Agriculture sector contributes 27 per cent share in State GDP. The agriculture plays an important role not only in the economy but also for achieving the food security for the state and also for the country. Our main challenges are, growing water scarcity, degrading natural resources like land and decreasing per capita availability of land and water resources. Andhra Pradesh is located in the southeastern part of the subcontinent ad bounded by Tamil Nadu to the south, Karnataka to the southwest and west, Telangana to the northwest and north and Odisha to the northeast. The eastern boundary is a 600-mile (970-km) coastline along the Bay of Bengal.

Land

The state has three main physiographic regions: the coastal plain to the east, extending from the Bay of Bengal to the mountain ranges; the mountain ranges themselves, the Eastern Ghats, which form the western flank of the coastal plain; and, in the southwest, the plateau to the west of the Ghats. The coastal plain, also known as the Andhra region, runs almost the entire length of the state and is watered by several rivers, flowing from west to east through the hills into the bay. The deltas formed by the most important of those rivers—the Godavari and the Krishna—make up the central part of the plains, an area of fertile alluvial soil. The Eastern Ghats are part of a larger mountain system extending from central India to the far south and running parallel to the east coast. Interrupted by the great river valleys, the mountains do not form a continuous range. The Penneru River forms the main drainage system. As the

result of erosion, the plateau is a region of graded valleys, with red sandy soil and isolated hills. Black soil is also found in certain parts of the area.

Climate

A summer that lasts from March to June, a season of tropical rains that runs from July to September, and a winter that lasts from October to February constitute the three seasons of Andhra Pradesh. Summers are extraordinarily hot and humid, with maximum daily temperatures exceeding 95 °F (35 °C) and even surpassing 104 °F (40 °C) in the central portion of the state. Summer nightly minimums drop to below about 70 °F (20 °C) only in the far southwest. Winters are somewhat cooler, with January maximum temperatures between 86 and 95 °F (30 and 35 °C) in all but the north-eastern portion of the state. Winter lows drop below about 60 °F (15 °C) only in the extreme northeast. Annual precipitation, which derives largely from the southwest monsoon rains, generally decreases toward the south-western plateau area. Coastal areas receive about 40 to 47 inches (1,000 to 1,200 mm) per year, while the westernmost part of the plateau may receive only half that much. Rainfall totals in portions of the north-eastern mountains exceed 47 inches and can be as high as 55 inches (1,400 mm).

Economy

Agriculture, forestry, and fishing

Agriculture, dominated by the production of food grains, is a major, although declining, sector of the state's economy, in terms of value. Andhra Pradesh is one of the leading rice-growing states in the country and is a major producer of India's tobacco. The state's rivers—particularly the Godavari and the Krishna, but also the Penneru—account for its agricultural importance. For a long time the rivers' benefits were restricted to the coastal districts of the Andhra region, which had the best irrigation facilities. Beginning in the mid-20th century, however, great efforts were made to tap the waters of the Godavari, Krishna, Penneru, and other rivers by constructing dams and reservoirs that benefit both coastal and drier upland regions. Canal irrigation in the Rayalaseema region of the plateau has given rise to agro-industrial complexes rivalling those of coastal Andhra Pradesh. The Nagarjuna Sagar multipurpose project, diverting the waters of the Krishna for irrigation, has substantially increased the production of rice and sugarcane. Rice flour, rice-bran oil, paints and varnishes, soaps and detergents, cardboard and other packaging materials, and cattle feed are all produced from local paddy rice. Other agricultural commodities grown state-wide include other cereal grains, pulses (peas, beans, and lentils), peanuts (groundnuts), corn (maize) and cotton—all of which are processed locally as well—and a variety of fruits and vegetables. Animal husbandry has increased significantly in Andhra Pradesh, especially since the start of the 21st century. Livestock rising contributes roughly half as much in overall value as crop production. Animals raised include cattle, water buffalo, sheep, goats, pigs, and poultry. Dairy and egg production have grown dramatically. The woodlands of Andhra Pradesh annually yield high-quality timber, such as teak and eucalyptus. Non-timber forest products—including sal seeds (from which an edible oil is extracted), tendu leaves (for rolling cigarettes), gum karaya (a type of emulsifier), and bamboo—are also important. With its long coastline and many rivers, the state has a significant and expanding fishing industry.

Resources and power

The state's principal mineral resources are asbestos, mica, manganese, barite and high-grade coal. Low-grade iron ore is found in the southern parts of the state. Andhra Pradesh produces a major share of the country's barite. It is the only state in southern India that possesses significant coal reserves. In the

early 21st century, large deposits of natural gas were discovered onshore and offshore in the basins of the Godavari and Krishna rivers. The diamond mines of Golconda were once renowned worldwide for producing the Koh-i-noor diamond and other famous stones; efforts have been made to revive production in the area. Quartz, limestone, and graphite also occur. The state has established a mining and metal-trading corporation to lead the exploitation of its mineral resources. Most of Andhra Pradesh's energy is produced by thermal generators in the public sector. Hydroelectric power stations—notably those on the Krishna River along the Telangana border at Srisailam and Nagarjuna Sagar—provide an important secondary source of energy. In addition, the government has established several wind farms. A number of private companies operate generators powered by natural gas; they also have worked to develop wind, biomass, and other nonconventional power sources.

Manufacturing

Andhra Pradesh since the mid-20th century has become one of the most highly industrialized states in India. Industry—including mining, utilities, and construction as well as manufacturing—contributes roughly the same value to the state income as does agriculture, although manufacturing itself accounts for only a small proportion of the overall income. Industries such as shipbuilding, aeronautics, and the manufacture of electrical equipment, machine tools, and drugs have been established in the Visakhapatnam area. Private enterprises, many of them located in and around the urban agglomeration of Vijayawada and Guntur in the east-central region, produce chemicals, textiles, cement, fertilizers, processed foods, petroleum derivatives, and cigarettes. A number of important enterprises of moderate size, such as sugar factories, are scattered across the medium-size and smaller urban areas. There is a mammoth steel plant at Visakhapatnam, where raw materials and port facilities are easily accessible; an oil refinery also is located there, as is a large shipbuilding yard. The increase in power generated by hydroelectric and thermoelectric projects since the late 20th century has benefited industrialization and irrigation.

CAUSES OF FARMERS SUICIDES

The large number of suicides by farmers in various parts of the country is perhaps the most distressing phenomenon observed in India over the last decade. These suicides, which reached almost epidemic proportions in certain pockets of the country, were first recognised and reported by an alert press around the late 1990s. The public concern that these press reports created forced some State governments, such as those of Karnataka, Andhra Pradesh, and Maharashtra, to set up Commissions to enquire into the phenomenon. The databases on which the press and the Commissions of Enquiry depended were somewhat uncoordinated and sporadic: they were either impressionistic, or based on information collated by activist sources and organisations such as Kisan Sabhas or small-scale surveys conducted by the Commissions of Enquiry. While the extremely useful role that the press and the Commissions of Enquiry played in informing the public about this distressing situation has to be recognised, these efforts could be — and often were — dismissed as the products of the fevered imaginations of some journalists and social activists (**Bhagwati and Panagariya, 2013[1]; Jadhav 2008[2]** and **Kapoor 2013[3]).**

Increased Costs

From seeds to fertilizers, from tools to big equipment, everything has become extremely expensive for the farmers to buy and grow crops. On top of it the livestock industry also needs a good amount of expense to look after the animals, their health, their food, their hygiene and so much more. All these

increased costs may affect the purchasing value for the farmers which could lead in low production or low output.

The Debt

When the costs for equipment and other facilities increase, farmers may not have a choice but get a loan. Again, when the income is low due to the low production, then naturally paying off the interest and the loan amount is going to be challenge. The burden of increasing interest and low income to pay it off can be a lot to bear. Suicides due to inability to pay off the loans are high in farmers and the biggest cause that leads then to this path of taking their own life.

Loss of Family's Support

Loss of support from peers or family members could also be one of the major reasons for farmers' suicide. When we say 'support' it is not just financial support, but also emotional and mental support, which is equally important. When families of farmers go one step ahead and create an empathetic support for them, then the feeling of being understood or knowing that they aren't alone or they can fight and find ways out of the problem can help them to take a step back from think about suicide.

Lack of Awareness

If farmers are educated frequently about the loan facilities, subsidies, new ways of farming and much more than their problem-solving skills may develop and they may think of different ways to look at a problem and find different solution other than suicide. The various reasons include monsoon failure, climate change, high debt burdens, government policies, mental health, personal issues and family problems among the reasons of farmers' suicides in Andhra Pradesh.

The surge in input costs

A major cause of the farmers' suicides in India has been the increasing burden on the farmers due to inflated prices of agricultural inputs. The culmination of these factors is seen in the overall increase in the cost of cultivation**,** for wheat, the cost at present is three times than it was in 2005.

Cost of chemicals and seeds

Be it the fertilisers, crop protection chemicals or even the seeds for cultivation, farming has become expensive for the already indebted farmers.

Costs of Agricultural equipment

The input costs, moreover, aren't limited to the basic raw materials. Using agricultural equipment and machinery like tractors, submersible pumps etc adds to the already surging costs. Besides, these secondary inputs have themselves become less affordable for the small and marginal farmers.

Labour costs

Likewise, hiring labourers and animals is getting costlier too. While this may reflect an improvement in the socio-economic status of the labourers, driven primarily by MGNERGA and hike in minimum basic income, this has not gone too well with boosting agriculture.

Distressed due to loans

The NCRB data points out that in 2474 suicides out of the studied 3000 farmer suicides in 2015 the victims had unpaid loans from local banks. This is clear enough an indication for drawing correlations between the two. Whether or not the banks had been harassing them, however, is a long-drawn debate and needs more specific empirical evidence. Moreover, a shift away from usual trend also revealed that of the loans taken by these farmers, only 9.8% were loans from money-lenders. Thus the pressure or muscle-power of money-lenders could be far from being a major driving force, as is otherwise perceived. Another source of strong linkages between farmer suicides and indebtedness is reflected from

the spread of the two. While Maharashtra had 1293 suicides for indebtedness, Karnataka had 946. Note that both these states saw one of the highest incidences of farmer suicides as well as indebtedness.

Lack of direct integration with the market

Although initiatives like the National Agricultural Market and contract farming are helping integrate the farmers' produce directly with the market, cutting the role of intermediaries, the reality is still lagging behind.

Lack of awareness

The digital divide, as well as the literacy gap, has made the marginal and small farmers particularly vulnerable due to their inability to utilise the positives of government policies. This is reflected in the continued unsustainable cropping practices – like cultivating sugarcane in water-deficit regions.

Water crisis

The concentration of these suicides in the water-deficit regions of states like Maharashtra, Karnataka is a manifestation of how the water crisis and thereby failure to meet production demands have intensified the menace. This is particularly true in the backdrop of continued failed monsoons.

Interstate water disputes

What has added to the already prevalent crisis is the unwillingness to cater to each other's water needs amongst the states. A case in point is the recently resurfaced Kaveri dispute that saw Karnataka and Tamil Nadu battle out water shortage both in and outside the tribunal even to the extent of non-compliance with the tribunal award.

Climate change

The climate change has acted as the last nail in the coffin by resulting in furthering of the uncertainties associated with the already uncertain monsoon system and hence agricultural production. While incidents like flash floods have led to crop losses, deferred monsoons have seen production shortfall year-in and year-out.

India's urban consumer driven economic policies

The political economy of India is driven more by the urban consumers than the rural producers. This is reflected in the *urgency to impose price controls* in case of price rise (imposing Minimum Export Prices, bringing items under Essential Commodities etc) and a *lacklustre withdrawal* once the price is under control. Contrast this with how we have been imposing minimum import price to secure our steel sector. This differential treatment to primary sector also limits profit margin and thereby hinders farmers' chances of breaking free from the cycle of indebtedness.

Loan waivers instead of restructuring, re-investment measures

Our approach of handling farmer indebtedness and hence farmer suicides has been appeasement politics like the recent move by the UP government to waive off Rs 36000 crore worth of loans. Surprisingly this comes at a time when agricultural yield is expected to be better in the wake of a good monsoon. In essence, the factors sum up to crop failure, unsustainable production and subsequent farmer indebtedness leading to failure of strengthening the economic state of the farmer as the driving force behind these suicides.

The economy of Andhra Pradesh is mainly dependent on agriculture. Two important rivers of India, the Godavari and Krishna, flow through the state, providing irrigation. Paddy, Sugarcane, Cotton and Tobacco are the local crops. Recently, crops used for vegetable oil production such as sunflower and peanuts have gained favour. There are many multi-state irrigation projects in development, including Godavari River Basin Irrigation Projects and Nagarjuna Sagar Dam, the world's highest masonry dam.

Agriculture is the main occupation of 60 per cent of population and related activities. Rice is the major food crop and staple food of the state. Other important crops are Jowar, Bajra, Maize and Ragi. The state has 23 per cent area covered with forest. Agriculture has been the chief source of income for the state's economy. Four important rivers of India, the Godavari, Krishna, Penna, and Thungabhadra flow through the state, providing irrigation.

FARMERS SUICIDES IN ANDHRA PRADESH

The district wise and year wise number of suicides by farmers for bifurcated Andhra Pradesh are presented in Table 1.

Table 1

Year-wise Farmers Suicides in Andhra Pradesh

Sl. No.	Name of the District	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	Srikakulam	4	1	0	0	1	1	2	2	1	0	0	1	14
2	Vizianagaram	0	0	0	0	0	0	0	0	0	0	0	1	1
3	Visakhapatnam	9	5	2	1	1	3	8	4	1	0	0	1	35
4	East Godavari	5	2	4	3	2	2	10	18	5	2	0	4	59
5	West Godavari	8	0	0	1	1	1	0	0	0	0	0	5	16
6	Krishna	24	13	6	4	2	4	6	2	3	3	3	0	74
7	Guntur	73	24	33	22	30	5	12	25	15	14	0	12	293
8	Prakasam	44	9	8	10	8	0	10	10	1	2	1	12	125
9	Nellore	6	7	0	1	1	2	1	0	0	0	2	1	23
10	Ananthapur	72	70	69	90	86	47	45	67	40	31	41	51	908
11	Chittoor	39	22	24	24	17	10	3	7	3	0	0	3	163
12	YSR Kadapa	21	17	9	26	20	11	4	8	2	1	0	6	131
13	Kurnool	76	62	75	85	75	71	42	44	26	3	1	4	610
	Total	381	232	230	267	244	157	143	187	97	56	48	101	2452

CV: Andhra Pradesh 2.04

Source: Commissionerate of Agriculture, Govt. of Andhra Pradesh, Amaravathi[4]

As per the data collected from newspapers and from the list prepared by Andhra Pradesh Rythu Sangam (before bifurcation) during the five year period i.e. October 1997 to September 2002, a total of 877 suicides by farmers were reported in the state. In 1998 a maximum of 353 farmers committed suicide. During 1990-99, 59 farmers and in 2000, 82 farmers committed suicide. Again in 2001 there was a steep rise in suicides, the number reaching 200. The year 2012 also saw a spate of suicides. By the end of August 2002, 112 cases were reported. Later the figure rose to 218 by the end of November (**Prajasakthi, November 21, 2002**).[5] Of the total of 877 suicides, Coastal Andhra and Rayalaseema

Regions accounted for around 13 percent each. Moreover in Ananthapur district 70 cases and 59 cases in Guntur district were reported.

It can be observed from the table that the number of suicides which was 381 in 2004 gradually reduced to 48 by 2014 in Andhra Pradesh. But in 2015 the suicides were reported to be 101, the reason may be attributed to the unexpected seasonal conditions and drought affects. During 2016, the suicides were reported as 79. This inferences that inspite of supplementary improvement programmes implemented in the state, the suicides are still continuing in the state. The reason may be attributed to the drought conditions and irrecoverable indebtedness. The coefficient of variation for number of suicides for the period 1998 to 2015 is estimated to be 144.22%. The log linear growth rates of number of suicides in the bifurcated Andhra Pradesh for the period 1998-2015 are found to be 0.97 percent for Guntur, 2.71 percent for Ananthapur and 2.04 percent for the state.

INTENSITY OF FARMERS' SUICIDES IN THE STATE

District-wise Details of Farmers

The district-wise details of farmers' suicides in the state (2015-16) are presented in table 2.

Table 2

District-wise details of farmers' suicide in Andhra Pradesh (July 2015 to June 2016)

Sl. No.	Name of the district	No. of farmers' suicide	% to state total	No. of farmers' suicide per lakh hectare of Net Sown Area = (no. of farmers' suicides x 100,000) / net sown area in ha)	No. of farmers' suicide per lakh hectare of Gross cropped area = (no. of farmers' suicides x 100,000) / gross cropped area in ha)	No. of farmers' suicide per lakh farming farmers = (no. of farmers' suicides x 100,000) / no. of armers)
1	Srikakulam	0	0.00	0.00	0.00	0.00
2	Vizianagaram	0	0.00	0.00	0.00	0.00
3	Visakhapatnam	2	2.53	0.72	0.57	0.42
4	East Godavari	4	5.06	0.93	0.59	0.57
5	West Godavari	7	8.86	1.65	1.01.	1.24
6	Krishna	0	0.00	0.00	0.00	0.00
7	Guntur	20	25.32	3.76	2.95	2.63
8	Prakasam	6	7.59	1.02	0.98	0.89
9	Nellore	1	1.27	0.23	0.22	0.22
10	Ananthapur	27	34.18	3.18	2.93	3.71
11	Chittoor	2	2.53	0.54	0.47	0.30
12	YSR Kadapa	9	11.39	2.65	2.27	2.04
13	Kurnool	1	1.27	0.12	0.11	0.16
	Total	79	100	1.30	1.05	1.04

Source: Commissionerate of Agriculture, Govt. of Andhra Pradesh, Amaravathi[6]

Suicide case of suicides reported in the state: During 2015-16 the cases of suicides reported in the state are 79. Of them 25.32 percent of the cases are reported from Guntur district and 34.18 percent are reported from Ananthapur district. Moreover the number of Farmers' suicides per lakh hectare of net

sown area is reported as 1.30, and the number of farmers' suicides per lakh hectare of gross cropped area is reported as 1.05 in the state. On the other hand the numbers of farmers' suicides per lakh farming families are reported as 1.04 in the state. Observing across the districts the number of farmers' suicides per lakh hectare of net sown area are reported to be 3.76 in Guntur district and 3.18 in Ananthapur district. Similarly the numbers of farmers' suicides per lakh hectare of gross cropped area are estimated to be 2.95 in Guntur district and 2.93 in Ananthapur district. Moreover the numbers of farmers suicides per lakh farming farmers are observed to be 2.63 in Guntur and 3.71 in Ananthapur. Observing across the districts of the state the suicides per lakh farming farmers varied from 0.16 is Kurnool district to 3.71 in Ananthapur district. No suicide cases are reported from Srikakulam, Vizianagaram and Krishna districts.

Month wise Farmers' Suicides

The details of month-wise farmers' suicides in the state (2015-16) are presented in table 3.

Table 3

Month-wise farmers' suicide in Andhra Pradesh

Sl. No.	Months	No. of Farmers' Suicides	Percent to total number of farmers' suicides
1	July 15	8	10.13
2	August 15	9	11.39
3	September 15	11	13.92
4	October 15	15	18.99
5	November 15	9	11.39
6	December 15	9	11.39
7	January 16	3	3.80
8	February 16	8	10.13
9	March 16	2	2.53
10	April 16	5	6.33
11	May 16	0	0.00
12	June 16	0	0.00
Total		79	100.00

Source: Commissionerate of Agriculture, Govt. of Andhra Pradesh

The table portrays that comparatively higher percentage of suicides was taken place in September and October months of 2015. Similar percentage of suicides was reported in August, November and December months of 2015. Moreover 10.13 per cent of suicides are reported in both July 2015 and February, 2016. No suicide cases were reported in May and June months of 2016. Observing across the months the percentage of suicide cases varied from 18.99 per cent in October 2015 to 2.53 per cent in March 2016.

CONCLUSION

Andhra Pradesh is called as rice bowl of India and 63 per cent of its population lives in rural areas and depends primarily on agriculture. The main reasons behind farmer's suicide could be lack of money, financial problems, carrying the burden of debt, extreme crop failure due to natural calamities etc. The reasons why farmers commit suicide are varied and the methods they use to end their lives are also

different. The number of suicides which was 381 in 2004 gradually reduced to 48 by 2014 in new Andhra Pradesh Observing across the districts of the state the suicides per lakh farming farmers varied from 0.16 is Kurnool district to 3.71 in Ananthapur district. No suicide cases are reported from Srikakulam, Vizianagaram and Krishna districts. The percentage of suicide cases varied from 18.99 per cent in October 2015 to 2.53 per cent in March 2016.Farmer's suicide in Andhra Pradesh is a major issue and it should be dealt with seriousness.

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FINE ARTS IN TAMIL SANGAM AGE

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Abstract- **The historic period of Tamil Nadu started with the sangam age. Education in the arts is an integral part of the development of each human being. This study mainly will give importance to the origin and development of the fine arts in the history of Sangam period. Sangam age to fine arts had its progress in various fields and inspired the coming generations. The fine arts like music, dance, drama and painting were all developed in a conspicuous measure. Tamils embraced, there from not only literature but also music and drama. The concept of Muttamil comprising Iyal, Is I and Natakam had attained currency as early as the Sangam age.**

Keywords: **Music, fine arts, sangam age, sangampeople, art forms, instruments.**

INTRODUCTION:

The sangam period as the classical age of the Tamils analogues. The Sangam age in Indian history witnessed the rapid development of Arts and literary works in the southern reasons. Various fine arts were very popular in the sangam age. Poetry, music and dance were quite popular among the sangam people. Various fine arts were very popular in the sangam age. During the sangam period music and dance were highly developed and popular. Musical instruments of various types are described and included many kinds of yal and varieties of drums.

Music

Music is the subtlest and finest of all fine arts and it develops the faculty of human imagination and appeals to the soul and conscience of the people. Through its melody or harmony it gives infinite pleasure to the mind and the heart. Tamils of the Sangam age possessed a highly developed system of music. The **Purananuru** shows that the Tamils had acquired a remarkable skill in music from an early time. They took a great delight in assembling in large numbers for the purpose of enjoying music, vocal and instrumental as well as dance performances. From **Pattinappalai** we come to know that the people of **Kavirippumpattinam** often resorted to the common place of the city in order to witness dances and enjoy music recitals. A class of bards known as Vairiyar used to provide music in the public assemblies of the village. It is learnt that when the guardian tree of a hostile ruler was felled the **Vairiyar** used to sing songs in merriment. The bards used to sing in praise of kings in their palaces early in the morning. There were the ubiquitous panar, the roving musicians and dancers. The groups of Panar proceeded from place to place. Their womenfolk **Viraliar** also sang the glories of Kings and Chieftains. The Porunars were the bards who accompanied kings to battlefields in order to cheer up the soldiers by their war songs and music.

Porunar

The Porunar were well known for their resourcefulness ready wit and conspicuous skill in conversation also. Rich presents were given to the Porunar and their womenfolk by the Kings munificently. When the king or chieftain Won a victory, golden flowers were given to the Porunar and jewels and ornaments were presented to the Viraliar, Among the Porunar and Panar, though they belonged to the same class, the former were more esteemed and more gitted poets and musicians than the Panar, However the Panar themselves were men or notable skill in music and Ldance. The artistic performances of the Panar and their women were immensely relished by the common people too.

Usal vari

From time immemorial there was in vogue the practice of women singing lullabies in order to lull babies in the cradle' to sleep. This variety of song was known as "Usal Vari". The girls used to sing songs when they were swinging in the Unchal i.e, swings from branches of trees or other hangers Women pounding rice resorted to a particular variety of song during the ourse of their work was described as Vallaippattu, Kurava women are said to have sung songs in order to miti~ato the pain and agony of their husbands when they were writhin with pain.

Asunam

A bird known as Asunam, mentioned in Ahananuru and Narrinai (it is said to be an animal) is said to have had a remarkably sensitive ear for music was called the '**Isai Art Paravai Paravai**. The cc mmon belief was that those who

wanted trap the bird sang suitable songs in order to entice it. from the Aliananuru it is learnt that even wild animals were stunned -by' the spell of sweet 'music. The application –'Isai' given to music, is itself significant; it denotes that which- moves or meets. According to Parimelalagar tbe verses of Paripadal were attuned to music.

High Degree

Tamils claimed the highest degree of musical perfection though they were much indebted to folk music in the evolutionary stages. They excelled in soft melodies through the gamut that consisted of seven notes or svaras. They were known as kural, tuttam, Kaikkilai, Ulai, ili vilari and taram. These were identical with the swarams or symbols, sa, ri, ga,ma, pa, da and ni, Their Sanskrit equivalents are Shadjam, Rishabham, Gandaram, Madhimam, Panchamam, Daivatam, Nishadam respectively. The seven tones were divided into 22 quarter tones or rutis or matras. In Puram 152, Venbaranar mentions the twentyone'Musical Stages'. The commentator explains this as the twentyone stages obtained by playing the seven svaras at the three places viz Tharam, Madhiyamam , Uchcham, His alternative explanation is that number twenty one refers to the number of 21 strings on a yal.

Patumalai

Pan was raga or tune. Sevvali, Marudam, Palai etc. were 'Pans'; it was prescribed that Sevvali was appropriate to the afternoon" and Marudam to the dawn. There were seven kinds of palai, viz Cempalai, Padumalalppa lai, Cevvalippalai, Ammpalai, Kotippalai, Vilarippalai, Mercempalai that were in practie. But, K. Kothandapani Pillai in his rook Pazhan tamil' mentions that seven palais are entirely different from 'Palai Nurperum Pannum Elu Perum Palaiyum' of Perunkatai. It is for musicologists to think *it* over and decide whether all tunes were the sub-divisions or offshoots of main tune palai or not. It may be surmised that the term palai was used in a broad se n-,e ~ignifyillg seven different main tunes since some names Cevvali, Patumalai and Vilari are associated with the wow -patai' , In the- initial stages the-principal -runes or airs were four in number Palai, Kurinchl Marudam and Cevvali. When the knowledge of music developed there were many variations for each time based on emotions such as war, marriage or ceremony.

Musical Instruments

"Instrumental music has played a prominent part in the evolution of music of both the Orienl and the accident Man became very conscious of the fundametntal principles of musical science, through musical instruments. The rnonophonous voice was not much help to him in practically working out and understanding the various musical laws and phenomena" says Prof. P. Sambamurthy, tbe musicologist. Tamilagam of the Sangam age has evolved different kinds of musical instruments suitable for chamber music, open air music aod marital music. The musical instruments were termed in Tarnil works as Turiyam, Iyam and Kalam.

They were carefully preserved in covers called 'Kalap pais'. On the basis of note technique, the musical instruments may be clasified into two kinds, the monophonnus in-trurnents that can produce only one note at a time like the horn, and the polyphonous instruments that can produce rn vr e than one note at a tim- like the Yal, Generally the musical instrurnenre are classified into four kind, as follows. (1) Torkaruvi, (2) Tulaikkaruvi, (3) Narampukkaruvi and (4) Kanchakkaruvi.

The Tamils of different tinais or regions had their separate parais and musical instruments. Parai, the percussion instru- ment, and Yal, the stringed instrument denote the distinctive features of Tamils. They find place in the list of Karupporul as follows. Local festivals and Individual ceremonies offered ample scope apd O,pportunities for the musicians to have splendid display or their musical talents. However, music played an important part as a unifying force of different strata of society in many ways.

Torkaruvi or Percussion Instruments

Percussion instruments are generally based on the principles of talam or layarn or rhythm. They vary in size,structure, sound and manipulation. They are also differentiated according to the different occasions such as 'festival, marriage, worship etc. The names of percussion instruments found in the ancient Sangam works are as follows : Muracu or panai, mulavu, tannumal, kinai, tatari, patalai, parai, tattam, tontakam, Pampai tuti, akuli, paoripparai, manror sirnparai, mattari etc.

Morasu

Murasu was a big drum which had unique honour in royal "lnalaces. During village festivals also murasu was used. The urasu was considered an important feature of war, camp and he battlefield This gave encouraging sensation to soldiers in heir progressive expeditions. Generally-the murasu sign.fied be honour of kings and chieftains in T amilagarn. The unique place it had in royal palace is already mentioned. It's sound was compared with the rainfalls and the roar or he sea, and it was used as a simile for the sound of Waterfalls rid thunder bolt. There are references to the high pitched, odaimurasu for announcing chat ities. This drum was used, Dot only for the mass feeding of gallant soldiers but also for the poor people. In Paripada l the sound of manamurasu (marriage drum) produced at Madurai was like the roaring sound of the sea and that of lndras thunderbolt. Its echo was beard in Tirupparankuodram, the temple of Murugan.

Mulavu

Mulavu can be identified with the modern mattalarn in shape only. From Malaipadukadam and Ahananuru it is known

that a stick (mulavin ta laik k.rl or rnulaviu errkurnil) was used for playing on mulavu; this stick was helpful for 'travelling artists on slippery path. Mulavu might have been - played on one side of it With fingers and on the other side with . stick. The Mulavu appears to be a big 'Udakkai' or Pampai. played with' stick and hand in local temp- les. The identification of it with Mattalam appears to be improbable. Mulavu is. given a central and important place to draw the minor muslcaj , defects of other instruments. This is evident from Madurark- kanchi, When the devotees of Lord Muruga holding in their bands their offering to tne Deity, the choicest offering among them was Mulavu,

Tannumai

As regards Tannumai there is no clear definition or shape about it. The term Tanuumai was used by the Sangam Tamils, in different meanings. It is referred to in Padirruppattu as makkattannumai (Tannumai with black spot, i.e., the black substance (Man) applied on the face of it, In that context there is also reference or note that it was played on by hand (Kaiyalai aluka). According to the commentaries of Padirrup pattu tannumai is interpreted as murasarn in this contexts.' orppuratannumai arppelunto muvala'. In Narrinai it is noted as 'palavai tannum d' In Ahananuru and Kuruntogai it is mentioned that tannumai was used by the Vcttakkavalar of Vetar clan especially whilst lifting cattle. In Purananuru here is an imagery about the honey bees alarmed by the sound of this drum (tannumai) flyaway from their honey combs bamboo tree. From MulJaikkali we infer that tannumai was considered as a marriage drum during the Sanga m age There is a reference to 'pookkoleya tannumai' in Ahananuru, and Purananuru. They speak of this instrument played for gallant warriors to select the flowers or symbols suitable to the situations of warfare.

Kinai and Tatari

The Kinai and tatari are different kinds of drums that give the sound syllabus-'kin kin' and 'tata tata' respectively. Kinai is a double faced drum since the old commentary Oil Purananuru identifies this as Udukkai. The movement Kinai is compared with that of turtle. This was also play with both sticks and hands. A Ceylonese scholar S.Vidyananthan identifies this Kinai with tatari. There are al references to show that kioai and tatari are one and the sum It may be said that kinai, tatari and udukkai are synonyms.

Patalai

Patalai is identified with single faced large drum called! 'Orukan Makkinair, fhere are references to 'Orukan Makkinai'' and 'PlItatai Orukan' in Purananuru. The musical souad *or* patalai was belpful to note the time measure. So it was called 'Dotitaru paniya patalai' in Malaipadukadam. Mayilai Seeni Venkatasami suggests that the modern term ‘tabla' (tapalai) is only the word patalai suffering metathesis.

Tattai

Nachinarkkiniyar says that tattai is an instrument made of bamboos and adds that it is called Tattai since it resembles the clapping of hands. It was used to scare away the birds coming towards the corn fields. Tattai is identified with Karadikai having the sound of bear.

Tontakam

Tontakam is a small drum played by the people of the hilly tracts to scare away the birds coming to eat millet in the fields. Ahananuru speaks of a folkdance participated by both males and females to tbe musical accompaniment or tontakam in the hilly streets. The Tirumurukarruppadai describes kuravaikkuttu performed by drunken jungle people with their relatives to the musical beat of tontakam *Manror Siruparai* mentioned in Malaipadugadam may be identified with tontakam since the description are alike.

Akuli and ElIari

Akuli is described in Maduraikkanchi as 'Nunnirakuli' Malaipadukadam says that the sound of owls was just like the sound of Akuli. Ellari is also a small drum mentioned in Malaipadukadam, According to Nachinarkkiniyar it is called 'Calli' since it has the sound of - Cal', Purananuru speaks of ellari' in the sense of ‘Calli’.

Tudi or Udukkai

In Porunararrupp::tdai, the side of rudi when beaten is compared with the circular foot of an young elephant. Tudiyan was one who played on Tudi. Tudi was played when offerings were made to the deities like ‘nadukal'. Paripadal mentions the use of tudi during the dance perfor- mances. It was useful to give caution to the agriculturists against sudden floods. Tolkappiyam explains a situation Tudinilai,

Pampai

Narrinai mentions about Pampai a, kind of drum which IS still in use in village festivals. Makuli and Mattarai are mentioned in Paripadal,

Parai

The term parai was used in a broad sense in the Sangam period. Kalittogai mentions about the sound of parai as a caution for the people to guard themselves from the ruttish elephants coming along the streets. The ancient poets speak about a peculiar animal called a cunama which could not tolerate the harsh sound of parai.

TULAIKKARUVI OR WIND INSTRUMENTS

Wind instruments are considered by the scholars as the earliest musical instruments of Tamils. In these instrumens sound is produced by setting in vibration a column of air inside th'e tube-like middle part. They are either mouth

blown or bellows blown. The antiquity of the wind instruments is explained by Captain Day in his book" The Musical instruments of Southern India and eccan." The following are the wind instruments mentioned ill the 'Saogam works: Flute, conch, Neduvankiyam or tumpu and Horn or trumpet.

Flute

Flute is the most universally common wind instrument amongst all musical instruments. The commentary on Paripadal speaks of 'Pakarkular' as a keynote instrument. The standard tonic note was set by the flute according to 'which the Yal was tuned. Kalittogai speaks of flute as coni . rolling the musical timbre of 'Yal.' In Perumpauarruppadal and its commentary some points regarding the process of making a flute are mentioned. In Paripadal there is a reference to flutes with seven and five holes. Ba-roboo. ampal stem konrai fruit were used for making flutes, The musical sound produced by the shepherds and cowherds during the evening hours was considered inducing pathos in the minds of' sepa rated 'lovers is picturised in Kurinchippattu, In' Pattinappala there is a detailed-description ofYelan Veriyadal, a kind of dance in which mention is made of flute as being one of the musical instruments to that dance. There is ample' reason to believe that it is a divine musical instrument as it is associated with Lord Muruga in Tirumurukarruppadai.

Tumpu or Neduvankiyam

In the world of music instruments, flute and turnpu are interpreted as Vankiyam and Neduvankiyam by the commentators of the Sangam works. The Tumpu should also be a flute of larger size with sligbt difference. As the term tumpu is also meant for the trunk of an elephant, and the sound of the tumpu or the appearance of an elephant is noted as resembling elephants sighting it seems that tumpu might have been a vertically blown pipe .

Horn or Udu Kompu

It should have been made of animal horn, whereas might have been made of the cone of strong wood •

Valai

The Valai or conch was also another musical instrument used during the festivals and war times. The conch was regarded as a sacred instrument. Its blowing indicated specially a success in the battle field; it might be a precursor of the trumpet.

NARAMPUKKARUVI OR STRINGED INSTRUMENTS

Yal (Yazh) is considered the oldest Tarnil musical instrument which paved the way for the emergence of a number of stringed instruments-plucked, bowed and struck varieties, Regarding the origin of this instrument Prof. P. Sambamurthy says, “When the primitive man shot an arrow he heard the fascinating sound emanating from the string of the bow. The bow string or Vil Yazh is the earliest stringed instrument in the history of human culture.”

The TamiIs had for every Tinai special instruments Vil, Yal and Parai suited to these tinais. In this connection there were Kurunchi Yal, Mnllai Yal, Marudbam Yal, Neydal Yal and Palai Yal. In Paripadal the term -Kuttam' is used for Yal in general. Four of the Pattuppattu works, Porunararruppadai, Sirupanarruppadai, Perumpanarruppadai and Ma la ipadukadam or Kootharar ruppadai have fine descriptions of Yal (Yazh). While describing, the shape and other observation of things and imagination. In the midst of differences of opinion regarding the real shape of the 'Yal' Swami Vipulanandar has thrown some light on this in his -Yalnul', ,

In Porunararruppadai there is a hyperbole that even the highway robbers of desert region are renouncing their robbery when they hear the charming music of the Palaiyal. Kalittogai has got a reference to point out that even wild elephant was brought under control by the music of YaL In Narrinai tltil sound of Yal is used as a simile for the sweet voice of Kuruku, (a kind of bird). The comparison that the sweet voice of a woman is like the music of Yal indicates that the Yal should have been very popular musical instrument among the highly. artistic minded people. The Panars were called Yalppanar.

KANCHAKKARUVI OR BELL METAL INSTRUMENTS

In the Sangam age, tala or rhythm held an important place in music -Iogy. In the opening stanza of Malaipadu kadarn there is a list of various musical instruments that were used by ancient musicians. In that list, there are two kinds of Cymbals, viz Pantil, and ElIari mentioned vividly. Pantil was made of well melted bronze and was circular in shape as to produce a ringing sound. While describing elari, the large cymbal, Per un Kaucikanar author of Ma1aipadukadam uses the attributed attributive words (that which is being bright and loud) signifying subtly the features of Cymbals i.e. sound and shining. In. Ahananuru, the cymbal 'is-mentioned. The large cymbal was made of gold. Though it is mentioned here so gold should be taken -a ,broad .rerm for-metals in general, since it is not possible to get the ringing or musical sound from genuine gold.

Bells

.Tbe sound of bells also was required as one of the musical accompaniments for the dance performances for the dance performances. In Ahananuru the dancer Attanatti has been described as wearing a belt of small bells around his hip in order to have the musical sound keeping time measure with his dance. In Kuruntogai it is described that the musical sound produced from the small bright bells was like the Vilarippan. In Purananuru it is mentioned that -Iraimanl' was

during the sentimental offerings to the deity in the hope of healing a hero's wounds and scaring way the ghosts. God Muruga is described as bolding a bell in one of his twelve hands in Tirumurukarruppadai,

Musicians

In the Sangam age musicians of high repute were patronised and gifts were given to them by Kings and other affluent persons. Lotus flowers made of gold as well as flowers knitted together with a silver string were presented to them. Occasionally lands and entire villages; too, were bestowed on them as gifts. Among the rulers of Tamilagam Pari, Nalankilli, 'Palai Padia Perunkadungo and the Pandian Nambi were some of the well known patrons of poets and musicians.

DANCE

Dancing was. developed with great enthusiasm during the Sangarn age. It attained a high degree of excellence in the peried of tbe post Sangam. The kings and Chieftains patronised "-dancing no less than music. Verses sung in praise of Kopperuncholan and Pari testify to this. The poet, Uraiyur Mudukannan Sattanar adverts to tbe patronage of dance by Nalam Killi.

Dancing was known by several names like 'Attam', 'Koothu; and Kunippu', Tolkappiyam shows' that dancing was resorted to by all classes of people. Tolkappiyam mentions Vallikkoothu and Kalanilaikkoothu. Vallikkoothu was the representation of the supposed dance of Valli the consort of Lord Muruga. The second one was held in honour of those soldiers who firmly stuck to their posts, relentlessly fighting the enemy even after many of their compatriots had retrated. Another pattern of dance is described in the section on the Puratrinai Iyalof Tolkappiyam. It was dance held by the fellow kings in honour of a ruler who was killed in the battle. The references to ritual dance was found in Kuruntogai and Maduraikkanchi, There is an interesting dance description in Kuruntogai held' in honour of Murugan.

Dance could be performed by men as well as women. Adi Mandi, the daughter of Karikalan's husband Attan Athi was a dancer. Madurai Tamila Kuttanar was a dancer from Madurai who bad specialised in the kind of dance peculiar to Tamilagam. A koothan or a porunan was a male dancer or actor and a Kootti, a femall dancer. The male dancer was called attan, the dance was attam and the stage aderkalarn. Anion the Sangam works, the Malaipadukadam and Porunararruppadai in particular describe the skill of these professional dancers.

Kuravai and Tunangai were group dances. The Kuravai though common *in* the Marudam region was also adopted the Kurinchi and Mullai. A ferocious type of Kuravai was the Verikkuravai, commonly resorted to by Kuravar when in a wild temper. This dance was common among the kurava soldiers. Adorning themselves with palmyra garlands these Kurava used to do dance in a frency. Tunangai generally to place in the open theatre of the village. In was a dance which men women participated. The women used to embraced each other in the course of the dance.

Apart from this associated with the battlefield there another type of' Tunangai ' when the victory was won, the or the leader of the triumphant army used to lead this dance in the midst of the corpses lying all around. On festive occasion groups of women performed the Tunangai dance. The Malaipadukadam shows that there was dancing at festivals and that, at other times, too, hillmen and their wives danced in order to amuse themselves. Kalittogai describes the attention devoted to pose and facial expression during dance.

How far the Tamilian technique of dance was influenced by the North Indian pattern has become a matter of controversy. "Whether the Tamil system of dance was indebted to. Bharatha or not one thing is clear, that is, that Bharata himself acknowledges the highly developed nature of South Indian music and dance."

"Chitra Dakshina Vrtte tu saptarupe prakirtita Sopohane sanirgite devastutyabhinandite Naradadyais tu gandharvaih sabhayam Devadanavah

Nirgitam sravitah samyag Iayatalasemanitam". (Natyasastra, v.31-2)

"Now when songs in seven forms and in Chitra and Dakshina Margas together with the Upohana and Nirgita were started by musical experts like Narada in praise of Gods, all the Gods and Danavas in the assembly were made to hear the Nirgita performed with proper tempo and time beat." The above, translation is given by Manmohan Ghosh(Bib. Indi, 1951, p. 81). This shows that the Dakshina Marga of the southern pattern of music had attained a high position when Bharata wrote his work. There is another reference in chapter XIV of Bharatha's Natya Sastra shows that the South Indian dance too bad attained high measure of development.

The host of pure Tamil terms occurring in the early literature of the Tamils indicates the indigenous origin and development of music, dance and other fine arts. Such are words like Isai, Koothu, Tunangai, Kuravai, TalaikkoI, Porunan, Yal,' Pan, Kannul, Ulai, Ili and Oviyam. During the post Sa ngam period due to Aryan influence there seems to have occurred a combination of Sou rh with North. The division of 'Ariyakkootu' (Northern Dance) and 'TamiI Koothu' (Southern Dance) is an indication of the distinction between the exotic and indigenous form. In certain cases the Tarnil patterns seem to bave been adopted by the Northern system and Sanskrit names. Ahakkoothu and Purakkoothu became "Nritya" and Nritta' in the aspects of Bharatha dance. These varieties of dance mentioned in Silappadikararn might have developed from certain types of Sangam age. It is agreeable to accept that basically the dance was that of the Tamils but it seems to have had some influence in details at the hands of the Arvan settlers.

DRAMA

Reference to Natakam are found in the Tolkappiyam and other early works. 'Nataka Valakkilum, Ulakiyal Valakkilum' (Tol. Porul, 53) Though the interpretation in' this contex had varied with writers, it seems to denote drama.

The Maduraikkanchi states that dramas were enacted night during festive occasions. It is unfortunate that no early dramatic composition has survived barring no doubt the Silampu which is as much a work of drama as of literature. Even with regard to Silappadikararn a scholar Madurai University Tamil Department points out that Silappadikararn was only a Therukkoothu or street drama. The various aspects like Kattiyankaran etc made him to come to the above conclusion.

The section of the Tolkappiyam which is immediately striking as concerns the dramatic arts is the meypattiyal. Even though it appears that nurpa 251 which enumerates eight *meypadukal* would seem to contain the most relevant information in this section, nurpa 249 is of vital importance this discussion here in that it gives us Tolkappiyar's idea of how these meypattu originates Nurpa 251 of this same section of the Tolkappiyam is giving us a list of the **meypadukal** makes the level of development of dramatic performances during the Sangarn period. '

“Nakaiye alukai I1ivaral marutkai accam perumitam Vekuli uvakaiyenru appal ettam meypadenba".

(They say laughter, weeping. desnisedness, wonder. Rear fortitude, anger and delight are the eight meipadukal)

Richard A. Frasca says that the primary importance of this nurpa is that it indicates the sophistication of the Tamils' concept of the theatre during this period. The fact that they nalysed and classified these varied emotional manifestations is ample proof that dramatic performance had a very important place in this society. The eight meypadukal clearly had to be the central concept around which ancient Dravidian theatrical traditions developed.

Professor George L. Hart of the U.S.A. in his detailed study of Sangam literature has given a discussion of the various performers of this ancient period but has certainly missed the point in describing them only as poets or musician). Many of the Sangarn poems are 'dramatic utterances'. The dancing girls were called ‘nataka makalir’ and the performance conducted by them was spoken of as Natakam, Drama was definitely an important aspect of the Sangtrn culture. But Tolkappiyam does not specifically mention Koothu or Nada , Kam in its list of compositions (Yappu), Prof. V. R. R. Dikshitar in his valuable translation with notes of the Silappadikaram makes a direct equivalence between the pattu of the Aham and Puram and drama.

PAINTING

Painting was known by the pure Tarnil word 'Oviyam'. the class of painters was called "Oviyar ' or "Oviya Makkal. painters were also described by the significant expression .Kannul Vinainar, Nachinarkkiniyar explains this term by stating that skillful painters had the gift of captivating the onlooks by their art.

It is learnt from Maduraikkanchi that figures of god as well as scences of Nature were painted-on walls as well as on Canvas, Tamil works like the Paripadal reveal that there existed some treatises on painting. Nedunalvadai calls the outline drawing : which was not painted as Punaiya Oviyam. The pictures on the walls of the temple at Kavirippumpattina are referred in the Pattinappalai. Palai Padia Perunkadunko stated to have compared the brush employed for painting with a kind of soft flower called' Padiri' in Narrinai.

The reference to the Pandyan King**, 'Chittira Madattuttunjiya Seranmaran'** indicates that the royal palace had a hall or a picture galIery containing art exhibits. The temple of Lord Murugan on the hill of Tirupparankundram contain painted pictures on the walls. We learn from the Madurail kanchi about the existence. of painting probably on the wall of Jain monasteries in Madurai, It is learnt that the canopi of the royal cot on which the Pandyan ...ing Nedunchelia usedto sleep as welI as the walls and- ceilings of the room halS~, drawings of astronomical drawings representing the positiel of planets. We are not able to get any archaeological evidences old painting to estimate the quality of paintings. The litera references, however tend to show that paintings of high m ..were found. The poet andarattanar compares a handso damsel to the painting of a girl executed by a skillful painte As far as the available information goes the sculpture the early Tamils does not seem to have attained high stag development.

CONCLUSION:

The age of the sangam in the extreme South India was one of cultural transformation. At the turn of the first century B.C. South India moved from pre-historic period. That South India was absorbed into the cultural development of the sub-continent, which was taking place at the time. Thus the sangam age constituted a glorious era in the history of South India.

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Role Of Women During The Civil Disobedience Movement In Rayalaseema

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Abstract

After the withdrawal of Non-Co-operation Movement in February 1922 there was a lull in the political activities in India. The Lahore Session of the Indian National Congress in 1929 is an important landmark in the History of the Indian Freedom Movement. Jawaharlal Nehru, representative of younger elements in the congress was elected as the President. Congress declared attainment of Purna Swaraj (complete Independence) to India as its objective. To achieve this goal it also decided to start Civil Disobedience Movement and if necessary no-tax campaign against the British Government. It was at this session the congress has adopted to observe 26th January 1930 as the day of Indian Independence.

Keywords: Women. Civil, Disobedience, Movement, Rayalaseema

Introduction

The great enthusiasm shown by the people in celebrating the 26th January 1930 and taking the pledge given by Gandhiji, has indicated the mood of the people and their willingness to participate in the Civil Disobedience Movement. Before taking a final decision on Civil Disobedience he gave another opportunity to British to prevent Civil Disobedience Movement. He addressed a letter to the Viceroy in which he has mentioned eleven demands, which if acceded by the Government he would not start Civil Disobedience Movement. Gandhi considered these eleven demands as the substance of Independence. His eleven demands are:

1. Total Prohibition
2. Lowering of the Rupee-Sterling Exchange ratio to 1s 4D
3. 50% reduction in land revenue.
4. Abolition of Salt Tax, and Govt. monopoly on Salt
5. Reduction of Military expenditure by atleast 50%
6. Reduction of salaries of the Higher level services.

7. Protection to Indian Textiles
8. Reservation of Coastal shipping for Indians
9. Release of all Political prisoners
10. Reform of C.I.D. or its popular control, and\
11. Liberal issue of licences for the use of Fire-Arms for self defence and the permission to all Indian exiles to return home.

Gandhi felt that the acceptance of these demands would have announced to the achievement of most of the objective for which Indians had been agitating. Their non- acceptance revealed the exploitative nature of the British Rule. The Viceroy made no response. On the country, the Government started arresting the prominent leaders as a preventive step. Subhas Chandra Bose was the first Congress Leader arrested by the Government and was sentenced to one year imprisonment. So, Gandhiji decided to launch the Civil Disobedience Movement by breaking the Salt Law first by himself at Dandi. On 11th March Gandhi declared wholesale illegal manufacture and auctioning of salt should begin, after he had himself violated the law at Dandi. On 12th March Gandhi started his march from Sabarmathi Ashram to the Sea at Dandi through the heartland of Gujarath with 71 Ashram Members. This is popularly known as Dandi March.

It attracted the attention of the entire country and the world. Enormous publicity was given to this event all over the world. The March reached Dandi on 5th April. The very next day Gandhi started Civil Disobedience Movement by picking a handful of salt lying on the shore. This was the signal for starting Salt Satyagraha throughout the country by manufacturing salt flouting the law. It was a deliberate act of defiance to the mighty British Government and a signal to the nation that another stage in the fight for freedom has begun. Where facilities for flouting salt law do not exist, i.e., interior areas far away from the sea shore, Tripple Boycott, of Liquor shops, Foreign Cloth, Educational Institutions and services has to be followed.

Civil Disobedience Movement, 1930

On 10th April 1930, Dhurgabayamma, Headmistress of Girl's High School at Kakinada, addressed a meeting at Gandhi Chowk in Chittoor. Audiences of about 100 persons were present. One Krishnaswami, who accompanied Dhurgabayamma, also addressed the meeting. They exhorted the audience to join the Civil Disobedience Movement and enrol themselves as national volunteers. On 11th April, Dhurgabayamma had an informal meeting at Chittoor with the women of the Brahmin Street in the house of M. Ananthashayanam Ayyangar. She requested the women to induce their husbands to join the movement. Another meeting was held in the Varadappa Nayudu Girl's High School, mostly for women. In the evening, a public meeting was held at Gandhi Chowk with M. Ananthashayanam Ayyangar as the President. Dhurgabayamma spoke on the occasion. She repeated what she said the previous day. About 150 to 200 people attended. They included also a dozen women. On 13th April, there was a meeting of about 50 persons, mostly students at Gandhi Chowk, in Chittoor, to celebrate the Jallianwala Bagh Day and the National Week. M. Ananthashayanam Ayyangar who presided over the meeting spoke on the Khaddhar and temperance movements and the salt campaign. In April 1930, K. Subramanyam of Pennaperur village in Kadapa District wanted to take advantage of the Brahmotsavam at Vontimitta and

convened a political conference. He invited V.L. Sastri, President, Madras Andhra District Congress Committee to address the conference. He also endeavoured to organise a no- tax campaign in Badvel Taluk when the Taluk Board attempted to secure volunteers at Chittoor. On 22nd June 1930, three agitations from Vellore in North Arcot District were invited to address the meeting at Chittoor. As the meeting was prohibited under Section 144 Cr.P.C., the three Congress emissaries from Vellore reached Tirupati. On 24th June 1930, they wanted to hold a meeting. They were served with an order under Section 144 Cr. P.C. and one of them disobeyed the same. He was arrested and put up before the Joint Magistrate, Chandragiri, who convicted him and sentenced him to six months rigorous imprisonment. On 9th July, 1930, another Congress emissary from Kadapa District arrived at Kuntrapakam a small village near Tirupati to organize meetings.

On 2nd October 1930, a procession consisting of a few students went through the streets of Madanapalle with a photo of Gandhi. A meeting was held in the evening and the President of the meeting had been warned. The pamphlets advertising the meeting were printed by a local press and its proprietor was warned. One Mahadheva Sastry who had been imprisoned for violation of Salt Laws and who was released from the jail arrived at Madanapalle on 31st October 1930 on his way to Tirupati. He lectured to the people urging them to join the movement and to boycott foreign cloth. An attempt was made by him to take out a procession. He was prosecuted under Sections 153 and 290 I.P.C. and was sentenced to six months R.I. and a fine of Rs.50/-. In November 1930, some young men of Korlakunta, a village in Pulivendula Taluk tried to organise a procession with the photos of Gandhi and Tilak.

Gandhi-Cap and Ceded District's College Incident

On 4th August 1930, a hartal was observed in Anantapur in connection with the arrest of Pandit Madan Mohan Malaviya and shops were closed. A number of students of the Ceded Districts College, Anantapur and also of the Municipal High School stayed away from their classes and went in a procession through the streets of the town. The next day, finding that two of the boys in the college were wearing Gandhi caps, the Principal sent them out and put up a notice prohibiting the wearing of Gandhi caps inside the college. This was exploited by the local Congressmen like Y.Ramamurthy and Lakshmana Pillai who exhorted the students to disobey the orders of the Principal. An order for a large number of Gandhi caps was placed with a local tailor. The situation was, however, tactfully managed and on the students assuring the Principal that the wearing of Gandhi caps did not show that they were associated with any political party and that they did not intend to join any political propaganda while at college, the Principal withdrew his prohibition order.

Civil Disobedience Movement in 1931

In Chittoor, the conditions saluting to the National Flag was prohibited. Holding meetings were also banned. On 31st July 1931, A. Kaleswara Rao, General Secretary of the APCC visited Chittoor and made a very stirring speech abusing the Government. On 23rd August 1931, two Congress volunteers defied the D.S.P's order and went in a procession through the streets of Kuppam carrying Congress flag. The Sub-Magistrate of Kuppam issued an order under Section 144 Cr. P.C. prohibiting meetings, processions and carrying of national flags.

In August, 1931, the police prosecuted under Section 108 Cr. P.C. the Congress Secretary of

Kadapa for publicly approving political assassination. At Rajampeta, the police dispersed a public meeting.

Achanta Rukmini Lakshmipathi's Tour, 1931

In August 1931, Achanta Rukmini Lakshmipathi of Tamil Nadu Congress Committee and A. Kaleswara Rao toured Anantapur District on the invitation of Kalluru Subba Rao. On the morning of 29th August 1931, there was a public meeting in the Church Compound at Gooty (Gutthy). Rukmini Lakshmipathi spoke in English. Her speech was translated into Telugu by A. Kaleswara Rao. At 11:00 AM., there was another meeting at Peddhavaduguru on the invitation of Chinna Narayana Reddy. C.P. Obi Reddy presided over the meeting.

At Anantapur, Rukmini Lakshmipathi and A. Kaleswara Rao addressed a women's meeting at Sharadha Samajam and urged the women to join the Civil Disobedience Movement. From there, they proceeded to Gandhi Chowk. She said that the country was passing through a difficult period. Tracing the history of the struggle launched by the Congress in 1885, she appealed to the people to fight unitedly for Swaraj. On 30th August 1931, Rukmini Lakshmipathi hoisted the national flag at Dharmavaram. On behalf of the Mahila Samaj, Smt. Ambamma garlanded her. At Penugonda, both Smt. Rukmini Lakshmipathi and A. Kaleswara Rao were taken in a procession from the railway station to the residence of T.Sivashankaram Pillai. At the meeting held at Ramaswamy Temple, Venguswami Ayyar garlanded the guests. Agali Narayana Rao proposed a vote of thanks. On 31st August 1931, Rukmini Lakshmipathi and A. Kaleswara Rao addressed a meeting at Hindupur. P. Ramacharlu and Kalluru Subba Rao also spoke.

A.P.C.C. Meeting at Chittoor, 1931

The Andhra Provincial Congress Working Committee met at Chittoor on 29th and 30th September 1931, under the presidentship of the Kumara raja of Gampalagudem. Among those present were Messrs. T. Prakasam, K. Nageswara Rao,

A. Kaleswara Ro, B. Gopal Reddy and Narayanamurthi. The Committee passed resolutions condemning the prosecutions of Messrs. Lingaraju and Subramanyam. The Committee adopted the Secretary's report to the AICC regarding breaches of Gandhi- Irwin pact by officials in Andhra.

The Sub-Magistrates of Chandragiri and Puttur issued orders not only prohibiting the hoisting of the flag but also prohibiting the holding or attending of any meeting in support of the Congress Party or creed. At Madanapalle, cases were lodged by the police against V.V. Vedhanthacharyulu and Nagarathnam Mudhaliar for trying to extend monetary help to some volunteers. Proceedings were instituted under Section

109 Cr.P.C. against four young strangers who came apparently from Madras to Rompicherla.

In Kurnool District, the Civil Disobedience Movement was led by Swamy Narayananda Saraswathi, D. Sesha Reddy and K. Chenchu Reddy. D. Sesha Reddy, invited Kalluru Subba Rao toured Athmakuru Taluk for one week and explained to the people about the evils of the British rule in India.

Repressive Measures

The Government struck heavily against the people by resorting to severe methods of repression. By a Gazette Extraordinary, the Madras Government declared the APCC, the District Congress Committee of Anantapur and Bellary Satyagraha Shibiram as unlawful associations.

Resignation of teachers and other Government servants

During the Civil Disobedience Movement, teachers and other government servants in Rayalaseema resigned in protest against the repressive measures of the government. Those who resigned were C.R. Reddy, the Vice-Chancellor of Andhra University, T.K.T. Veeraraghavacharya and R.Venkata Reddy (Chittoor District), Nivarthi Venkata Subbaiah, D.H. Krishna Rao and D.Govinda Doss (Kurnool District),

D. Rama Reddy, M. Rangaiah Naidu and K. Subramanyam (Kadapa District).

Boycott of Educational Institutions

The students who gave up their studies during the Civil Disobedience Movement in Rayalaseema were: A. Chidhambara Reddy, N. Sanjeeva Reddy and H. Narasinga Rao (Anantapur District), M. Durvasulu Naidu, K. Mal Reddy,

V. Ramachandra Reddy, P. Thimma Reddy, A.P. Vajravelu Chetty, K. Venkatesayya (Chittoor District), M. Shamsheer Baig and A. Venkatasubbayya (Kurnool District). **Action against Local Bodies**

The Anantapur District Board which met on 31st May 1930 and passed a resolution condemning the action of the government for arresting national leaders like Jawaharlal Nehru, Sardar Patel, Abul Kalam Azad and others, was superceded on its refusal to cancel that resolution.

Action against the Press

The Telugu newspapers in Rayalaseema did their best to cover the movement and sent the messages to the nook and corner of the region. Therefore, the government's censor fell upon them to restrict their freedom. The Government had included a list of printing presses and newspapers in its blacklist. Warnings were issued or security was demanded from them. Among them were the Kowmodaki and Aindravathi published from Nandyal and Pattikonda respectively in Kurnool District. Kypa Subramanya Sarma, Editor and Publisher of Kowmodaki and P. Kondaiah Chetty, Keeper of Vani Nikethan Press were warned for publishing three articles, "Boycott of foreign cloth", "Prohibition" and "Mr.Gandhi's March" in their paper dated 27th June 1930. Vanam Sankara Sarma, Editor of Aindravathi was warned for publishing an article "The Gandhi Cap" in his paper dated 4th July 1930. P. Ramacharlu, Editor and publisher was warned for publishing two articles, "The Round Table Conference" and "The Cease of toddy shops and Kapus and Reddis" inhis paper Sri Sadhana published from Anantapur. In 1930, Rayalaseema Ugadhi Kaanuka, a Telugu annual was published from Tadipathri by K. Venkatarangachar. It contained a seditious article, "Wash thy feet in warm blood". It was a prayer to the Goddess of Freedom written by K. Venkataramanacharyulu, a partner of Deshabhandhu press where the journal was published. The government warned the printer and publisher for publishing the objectionable article.

Gandhi's Harijan Tour, 1933-1934

Gandhi, as part of the 'Harijan' uplift campaign, once again, visited Rayalaseema from 31st December 1933 to 4th January 1934 and covered places like Kalahasthi, Renigunta, Tirupati, Kadapa, Gooty, Peddhavaduguru, Ramarajupalle, Thimmancherla, Guntakal, Penugonda, Konakondla, Uravakonda, Vajrakaruru, Anantapur, Hindupur and Alur. He was accompanied by M.Bapineedu, Secretary, Andhra Harijan Sevak Sangh. Prof. Malkani, Meerabehan, Chandra Shankar Shukla, Uma Bajaj, Krishna Behan, Viswanatha Pandya, Dhamodhar Dhass, Ramanarayana Choudhary and one Mr.Sarma.

Gandhi Jayanthi Celebrations in Rayalaseema

In this conection, activities such as the portrayal of the life tof Gandhi importance of Khaddhar feeding of poor people, public meetings and processions were organized at Jammalamadugu, Kurnool, Kuppam, Nandyal, Proddatur, Palamaneru (Pallavan Eri means Pallavas Tank), Madanapalle and Narayanavanam. Prayers were also held in the Mahanandiswara Swamy temple.

Rajendra Prasad's visit, 1935

A notable event of 1935 was the visit of Rajendra Prasad, the President of the INC to Rayalaseema. From 23rd to 26th November 1935, he toured places like Nandyal, Panyam, Kurnool, Adoni, Nemakal, Guntakal, Vajrakaruru, Uravakonda, Kuderu, Tadipathri, Jalalpuram, Anantapur, Dharmavaram, Kuntimaddhi, Penugonda, Hindupur, Parigi, Lepakshi, Chilamatthuru, Kodikonda, Pathapalyam, Palasamudrum, Gorantla, Obuladhevara Cheruvu, Kadiri, Thanakal and Madanapalle. During his tour, he was accompanied by Acharya Kripalani, Hukkerikar, Chakradhara Saran, T. Prakasham, P. Ramacharlu and Kalluru Subba Rao.

Keshava Vidyanilayam

On the evening of 25th November 1935, Rajendra Prasad opened Keshava Vidyanilayam (behind District Board office at Anantapur), built for Harijans in memory of P. Keshava Pillai. Yerramala Kondappa donated two acres of land for the said school during Gandhi's Harijan tour of Rayalaseema in 1933-1934.

I. Sadhashivan was kept in charge of the school. Addressing the students, he appealed to them to sacrifice their lives for the service of the motherland.

N. G. Ranga's Election Tour, 1937

On 6th January 1937, a meeting was held at Thimmancherla near Guntakal in Anantapur District. N.G. Ranga addressed public meetings at Madanapalle, Anantapur, Dharmavaram, Pamidi organized the public meetings. At Pamidi, N.G. Ranga asked the people to defeat the Justice Party and vote for Congress. From Pamidi, N.G. Ranga left for Adoni.

Dhuvvuru Subbamma's Speech, 1937

In 18th April 1937, Desabhandhavi Dhuvvuru Subbamma from Nellore also addressed a public meeting at Gooty. She spoke about the political situation in the country. She criticised the Justice Party Government headed by K.V.Reddy Nayudu. She appealed to the voters to elect the Congress Party in the coming elections. She also addressed a women's meeting separately and asked the women to join

the freedom struggle. On 20th April 1937, Subbamma addressed a meeting at Pamidi. It was presided over by M. Sethu Rao.

C. Rajagopalachari's visit to Rayalaseema, 1938

In 1938, Gandhi Jayanthi was celebrated at Kadapa with the introduction of prohibition by C. Rajagopalachari, Premier of the Madras Government. At Rayachoti,

C. Rajagopalachari asked the people to give up drinking. At Chittoor, the prohibition was inaugurated by Yakub Hussain, Minister for Public Works of the Madras Government. Later Yakub Hussain, C.R. Parthasaradhi Ayyangar, R. Venkata Reddy, District Congress Secretary, L.Sundhararaja Ayyangar, Secretary, Prohibition Committee, Andhra region visited Murukkambhat, Kalavakunta, Penumury, Kothapeta, Poothalapattu, Venganapalli and asked the people to vacate the toddy and arrack shops. C. Rajagopalachari accompanied by Yakub Hussain, Muniswamy Pillai and S. Ramanatham visited Chittoor and expressed happiness as the toddy and arrack shops were closed. In the evening, they addressed a meeting near the police grounds.

Peasant Movement in Rayalaseema

A notable feature of 1930's in Rayalaseema was the organisation of Summer Schools of Economics and Politics for peasant activities. A Rayalaseema Peasants' School of Politics and Economics was opened at Giddhaluru in Kurnool District on 22nd December 1937 under the direction of N.G. Ranga in which about 25 students were enrolled.

N. G. Ranga also started in 1938 a Political and Economic Summer School at Madhanapalle in Chittoor District. It had 75 students on its rolls and it was an organ of socialistic propaganda. The lectures dealt with the evils of Imperialism and Capitalism and were intended to direct the energies of the students towards active participation in movements aiming at the abolition of these forms of domination.

A Summer School of Economics and Politics was organised during 20th May to 20th June 1939 at Kalwabugga in Kurnool District. G. Harisarvothama Rao was its Principal and it had strength of 64 students.

In Andhra all the Prominent Leaders of the Congress like Tanguturi Prakasham Pantulu, Pattabhi Seetharamaiah, Mutnuri Krishna Rao, Bulusu Sambamurthi and Pyda Bapayya were arrested. In spite of these arrests, the Congress volunteers continued the boycott and the swadeshi.

The prominent leaders of Rayalaseema and their followers in various districts participated in the second phase of the Civil Disobedience Movement. They had organized hartals in several places like Guntakal, Adoni, Kuppam and Nandyal. Gooty Kesava Pillai condemned the arrests of the Gandhiji and other leaders. The popular leaders like Kalluri Subbarao, Pappuri Ramacharyulu and Idhukallu Sadhasivan raised the revolt in Rayalaseema, but were arrested and sent to Jail. Several individuals sacrificed a great deal by participating in this Movement.

Participation of Women

Thousands of women participated in the second phase of the Civil Disobedience Movement in 1932. The participants like Vallabhaneni Sithalakshmamma, Digomerti Janakamma, Chukkamma, Duggirala Kanakamba, Kanagarthi Nagarathnamma, Vasireddy Hanumayamma, Dasari Krishnavenamma, Harikapudi Manikyamma, Suguna, Mahalakshmamma, Cherukuri Sowbhagyamma, Kotamarthi Kanakamma, Tripuraneni Kausalyamma, Vedhantham Kamala Devi, Kambampati Manikyamma were very prominent in the propagation of defying salt laws, picketing of liquor shops and boycott of foreign cloth. All the women were awarded one year imprisonment. Smt. Manikyamma had to go to prison with six months old baby in her arms. The women detenues were treated very badly. At this juncture, the Rayalaseema women were inspired by the leadership of Bharathi Devi Ranga wife of N.G.Ranga who led a campaign in Guntur district. She came to Rayalaseema Districts to propagate the movement among the women of Rayalaseema. She was arrested and sentenced to one year imprisonment and a fine of Rs.500/-.

During the Civil Disobedience Movement, number of Teachers serving in Municipal Schools, District Boards and Government Schools in Rayalaseema resigned to their jobs in protesting against the attitude of the Government. C.R.Reddy, Chittoor; Nivarthi Venkata Subbaiah, Kurnool,; M. Rangaiah Naidu from Kadapa District. Many of the students of Rayalaseema gave up their studies during the Second phase of the Civil Disobedience Movement.

Anantapur District

Lakshmi Devi D/o Narasayya

She was born in 1896, daughter of Seshamma and Narasayya. She was very much interested in studies but her parents got her married early and soon she became a widow. Even then she did not give up her hopes about studies. It was her uncle (mother's brother) who supported her in her studies. By 1925, she became the first Doctor in the Anantapur District. While studying Medicine in Bombay, she had observed social and political leaders and developed independent views. She got married in 1929 with Nivarthi Mrutyunjaya Sastri, a Junior Lawyer under her Uncle. She started her medical practice for common people. She was interested in maintaining not only a healthy body but also a healthy society.

By 1930 she was driven towards the Salt Satyagraha Movement. She met Gurgabayamma under whose influence she started addressing the people in large gatherings and picketing foreign goods. The police arrested her and brought her before the Sub-Magistrate Court. After heated arguments she was sentenced to six months Rigorous Imprisonment and a fine of Rs.200/- or in default of which further two months imprisonment. She was lodged in Vellore Jail in 1932.

Lakshmi Devi, worked for Harijan upliftment. She encouraged and followed inter-dinning and collected Harijan Fund when Gandhiji visited Bellary in 1934.

She was also served as Vice-President of the D.C.C. and worked for involving more women in the Congress and its movements. In 1935, she was elected as a member of composite Madras State Assembly for Two and half years and worked hard for her constituency. She was a representative from Bellary to the All India Women's Conference. The Sastri couple suggested change of the name of Ceded Districts as Rayalaseema they also suggested Tungabhadra project for improving irrigation

facilities in that region. She worked for the cause of unity and integrity. She died in February 1976.

Kadapa District

Kadapa Rama Subbamma

She was born in 1902 in Kadapa district, daughter of Ramachandra Reddy and Atchamamba. Her father was a great Sanskrit Scholar. She was married to Kadapa Koti Reddy in 1917. He was a Barrister Law in London and Oxford University, but turned a nationalist and inspired Rama subbamma. As a result of this atmosphere she joined the Congress in 1921 and started her political activities. She was highly inspired by T. Prakasam activities during the boycott of Simon Commission at Madras. She participated in the Salt Satyagraha of 1930 along with Durgabayamma, Dronam Raju Lakshmi Bayamma, Ponaka Kanakamma and other great leaders.

During the Individual Satyagraha in 1941 she participated along with her husband but was not arrested. When her husband was arrested, she organized the movement from 1918, and served as its Vice-President. She served as the Municipal Councilor for 40 years and did great service. She worked for women upliftment. She was the President of District Congress Committee from 1938-43. She left it during the Quit India Movement.

She was the President of All India Women's Conference State Wing. She toured extensively throughout the State. She was a great social worker and worked for the establishment of a Women's College in Kadapa. She donated One Lakh rupees for this purpose. She served as a Member of All India Social Welfare Board. State Social Welfare Board and President of Guild of Services. She worked in the relief programme of Rayalaseema famine. She was a member of All India Congress Executive Committee. She visited foreign countries. While addressing a meeting of Andhra Yuvathi Mandali. Hyderabad in 1940 she inspired the women of Hyderabad to come out of the seclusion. Though she was not arrested. She took an active part in the freedom struggle and social field.

Dr. Muthulakshmi Reddy

Dr. Muthulakshmi Reddy was one of the great women leaders of this period. Though her work was confined to Madras Women of Andhra derived benefit of her services as a Member of the Legislative Assembly. She was responsible for the enactment of laws concerning education and Health of Women, the abolition of Devadasi System and the suppression of prostitution. All her reforms had their impact on women in Andhra as there was already awakening in these matters dawned by the social reformers. Prominent person's likeYamini Purnatilakam, her daughter Rama Tilakam and the famous cinema star of the day Bezawada Ranla Tilakam had carried a movement for abolition of the Devadasi System. Dr. Muthulakshmi Reddy started a number of institutions for women. She did not participate in the Salt Satyagraha or in picketings and boycotting like other women of Andhra. But as a staunch follower of Gandhiji as an educated lady, she tried to awakening the women through meetings, discussions and organizations. As a follower of Gandhiji she resigned her membership in the Legislature in 1930. She represented Women's Indian Association and attended the Round Table Conference at England. When Gandhiji visited Madras in 1933, she was the President of Women's Indian Association and organized a large women meeting with Gandhiji. These women took a pledge that they would carry on the campaign against untouchability. She had already established Avvai Home, in which she

sheltered women of all castes. She took up the task of constructing a Cancer Hospital through the Women's Indian Association and collected huge donations. Though her eyesight was deteriorating due to age she convinced Gandhi and carried on the work.

Dr. Muthulakshmi Reddy was the first lady Doctor in the composite Madras Province. She was highly influenced by the Brahmo Samaj and its founder and leaders. **Conclusion**

Thus, Mahatma Gandhi's call of Civil Disobedience Movement has enormous effect which spread to the nook and corner of the country symbolizing that irrespective of age, education, profession, religion all joined together for the cause of freedom for the country. It is important to note here that because of the sacrifices made by the lakhs of people who suffered in the hands of the British by serving jail sentences, hangings, firings and Lathi charges. We are enjoying freedom. In this context the role played by Rayalaseema Women freedom fighters who involved in this movement played a key role in arousing national sentiment among the people for the cause of national independence.

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Editor-In Chief

With the disintegration of the Soviet Union and the end of the Cold War, India reoriented its foreign policy priorities. The intense historical ties and the presence of a vast Indian diaspora in the region made it easy for India to unveil the "Look East Policy" (LEP) in the 1990s. The increasing harmony between India and ASEAN led to the acceptance of India as ASEAN's sectoral partner in 1992, full dialogue partner in 1996 and Summit-level partner in 2002.

FROM LOOK EAST TO ACT EAST

Prime Minister Narendra Modi, who came to power in 2014, rephrased India's Look East Policy to "Act East Policy" (AEP) at the 12th ASEAN-India Summit in 2014 held in Nay Pyi Taw in Myanmar. The amended message was that India was keen to act on its promises. More emphasis was given to connectivity, with the Cambodia, Laos, Myanmar and Vietnam (CLMV), which had not had priority attention in the LEP. AEP is a comprehensive policy that looks beyond ASEAN to include countries in East Asia and the West that is, the Indo-Pacific region. At the 16th India-ASEAN Summit, Prime Minister Modi declared that, "India's Act East policy is an important part of our Indo-Pacific vision and ASEAN lies at the core of it. India-ASEAN share a principle of regional architecture that is open, inclusive, sustainable, transparent and rules based".

In August 2015, under the ASEAN-India Plan of Action for the period 2016–2020, security, economic and socio-cultural aspects were identified as three priority areas for cooperation. Enhancing strategic ties with the vibrant ASEAN, India's fourth largest trading partner, through trade, investment, education and culture is considered a critical aspect of India's AEP. Bilateral trade between India and ASEAN grew from US$ 12 billion in 2003 to US$ 142 billion in 2018. India hosted the leaders of all ten member states of ASEAN at India's Republic Day parade on 26 January 2018 to mark 25 years of the ASEAN-India Dialogue Partnership. It also hosted a two-day Summit in New Delhi in January 2018 to commemorate the 25th Anniversary of the ASEAN-India Dialogue Relations, under the theme of "Shared Values, Common Destiny".

SOFT POWER APPROACH TO INDIA-ASEAN RELATIONS

The soft power of a country essentially rests on three resources, namely, culture, political values and foreign policy. Soft power-building tools include cultural and academic exchange programmes, media, international products, development assistance programmes, disaster relief programmes, etc.

India carries the image of a civilisation with no history of military and colonial interventions abroad. It has an immense reputation in the UN peacekeeping and religious. The diverse heritage and resources of India in sciences, medicine, arts, architecture, culture, festivals, cuisine, languages, literature, music, dance, movies and worship yoga is attractive to many people across the world, and the International Yoga Day is celebrated on 21st June in all ASEAN member states. The messages of peace and non-violence of Indian historical figures such as the Buddha and Gandhi are famous. India has nearly 400 million people in the middle class who play a key role in stabilising the political and economy. India has a large English-speaking population and is the largest publishing centre for books in English. India ranks third in the world in terms of scientific base. Many graduates of educational institutions like Indian Institutes of Technology (IIT) and the Indian Institutes of Management (IIM) have made it to top positions in global business corporations.

The soft power approach is about cooperation on the basis of respecting the interests of the parties involved, preserving indigenous cultures, and the acquisition and adoption of cultures from external sources. Gandhi had asserted that power based on love is a thousand times more effective and permanent than the one derived from the fear of force. Southeast Asia is crucial to India's vision of the Indo-Pacific region as well as in its Act East Policy. The Indian government supports the ASEAN Outlook on the Indo-Pacific (AOIP).

Since 2014, Prime Minister Narendra Modi has successfully attracted, engaged and connected with the overseas Indians. India's diplomats at the Annual

Bilateral trade between India and ASEAN grew from US$ 12 billion in 2003 to US$ 142 billion in 2018. India hosted the leaders of all ten member states of ASEAN at India's Republic Day parade on 26 January 2018 to mark 25 years of the ASEAN-India Dialogue Partnership.

Moreover, syncretism is apparent in Indian symbols found in Southeast Asia. The statue of Indonesia is nestled after Garuda, a statue of Indian origin associated with the Ramayana. The image of Indian attire in Malaysian Muslim weddings, the Buddhist temple practiced in the Hindu temples of Cambodia are major examples of Indian influence in Southeast Asia.

The influence of India is also evident in the food and flavours of Southeast Asia. There are many spices in common between Indian and Southeast Asian foods. Most of the people of the Southeast Asian region eat rice and curry like the people of Eastern India with many common ingredients. Indian herbal remedies also reached Southeast Asia from ancient times and are used even today in many countries.

SHARED CULTURAL HERITAGE

In the context of India-ASEAN relations, cultural heritage played a significant role in the exchange of religions, scientific and philosophical values and concepts, artefacts, oral or folk heritage, languages and literature, traditional arts and crafts, architecture, performing arts, games, indigenous knowledge systems and practices, myths, customs and beliefs, rituals and other living traditions.

The process of acculturation of India and Southeast Asia began in ancient times. The exchanges via trade, the influence of Sanskrit and the Indian epics in Southeast Asia and technological innovations shared between the two regions are well documented. The commonalities between India and Southeast Asia provide a platform for building synergies with the countries of the region. Therefore, culture is the key to the India-ASEAN partnership.

The increased interactions resulted in exchanges of various features of practises ranging from religion to food and customs with the settling of Indians in the region and intermarriages with indigenous populations. This resulted in a process of hybridisation in cultural practices and localisation of Indian culture in Southeast Asian countries visible even today.

DECONSTRUCTING COLONIAL PARADIGMS

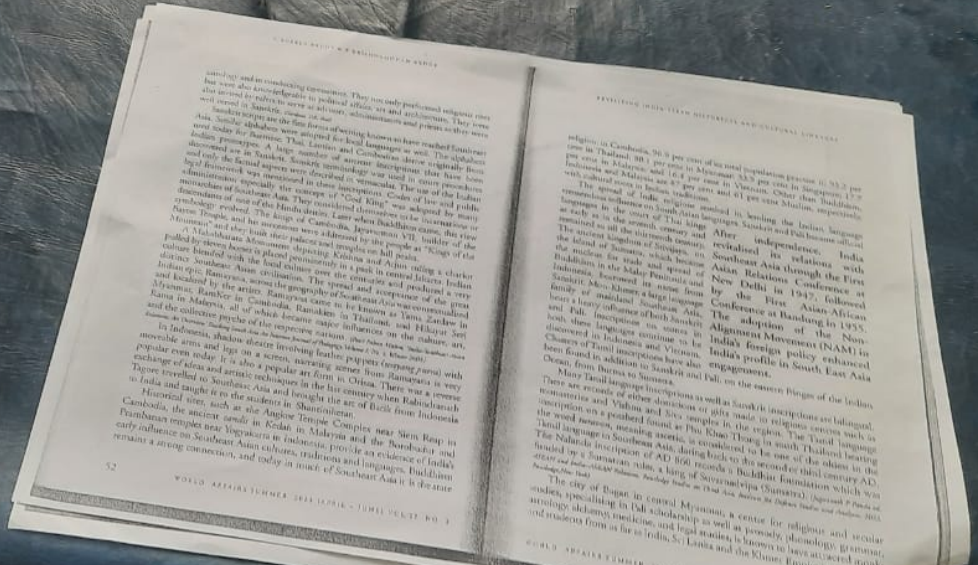
The interactions between India and Southeast Asia were viewed from colonial perspectives in the early part of the twentieth century. There was a need to

deconstruct and deconstruct the colonial paradigms and intellectual structures to understand the interactions from a closer and more objective perspective.

After independence, India articulated its relations with Southeast Asia through the First Asian Relations Conference at New Delhi in 1947, followed by the First Asian-African Conference at Bandung in 1955. These conferences were significant landmarks in shaping post-independence India's relations with Southeast Asia or the ASEAN countries. The adoption of the Non-Aligned Movement (NAM) in India's foreign policy enhanced India's profile in South East Asia engagement. India extended support to the Indonesian struggle for independence in the 1950s as well as in the Indochina crises in the 1960s. The signing of friendship treaties with Indonesia, Myanmar and the Philippines aided India in consolidating its bilateral diplomatic relations with the regional bilaterals. However, the Cold War politics affected the relations between India and Southeast Asia. Some of the countries became members of the newly-formed Southeast Asia Treaty Organization (SEATO), forging an alliance with the United States to address their security needs. India distanced itself from such treaties and instead moved close ties with the Soviet Union.

The formation of ASEAN (Association of Southeast Asian) on 8 August 1967 in Bangkok, Thailand, was a significant landmark. The ASEAN Declaration (Bangkok Declaration) was signed by Indonesia, Malaysia, Philippines, Singapore and Thailand, while India focused on its bilateral problems with Pakistan and China. India signed the Indo-Soviet Treaty of Friendship and Cooperation, in August 1971. The pro-American countries of ASEAN like Thailand, Malaysia and Singapore were apprehensive of India's drift towards the Soviet Union, as they felt this would aid Moscow in advancing its interests beyond South Asia. They were also worried about communist Vietnam and its potential threat to the region. As a result, India and Southeast Asia navigated in different directions with diverging strategic interests.

Prime Minister Narendra Modi, who came to power in 2014, rephrased India's Look East Policy (LEP) as the "Act East Policy" (AEP) at the 12th ASEAN-India Summit in Nay Pyi Taw in Myanmar. More emphasis was given to improving ties with the Cambodia, Laos, Myanmar and Vietnam (CLMV), which had not had priority attention in the LEP.



Revisiting India-ASEAN Historical and Cultural Linkages

The relationship between India and Southeast Asia dates back many millennia. Historically and culturally Southeast Asia, now known as the ASEAN region, was comprising Myanmar, Thailand, Malaysia, Singapore, Laos, Cambodia, Vietnam, Indonesia, the Philippines and Brunei, has been one hub of Indian cultural outreach for more than 2,000 years. The historical and cultural links ranging from particularly excellent exchanges in the expansion of Buddhism, Hinduism and Islam across the Bay of Bengal and impact, collaboration in the early twentieth century by Indian intellectual and political leaders like Nobelprize winner Tagore. This article explores the political and civilizational linkages between India and the ASEAN states to facilitate and substantiate those links for mutual economic and geopolitical benefits.

C Sheela Reddy & P Krishnamohan Reddy

Historical Backdrop

Southeast Asia was particularly attractive to the Indian mercantile class and they named the faraway lands Suvarnabhumi (land of gold), Suvarnadvipa (island of gold), Narikeladvipa (island of coconuts), Karpuradvipa (island of camphor), and Yavadvipa (island of barley).

Hindu priests and Buddhist monks accompanied the merchants and seafarers and assumed a leading role in spreading the message of Indian thought and culture in the entire Southeast Asian region. The local people welcomed them since they had no political ambitions and lived in harmony and tolerance. India's culture, religion and civilization spread to different parts of Southeast Asia as monks and Hindu Brahmins priests travelled to faraway kingdoms like Cambodia and Indonesia. The kings of the region wore Indian-made silk during

commercial settlements and donated jewels imported from India. The interaction people performed religious and cultural activities.

Hinduism and Buddhism, and to an extent Islam, which spread into countries from India to Southeast Asia, serve as an important cultural linkage. Buddhism came to Southeast Asia from India in the third century BCE when Buddhist missionaries were sent by King Ashoka. Mahendra, a son of Indian Buddhist minister of the Dharmasastra of Buddhist monasteries and communities. However, some of the elements of Hinduism and Ramayana, across the geography of these religions with pre-existing conventional with the Hindus in a Southeast Asia for the Asian countries for the past.

Buddhism entered from the Southeast Asian region also impacted on Indian monuments in the eastern Indian caves of Nalanda, Sarnath and Sanchi (Varanasi) and the continues even today. The multifaceted society of Khasis in Meghalaya, India, is one the matrilineal matrimonial society of Sumatra (Minangkabau) in Indonesia, where women head the family and inherit property through the daughters.

India never established colonies in Southeast Asia, and the movement was more of ideas rather than peoples. The Indians who went there did not go to rule but had only interest in exercising political control from the Indian religion, political thought, literature, mythology, arts, morals and style, were absorbed deeply into local culture as greater interaction with Indians who settled in the courts of Southeast Asia took place.

In medieval times, from the sixth to fourteenth century, many Indian artisans from Kalinga (modern day Orissa) came to work temporarily in the courts of the great maritime empire based in the Indonesian islands of Java and Sumatra. They helped in building great temples and monuments. Many of the murals on the walls of Borobudur and Angkor Wat resemble carvings of Konarak and other medieval temples of eastern India. Brahmins also played an important role in the Sukhone (Thai), Cambodian, Lisonian and Annamese courts as experts in

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cultural exchange programme between India and ASEAN. The first-ever delegation of State Ramayana ballet performances was conducted in the Prambanan temple complex of Yogyakarta, Indonesia, in 2011.

Under the aegis of the Archaeological Survey of India (ASI), initiatives for restoring temples and cultural monuments across ASEAN promote the close cultural links that India has ordinarily, periodically. ASI undertook restoration of the Ta Prohm temple in Cambodia in 2011, the restoration of Cham monuments in 2015 of Vietnam and the conservation project of Vat Phou temple in Champasak province of the Lao PDR in 2014. The ASEAN-India Film Festival organized in 2018 by the Indian Ministry of External Affairs in cooperation with the Ministry of Information and Broadcasting showcased films of different genres from India and ASEAN member states, [illegible]

The similarities in lifestyle and culture together with the low-cost tourism offered by Thailand and Malaysia attract Indians. According to statistics, by 2020, six million are expected to visit Thailand, while the percentage of Indian tourists expected to go up from 4 per cent to 15 per cent. The Thailand Tourism Authority reports that Indians spend 11 per cent more than foreign visitors. Equally, the number of tourists from ASEAN countries to India is growing yearly, from seven lakh (seven hundred thousand) in 2016 to 8.8 lakh in 2018. Most sought-after tourist destinations for Indians are in Thailand, Singapore, Malaysia, Cambodia and Indonesia, given the low-cost affordable packages, presence of Indian diaspora and similarity of culture and cuisine. The cities often visited by Indians visit more in ASEAN countries are Bangkok, Pattaya, Kuala Lumpur, Singapore, Phnom Penh, Jakarta and Manila.

In the education sector, India and ASEAN developed different mechanisms to promote more exchange of students among them. ICCR, as the coordinating body from the Indian side that provides scholarships and exchange programmes to students from ASEAN countries. Annually, ICCR provides more than 100 scholarships for studying Indian heritage, culture, music, dance and yoga in India. In addition, the Ministry of Ayush (traditional and holistic medicine) in connection with ICCR provides 29 scholarships yearly to Southeast Asian nationals to study Ayurveda, Unani, Siddha and Homeopathy medicine in India. India also accepts ASEAN students under the aegis of the Cultural Exchange Programme (CEP). The year 2022 marked thirty years of ASEAN-India relations

and a new designation as ASEAN-India Friendship Year by the leaders in October 2021. [illegible]

CONCLUSION

India and the Association of Southeast Asian Nations (ASEAN) are home to more than 1.8 billion people and have an economic GDP of US$ 6.8 trillion and a substantial share. The other programmes of world economic, economic and aimed at boosting people-to-others. They share land and maritime boundaries. ASEAN remains the main people ties between India and focus for India's cultural diplomacy as ASEAN are students exchange the centuriesold cultural linkages are programmes, a special training among with a major thrust on people course for ASEAN diplomats, to-people relations. The plurilateral parliamentarians exchange ethos in all the member-states shared through the ASEAN Inter-cultural, civilizational ties, religious Parliamentary Assembly (AIPA) affinity, maritime incidents and historical linkages can help them since 2010, the participation of to move towards a comprehensive ASEAN students in National strategic partnership. The Indian Children's Science Congress, government is trying to secure and the ASEAN-India Network of remain various kinds of cultural ties Think Tanks et al.

by establishing and funding a large number of local organizations. The interactions and exchange of ideas that took place in the past can offer models for future cultural interactions and the free flow of people. Historical research can help in rediscovering or regenerating old bonds to suit the modern context and the evolving geo-political situation. ■

[illegible]

Non-Alignment Or Veiled Alignment?

The author highlights the pro-socialistic bent of the Non-Aligned Movement (NAM), inspired by the desire to resist the influence of the former colonial powers and their capitalistic hegemony. The article points out that the co-founder of NAM, Pandit Nehru, even before Independence, leaned towards USSR and other communist policies, despite Stalin's will to bring the communists to power in independent India. Nehru's ideological tendencies led him to ignore Soviet and later Chinese hostility to India's political system and to support Maoist China in various ways while accommodating the Indian Communist Parties.

P KRISHNA MOHAN REDDY

While analysing whether Jawaharlal Nehru's Non-Alignment Movement (NAM) is Veiled Alignment, we should study his anti-West, pro-Socialist leanings as the core of NAM. As we can see, in the name of the fight against imperialism and for democracy and freedom, he consistently attacked the Capitalist West. Nehru admired the Soviet Union ever since he had visited it way back in 1927. From the time of his speech as Vice President of the Interim Government in 1946, he struck and maintained a friendly approach towards the Union of Soviet Socialist Republics (USSR). *(Bipan Chandra, Mridula Mukherji, Aditya Mukherji, India Since Independence, Penguin, New Delhi, 2008, p201)* He continued to keep silent about the totalitarian regimes of Communist Eastern Europe, Soviet Union and China. He never criticised the horrors committed on the domestic populations in USSR under Stalin or in China under Mao. Nehru expressed his regard for Socialism and the USSR despite the fact that Stalin personally supervised the Communist Party of India's (CPI) activities, some of which were detrimental to India's interests. Nehru refused to interpret the communist insurgency in India as proof of Soviet unfriendliness. Even before independence, as a special gesture, he offered diplomatic relations, and sent his sister Vijayalakshmi Pandit as ambassador

to the Soviet Union. *(Ibid)* The CPI, under Soviet guidance, declared in December 1947 that "India's independence was fake, 15th August was a day of national betrayal, Congress had gone over to imperialism and feudalism, Nehru had become a stooge of imperialism, the government was ruling in a fascist manner, and the constitution that was being framed was a charter of slavery. The communists had, therefore, to take up the anti-imperialist and anti-feudal tasks, fight for freedom and democracy and initiate an armed struggle". *(Bipan Chandra, Mridula Mukherji, Aditya Mukherji, India Since Independence , Penguin, New Delhi, 2008, p258)* The CPI gave a call for an immediate armed uprising. It decided to continue the armed peasant struggle in Telangana which had been going on against the Nizam of Hyderabad since 1946, but now directed it against the Indian government. *(Ibid)* During the national railway strike launched by the CPI in March 1949, although a complete flop, the Party indulged in several terrorist acts. As a consequence it was banned in several states. *(Op.cit, pp258-259)*

The CPI, under Soviet guidance, declared in December 1947 that "India's independence was fake, 15th August was a day of national betrayal, Congress had gone over to imperialism and feudalism, Nehru had become a stooge of imperialism, the government was ruling in a fascist manner, and the constitution that was being framed was a charter of slavery. The communists had, therefore, to take up the anti-imperialist and anti-feudal tasks, fight for freedom and democracy and initiate an armed struggle".

Even as a late as the end of 1951, under the direct guidance of Stalin, the CPI still considered India essentially a colony, the transfer of power in 1947 as "betrayal", the Indian government as subservient to imperialism, and the Indian political system as basically undemocratic and authoritarian with the government having established a police state. The political task of the CPI remained the eventual overthrow of the Indian state through armed struggle. However, the new element in its policy was that the overthrow of the state was to be postponed and left for a future agenda because the people were not yet ready for the task. The Party was, therefore, immediately to turn away from revolution-making, withdraw from the armed struggle in Telangana, and participate in the approaching general elections. Nehru was in full command of the government by then. He cleared the way for the CPI by legalising the party

AFRICA	ASIA
1. Algeria (1961)	24. Sudan (1961)
2. Benin (1964)	25. Tanzania (1964)
3. Burundi (1964)	26. Togo (1964)
4. Cameroon (1964)	27. Tunisia (1961)
5. Central African Republic (1964)	28. Uganda (1964)
6. Chad (1964)	29. Zambia (1964)
7. Democratic Republic of the Congo (1961)	
8. Egypt (1961)	AMERICAS
9. Ethiopia (1961)	1. Cuba (1961)
10. Ghana (1961)	
11. Guinea (1961)	ASIA
12. Kenya (1964)	1. Afghanistan (1961)
13. Liberia (1964)	2. Cambodia (1961)
14. Libya (1964)	3. India (1961)
15. Malawi (1964)	4. Indonesia (1961)
16. Mali (1961)	5. Iraq (1961)
17. Mauritania (1964)	6. Jordan (1964)
18. Morocco (1961)	7. Kuwait (1964)
29. Nigeria (1964)	8. Laos (1964)
20. Republic of the Congo (1964)	9. Lebanon (1961)
21. Senegal (1964)	10. Myanmar (1961)
22. Sierra Leone (1964)	11. Nepal (1961)
23. Somalia (1961)	12. Saudi Arabia (1961)
	13. Sri Lanka (1961)
	14. Syria (1964)

Source: Wikipedia

Currently every African country (except South Sudan and the Western Sahara) is a member of the Non-Aligned Movement.

The list of the member-nations of the Non-Aligned Movement during the final years of Nehru's government clearly indicates that most of the members were in the socialist camp. While campaigning for NAM it appears as if Nehru was building up a group of nations which were pro-Soviet to support the USSR and communists in the United Nations. The Marxist historians highlight this fact: "In the UN, for example, whose membership had swollen with their entry, the one country, one vote system enabled the non-aligned bloc, often helped by the Soviets, to check domination by the Western Bloc". *(Bipan Chandra, Mridula Mukherji, Aditya Mukherji, India Since Independence , Penguin, New Delhi, 2008, p. 344)* The character of NAM and

the guiding philosophy of the Soviet model of economy continued till the end of the Cold War, coinciding with the economic reforms introduced by Prime Minister PV Narasimha Rao in 1991.

CONCLUSION

In order to understand whether Jawaharlal Nehru's Non-Aligned Movement (NAM) is a Veiled Alignment, one needs to study his ideology and policies from 1927 onwards, both in foreign and in domestic affairs. He openly advocated his preference for socialism and the Soviet Model of Economic Policy for India. He refused to accept that the communist insurgency in India was sponsored by the Soviets when Stalin was guiding the Communist Movement in India personally. Nehru's policies towards China were no different. The list of countries in NAM welcomed by Nehru clearly demonstrates NAM's anti-Capitalist Stand. The analysis of Nehru's domestic policies/ideologies, together with his foreign policy, leaves no doubt that the Non-Alignment he advocated and built up amounted to a veiled alignment with the Soviets, Chinese and communist nations.

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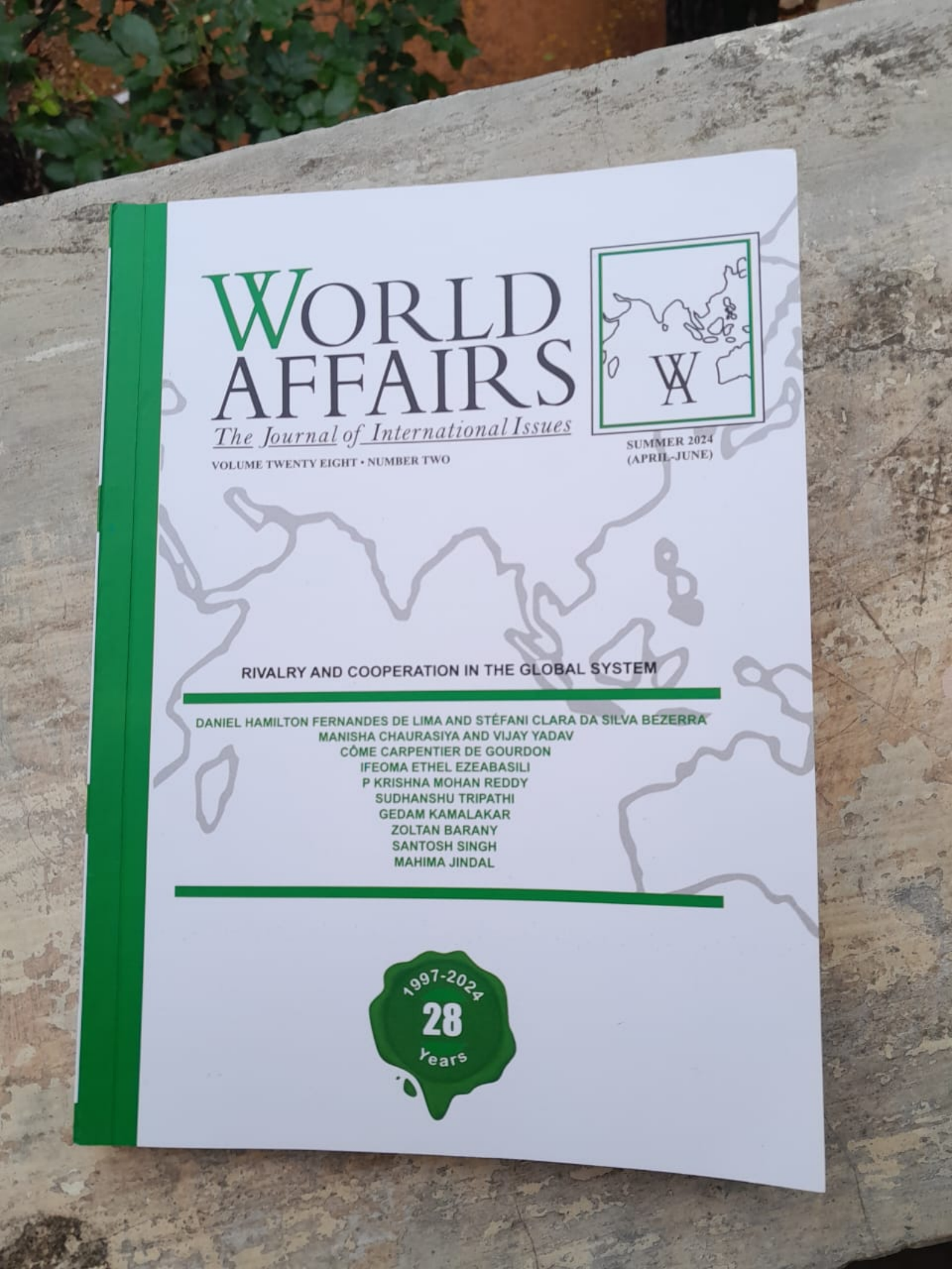
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1997-2024
28
Years

Heads of ASEAN missions engaged actively with the diaspora to promote Indian and Asean friendly programmes like Make in India, Skill Development, Digital India and Smart Cities. The government has also merged two capital award to People of Indian Origin and Overseas Citizen of India in 2002 and 2005 respectively. It offered dual citizenship among these Southeast Asian, launching the 2015 Indian Diaspora Investment Initiative. Modi's policy towards the diaspora focussed on 3Cs: connect (with India), celebrate (cultural heritage), and contribute (to India's development). [7 Nishant Sahdev and Rahul Sen, 'India–East Asia Cooperation: A New Era?', *East Asia: An International Quarterly*, Vol. 32, No. 3 (2015), September 2015, pp. 193–210, 206, and here.]

CULTURE AND DIPLOMACY

Since 2014, India's foreign policy is markedly characterized by dynamism, initiative and intervention. The commitments of the Indian government to building relationships with both big and small countries reflects the spirit of 'Vasudhaiva Kutumbakkam', which means the whole world is one family.

India has shown agency in engineering reality when defining economy and knowledge as the key attributes of the 'New India Strategy'. The Indian government has shifted from the 'primary neighbour' policy to the 'neighbour is the first priority' policy from an regionally defensive maritime policy to a cohesive policy for the Indian Ocean region. This has resulted in projecting a comprehensive vision for the Indo-Pacific, from a Look East Policy to Act East Policy (AEP), from a "non-interference" to "multi-link" policy. India is keen on projecting herself as a soft power using the "Buddha connects" in both the political and economic diplomacy. [Shiv Poonia, 'Interconnectedness Between Buddhism and India–ASEAN Relations', *Routledge Studies on Think Asia: Buddhism The Highest Dharma and Inception 2015*, Routledge, New York, and others.]

Indian diplomacy also emphasises economic connectivity and education along with the cultural connection and national values. India attaches great importance to infrastructure, institutional and digital connectivity to enhance integration. The construction of 1,360 km of roads connecting India, Myanmar and Thailand will help link the Northeastern region of India with ASEAN. India also proposed extending this road to Cambodia, Laos and Vietnam. The link between culture and education is also very specific and can be clearly seen in the steps taken to promote study and research in India by ASEAN students. In the year 2018, along with the enhancement of the ASEAN-India Strategic

Partnership, India offered 7,000 scholarships for PhDs in Indian IITs. ASEAN regards India as a trusted partner in the region, while India views ASEAN as the main pillar of its AEP. The reciprocity between the two sides are quite apparent in this region. India always supports the central and leading role of ASEAN in the evolving regional structure. The soft power approach in ASEAN-India relations is concentrated on the historical and cultural linkages and is sustainable as well.

Culture and connectivity are the key areas of partnership identified by both India and ASEAN. The first international conference on 'ASEAN-India Cultural Links: Historical and Contemporary Dimensions' that was held in New Delhi from 23 to 24 July 2018 and the subsequent one on 'ASEAN-India Cultural and Civilizational Links' held in Jakarta on 19 January 2017, and later, the ASEAN-India youth awards ceremony in New Delhi on 25 January 2018 and the India-ASEAN youth summits conducted annually are some of the successful initiatives in their domain.

The other programmes aimed at boosting people-to-people ties between India and ASEAN are student exchange programmes, a special training course for ASEAN diplomats, parliamentarians exchange through the ASEAN Inter-Parliamentary Assembly (AIPA) since 2010, the participation of ASEAN students in National Children's Science Congress, the ASEAN-India Network of Think Tanks (to be established in 2001-2010), ASEAN-India Media Exchange Programme, India-ASEAN annual Youth Summits and ASEAN-India Eminent Persons Lecture Series, etc. [Prem Chandrasekaran, 'Beyond India and ASEAN: Partners in Security by Pit Act Contemporary Southeast Asia, Vol. 21, No. 1 (April 2009), pp. 21 – 42. http://www.jstor.org/stable/25798740]

CONTEMPORARY CULTURAL TIES

India promotes cultural diplomacy, through arts, literature and dance, et al, through the Indian Council of Cultural Relations' (ICCR) MoUs (Memoranda of Understanding) with different universities across Southeast Asia. India has

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CHILD LABOR, EDUCATION AND CHILDREN'S RIGHTS

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Abstract
This paper reviews the international legal framework relating to child labour as well as access to education and provides a statistical portrait of child labour and education participation. Moreover, it looks at why children work from the perspective of household decision making. Various policy options are also considered, including those which can improve the incentives to education relative to labour, remove constraints to schooling and increase education participation through legislation. Conclusions are drawn in the final section.

Introduction

"Nonetheless, if the fundamental rights behind our cause are not sufficient to move people to act, then let it be the economic and social rationale behind it. Either way, we are going to challenge people to act."

Nelson Mandela

Child Labour (Prohibition and Regulation) Act of India, 1986 defined that the child is a person who has not completed the age of fourteen years. A child of such tender age is expected to play, study and be carefree about his life. But, as a fact of nature, expectations seldom meet reality. Children, by willy-nilly or by force, are employed to work in the harsh conditions and uncongenial atmosphere which become a threat to their precious life. Child labour leads to underdevelopment, incomplete mental and physical development, which in turn, result in stunted growth of children.

Child labour is retribution to the child and is widespread around the world. It is a curse for development of both the individual child and society and economy in which she/he lives. If allowed to persist to the current extent, child labour will prevent the achievement of the Millennium Development Goals of halving poverty and achieving education for all. All of the countries in the world have ratified international human rights conventions which call for the elimination of child labour and the provision of universal primary education. Fulfilling these commitments is of immensely importance for development.

Child labour is a violation of fundamental human rights and has been a stumbling block to children's development, potentially leading to life-long physical or psychological damage. The fundamental ILO standards on child labour are the two legal pillars of global action to combat child labour.

Over 200 million children between the ages of 5 and 14 years are working around the world. This figure represents one-fifth of the total population of girls and boys in this age group. About 111 million children are in "hazardous work" which refers to forms of labour which are likely to have adverse effects on the child's safety, health and moral development. Nearly 10 million of these children are engaged in some form of slave labour, armed conflict, prostitution or pornography, or other illicit activities. Some observers believe that these figures understate the real magnitude of child labour. The hazardous and worst forms of child labour are of universal prime concern, given the obvious harm that they inflict on the lives of these children and their possibilities for a hopeful future. Child labour also has important various economic implications. Among them the most notable are the

substantial future income losses that working children will incur because of the negative consequences working will have on their human capital, including their health and education. Since children are more likely to work and not go to school if their parents worked as children, the economic losses associated with child labour and their implications for poverty are often transmitted across generations (ILO, 2020).

Child labour, of course, has already received ample attention. Most countries have long had prescriptive legislation as well as compulsory education laws. At the international level, child labour has been the focus of various conventions and recommendations. Among them the UN Convention on the Rights of the Child (1989) and two ILO conventions, the Minimum Age Convention (No. 138, 1973) and the Worst Forms of Child Labour Convention (No. 182, 1999) are most significant. In promoting children's rights, each of these instruments – in very different ways -- has been motivated by an interest in protecting children from exploitation through their labour and providing for education as a preferable alternative.

Human Rights Instruments

The principal international legal instruments for addressing child labour include the UN Convention on the Rights of the Child (1989) that covers both child labour and the right to education and two ILO conventions, the Minimum Age Convention (No. 138, 1973) and the Worst Forms of Child Labour Convention (No. 182, 1999). The UN Universal Declaration on Human Rights (1948) and the International Covenant on Economic, Social and Cultural Rights also address the right to education but the above-listed instruments provide more detail and are commonly seen as the key international instruments for addressing children's rights (Table 1). The Convention on the Rights of the Child (CRC) and the ILO child labour conventions have received widespread international support, the former being ratified by 192 countries – all U.N. members, in fact, save the United States and Somalia. ILO Convention 182, prioritizing action against the worst forms of child labour, was the first convention adopted unanimously and has been the most rapidly ratified convention.

Table 1, International Human Rights Instruments Related to Education and Child Labour

Sl. No.	Title	Date	Ratified	Provisions (Articles)
1.	Universal Declaration on Human Rights	1948	N/A	Right to Education (26)
2.	International Covenant on Economic, Social and Cultural Rights (CESCR)	1966	148	Compulsory and free primary education (13)
3.	ILO Convention 138: Minimum Age	1973	131	Compulsory and free primary education (13)
4.	Convention on the Rights of the Child (CRC)	1989	192	Freedom of association (15); primary education; (28) rest and leisure (31); no hazardous child labour (32); protection from sexual exploitation (34) and trafficking (35)
5.	ILO Convention 182: Worst Forms of Child Labour	1999	147	Ban slavery, use in armed conflict, prostitution, drug trade; Work harmful to health safety, morals.

Source: United Nations High Commissioner for Human Rights (http://www.un.org/rights/) and International Labour Organization (www.ilo.org)

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Global and Regional Overview

Child labour remains unacceptably common in the world today. At the start of 2020, prior to the outbreak of the COVID-19 pandemic, 160 million children – 63 million girls and 97 million boys – were in child labour, or 1 in 10 children worldwide. Seventy-nine million children – nearly half of all those in child labour – were in hazardous work directly endangering their health, safety and moral development.

This global estimate masks large variations across regions. Child labour prevalence stands at 24 per cent in sub-Saharan Africa, three times that of Northern Africa and Western Asia, the region with the second highest prevalence. In absolute terms, the nearly 87 million children in child labour in sub-Saharan Africa are more than in the rest of the world combined.

Recent history provides cause for copious concern. In the last four years, for the first time since 2000, the world did not make any progress in reducing child labour. The absolute number of children in child labour was increased by over 8 million to 160 million while the proportion of children in child labour remained still unchanged. Children in hazardous work mirrored these patterns: The share remained almost unchanged but the number rose by 6.5 million to 79 million.

The pace of progress has varied dramatically across regions. The proportion and number of children in child labour have declined consistently since 2008 in Asia and the Pacific and Latin America and the Caribbean. Similar progress has proved elusive in sub-Saharan Africa, where child labour has actually gone up since 2012, a trend especially pronounced over the last four years when the region accounted for much of the global increase.

At present, the world is not on track to eliminate child labour by 2025. For meeting this target, global progress would need to be almost 18 times faster than the rate observed over the past two decades. According to pre-COVID-19 projections based on the pace of change from 2008 to 2016, close to 140 million children will be in child labour by 2025 without an accelerated action. The COVID-19 crisis is making these scenarios even more worrisome, with many more children at risk of being pushed into child labour. Global progress against child labour has stalled since 2016.

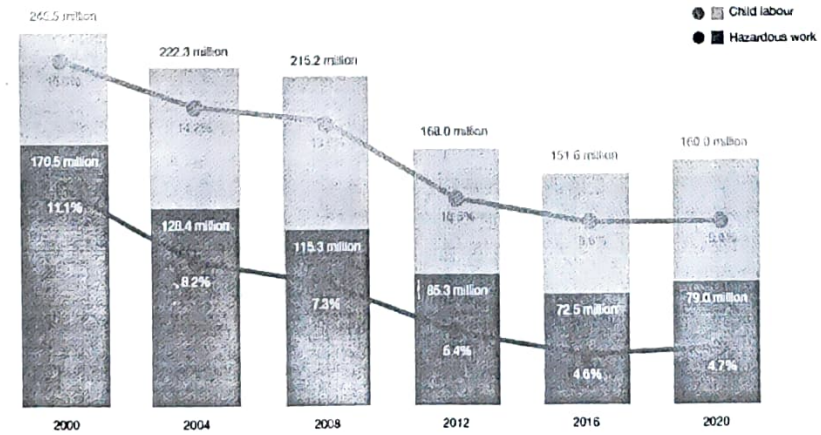


Fig.1. Percentage and number of children aged 5 to 17 years in child labour and hazardous work.

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Child Labour across Ages

The results of the global estimates make clear that child labour remains an important concern across the spectrum of children aged 5 to 17. Of the 160 million children in child labour, 89.3 million are young children aged 5 to 11, 35.6 million are children aged 12 to 14, and 35 million are children aged 15 to 17. Child labour among children aged 12 to 14 and 15 to 17 continued to fall in both absolute and percentage terms over the last four years. By contrast, the 2016-2020 period saw a worrying rise in child labour among young children aged 5 to 11. In 2016, there were signs of slowing progress among young children. Today the trend line is moving in the wrong direction. The reason for backtracking is not clear and direly needs to be investigated as a priority. Hazardous work accounted for about two fifths of the total number of additional children aged 5 to 11 in child labour during the four-year period. While children of all ages must be protected from hazardous work, its persistence and now growth among younger children is a particular concern.

Boys and girls in child labour

Involvement in child labour is more common for boys than girls at all ages. For children aged 5 to 17, child labour prevalence is nearly one third higher for boys. The gender gap grows with age, and boys are roughly twice as likely as girls to be in child labour in the 15 to 17 age range. Comparisons of child labour estimates for boys and girls must be accompanied by an important caveat. The definition of child labour upon which the estimates are based does not include involvement in household chores in children's own homes, an area of work for which girls shoulder a disproportionate burden of the responsibility in most societies.

The 2020 global estimates look for the first time at how the inclusion of household chores affects overall child labour estimates as well as estimates of male child labour relative to female child labour. The results are noteworthy. When the definition of child labour is expanded to include involvement in household chores for 21 hours or more per week, child labour prevalence increases for both sexes, but the rise in female child labour is much larger. As a result, the gender gap in child labour prevalence is reduced by almost half, from 2.8 percentage points to 1.6 percentage points. Child labour is more prevalent among boys than girls at every age

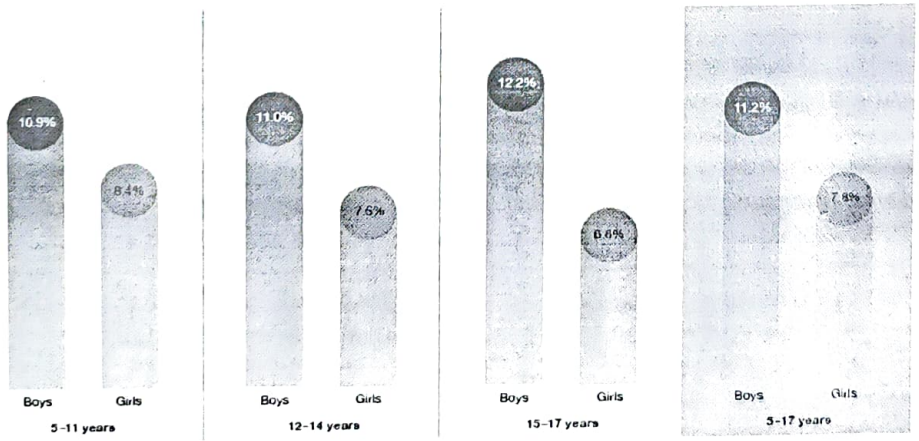


Fig.2. Percentage of children aged 5 to 17 years in child labour, by age and sex

Causes of Child Labour

Major causes of child employment which can be understood keeping in mind the Indian scenario are:

Poverty

In developing countries like India it is quite impossible to control child labour as children have been considered as helping hand to feed their families, to support their families and to feed themselves. Due to poverty, illiteracy and unemployment parents are unable to bear the burden of feeding their children and to run their families. Thus, the poor parents send their children for work in inhuman conditions at lower wages.

Previous Debts

The poor economic conditions of people in India force them to lend money. The illiterate population goes to money lenders and sometimes mortgage their belongings in turn of the debt taken by them. But, due to insufficiency of income, debtors find it quite difficult for paying back the debt and the interest. This vicious circle of poverty drags them towards working day and night for the creditor and then the debtors drag their children too in assisting them so that the debts could be paid off.

Professional Needs

There are some industries such as the 'bangle making' industry, where delicate hands and little fingers are needed to do very minute work with extreme excellence and precision. An adult's hands are usually not so delicate and small, so they require children to work for them and do such a dangerous work with glass. This often resulted in major eye accidents of the children.

Legislation

When in the 20th Century, child labour became so prominent that news of factory hazards and mishappenings taking innocent children's life, flashed all around in the newspapers, then was the time, a need for legislations and statutes were felt to prohibit the malpractice of child labour. Today, there are sufficient statutes condemning and prohibiting child labour such as:

The Factories Act of 1948

The Act prohibits the employment of children below the age of 14 years in any factory. The law also placed rules on whom, when and how long can pre-adults aged 15–18 years be employed in any factory.

The Mines Act of 1952

The Act prohibits the employment of children below 18 years of age in a mine. Mining being one of the most dangerous occupations, which in the past has led to many major accidents taking life of children, is completely banned for them.

The Child Labour (Prohibition and Regulation) Act of 1986

The Act prohibits the employment of children below the age of 14 years in hazardous occupations identified in a list by the law. The list was expanded in 2006, and again in 2008.

The Juvenile Justice (Care and Protection) of Children Act of 2000

This law made it a crime, punishable with a prison term, for anyone to procure or employ a child in any hazardous employment or in bondage. This act provides punishment to those who act in contravention to the previous acts by employing children to work.

The Right of Children to Free and Compulsory Education Act of 2009
The law mandates free and compulsory education to all the children aged 6 to 14 years. This legislation also mandated that 25 per cent of seats in every private school must be allocated for children from disadvantaged groups and physically challenged children.

Conclusion
Child labour is by no means strictly a low income country problem. Three of every five children in child labour live in middle-income countries. For greater national health to translate into reduced child labour, economic growth must be inclusive and its benefits equitably be distributed. The tax revenues it generates must be invested in programmes and services which make a difference for children, above all in education and social protection. The large pockets of child labour persist even in relatively rich countries points to important remaining policy challenges. It is an utmost urgent to put action to end child labour back on track, in line with global commitments and goals.

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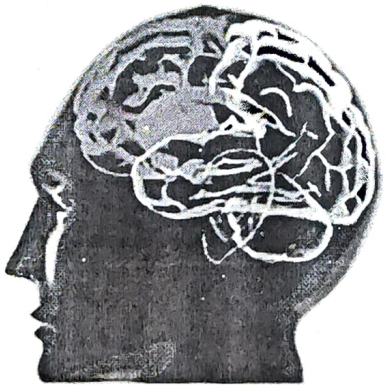
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ENFORCING ENVIRONMENTAL RIGHTS: JUDICIAL RESPONSES TO AIR POLLUTION IN INDIA

Dr.G Adinarayana

ABSTRACT:

Air pollution comes from many sources, depending on location and development. Human actions, like heavy industry, resource overuse, and population growth, are the main culprits. As globalization and industrialization take hold, worsening air quality is a big worry. Protecting the environment from pollution isn't a new idea; it's been crucial for societies forever. Courts, a vital part of our country, play a key role in ensuring environmental justice for those affected by air pollution. They set the rules and hold polluters accountable. This article explores how Indian courts have interpreted laws to control and reduce air pollution, promoting environmental justice in India.

Key words: Air Pollution, resource, globalization, environmental justice, National Green Tribunal.

INTRODUCTION:

When dangerous compounds exist in the Earth's atmosphere and have the potential to negatively impact human health, the environment, and air quality generally, it is referred to as air pollution. These pollutants can come in a variety of forms, such as gases, particles, and chemicals, and they can come from both natural and man-made sources. There are many different effects that air pollution can have, both locally and globally. There have been numerous initiatives in India to address air pollution, such as the adoption of laws, the application of court rulings by the Indian judiciary, the use of cleaner technologies, the promotion of renewable energy sources, the encouragement of sustainable transportation, and the education of the public about the value of clean air. In addition to international agreements and organizations, the judiciary is involved in resolving the problem of transboundary air pollution.

The court, particularly the higher judiciary, has rendered numerous important rulings that have helped to stop the decline in India's air quality. By interpreting and upholding environmental laws, issuing directives, and ensuring that government agencies and businesses take the required steps to lessen the harmful impacts of air pollution, the Indian court plays a critical role in the control of air pollution. The function of the judiciary is especially crucial when environmental rules and regulations are broken.

The enforcement of air pollution control laws, the issuance of guidelines and directives to various governmental agencies and industries, etc., the monitoring and oversight of the implementation of pollution control measures, the provision of compensation and remedies, the dissemination of public awareness and education, and the application of the precautionary principle, which permits preventive action even in the absence of complete scientific certainty about the impacts of air pollution, are just a few of the ways that the Indian judiciary contributes to the mitigation, prevention, or control of air pollution in India. The Supreme Court has rendered several significant rulings in the fight against air pollution, some of which are listed below:

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The Bhopal Gas Leak Disaster, a horrific industrial accident, happened in 1984. A poisonous gas called Methyl Isocyanate leaked from a Union Carbide pesticide plant in Bhopal, India. This tragedy caused thousands of deaths and left hundreds of thousands injured, many with permanent disabilities. The case highlights the plight of the numerous victims and criticizes the lengthy court battle for compensation. It emphasizes the severity of the disaster, calling it the worst industrial accident ever, with a leak of nearly 40 tons of toxic gas. For context, the factory belonged to a US company, Union Carbide Corporation.

The Bhopal gas leak caused a huge number of injuries and deaths, raising a complex legal issue how to get fair compensation for so many victims. There was a risk of countless lawsuits, and the severity of harm suffered by each person varied greatly. To avoid this mess of individual cases, the Indian Parliament passed a law in 1985 . This law gave the Indian government the power to sue on behalf of all the victims. This is based on a legal principle called "parens patriae," which allows the government to act as a parent for those who can't represent themselves in court. The Indian government decided to sue in the United States, where the parent company of the factory that caused the disaster was located. They believed the Indian legal system wasn't developed enough to handle such a big case and get the best possible outcome for the victims. However, the company argued that Indian courts were the most appropriate place for the case. Despite the Indian government's objections, the American court agreed with the company and sent the case back to India.

The Bhopal gas leak case started in Indian courts after US courts refused to hear it. Initially, the Madhya Pradesh High Court lowered the compensation amount from 3.5 billion rupees to 2.5 billion rupees. Both the Indian government and Union Carbide appealed to India's Supreme Court. The Supreme Court ordered a final settlement. Union Carbide would pay $470 million to the Indian government to cover all claims from the disaster. This money had to be paid by the end of March 1989. The Supreme Court also used its special authority to end all legal proceedings related to the disaster, including civil lawsuits, criminal cases, and contempt of court charges. These Supreme Court decisions were criticized for being unusually brief and lacking the detailed reasoning typically expected in such a significant case. Some argued the Court based its choices mainly on compassion for the victims.

The Indian Supreme Court took a significant step to protect historical treasures like the Taj Mahal from air and environmental pollution . They ruled that industries in the TTZ must switch to cleaner burning natural gas or relocate outside the zone if they can't use gas. This decision was based on scientific reports and the idea that polluters should be responsible for the damage they cause and that environmental protection should be a priority . The Court actively championed environmental protection through public interest litigation and relied on various parts of the Indian Constitution that guarantee the right to life and a healthy environment. Additionally, they used environmental laws like the Water and Air Pollution Acts to support their judgement. Delhi Vehicular Pollution Case addressed air pollution in Delhi. The Supreme Court ordered several measures to tackle this issue, such as phasing out leaded petrol, replacing old vehicles, building new bus terminals, and improving air quality monitoring. In Vellore Citizen Welfare Forum v. Union of India , the Court emphasized two key environmental principles: the Pre-

cautionary Principle (taking preventive action) and the Polluter Pays Principle (holding polluters accountable). They directed the Indian government to prioritize supplying cleaner-burning natural gas for vehicles nationwide.

Finally, the Oleum Gas Leak case led the Court to recommend a national policy for locating hazardous industries away from populated areas. They also suggested creating a neutral scientific body to advise courts and government, and establishing specialized environmental courts for pollution cases. The Supreme Court took a stand against secondhand smoke, citing the right to life enshrined in the Indian Constitution . They banned smoking in public places and ordered the government to implement this effectively. This is one example of how the Indian courts have championed environmental protection. They've introduced several principles to combat air pollution. The Precautionary Principle was first used in the Vellore Citizens' Welfare Forum case. The Polluter Pays Principle was applied in the Indian Council for Enviro-Legal Action case. And the Public Trust Doctrine was used in the M.C. Mehta v. Kamal Nath case.

PRINCIPLES ADOPTED BY THE COURTS

India's Supreme Court has significantly advanced environmental law by establishing important principles. These principles, developed mainly by the Supreme Court, are like stepping stones that pave the way for cleaner air in India. The Court has incorporated these principles into its decisions, considering international agreements and conferences . This is a major contribution to India's environmental legal system. Some of the principles are;

1. Polluter pays principle
2. Principle of non-discrimination
3. Precautionary principle
4. Principle of intergenerational equity
5. Doctrine of common but differentiated responsibility
6. Public trust doctrine

India's courts have established key principles to fight air pollution. The Precautionary Principle, explained in the Vellore Citizens' Welfare Forum case , states that preventing environmental damage is a government duty, and scientific uncertainty shouldn't delay action. The Polluter Pays Principle, affirmed in the Indian Council for Enviro-Legal Action case, holds polluters responsible for compensating victims and restoring the environment. Finally, the Intergenerational Equity Principle, implies a duty to future generations to leave them a healthy environment. These principles, along with the Public Trust Doctrine, have led to significant court judgements to control air pollution. However, tackling air pollution requires a combined effort. Laws, regulations, technology, public participation, and commitment from everyone are all necessary for clean air.

NGT , established in 2010, is responsible for handling cases related to urban air pollution in India. It aims to fulfill both the constitutional right to a healthy environment (Article 21) and the goals outlined in the NGT Act itself. This Act empowers the NGT to deal with environmental protection, resource conservation, enforce environmental rights, and provide compensation for damages. However, despite significant air pollution problems, there haven't been many cases brought before the NGT regarding this issue.

The National Green Tribunal Act, passed in 2010, reflects India's commitment to international environmental agreements. This is because India participated in major

conferences like Stockholm in the year 1972 and Rio in the year 1992. The NGT is required to consider these international principles, such as sustainable development, the precautionary principle, and the polluter pays principle, when making decisions on environmental protection cases. These international principles are used alongside Indian laws to effectively enforce environmental rights and responsibilities in India. The NGT primarily focuses on protecting environmental legal rights and addressing problems caused by enforcing environmental laws listed in Schedule 1 of the Act.

Vardhaman Kaushik v. Union of India , the first lawsuit under the previously described category 1, was filed in 2014 and concerned harmful air quality in the National Capital Region. The NGT issued numerous directives over the course of four years through judgments and verdicts, including prohibiting polluting companies, controlling traffic, requesting action plans from the government, and demanding certain measures for waste disposal and dust management, among other things. A suo moto case was filed in 2018 in response to the nation's declining urban air quality, based on a Times of India newspaper piece that examined the National Clean Air Programme's timeframes. The NCAP case required 102 'non-attainment cities', or those that had average annual concentration levels of notified criteria, surpassing certain thresholds for five years in a row, to take corrective action regarding air pollution. This lawsuit sought to address the problem of urban air pollution nationwide and mandated that each state and local government prepare action plans under the NCAP, address vehicle pollution, and conduct thorough carrying capacity evaluations for each city.

In both instances, the Tribunal criticized the federal and state administrations and demanded more vigorous action to reduce air pollution by using Right to Life and the three guiding principles of environmental jurisprudence. As a result, the two cases have emerged as the centerpiece of the Tribunal's urban air pollution intervention. Since then, any cases pertaining to urban air quality that are brought before the Tribunal are handled by subsequent benches utilizing the rulings in the two instances as well as the several directions rendered by the Supreme Court in MC Mehta v. Union of India. For instance, the South Zone bench in Vinay Shivanand Naik v. State of Karnataka , a case concerning urban air pollution in Bengaluru associated with vehicle pollution, requested that the State Government adhere to action plans developed under the National Clean Air Plan, as filed in the NCAP Case. In a related case, LG Sahadevan v. Union of India , for Chennai, the Bench requested that an action plan be created taking into account the directives from the NGT regarding the Vardhaman Kaushik issue.

Concerns about air pollution and other environmental issues have been extensively pursued by the NGT. The NGT contributes significantly to the fight against air pollution in the following ways:

1. The NGT has the authority to consider appeals and cases involving environmental infractions, particularly those involving air pollution. It may decide to take up cases on its own initiative or in response to petitions submitted by people, groups, or governmental entities. The tribunal has the authority to penalize and punish polluters as well as individuals who violate environmental standards.

2. The NGT keeps an eye on how environmental laws and rules-including those pertaining to air quality standards-are being applied. It guarantees that businesses and governmental organizations follow established emission guidelines and pollution prevention techniques. The NGT has the authority to make orders to resolve any infractions.

3. The NGT has the authority to enforce the precautionary principle, which stipulates that the burden of proof rests with those promoting an action if it has the potential to harm the environment or the public, even in the absence of conclusive scientific evidence. This approach permits the NGT to regulate air pollution even in the absence of total scientific knowledge by taking preemptive action.

4. The NGT has the authority to mandate routine air quality monitoring and the application of pollution management strategies. In order to evaluate the status of efforts to reduce air pollution and meet established air quality requirements, it may also request periodic reports from the appropriate authorities.

5. The NGT can help spread knowledge about the negative effects of air pollution and the value of environmental preservation. The public is helped to understand the need of addressing air pollution by the frequent media coverage of its rulings and decisions.

6. In order to stop and manage air pollution, the NGT may publish guidelines and recommendations. A broad range of businesses, including waste management, construction, transportation, and industry, may be covered by these guidelines.

It is noteworthy that there may have been changes in the NGT's function and efficacy since my last report. To obtain up-to-date and precise details regarding the NGT's operations and its function in mitigating air pollution, it is advisable to consult official government resources or recent news stories.

Conclusion :

Even with international agreements and laws to fight air pollution, it's still a major health and environmental threat worldwide. This is due to several reasons: a lack of political commitment to enforce existing laws, poor coordination between government agencies, weak institutions, and limited public awareness. To tackle this urgent crisis, we need stricter controls and better technology transfer from developed to developing countries. Additionally, simplifying environmental laws by merging them into one comprehensive piece of legislation would be beneficial. Courts play a crucial role in controlling air pollution in India. They interpret existing environmental laws broadly to fill any gaps and enforce them when the government fails to do so. This "judicial activism" helps protect the environment, which is especially important because environmental damage is often irreversible. However, to be truly effective, the judiciary needs proper resources and qualified judges specializing in environmental cases. Public participation is also essential. The text doesn't continue about public participation, but the idea is that public awareness and action are necessary alongside legal enforcement. Public awareness and participation are key to tackling air pollution. People need to understand their own responsibility for environmental protection. This can be achieved through environmental education programs targeting everyone, especially young people, women, and students. Mass media

also plays a crucial role in spreading awareness. The fight against air pollution requires a multi-pronged approach. The government and NGOs need to work together. The government, in particular, should provide financial aid and annual awards to recognize and encourage environmental activists at various levels (local, regional, national). This will incentivize public participation and help curb air pollution across the country.

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FOOD SECURITY IN INDIA- JUDICIAL PROSPECTIVE

Dr. G. Adinarayana

Abstract:

Food security is "an economic and social condition of ready access by all members of a household to nutritionally adequate and safe food". In 1974 at The World Food Conference, Rome, it defines food security as "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices. M.S. Swaminathan in 1986 defined food security in terms of "Nutrition Security" as "physical, economic and social access to balanced diet, clean drinking water, environment hygiene, primary health care and nutrition literacy". The activist approach of judiciary through its decisions in various cases gradually paved way for evolving food jurisprudence in India. Some significant verdicts by the Supreme Court of India proclaiming the right to food and allied rights guaranteeing food security of people are discussed hereunder this article. Population explosion, illiteracy, poverty and gender inequality are responsible for food insecurity in India. Effective implementation of the PDS can reduce food insecurity levels and restoration of joint family system to improve food security situation in India. Food security is guaranteed as a statutory right by the enactment of the National Food Security Act, 2013.

Key words: Food security, Nutrition Security, right to food, National Food Security Act, 2013, Judicial activism.

Introduction:

Hunger is not an issue of charity it I an issue of justice. - Jacques Diouf

Since independence India has struggled severely to achieve growth and development. India as a development nation has achieved severely milestones for the promotion of social welfare. In spite of reaching great heights, the nation still faces the basic hurdle of proving the basic necessities of life to its citizens. In spite to its various promises of equality and justice provided under the India constitution either in the form of directive principle of the state policy or the fundamental rights provided to its citizens, the country has failed to take care of the fundamental fights provided to its citizens, the country has failed to take care of the basic right i.e. Right to Food of its millions of citizens even today.

The GHI Report 2019 prepared jointly by Irish aid agency Concern Worldwide and German Organisation Welt Hunger Hilfe termed the level of hunger in India "Serious". India's ranking has dropped from out of 117 countries). India's masses are suffering hunger and malnutrition although there is surplus food grain production and lakhs of tons of food grain stored in FCL godowns. The causes of hunger and malnutrition cannot be attributed to simple natural and manmade disasters but they are enormously complex in nature. The right to food is violated when people suffer hunger and malnutrition. The prominent reasons are discrimination, political economic exclusion and social injustice. 0ften the hungry and malnourished are denied access to sufficient resources as well as adequate incomes such as land, water, livelihoods, etc., which enables them to take care of their families to lead a dignified life.

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Food Security Meaning:

The dictionary meaning of the term "Food security" is "an economic and social condition of ready access by all members of a household to nutritionally adequate and safe food". The Merriam webster dictionary defines it as "the ability to consistently access or afford adequate food".

Food security - definition:

The first and foremost definition of "Food security" evolved in 1974 at The World Food Conference, Rome. It defines food security as "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices"

After a decade later in 1983 it Was and expanded by the Food and Agriculture Organization as "ensuring that all people at all times have physical and economical access to the basic food that they need".

The World Bank in 1986 defined it as "access of all people at all times to enough food for an active and healthy life".

M.S. Swaminathan in 1986 defined food security in terms of "Nutrition Security" as "physical, economic and social access to balanced diet, clean drinking water, environment hygiene, primary health care and nutrition literacy". This definition of food security not only stresses on nutrition security but also on livelihood security to achieve food security in the long run.

Constitutional and legal prospectives:

The progress of identifying the "Right to Food" as part of the right to life under Article 21 may be attributed to India's wholehearted commitment to implement the provisions of international conventions and declarations such as UDHR, ICESCR, CEDAW, CRC and UDEHM, harmonizing the directive principles of state policy and fundamental rights and adopting human- rights based approach to concept of food security on par with countries like Brazil, South Africa, Colombia, Guatemala, Cuba, Ukraine , Ecuador , Srilanka, ete.

Article 39(a) and (d) directs the state to frame policies to secure adequate means of livelihoods and equal pay for equal work to both men and women equally as they play a key role in the availability, accessibility and affordability of food ensuring food security to people.

India also made significant attempts to ensure food security through enactment of various piece- meal legislations. Some of them are

- The Prevention of Food Adulteration Act, 1954
- The Essential Commodities Act, 1955
- The Food Corporation of India Act, 1964
- The Maternity Benefit Act , 1961
- The Disaster Management Act,2005
- The Food Safety and Standards Act, 2006 etc..

However , with the heave by the decision of Super Court in People's Union for Civil Liberties Vs Union of India & others the National Food Security Act was enacted in 2013.

Judicial Prospectives towards ensuring Food Securities in India:

The activist approach of judiciary through its decisions in various cases gradually paved way for evolving food jurisprudence in India. Some significant verdicts by the Supreme Court of India pro-

claiming the right to food and allied rights guaranteeing food security of people are discussed hereunder.

Azad Rickshaw Puller's Union Vs State of Panjab & Ors

In this case the denial of grant of license to petitioners under the Punjab Cycle Rickshaws (Regulation of license) Act was challenged as violative of Article 14,19 (1) (g) and 21 of the Constitution of India. The Indian Judiciary in this case has showed concern to uphold claims of poor and weaker sections of society rather than fasten strictly to provisions of legislation determining their rights to ensure social justice. It also ordered to provide credit facilities for those people to own rickshaws ensuring food security freeing from poverty, hunger and bondage.

Crown Aluminium Works Vs Their Workmen:

The Supreme Court held that it is quite likely that in under -developed countries, where unemployment prevails on a very large scale, unorganized labour may be available on starvation wages; but the employment of labour on starvation wages cannot be encouraged or favored in a modern democratic welfare state. The employer must at least pay minimum wages guaranteeing to a worker who toil for fulfilling his basic necessities such as adequate food shelter and clothing to avoid starvation and poverty.

Sodan Singh Vs New Delhi Municipal Committee:

In this case the Supreme Court held that street trading is an age-old vocation adopted by human beings to earn living. The court observed that the right to fiid and food security of poor cab be realized only when livelihoods are protected.

Shantistar Builders Vs Narayan Khimalal Totame &Ors:

Justice K Ramaswamy held that the right to life would take within its sweep the right ti food, the right to clothing, the right to decent environment and a reasonable accommodation to live in.

P.G Gupta Vs State of Gujarat & Ors

In this case the government resolution excluding certain categories of employees for allotment of houses converted from rental to hire- purchase scheme was challenged as it violates Article 14, 19, and 21 of Indian Constitution. The Apex Court held that the protection of life assured under Article 21 of Indian Constitution includes the right to food, clothing and shelter.

Delhi Transport Corporation Vs D.T.C Mazdoor Corporation

The supreme court held that " employment is not a bounty from the State nor can its survival be at their mercy. Income is the foundation of many Fundamental Rights when work is the sole source of income, the right to work becomes as much fundamental." Food Security of people can be ensured only when their right to work is protected.

People's Union of Civil Liberties (PUCL) Vs Union of India

It is a landmark case in the history of Indian Judiciary realizing the right to food as an integral part of right to life. A PIL was filed highlighting about people going hungry while food grains stored in FCI go-downs were rotting and excessive food storage was there due to maladministration of food grains in these godowns. The court directed to the government to distribute food grains free of costs to starving poor people who cannot afford to purchase them.

It especially recognized the right to food of aged, infirm, disabled, destitute, pregnant and lactating mothers and children as part of right to life.

Inre Problems and Miseries of Migrant Labourers Vs Union of India

The Supreme Court Suo moto motto took cognizance of problems and miseries of migrant labourers during COVID -19 pandamic. The Apex court held that the ' right to life' confers the right to every human being to live a life of dignity with access to at least the bare necessities of life.

Gulshan Khatun & Ors Vs Delhi Urban Shelter Improvement Board & Ors

The Delhi High Court in this case had observed that it was of utmost importance to see that food is provided to the aged , inform , disabled , destitute women , destitute men who are in danger of starvation, pregnant and lactating women and destitute children, especially incases where they or members of their family do not have sufficient funds to provide food for them.

Conclusion:

Man's survival depends indispensably in food. In a narrow sense food is described as anything to fill hungry stomach. In broadest sense food means sufficient quantity and equality in terms of both calories and nutrients necessary for growth and development as well as health and wellbeing of human being. Initially food insecurity is described as physical unavailability of food at national, regional or household levels.

Indian Judiciary is playing an activist prudent role its various decisions incorporated several Directive Principles of State Policy into Fundamental rights and declared the right to food as an integral part of the right to life under Article 21 guaranteeing food security. Population explosion, illiteracy, poverty and gender inequality are responsible for food insecurity in India. Effective implementation of the PDS can reduce food insecurity levels and restoration of joint family system to improve food security situation in India. Food security is guaranteed as a statutory right by the enactment of the National Food Security Act, 2013. The Constitution of India has no expressed provision directly ensuring right to food security does not hold good as other provisions ensured food security in India.

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Apoorva Ragas of Saint Thyagaraja

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Abstract: Thyagaraja is one of the greatest name in the history of Carnatic Music. Thyagaraja has composed brilliant kritis in number of ragas. Thyagaraja had created new ragas through his compositions. These new ragas are called apoorva (Rare) ragas. Apoorva means there is no vogue. Thyagaraja has created 80 apoorva ragas not handled by any other composers.

Introduction: Carnatic music is based on raga system. The musical compositions are concrete forms of the abstract raga. Raga is pivotal concept of our carnatic music. The term raga means a melodic and intricate combinations of swara phrase which is appealing and pleasing to all.

Apoorva Raga: Apoorva is a word which means uncommon, excellence and exceptional. Many of the apoorva ragas came to known for the first time through Thyagaraja's compositions. These apoorva ragas are janya and also include melakarta ragas in which Thyagaraja composed brilliantly for the first time and showed their melodic possibilities. In these 80 apoorva ragas only one composition is available in one raga.

Few apoorva ragas:

Raga	**Kriti**
Amrita Vahini	Sree Rama Padama
Andolika	Raga sudha rasa
Bindumalini	Enta muddo
Chayanata	Idi samayamura
Jingla	Anathudanu ganu
Jayanta sena	Vinatasuta

In some apoorva ragas there are 2 compositions:

Raga	**Kriti**
Chandra Jyoti	1)Bagaayenayya 2)Sasivadana
Jayamanohari	1) Nee bhakti Bhaya sudha 2) Sree ramya chittalankara
Kalyana Vasantam	1) Nadaloludai 2) Kanulu takanee

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In some apoorva ragas there are 3 compositions

Raga	Kriti
Bangala	1) Giri raja suta tanaya 2) Munupe teliyaka 3) sakshi ledanuchu
Janaranjani	1) Vidajaladura 2) Smarane sukhamu 3) Nadaadina mata
Suddha Bangal	1) Rama Bhakti 2) Toli ne jesina 3) Tappakne vachuna

Thyagaraja created distinctive elements in this apoorva raga compositions.

1) Swaraksharas: This is one of the "Kriti Alankarikas". Thyagaraja swami used the swaraksharaas in this composition 'Sree Rana Padama' – Raga: Amrita Vahini. In this kriti the word "padama" appears both in swara and sahitya. This is called "suddha swara". This is one of the rare prayogas used by Thyagaraja.

2) Chitta swaram: The raga 'Chenchu Kamboji' the kriti – vara raga layagnulu Thyagaaja created the beautiful chitta swaram "sa pa ma ga ma da ni sa".

3) Nishadyanta Raga: The raga is Chitta ranjani. in the kriti "Nada tanumanisham" the arohana 'ni sa ri ga ma pa da ni' – avarohana 'nti da pa ma ga ri sa ni'. In this scope the raga is mandrasthayi nishadam to tarasthayi nishadam. Tara thayi shdjamam not occurs in this raga.

4)Vivadi ragas: In carnatic music shat srti rishabha, suddha gandhaara, shat sriti daivta, suddha nishada are four vivadi swaras. Among these if any raga takes one swara is called vivadi raga.

Raga	**Kriti**
Gambhira vani	Sadamadin dalatu gadara
Sruti ranjani	Ee dari sancharintu
Sreemni	Eemandune
Chayanata	Idi samayamura

5) Pratimadhyama ragas:

Raga	Kriti
Mandari	Paraloka Bhayamu
Saraswati	Anuragamu leni

6) Melakarta Ragas:

Raga	**Kriti**
Ganamurti	Ganamurte

Vagadeeswari	Paramatmudu velige

7) Siva keertanas:

It is known that Thyagaraja composed his compositions in the praise of Lord Sri Rama. Some of compositions are composed on Lord Siva also.

Raga	**Kriti**
Gambhira vani	Sada madin dalatu gadara
Chittaranjani	Nadatanu manisham

8) Sapta swara vivarana: Sapta swara vivarana in some apoorva raga compositions. In the kriti Nada tanu manisham sankaram charanam contains 'sarigamapadani vara sapta swara'. The importance of sapta swara mentioned in this kriti.

In the raga jaganmohini the kriti 'Shobillu saptaswara' he mentioned the importance of sapta swara.

9) Social events in the compostions: In the vivardhini raga the kriti 'vinave o manasa, vivarambuga ne telipeda'. In this kriti thyagaraja swami explained the pshycology of human and also explained the way of attainment of sree rama sannidhya.

In the pratapa varali raga the kriti vinanasa goni yunnanura. In this kriti charnam 'Seeta ramani tho vomana guntaladi gelchuta' - denotes one of the game vomanagunta. Also in the charnam 2nd line 'chetanokarikokaru choochi aa bhavamerigi' denotes sringara bhava, It is one of the distinctive nature of kritis.

Conclusion: As explained above Thyagaraja swami mentioned many rare contributions to the Music World.

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Role Of Women During The Civil Disobedience Movement In Rayalaseema

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Abstract

After the withdrawal of Non-Co-operation Movement in February 1922 there was a lull in the political activities in India. The Lahore Session of the Indian National Congress in 1929 is an important landmark in the History of the Indian Freedom Movement. Jawaharlal Nehru, representative of younger elements in the congress was elected as the President. Congress declared attainment of Purna Swaraj (complete Independence) to India as its objective. To achieve this goal it also decided to start Civil Disobedience Movement and if necessary no-tax campaign against the British Government. It was at this session the congress has adopted to observe 26th January 1930 as the day of Indian Independence.

Keywords: Women. Civil, Disobedience, Movement, Rayalaseema

Introduction

The great enthusiasm shown by the people in celebrating the 26th January 1930 and taking the pledge given by Gandhiji, has indicated the mood of the people and their willingness to participate in the Civil Disobedience Movement. Before taking a final decision on Civil Disobedience he gave another opportunity to British to prevent Civil Disobedience Movement. He addressed a letter to the Viceroy in which he has mentioned eleven demands, which if acceded by the Government he would not start Civil Disobedience Movement. Gandhi considered these eleven demands as the substance of Independence. His eleven demands are:

1. Total Prohibition
2. Lowering of the Rupee-Sterling Exchange ratio to 1s 4D
3. 50% reduction in land revenue.
4. Abolition of Salt Tax, and Govt. monopoly on Salt
5. Reduction of Military expenditure by atleast 50%
6. Reduction of salaries of the Higher level services.

7. Protection to Indian Textiles
8. Reservation of Coastal shipping for Indians
9. Release of all Political prisoners
10. Reform of C.I.D. or its popular control, and\
11. Liberal issue of licences for the use of Fire-Arms for self defence and the permission to all Indian exiles to return home.

Gandhi felt that the acceptance of these demands would have announced to the achievement of most of the objective for which Indians had been agitating. Their non- acceptance revealed the exploitative nature of the British Rule. The Viceroy made no response. On the country, the Government started arresting the prominent leaders as a preventive step. Subhas Chandra Bose was the first Congress Leader arrested by the Government and was sentenced to one year imprisonment. So, Gandhiji decided to launch the Civil Disobedience Movement by breaking the Salt Law first by himself at Dandi. On 11th March Gandhi declared wholesale illegal manufacture and auctioning of salt should begin, after he had himself violated the law at Dandi. On 12th March Gandhi started his march from Sabarmathi Ashram to the Sea at Dandi through the heartland of Gujarath with 71 Ashram Members. This is popularly known as Dandi March.

It attracted the attention of the entire country and the world. Enormous publicity was given to this event all over the world. The March reached Dandi on 5th April. The very next day Gandhi started Civil Disobedience Movement by picking a handful of salt lying on the shore. This was the signal for starting Salt Satyagraha throughout the country by manufacturing salt flouting the law. It was a deliberate act of defiance to the mighty British Government and a signal to the nation that another stage in the fight for freedom has begun. Where facilities for flouting salt law do not exist, i.e., interior areas far away from the sea shore, Tripple Boycott, of Liquor shops, Foreign Cloth, Educational Institutions and services has to be followed.

Civil Disobedience Movement, 1930

On 10th April 1930, Dhurgabayamma, Headmistress of Girl's High School at Kakinada, addressed a meeting at Gandhi Chowk in Chittoor. Audiences of about 100 persons were present. One Krishnaswami, who accompanied Dhurgabayamma, also addressed the meeting. They exhorted the audience to join the Civil Disobedience Movement and enrol themselves as national volunteers. On 11th April, Dhurgabayamma had an informal meeting at Chittoor with the women of the Brahmin Street in the house of M. Ananthashayanam Ayyangar. She requested the women to induce their husbands to join the movement. Another meeting was held in the Varadappa Nayudu Girl's High School, mostly for women. In the evening, a public meeting was held at Gandhi Chowk with M. Ananthashayanam Ayyangar as the President. Dhurgabayamma spoke on the occasion. She repeated what she said the previous day. About 150 to 200 people attended. They included also a dozen women. On 13th April, there was a meeting of about 50 persons, mostly students at Gandhi Chowk, in Chittoor, to celebrate the Jallianwala Bagh Day and the National Week. M. Ananthashayanam Ayyangar who presided over the meeting spoke on the Khaddhar and temperance movements and the salt campaign. In April 1930, K. Subramanyam of Pennaperur village in Kadapa District wanted to take advantage of the Brahmotsavam at Vontimitta and

convened a political conference. He invited V.L. Sastri, President, Madras Andhra District Congress Committee to address the conference. He also endeavoured to organise a no- tax campaign in Badvel Taluk when the Taluk Board attempted to secure volunteers at Chittoor. On 22nd June 1930, three agitations from Vellore in North Arcot District were invited to address the meeting at Chittoor. As the meeting was prohibited under Section 144 Cr.P.C., the three Congress emissaries from Vellore reached Tirupati. On 24th June 1930, they wanted to hold a meeting. They were served with an order under Section 144 Cr. P.C. and one of them disobeyed the same. He was arrested and put up before the Joint Magistrate, Chandragiri, who convicted him and sentenced him to six months rigorous imprisonment. On 9th July, 1930, another Congress emissary from Kadapa District arrived at Kuntrapakam a small village near Tirupati to organize meetings.

On 2nd October 1930, a procession consisting of a few students went through the streets of Madanapalle with a photo of Gandhi. A meeting was held in the evening and the President of the meeting had been warned. The pamphlets advertising the meeting were printed by a local press and its proprietor was warned. One Mahadheva Sastry who had been imprisoned for violation of Salt Laws and who was released from the jail arrived at Madanapalle on 31st October 1930 on his way to Tirupati. He lectured to the people urging them to join the movement and to boycott foreign cloth. An attempt was made by him to take out a procession. He was prosecuted under Sections 153 and 290 I.P.C. and was sentenced to six months R.I. and a fine of Rs.50/-. In November 1930, some young men of Korlakunta, a village in Pulivendula Taluk tried to organise a procession with the photos of Gandhi and Tilak.

Gandhi-Cap and Ceded District's College Incident

On 4th August 1930, a hartal was observed in Anantapur in connection with the arrest of Pandit Madan Mohan Malaviya and shops were closed. A number of students of the Ceded Districts College, Anantapur and also of the Municipal High School stayed away from their classes and went in a procession through the streets of the town. The next day, finding that two of the boys in the college were wearing Gandhi caps, the Principal sent them out and put up a notice prohibiting the wearing of Gandhi caps inside the college. This was exploited by the local Congressmen like Y.Ramamurthy and Lakshmana Pillai who exhorted the students to disobey the orders of the Principal. An order for a large number of Gandhi caps was placed with a local tailor. The situation was, however, tactfully managed and on the students assuring the Principal that the wearing of Gandhi caps did not show that they were associated with any political party and that they did not intend to join any political propaganda while at college, the Principal withdrew his prohibition order.

Civil Disobedience Movement in 1931

In Chittoor, the conditions saluting to the National Flag was prohibited. Holding meetings were also banned. On 31st July 1931, A. Kaleswara Rao, General Secretary of the APCC visited Chittoor and made a very stirring speech abusing the Government. On 23rd August 1931, two Congress volunteers defied the D.S.P's order and went in a procession through the streets of Kuppam carrying Congress flag. The Sub-Magistrate of Kuppam issued an order under Section 144 Cr. P.C. prohibiting meetings, processions and carrying of national flags.

In August, 1931, the police prosecuted under Section 108 Cr. P.C. the Congress Secretary of

Kadapa for publicly approving political assassination. At Rajampeta, the police dispersed a public meeting.

Achanta Rukmini Lakshmipathi's Tour, 1931

In August 1931, Achanta Rukmini Lakshmipathi of Tamil Nadu Congress Committee and A. Kaleswara Rao toured Anantapur District on the invitation of Kalluru Subba Rao. On the morning of 29th August 1931, there was a public meeting in the Church Compound at Gooty (Gutthy). Rukmini Lakshmipathi spoke in English. Her speech was translated into Telugu by A. Kaleswara Rao. At 11:00 AM., there was another meeting at Peddhavaduguru on the invitation of Chinna Narayana Reddy. C.P. Obi Reddy presided over the meeting.

At Anantapur, Rukmini Lakshmipathi and A. Kaleswara Rao addressed a women's meeting at Sharadha Samajam and urged the women to join the Civil Disobedience Movement. From there, they proceeded to Gandhi Chowk. She said that the country was passing through a difficult period. Tracing the history of the struggle launched by the Congress in 1885, she appealed to the people to fight unitedly for Swaraj. On 30th August 1931, Rukmini Lakshmipathi hoisted the national flag at Dharmavaram. On behalf of the Mahila Samaj, Smt. Ambamma garlanded her. At Penugonda, both Smt. Rukmini Lakshmipathi and A. Kaleswara Rao were taken in a procession from the railway station to the residence of T.Sivashankaram Pillai. At the meeting held at Ramaswamy Temple, Venguswami Ayyar garlanded the guests. Agali Narayana Rao proposed a vote of thanks. On 31st August 1931, Rukmini Lakshmipathi and A. Kaleswara Rao addressed a meeting at Hindupur. P. Ramacharlu and Kalluru Subba Rao also spoke.

A.P.C.C. Meeting at Chittoor, 1931

The Andhra Provincial Congress Working Committee met at Chittoor on 29th and 30th September 1931, under the presidentship of the Kumara raja of Gampalagudem. Among those present were Messrs. T. Prakasam, K. Nageswara Rao,

A. Kaleswara Ro, B. Gopal Reddy and Narayanamurthi. The Committee passed resolutions condemning the prosecutions of Messrs. Lingaraju and Subramanyam. The Committee adopted the Secretary's report to the AICC regarding breaches of Gandhi- Irwin pact by officials in Andhra.

The Sub-Magistrates of Chandragiri and Puttur issued orders not only prohibiting the hoisting of the flag but also prohibiting the holding or attending of any meeting in support of the Congress Party or creed. At Madanapalle, cases were lodged by the police against V.V. Vedhanthacharyulu and Nagarathnam Mudhaliar for trying to extend monetary help to some volunteers. Proceedings were instituted under Section

109 Cr.P.C. against four young strangers who came apparently from Madras to Rompicherla.

In Kurnool District, the Civil Disobedience Movement was led by Swamy Narayananda Saraswathi, D. Sesha Reddy and K. Chenchu Reddy. D. Sesha Reddy, invited Kalluru Subba Rao toured Athmakuru Taluk for one week and explained to the people about the evils of the British rule in India.

Repressive Measures

The Government struck heavily against the people by resorting to severe methods of repression. By a Gazette Extraordinary, the Madras Government declared the APCC, the District Congress Committee of Anantapur and Bellary Satyagraha Shibiram as unlawful associations.

Resignation of teachers and other Government servants

During the Civil Disobedience Movement, teachers and other government servants in Rayalaseema resigned in protest against the repressive measures of the government. Those who resigned were C.R. Reddy, the Vice-Chancellor of Andhra University, T.K.T. Veeraraghavacharya and R.Venkata Reddy (Chittoor District), Nivarthi Venkata Subbaiah, D.H. Krishna Rao and D.Govinda Doss (Kurnool District),

D. Rama Reddy, M. Rangaiah Naidu and K. Subramanyam (Kadapa District).

Boycott of Educational Institutions

The students who gave up their studies during the Civil Disobedience Movement in Rayalaseema were: A. Chidhambara Reddy, N. Sanjeeva Reddy and H. Narasinga Rao (Anantapur District), M. Durvasulu Naidu, K. Mal Reddy,

V. Ramachandra Reddy, P. Thimma Reddy, A.P. Vajravelu Chetty, K. Venkatesayya (Chittoor District), M. Shamsheer Baig and A. Venkatasubbayya (Kurnool District). **Action against Local Bodies**

The Anantapur District Board which met on 31st May 1930 and passed a resolution condemning the action of the government for arresting national leaders like Jawaharlal Nehru, Sardar Patel, Abul Kalam Azad and others, was superceded on its refusal to cancel that resolution.

Action against the Press

The Telugu newspapers in Rayalaseema did their best to cover the movement and sent the messages to the nook and corner of the region. Therefore, the government's censor fell upon them to restrict their freedom. The Government had included a list of printing presses and newspapers in its blacklist. Warnings were issued or security was demanded from them. Among them were the Kowmodaki and Aindravathi published from Nandyal and Pattikonda respectively in Kurnool District. Kypa Subramanya Sarma, Editor and Publisher of Kowmodaki and P. Kondaiah Chetty, Keeper of Vani Nikethan Press were warned for publishing three articles, "Boycott of foreign cloth", "Prohibition" and "Mr.Gandhi's March" in their paper dated 27th June 1930. Vanam Sankara Sarma, Editor of Aindravathi was warned for publishing an article "The Gandhi Cap" in his paper dated 4th July 1930. P. Ramacharlu, Editor and publisher was warned for publishing two articles, "The Round Table Conference" and "The Cease of toddy shops and Kapus and Reddis" inhis paper Sri Sadhana published from Anantapur. In 1930, Rayalaseema Ugadhi Kaanuka, a Telugu annual was published from Tadipathri by K. Venkatarangachar. It contained a seditious article, "Wash thy feet in warm blood". It was a prayer to the Goddess of Freedom written by K. Venkataramanacharyulu, a partner of Deshabhandhu press where the journal was published. The government warned the printer and publisher for publishing the objectionable article.

Gandhi's Harijan Tour, 1933-1934

Gandhi, as part of the 'Harijan' uplift campaign, once again, visited Rayalaseema from 31st December 1933 to 4th January 1934 and covered places like Kalahasthi, Renigunta, Tirupati, Kadapa, Gooty, Peddhavaduguru, Ramarajupalle, Thimmancherla, Guntakal, Penugonda, Konakondla, Uravakonda, Vajrakaruru, Anantapur, Hindupur and Alur. He was accompanied by M.Bapineedu, Secretary, Andhra Harijan Sevak Sangh. Prof. Malkani, Meerabehan, Chandra Shankar Shukla, Uma Bajaj, Krishna Behan, Viswanatha Pandya, Dhamodhar Dhass, Ramanarayana Choudhary and one Mr.Sarma.

Gandhi Jayanthi Celebrations in Rayalaseema

In this conection, activities such as the portrayal of the life tof Gandhi importance of Khaddhar feeding of poor people, public meetings and processions were organized at Jammalamadugu, Kurnool, Kuppam, Nandyal, Proddatur, Palamaneru (Pallavan Eri means Pallavas Tank), Madanapalle and Narayanavanam. Prayers were also held in the Mahanandiswara Swamy temple.

Rajendra Prasad's visit, 1935

A notable event of 1935 was the visit of Rajendra Prasad, the President of the INC to Rayalaseema. From 23rd to 26th November 1935, he toured places like Nandyal, Panyam, Kurnool, Adoni, Nemakal, Guntakal, Vajrakaruru, Uravakonda, Kuderu, Tadipathri, Jalalpuram, Anantapur, Dharmavaram, Kuntimaddhi, Penugonda, Hindupur, Parigi, Lepakshi, Chilamatthuru, Kodikonda, Pathapalyam, Palasamudrum, Gorantla, Obuladhevara Cheruvu, Kadiri, Thanakal and Madanapalle. During his tour, he was accompanied by Acharya Kripalani, Hukkerikar, Chakradhara Saran, T. Prakasham, P. Ramacharlu and Kalluru Subba Rao.

Keshava Vidyanilayam

On the evening of 25th November 1935, Rajendra Prasad opened Keshava Vidyanilayam (behind District Board office at Anantapur), built for Harijans in memory of P. Keshava Pillai. Yerramala Kondappa donated two acres of land for the said school during Gandhi's Harijan tour of Rayalaseema in 1933-1934.

I. Sadhashivan was kept in charge of the school. Addressing the students, he appealed to them to sacrifice their lives for the service of the motherland.

N. G. Ranga's Election Tour, 1937

On 6th January 1937, a meeting was held at Thimmancherla near Guntakal in Anantapur District. N.G. Ranga addressed public meetings at Madanapalle, Anantapur, Dharmavaram, Pamidi organized the public meetings. At Pamidi, N.G. Ranga asked the people to defeat the Justice Party and vote for Congress. From Pamidi, N.G. Ranga left for Adoni.

Dhuvvuru Subbamma's Speech, 1937

In 18th April 1937, Desabhandhavi Dhuvvuru Subbamma from Nellore also addressed a public meeting at Gooty. She spoke about the political situation in the country. She criticised the Justice Party Government headed by K.V.Reddy Nayudu. She appealed to the voters to elect the Congress Party in the coming elections. She also addressed a women's meeting separately and asked the women to join

the freedom struggle. On 20th April 1937, Subbamma addressed a meeting at Pamidi. It was presided over by M. Sethu Rao.

C. Rajagopalachari's visit to Rayalaseema, 1938

In 1938, Gandhi Jayanthi was celebrated at Kadapa with the introduction of prohibition by C. Rajagopalachari, Premier of the Madras Government. At Rayachoti,

C. Rajagopalachari asked the people to give up drinking. At Chittoor, the prohibition was inaugurated by Yakub Hussain, Minister for Public Works of the Madras Government. Later Yakub Hussain, C.R. Parthasaradhi Ayyangar, R. Venkata Reddy, District Congress Secretary, L.Sundhararaja Ayyangar, Secretary, Prohibition Committee, Andhra region visited Murukkambhat, Kalavakunta, Penumury, Kothapeta, Poothalapattu, Venganapalli and asked the people to vacate the toddy and arrack shops. C. Rajagopalachari accompanied by Yakub Hussain, Muniswamy Pillai and S. Ramanatham visited Chittoor and expressed happiness as the toddy and arrack shops were closed. In the evening, they addressed a meeting near the police grounds.

Peasant Movement in Rayalaseema

A notable feature of 1930's in Rayalaseema was the organisation of Summer Schools of Economics and Politics for peasant activities. A Rayalaseema Peasants' School of Politics and Economics was opened at Giddhaluru in Kurnool District on 22nd December 1937 under the direction of N.G. Ranga in which about 25 students were enrolled.

N. G. Ranga also started in 1938 a Political and Economic Summer School at Madhanapalle in Chittoor District. It had 75 students on its rolls and it was an organ of socialistic propaganda. The lectures dealt with the evils of Imperialism and Capitalism and were intended to direct the energies of the students towards active participation in movements aiming at the abolition of these forms of domination.

A Summer School of Economics and Politics was organised during 20th May to 20th June 1939 at Kalwabugga in Kurnool District. G. Harisarvothama Rao was its Principal and it had strength of 64 students.

In Andhra all the Prominent Leaders of the Congress like Tanguturi Prakasham Pantulu, Pattabhi Seetharamaiah, Mutnuri Krishna Rao, Bulusu Sambamurthi and Pyda Bapayya were arrested. In spite of these arrests, the Congress volunteers continued the boycott and the swadeshi.

The prominent leaders of Rayalaseema and their followers in various districts participated in the second phase of the Civil Disobedience Movement. They had organized hartals in several places like Guntakal, Adoni, Kuppam and Nandyal. Gooty Kesava Pillai condemned the arrests of the Gandhiji and other leaders. The popular leaders like Kalluri Subbarao, Pappuri Ramacharyulu and Idhukallu Sadhasivan raised the revolt in Rayalaseema, but were arrested and sent to Jail. Several individuals sacrificed a great deal by participating in this Movement.

Participation of Women

Thousands of women participated in the second phase of the Civil Disobedience Movement in 1932. The participants like Vallabhaneni Sithalakshmamma, Digomerti Janakamma, Chukkamma, Duggirala Kanakamba, Kanagarthi Nagarathnamma, Vasireddy Hanumayamma, Dasari Krishnavenamma, Harikapudi Manikyamma, Suguna, Mahalakshmamma, Cherukuri Sowbhagyamma, Kotamarthi Kanakamma, Tripuraneni Kausalyamma, Vedhantham Kamala Devi, Kambampati Manikyamma were very prominent in the propagation of defying salt laws, picketing of liquor shops and boycott of foreign cloth. All the women were awarded one year imprisonment. Smt. Manikyamma had to go to prison with six months old baby in her arms. The women detenues were treated very badly. At this juncture, the Rayalaseema women were inspired by the leadership of Bharathi Devi Ranga wife of N.G.Ranga who led a campaign in Guntur district. She came to Rayalaseema Districts to propagate the movement among the women of Rayalaseema. She was arrested and sentenced to one year imprisonment and a fine of Rs.500/-.

During the Civil Disobedience Movement, number of Teachers serving in Municipal Schools, District Boards and Government Schools in Rayalaseema resigned to their jobs in protesting against the attitude of the Government. C.R.Reddy, Chittoor; Nivarthi Venkata Subbaiah, Kurnool,; M. Rangaiah Naidu from Kadapa District. Many of the students of Rayalaseema gave up their studies during the Second phase of the Civil Disobedience Movement.

Anantapur District

Lakshmi Devi D/o Narasayya

She was born in 1896, daughter of Seshamma and Narasayya. She was very much interested in studies but her parents got her married early and soon she became a widow. Even then she did not give up her hopes about studies. It was her uncle (mother's brother) who supported her in her studies. By 1925, she became the first Doctor in the Anantapur District. While studying Medicine in Bombay, she had observed social and political leaders and developed independent views. She got married in 1929 with Nivarthi Mrutyunjaya Sastri, a Junior Lawyer under her Uncle. She started her medical practice for common people. She was interested in maintaining not only a healthy body but also a healthy society.

By 1930 she was driven towards the Salt Satyagraha Movement. She met Gurgabayamma under whose influence she started addressing the people in large gatherings and picketing foreign goods. The police arrested her and brought her before the Sub-Magistrate Court. After heated arguments she was sentenced to six months Rigorous Imprisonment and a fine of Rs.200/- or in default of which further two months imprisonment. She was lodged in Vellore Jail in 1932.

Lakshmi Devi, worked for Harijan upliftment. She encouraged and followed inter-dinning and collected Harijan Fund when Gandhiji visited Bellary in 1934.

She was also served as Vice-President of the D.C.C. and worked for involving more women in the Congress and its movements. In 1935, she was elected as a member of composite Madras State Assembly for Two and half years and worked hard for her constituency. She was a representative from Bellary to the All India Women's Conference. The Sastri couple suggested change of the name of Ceded Districts as Rayalaseema they also suggested Tungabhadra project for improving irrigation

facilities in that region. She worked for the cause of unity and integrity. She died in February 1976.

Kadapa District

Kadapa Rama Subbamma

She was born in 1902 in Kadapa district, daughter of Ramachandra Reddy and Atchamamba. Her father was a great Sanskrit Scholar. She was married to Kadapa Koti Reddy in 1917. He was a Barrister Law in London and Oxford University, but turned a nationalist and inspired Rama subbamma. As a result of this atmosphere she joined the Congress in 1921 and started her political activities. She was highly inspired by T. Prakasam activities during the boycott of Simon Commission at Madras. She participated in the Salt Satyagraha of 1930 along with Durgabayamma, Dronam Raju Lakshmi Bayamma, Ponaka Kanakamma and other great leaders.

During the Individual Satyagraha in 1941 she participated along with her husband but was not arrested. When her husband was arrested, she organized the movement from 1918, and served as its Vice-President. She served as the Municipal Councilor for 40 years and did great service. She worked for women upliftment. She was the President of District Congress Committee from 1938-43. She left it during the Quit India Movement.

She was the President of All India Women's Conference State Wing. She toured extensively throughout the State. She was a great social worker and worked for the establishment of a Women's College in Kadapa. She donated One Lakh rupees for this purpose. She served as a Member of All India Social Welfare Board. State Social Welfare Board and President of Guild of Services. She worked in the relief programme of Rayalaseema famine. She was a member of All India Congress Executive Committee. She visited foreign countries. While addressing a meeting of Andhra Yuvathi Mandali. Hyderabad in 1940 she inspired the women of Hyderabad to come out of the seclusion. Though she was not arrested. She took an active part in the freedom struggle and social field.

Dr. Muthulakshmi Reddy

Dr. Muthulakshmi Reddy was one of the great women leaders of this period. Though her work was confined to Madras Women of Andhra derived benefit of her services as a Member of the Legislative Assembly. She was responsible for the enactment of laws concerning education and Health of Women, the abolition of Devadasi System and the suppression of prostitution. All her reforms had their impact on women in Andhra as there was already awakening in these matters dawned by the social reformers. Prominent person's likeYamini Purnatilakam, her daughter Rama Tilakam and the famous cinema star of the day Bezawada Ranla Tilakam had carried a movement for abolition of the Devadasi System. Dr. Muthulakshmi Reddy started a number of institutions for women. She did not participate in the Salt Satyagraha or in picketings and boycotting like other women of Andhra. But as a staunch follower of Gandhiji as an educated lady, she tried to awakening the women through meetings, discussions and organizations. As a follower of Gandhiji she resigned her membership in the Legislature in 1930. She represented Women's Indian Association and attended the Round Table Conference at England. When Gandhiji visited Madras in 1933, she was the President of Women's Indian Association and organized a large women meeting with Gandhiji. These women took a pledge that they would carry on the campaign against untouchability. She had already established Avvai Home, in which she

sheltered women of all castes. She took up the task of constructing a Cancer Hospital through the Women's Indian Association and collected huge donations. Though her eyesight was deteriorating due to age she convinced Gandhi and carried on the work.

Dr. Muthulakshmi Reddy was the first lady Doctor in the composite Madras Province. She was highly influenced by the Brahmo Samaj and its founder and leaders. **Conclusion**

Thus, Mahatma Gandhi's call of Civil Disobedience Movement has enormous effect which spread to the nook and corner of the country symbolizing that irrespective of age, education, profession, religion all joined together for the cause of freedom for the country. It is important to note here that because of the sacrifices made by the lakhs of people who suffered in the hands of the British by serving jail sentences, hangings, firings and Lathi charges. We are enjoying freedom. In this context the role played by Rayalaseema Women freedom fighters who involved in this movement played a key role in arousing national sentiment among the people for the cause of national independence.

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RHYTHMIC DANCE PATTERNS IN COMPOSITIONS OF ŪTUKKĀḌU VENKAṬA KAVI

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ABSTRACT

India is a country of many art forms and cultures which are interrelated and inter-dependant in many ways. Especially the fine arts - music and dance are like inseparable twins- bhāva and laya being the most common factors. Music and Dance always complete each other. In South India, Carnatic music compositions are the choice for many classical dancers for their performances. Many South Indian Composers have contributed immensely towards the Dance musical forms like Jatisvaram, Padavarnam, Padam, Tillana etc., which in general figure in a dance recital. Also, there are many compositions that particularly suited for dance with many jati-s, sōlkaṭṭu syllables with svara passages etc., though not intended specifically for dance, that are chosen for classical dance performances as they offer vide scope for the dancers for visual interpretation interspersed with dance specific jati-s and many more dance related aspects. Ūtukkāḍu Venkaṭa Kavi's compositions are one such favourite choice for many dancers belonging to classical dance forms like Bharatanāṭyam and Kūcipūḍi. The present paper aims to bring out the genius of Venkaṭa Kavi's compositions as a choice for dance performances, highlighting various aspects of dance centric rhythmic patterns present in his compositions.

KEY WORDS: *Music, Dance, Rhythm, Jati, Venkaṭa Kavi, Bharatanāṭyam*

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INTRODUCTION

Classical Music and Dance have a prominent place in our culture and are the proud treasures of the heritage of our nation. Both Carnatic Music and Dance have prominent place in the Cultural and Fine Arts set up. These have not only swayed the hearts of the ethnic Indian community but also the hearts of the Universe breaking all the barriers. Together they have a great role in the Cultural Diplomacy and make the world a better and befitting place to live. Music is an inseparable part of Dance. They both are incomplete without each other. It is the music- 'Sangīta'- that adds sparkle to the graceful dancing.

In the early Indian context, the term Sangīta meant a composite art-form comprising of Gīta, Vādya and Nṛtta – vocal singing, instrumental accompaniments and the limb movement or dance. The third component of Sangīta, viz., Nṛtta, again involved the use of other two components - Gīta and Vādya.

"Gītam vādyam tathā nṛtyam trayam sangīta muçyatē" (Sangīta Ratnākara)

Thus, the term Sangīta combined in itself all the different phases of music, including dance. For Dance (Nṛtta), just as in the case of vocal (Gīta) and instrumental (Vādya) music, the rhythm (Laya) is very vital. The Dance too was

regarded as a kind of music. This is similar to human body where the different limbs function in harmony with the body's rhythm.

Thus, a dance performance is a feast for both eyes and ears. Music becomes visual in a dance performance. The text (lyrics) of the song is translated to action and through that media, the message is conveyed, the story is narrated, the incident described and the feeling expressed. According to the well-known adage - "There can be music without dance, but there can be no dance without music".

Repertoire

Many dance forms flourished in India, each of these having their own individual style of music. Carnatic music has been playing an important role, particularly in South Indian classical dance forms like Bharatanāṭyam, Kūcipūḍi etc. Several musical forms that are suitable exclusively for dance recital were composed down the centuries. Apart from such regular dance proforma, compositions of many Vaggēyakāra-s, though not particularly intended for dance, have become the choice of many classical dancers, to bring out and expose the vast and varied elements of Abhinaya and various rhythmic patterns contained in them.

Ūtukkāḍu Venkaṭa Kavi's compositions are one such favourite choice featuring in South Indian Classical Dances like Bharatanāṭyam and Kūcipūḍi repertoire.

Ūtukkāḍu Venkaṭa Kavi

Ūtukkāḍu Venkaṭa Kavi (1700-1765) was one of the pioneering composers of South India. His contribution to music, dance and spiritual lore is immense. He was born in the month of Aippāsi, (Saptami – Makham star) at Mannārguḍi to Rāmaçandra and Kamalānārāyaṇi. Venkaṭa Kavi had learnt elementary music from Pūranūr Naṭēśa Bhāgavatār alias Rāja Bhāgavatār and could find none to teach him further and ultimately found his 'Mānaśīka' Guru in the Lord Kṛṣṇa Himself.

Composer Par Excellence

Venkaṭa Kavi's compositions consist of various aspects like Melody, Rhythm, Lyrics, Opera, Dance, Indian Culture, Historic luminaries and various other themes. His compositions have been the outpouring of his divine spiritual experiences glittering with lyrical feat and musical feast replete with rāga-bhāva-rasa-anubhava. He has followed the kṛti pattern of the earlier composers (like Annamāçārya and Purandaradāsa), and the kannigaḷ pattern (number of stanzas sung to the same tune) of the Divya Prabandham of the earlier Āḻvar-s and sollukaṭṭu-s and sāhitya-s for them comparable to Aruṇagirināthar are in abundance in his compositions.

Venkaṭa Kavi had a deep devotion for the presiding deity of the Ūtukkāḍu temple, Kāḷinganartana Perumāḷ. His works express the closeness he felt towards the Lord and his deep devotion which is reflected in every verse he wrote. His compositions – especially those on Lord Kṛṣṇa have a reference to Kṛṣṇa's Kāḷinga Nartana.

Dance Compositions

Most of his compositions are dance-oriented, and contain plenty of *sōlkaṭṭu jati*-s, and madhyamakāla passages. He was a master of intricate rhythmic patterns. His compositions are well suited for concerts, bhajans and dance. The most fascinating thing in his compositions is the combination of svara, sāhitya and jati which he employed.

According to family sources – 'Rhythmic excellence and soul-filling music of Venkaṭa Kavi has all the elements of Bharatanāṭyam like alarippu, sabda-s, jatisvaram, varṇam, jāvaḷi, tillāna-jati-s and varṇameṭṭu-s and have therefore become the favourite of dancers.' The Maestro wrote Rudra Sabdam, Nandana Gīta, Rājagōpāla Nityōtsavam, Kāḷinga Nartana Prabhāvam and Śrī Kṛṣṇa Gānam with a part in kṛti form known as Rāsa padam.

Choice of Dancers

The works of Venkaṭa Kavi are always a delight for dancers. His compositions are a blend of intricate rhythms with Bhāva laden lyrics which offers vide scope for beautiful visualisation and choreography that can transport the artist to a higher dimension. Known for picturesque descriptions steeped in devotion and sparkling jati-s, Venkaṭa Kavi's compositions succeeded in gaining admiration and attraction in dance circles.

Visualisation

Venkaṭa Kavi's knowledge and fondness for dance are evident in many of his compositions. It seems he was inspired very much by the divine visionary of the dances of Kṛṣṇa, Vināyaka and Śiva. Also, the influence of Bhāgavata mela tradition that was prevalent those days in his region is also seen much in his works, which inspired him to compose pieces suitable for dance.

His description of dance reveals his extraordinary visualisation. This is evident from his approach to jati-s, svara-s and yati-s readily falling into places and blending seamlessly with the abhinaya-centric parts.

The following is an admirable example of his visualisation about Kṛṣṇa's dance in Rāga Nāṭṭai

Pallavi

āḍinān nartanam ādinān rāsa nartanam ādinān sarasa rāsa nartanam āḍinān sundarigaluḍan sarasa rāsa nartanam āḍinān vraja sundarigaluḍan sarasa rāsa nartanam mighu bhakti koṇḍa vraja sundarigaluḍan sarasa rāsa nartanam antaranga mighu bhakti koṇḍa vraja sundarigaluḍan sarasa rāsa nartanam…..

Here the Rāslīla of Kṛṣṇa – dancing with Gōpikas-s of Vraj - is visualised through the lyrics beautifully

Jati Patterns (Dance centric Rhythmic Syllables)

Venkaṭa Kavi stands ahead of many Carnatic composers for his affinity, spontaneity, versatality and variety when it comes to jati-s (rhythmic or dance syllables). He has incorporated wonderful jati-s in many of his compositions. The following are some beautiful examples:

1. Ananda nartana gaṇapatim – Nāṭṭai – Ādi

In this wonderfully rhythmic song, Venkaṭa Kavi prays to Vināyaka while He dances His divine dance.

Jati pā ma ga mā ga sa sā sa ri sā taka taṇaku dhimita kiṭa taṇangu taka dhimita dhimita tām taiï yaï tāmï tām taṇandari tām taka jhaṇam taṇandariï tāïm tām taṇandari jhaṇam taṇandari; tari tari tari; dhimi dhimi dhimi; ; . kiṭa kiṭa kiṭa.; jhaṇa jhaṇa jhaṇa; divipatinutam; padasarasijam ma ga pa ma ni pa ; marakatanibham ; mada karimukham ; praṇava ninadam ; ajitam anagham sugatam paramam kanakāmbara dharaṇam Eka radanam tattit taka jhaṇanta naga tari dhit taka jhaṇanta naga tari taka jhaṇanta naga tari tām tattit taka jhaṇanta naga tari dhit taka jhaṇanta naga tari taka jhaṇanta naga tari tām ; ; tattit taka jhaṇanta naga tari dhit taka jhaṇanta naga tari taka jhaṇanta nakaparam

2. Marakata maṇimaya çēla – Ārabhi – Ādi Tāḷam

In the last section of this kṛti, there is a mathematical reduction (kuraippu) from one cycle to half cycle before capping it off with another cycle. This feature is usually seen in solfa improvisations (kalpana svara-s). The composer brings in much beauty by switching between jati and lyrics in every alternate line. Most obviously, it is a popular choice in the world of dance.

Çaraṇam mānita guṇa śīlā dayālā mām pālayā varabālā gōpālā sā ni dha pa ma ga ri

muraḷīdharā nanda mukundā mama mānasa pada sarasīruha daḷa yugaḷā ādi

madhyānta rahitā vaibhava anantā kalyāṇa guṇā mama rakṣaka

Jati(madhyamakāla)

takiṭa dhrimita taka taka dhimi dhīmtaka taka tika tōm taka tōm taka dhiranā

vanaja nayana rādhāmukha madhukara rasika rasikavara rāsa vilāsa

takiṭa dhrimita taka taka dhimi dhīmtaka taka tika tōm takatōm taka dhiranā

navarasa kaṭitaṭa śōbhita vallabha nava vrajayuvatī manōllāsa

taka tika tōm taka taka tōm taka dhiranā kanaka maṇimaya nūpura dharaṇā

taka tika tōm taka tōm taka dhiranā kamala bhavanuta śāśvata caraṇā

kalpita kali kaluṣajvara mardana kāḷinga nartana katitha janārdana

3. Nīlavanam tanil – Punnāgavarāḷi – Ādi

This kṛti has jati interwoven in the Çaraṇa part as follows.

çaraṇam nadik-karaiyōrattilē (yamunai) anru oru nāl innērattilē anralarnda narumaṇa malarō

malaridaśhō un matimukham enradum mati mayangi vashamiśhanda enniḍam

manadirangi arul purindu shenradum maravēnē kaṇam tariyēnē dhittriku tariku dhīm-tattari dhīmita jhaṇuta jhaṇuta dhīm taka tadhingiṇatōm tattit takaṇak jhantari

dhittaṇaka jhantari takaṇaka jhantari kalangamilāda

4. Vanamālī svāgatam – Nāṭṭaikkuranji - Ādi

In this composition, one can find jati patterns in Anupallavi as well as Çaraṇam with gati bhēdam of Çaturaśra and Khaṇḍa gati as well.

Anupallavi sanaka sanādi muni gaṇārçita suguṇā çandra vadanā krta tākiṭa taka jhaṇanta

taka jhoṇutaka kiṭataka tari kiṭatōm takatari kiṭataka tākiṭa taka jhaṇanta taka

jhoṇutaka kiṭataka tarikiṭatōm tattōm taka tōm taka tiri tōm taka tari kiṭataka taka

tām ta śa ni dha ni śa śa ni ni dha ni ma ma ga sa sa ni kiṭataka tarikiṭatōm

tām ta ŝa ni dha ni ŝa ŝa ni ni dha ni ma ma ga sa sa ni kiṭataka tarikiṭatōm sa ma ga mā ; ma ga ma ni dha guṇānga taka taḷāngu taka tōm ta

(khaṇḍagati) tattit dhṛkam dhṛka tataka tillānā - tattit dhṛkam takadhṛkam tataka tillānā

dhṛkata tillānā - tadingiṇat-tōm tāmta tillānā - tadingiṇatōm tāmtāmta tillāna

tadingiṇatōm

5. Nīradasama nīla Kṛṣṇa – Jayantaśrī – Ādi Triśranaḍa

In this composition, we can come across jati-s in both the gati-s, the triśra gati and khanḍagati. The jati is spread over both anupallavi and çaraṇam.

Anupallavi naravara stuti rūpa vēṣa nava vraja yuvatī samēta

nādhiru tadingiṇatōmdhittām kiṭataka tarikiṭa

nādhiru tadingiṇatōm dhittām kiṭataka tarikiṭa

(khaṇḍagati)
çaraṇam
makara kuṇḍala dharita mahanīya vēṣā sakala jana munigaṇa samūha mana mōhā tara

kaṭaka karatala jvla jvalita jālā / taka takiṭa tadingiṇatōm dhittām sa sa ma dha ni sa sa ga

ma dha ni ni sa ga ma pā pā ma dhā ni sa ga takku dhinnam tariku tarikiṭaku kukutattai

kukutaṇaku ḍhiṇḍhīngu tikuṇa kuku kiṭataka tarikiṭatōm

6. Muddu Kṛṣṇā Mēmudam Dēhi – Janjhūṭi – Ādi

In this composition, the jati is set in vilamba kāla at first then followed by jati in madhyamakāla, combining a high degree of sophistication and aesthetic sense.

Anupallavi

nitya yauvanālankṛtākāra nīla mēgha kōmaḷānga śarīra navanīta çōra mahanīya rūpa

rādhā vilōla tara vēṇugāna gōpālā vara bālā agaṇita vitaraṇa guṇaśīlā

Jati

{Vilamba kala} - dhittariku tariku tadingiṇatōm taka tadingiṇatōm takadika takadika

tadingiṇatōm / ga ma pa ni dha pā dha ma dha pa ma ga ri sa ri ga ma pā / tatām tadhīm

taṇam takum - tatām tadhīm taṇam takum – {Madhyamakala}(tatām tadhīm taṇam takum) / takkiṭa dhimi tirikiṭa dhimi taḷāngu takajham tari takkiṭa dhimi tirikiṭa dhimi

taḷāngu takajham tiri takkiṭa dhimi tirikiṭa dhimi taḷāngu takajhañu taḷāngu takajhaṇu

kāḽinga Nartana

7. Bṛndāvana nilayē – Rītigauḷa – Ādi

In this composition, we can find beautifully interspersed jati pattern in the samiṣṭi çaraṇa as follows

Samiṣṭi Çaraṇa

śṛngāra rasōllāsa caturē ……

vasudēva dēvaki nanda mukunda gōvinda kāḷinga nartana rasikē

Jati

takkiṭa taddhimi tattari tajjhaṇu tām sā ni dha ma gā ri sa ni takkiṭa taddhimi tattari tajjhaṇu tām / kiṭatōm dhīngiṇatōm tadhīngiṇa tōm / tām dhingiṇa tōm tām tām dhīngiṇatōm tām tām dhīngiṇa tōm tām dhīngiṇatōm tām tām dhīngiṇatōm tām tām dhīngiṇatōm tata jhaṇu tadingiṇa tōm taka tadingiṇa tōm taka tika tadhingiña tōm tām / ga ga ma ri ga ma sa ga ri ga ma ni ni sa ga ri ma ni ni sa sa nI sa sa ri sā ; ghiṇatōm taghiṇatōm tadhighiṇatōm taka tadhighiṇatōm taka tika tadhighiṇatōm

8. Bhuvana Mōha Saundara Sukumāra – Dhanyāsi – Ādi

In this composition, Venkaṭa Kavi has created jati patterns interspersed with svara-s and then composed lyrics to match these in the next line

Çaraṇam

muhūrita ravatu sanga tarangita kumkuma candana kaḷabha samiśṛta sundaram

……

su-vacanā tāpa samida mama kānta kānta taka dhīmta dhīmta kāḷinga nartana

(madhyamakālam)

tānamkiṭa tajham tarita sa ga ri ni sā tajham taṇam takum tarita - (jati with svara)

padāmbuja svayam jvalita naṭanavarā tajham taṇam takum tarita - (lyrics)

tānamkiṭa tajham tarita sa ga ri ni sā tajham taṇam takum tarita - (jati with svara)

pītāmbaradhara maṇimaya makara kuṇḍalam idam jhalam jhalana – (lyrics)

dhitōm dhitōm ri sā pa nī sa ni dha pa taṇangu kiṭa taḷāngu taka dhīmta

takku tarikiṭaku tarikiṭaku kiṭata tatdhṛta kiṭa jhaṇata tānam tadhīmta

nṛtya nṛtya vṛṣa-bhānu sukumāri vidhṛta pa-danyāsa bhāvāva rasika

ati nūtana kusumākara vraja mōhana sarasīruha daḷa lōcana mama

mānasa paṭu śōra su-svara gīta su-muraḷīdhara suramōdita bhava mōcana

9. Svāgatam Kṛṣṇā – Mōhana – Ādi (Triśra and Çaturaśra gati-s)

In this composition, the Pallavi and anupallavi are in triśra gati and çaraṇam is in çaturaśra gati followed by a combination of svaram and jati – first in çaturaśra gati and then in triśragati.

Çaraṇam – (çaturaśram)

muṣṭikāśūra çāṇūra malla malla viśārada mudhusūdanā

----

vraja yuvatī jana mānasa pūjita

Jati

sā dha pā ga rī pa ga ri sa dha sā

taddhit takajhaṇu tām / dhit takajhaṇu tām / takajhaṇu tām

takatari kuku taṇa kiṭataka dhīm / takatari kuku taṇa kiṭataka dhīm

takatari kuku taṇa kiṭataka dhīm / takatari kuku taṇa kiṭataka dhīm

(triśragati)
takatari kuku taṇa kiṭataka dhīm / takatari kuku taṇa kiṭataka dhīm / takatari kuku taṇa kiṭataka / takatari kuku taṇa kiṭataka dhīm / tari kuku taṇa kiṭataka dhīm / kuku taṇa kiṭataka

10. Kanaka sabhā nāyaka – Nāṭṭai - Ādi

This composition of Venkaṭa Kavi in Tamil on Lord Śiva is again an explicit example resplendent with beautiful and elegant madhyamakāla jati towards the end of the composition, ideal for a dance finale.

Çaraṇam

vēda kāṭṭilē viḷainda mai jñāna vittagamēviya karpakē aruḷ vindaiyē

----

pançākṣara vaḍivāghiya namah śivāyaverum narum tēnai aḷitta nanmalarē

Jati (madhyamakāla)

nādhru takkat-takkattōm dhrutaka takkattōm takkattōm dhinattināvena nakuntaraku

dhina tillāna dhittillāna dhīm tarana dhīrana tāngu taṇattari jhomuku taṇattari taṇakiṇa

taṇakiṇa tākkināākta nagajhaṇu dhīm tanāk-tinākta nagajhaṇu dhīm tatā tatī tataita

jhomta kiṭaku tarikiṭaku dhittillāt-tatakajham tiritilātta takkakajham dhittillātta

tiri tillātta takajham tadikiṇatōm tatikiṇatōm tadīngiṇatōm

CONCLUSION

Many choreographers separately include various jati patterns (dance rhythms) in the compositions they choose, to create different movements in their dances. But we can find the natural flow of jati patterns interspersed in the main text of many compositions of Venkaṭa Kavi enabling many dancers and choreographers follow the song as it is, still creating the magical feat they wish for.

Thus, the genius of Ūtukkāḍu Venkaṭa Kavi can be highlighted through some of his compositions repleting with rhythmic dance syllables(jati-s) and can be considered a great choice for classical dance performances.

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SANKĪRTANĀÇĀRYA ŚRĪ ANNAMĀÇĀRYA

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ABSTRACT

Śrī Tāḷḷapāka Annamāçārya is one of the early vāggēyakāra-s in Telugu. He is well-known as '*Pada Kavitā Pitāmaha'* and '*Sankīrtanāçārya'*. His Sankīrtana-s contained the essence of Vēda-s, Itihāsa-s and Purāṇa-s. They were sung by him with great Viṣṇu Bhakti and Śaraṇāgati Bhāva to Lord Śrī Venkaṭēśwara of Tirumala. They came out from the depth of his heart and hence are of great interest to the sādhaka-s of the Bhakti-cult. Hearing them rendered musically is a great feast to the ears. They bring happiness to the mind. It is therefore no wonder, they are popular.

The present paper focuses on throwing some light on the sankīrtana-s of Śrī Annamayya, hailing his prowess as 'Sankīrtanāçārya'.

Key words: Annamāçārya, Sankīrtanāçārya, Sankīrtana, Bhakti, Vāggēyakāra

INTRODUCTION

India is a land of spirituality and Indian music is mostly spiritual in nature, finding its roots in the Sāmavēda with bhakti being an important factor ruling over it. It has been enriched with a large and vast repertoire of devotional literature by many Vāggēyakāra-s. Music became the vehicle to many of them to express their longing towards the Supreme Bliss and to outpour their feelings and emotions to the Almighty they strongly believed in. Thereafter, the Bhakti movement influenced music invariably for centuries.

Both North and South India made their own significant contributions towards the field of music with their divine writings. We had Jayadēva, Līlāśuka, Tulsīdās, Kabīrdās, Mīra etc., in the North whereas in the South, Aḷvārs – following the philosophy of Viśiṣṭādvaita of Śrī Rāmānuja propagated bhakti through the hymns of Nālāyira Divya Prabandham and Nāyanār-s, the Saivaite saints expressed their devotional emotions through Tirumurai and Tēvāram-s in Tamil. Meanwhile, in Kannada the ecstatic outpourings of Haridāsa-s called 'Dēvaranāma-s' and 'Dāsara Padagaḷu' gained tremendous popularity along with the 'Vaçana-s' of Śiva śaraṇa-s. Before the advent of Annamāçārya, in Telugu we had Kṛṣṇamāçārya's 'Simhagiri vaçana-s' and 'Narahari vaçana-s'. Annamayya's arrival on this scenario of India's devotional literature marked the beginning of a new era in the 15th century.

"Nāma sankīrtanam yasya - Sarva pāpa praṇāśanam" ||

(Bhāgavatam 12-13-23)

Endowed with a fertile imagination, Annamāçārya was a great scholar, Saint poet and his works described as 'Padakavita-s' are repositories of ancient wisdom. Through his Pada-s he sang the praise of the auspicious qualities of the Lord of the Universe embedding those songs with great philosophical truths. He brilliantly employed music and literature as tools to give spontaneous expression to his Bhakti Bhāva.

Life Sketch

The life sketch of Tāḷḷapāka Annamāçārya can be known from the diligent work titled "Annamayya Jīvita Çaritramu" by Tāḷḷapāka Tiruvēngaḷanātha (Śrī Annamāçārya's grandson) presented in the genere of "Dvipada kavya". Annamayya was born in 1408 in a small village called Tāḷḷapāka of Cuddapah district in Andhra Pradesh. His father was Nārāyaṇa Sūri and mother Lakkamāmba. They belong to Smārta Nandavarīka Brahmin family and are devotees of Lord Viṣṇu. Annamayya is said to be the incarnation of 'Nandaka' (the sword of Lord Viṣṇu).

Pilgrimage to Tirumala

Annamayya left Tāḷḷapāka village at the age of eight. He wanted to climb the Tirumala Hills on foot. At the very sight of the Tirumala Hills, Annamayya sings in ecstacy as follows

"Adivō Alladivō Śrīharivāsamu – padivēla śēṣula paḍagala mayamu"

While climbing the hills, he was tired and slept under a cool bamboo groove at a spot called 'Mōkāḷḷa Miṭṭa". The Tirumala hills are said to be full of Sālagrāma stones and he committed the mistake of wearing the foot wear unknowingly while climbing such auspicious hill. Goddess Alamēlumanga, the divine consort of Lord Venkaṭēśvara came to his rescue with abundant motherly affection. She blessed him with Lord's prasādam with which he regained his vigour and strength and resumed the journey. Inspired by the divine mother's flow of mercy, he spontaneously rendered one hundred verses in Her praise and dedicated to Goddess Alamēlumanga.

Vaiṣṇavism

Annamayya stayed in the sacred hills for eight years. He was initiated into Vaiṣñavism fold by a sanyasi 'Ghana Viṣṇu', after completing 'Pança samsakara-s'. From the age of 16, Annamāçārya took a vow to offer at least one composition a day to the lotus feet of the Lord. This mission was carried on by Annamāçārya till his last breath (Phālguṇa Bahuḷa Dvādaśi – 1503).

Back to Tāḷḷapāka – Marriage

Annamāçārya's parents came in search of him and obeying Lord's advice, he returned to his village with them. He married Timmakka and Akkalamma and had three children, Peda Tirumalāçārya being one among them.

Annamāçārya was greatly influenced by the pontiff of Ahōbala Muṭṭ – 'Śrī Ādivan Śaṭhagōpa Yati', and gave the essence of Viśiṣṭādvaita Philosophy to the understanding of the common folk, in his sankīrtana-s.

Sāḷuva Narasimharāya

Annamāçārya adorned the court of King Sāḷuva Narasimharāya of Penukoṇḍa. One day, overwhelmed by the sweetness of a particular sankirtana - ***"Emokō çiguruṭa dharamuna – eḍaneḍa kasturi niṇḍenu"*** composed by Annamayya, the king requested him to compose such a song on him also. Annamayya refused to do so, declaring that his songs are dedicated only and only on Lord Venkaṭēśvara and that he will not compose in praise of human beings, however great they may be. Felt insulted by this refusal, the king ordered the imprisonment of the saint composer. Annamayya prayed the Lord through the following Sankīrtana –

"Ākaṭi vēḷala alapaina vēḷala – tēkuva Hari nāmamē dikku mari lēdu"- who came for his rescue by breaking the chains. The king realised the greatness of Annamayya and fell at his feet. Annamayya disgusted with the court service, returned to Tirumala and settled there for the rest of his life.

Annamayya composed innumerable songs covering different aspects of life and afterlife. His sankīrtana-s cover all temple rituals, utsavam-s, processions etc. It is said that the famous dāsa saint of Karnataka – Purandaradāsa praised Annamayya as the incarnatiom of Lord Venkaṭēśvara and his sankīrtana-s as 'Parama Mantra-s'. Annamayya's sankīrtana arçana was carried by his son Peda Tirumalāçārya and his grandson Çina Tirumalāçārya. Another grandson Çina Tiruveṇgaḷanathuḍu known as 'Çinnanna' wrote his biography. Çina Tirumalāçārya also translated 'Sankīrtana Lakṣaṇamu' of Annamayya which was originally in Sanskrit and currently obsolete into Telugu language. This treatise explains the lakṣaṇa (theory) of the form Sankīrtana for which lakṣya (practical) can be found in Annamāçārya's sankīrtana-s.

Copper plates - Sankīrtana Bhāṇḍāramu

Annamāçārya's yeoman services to the field of poetry, music and bhajana tradition is very significant. He is aptly hailed as 'Padakavitā Pitāmaha', 'Sankīrtanāçārya' and 'Drāviḍāgama Sārvabhauma'. He composed 32,000 sankīrtana-s, but because of some greedy people and their ignorance we lost a major part of the greatest treasure. Presently only around 14,000 are available out of them. These are engraved on copper plates under the direct supervision of Peda Tirumalāçārya. The tradition of having compositions inscribed on copper plates is exclusive and unique to Tāḷḷapāka composers. They were stored in a place called 'Sankīrtana Bhāṇḍāramu' inside the temple premises at Tirumala, some at Ahōbilam and some in Śrīrangam. We find some palm leaf manuscripts of the same at Tanjore Sarasvati Mahal Library and Madras Oriental Manuscripts Library. It was A.D. Campbell who first mentioned the existence of these compositions way back in 1816. But these copper plates came to light only in 1922 through the discovery of The Tirumala Tirupati Devasthanams, TTD. The Sankīrtana Bhāṇḍāramu' in Tirumala temple holds the statues of Annamāçārya and his son Peda Tirumalāçārya on either side. Even to this day, the Lord of Seven Hills wakes up to Annamāçārya Sankīrtana which has become a part of the daily rituals at the hill temple.

Sankīrtana Legecy

Annamāçārya's sankīrtana-s can be broadly classified under two categories – Adhyātma sankīrtana-s (the devotional and philosophic compositions) and Śṛngāra sankīrtana-s (the erotic compositions replete with madhura bhakti concept). His compositions were mainly in Telugu language and a few in sanskrit language. His sankīrtana-s were a confluence of language and literature, the music and musicology and the philosophy and message. The style of the sankīrtana-s is simple, direct and colloquial. The common vocabulary of the contemporary age was liberally used and the native idiom is well expressed.

He adopted song as a mass medium to convey his ideas and ideologies and to propagate the 'Srinivasa Tatvam'. Ha called his song "Sankīrtana". Sankīrtana form was systematised and streamlined by Annamayya with a Pallavi, Anupallavi (rare usuage) and Ćaraṇam-s. The Pallavi contains the central idea of the sankīrtana and the theme is elaborated in the ćaraṇam-s following. Only rāga names were mentioned on the copper plates for the 14,000 odd compositions we have inherited of Annamāćārya, only 89 rāga-s have been employed out of which 25 have been used frequently. Though there is no mention of tāḷa-s on the copper plates, their pattern of singing employing different tala-s can be inferred from the pada singing tradition followed in Karnataka and Andhra according to Śrī Rāḷḷapalli Ananta Kṛṣṇa Śarma. He says, the bhava and language of the song itself leads us to infer its music. Many renowned Musicologists and contemporary musicians have composed tunes and published notations to the sankīrtana-s of Annamayya.

Annamyya extols the greatness of Sankīrtana in many of his own compositions. The following are a few of them:

- Annamayya conveys that Sankīrtana of Viṣṇu only is the pure eternal knowledge and that there is no other tool beyond Sankīrtana to attain eternity,

  "Mādṛśānām bhavāmaya dēhinām ----------

  ----------kēćidapinā viṣṇukīrtanam prītyā – sūćayantō vā śrōtum nanatiḥ"
- ***"Ćāladā bramhamidi sankīrtanam – jālella naḍagiṇću sankīrtanam***

  Sāmajamu gāćinadi sankīrtanam – sāmamuna kekkuḍī sankīrtanam

  Sāmīpyamindariki sanakīrtanam – sāmānyamā Viṣṇu sankīrtanam"
- ***"Ćaladā harināma soukhyāmṛtamau tamaku ----------***

  Tagu vēnkaṭēśu kīrtanamokaṭi ćaladā – jagamulō kalpabhūjammu valenunḍa"
- In the following sankīrtana he says – one sankīrtana is enough to protect me, let the rest be hidden in the treasure house.

  "Okka sankīrtanē ćālu oddikai mamu rakṣimpaga

  Takkinavi bhāṇḍārāna dāćiyunḍanī"

Conclusion

Annamāćārya's sankīrtana-s dazzle in poetic excellence and with a chiselled structure, carryout understanding musical element along with strong emotional element, enhancing their melodic, aesthetic and rhetorical value leading us through a great spiritual journey to attain the eternal bliss. Thus, Annamāćārya is hailed as 'Pada Kavitā Pitamaha' and 'Sankīrtanāćārya' in the right way.

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FINE ARTS IN TAMIL SANGAM AGE

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Abstract- **The historic period of Tamil Nadu started with the sangam age. Education in the arts is an integral part of the development of each human being. This study mainly will give importance to the origin and development of the fine arts in the history of Sangam period. Sangam age to fine arts had its progress in various fields and inspired the coming generations. The fine arts like music, dance, drama and painting were all developed in a conspicuous measure. Tamils embraced, there from not only literature but also music and drama. The concept of Muttamil comprising Iyal, Is I and Natakam had attained currency as early as the Sangam age.**

Keywords: **Music, fine arts, sangam age, sangampeople, art forms, instruments.**

INTRODUCTION:

The sangam period as the classical age of the Tamils analogues. The Sangam age in Indian history witnessed the rapid development of Arts and literary works in the southern reasons. Various fine arts were very popular in the sangam age. Poetry, music and dance were quite popular among the sangam people. Various fine arts were very popular in the sangam age. During the sangam period music and dance were highly developed and popular. Musical instruments of various types are described and included many kinds of yal and varieties of drums.

Music

Music is the subtlest and finest of all fine arts and it develops the faculty of human imagination and appeals to the soul and conscience of the people. Through its melody or harmony it gives infinite pleasure to the mind and the heart. Tamils of the Sangam age possessed a highly developed system of music. The **Purananuru** shows that the Tamils had acquired a remarkable skill in music from an early time. They took a great delight in assembling in large numbers for the purpose of enjoying music, vocal and instrumental as well as dance performances. From **Pattinappalai** we come to know that the people of **Kavirippumpattinam** often resorted to the common place of the city in order to witness dances and enjoy music recitals. A class of bards known as Vairiyar used to provide music in the public assemblies of the village. It is learnt that when the guardian tree of a hostile ruler was felled the **Vairiyar** used to sing songs in merriment. The bards used to sing in praise of kings in their palaces early in the morning. There were the ubiquitous panar, the roving musicians and dancers. The groups of Panar proceeded from place to place. Their womenfolk **Viraliar** also sang the glories of Kings and Chieftains. The Porunars were the bards who accompanied kings to battlefields in order to cheer up the soldiers by their war songs and music.

Porunar

The Porunar were well known for their resourcefulness ready wit and conspicuous skill in conversation also. Rich presents were given to the Porunar and their womenfolk by the Kings munificently. When the king or chieftain Won a victory, golden flowers were given to the Porunar and jewels and ornaments were presented to the Viraliar, Among the Porunar and Panar, though they belonged to the same class, the former were more esteemed and more gitted poets and musicians than the Panar, However the Panar themselves were men or notable skill in music and Ldance. The artistic performances of the Panar and their women were immensely relished by the common people too.

Usal vari

From time immemorial there was in vogue the practice of women singing lullabies in order to lull babies in the cradle' to sleep. This variety of song was known as "Usal Vari". The girls used to sing songs when they were swinging in the Unchal i.e, swings from branches of trees or other hangers Women pounding rice resorted to a particular variety of song during the ourse of their work was described as Vallaippattu, Kurava women are said to have sung songs in order to miti~ato the pain and agony of their husbands when they were writhin with pain.

Asunam

A bird known as Asunam, mentioned in Ahananuru and Narrinai (it is said to be an animal) is said to have had a remarkably sensitive ear for music was called the '**Isai Art Paravai Paravai**. The cc mmon belief was that those who

wanted trap the bird sang suitable songs in order to entice it. from the Aliananuru it is learnt that even wild animals were stunned -by' the spell of sweet 'music. The application –'Isai' given to music, is itself significant; it denotes that which- moves or meets. According to Parimelalagar tbe verses of Paripadal were attuned to music.

High Degree

Tamils claimed the highest degree of musical perfection though they were much indebted to folk music in the evolutionary stages. They excelled in soft melodies through the gamut that consisted of seven notes or svaras. They were known as kural, tuttam, Kaikkilai, Ulai, ili vilari and taram. These were identical with the swarams or symbols, sa, ri, ga,ma, pa, da and ni, Their Sanskrit equivalents are Shadjam, Rishabham, Gandaram, Madhimam, Panchamam, Daivatam, Nishadam respectively. The seven tones were divided into 22 quarter tones or rutis or matras. In Puram 152, Venbaranar mentions the twentyone'Musical Stages'. The commentator explains this as the twentyone stages obtained by playing the seven svaras at the three places viz Tharam, Madhiyamam , Uchcham, His alternative explanation is that number twenty one refers to the number of 21 strings on a yal.

Patumalai

Pan was raga or tune. Sevvali, Marudam, Palai etc. were 'Pans'; it was prescribed that Sevvali was appropriate to the afternoon" and Marudam to the dawn. There were seven kinds of palai, viz Cempalai, Padumalalppa lai, Cevvalippalai, Ammpalai, Kotippalai, Vilarippalai, Mercempalai that were in practie. But, K. Kothandapani Pillai in his rook Pazhan tamil' mentions that seven palais are entirely different from 'Palai Nurperum Pannum Elu Perum Palaiyum' of Perunkatai. It is for musicologists to think *it* over and decide whether all tunes were the sub-divisions or offshoots of main tune palai or not. It may be surmised that the term palai was used in a broad se n-,e ~ignifyillg seven different main tunes since some names Cevvali, Patumalai and Vilari are associated with the wow -patai' , In the- initial stages the-principal -runes or airs were four in number Palai, Kurinchl Marudam and Cevvali. When the knowledge of music developed there were many variations for each time based on emotions such as war, marriage or ceremony.

Musical Instruments

"Instrumental music has played a prominent part in the evolution of music of both the Orienl and the accident Man became very conscious of the fundametntal principles of musical science, through musical instruments. The rnonophonous voice was not much help to him in practically working out and understanding the various musical laws and phenomena" says Prof. P. Sambamurthy, tbe musicologist. Tamilagam of the Sangam age has evolved different kinds of musical instruments suitable for chamber music, open air music aod marital music. The musical instruments were termed in Tarnil works as Turiyam, Iyam and Kalam.

They were carefully preserved in covers called 'Kalap pais'. On the basis of note technique, the musical instruments may be clasified into two kinds, the monophonnus in-trurnents that can produce only one note at a time like the horn, and the polyphonous instruments that can produce rn vr e than one note at a tim- like the Yal, Generally the musical instrurnenre are classified into four kind, as follows. (1) Torkaruvi, (2) Tulaikkaruvi, (3) Narampukkaruvi and (4) Kanchakkaruvi.

The Tamils of different tinais or regions had their separate parais and musical instruments. Parai, the percussion instru- ment, and Yal, the stringed instrument denote the distinctive features of Tamils. They find place in the list of Karupporul as follows. Local festivals and Individual ceremonies offered ample scope apd O,pportunities for the musicians to have splendid display or their musical talents. However, music played an important part as a unifying force of different strata of society in many ways.

Torkaruvi or Percussion Instruments

Percussion instruments are generally based on the principles of talam or layarn or rhythm. They vary in size,structure, sound and manipulation. They are also differentiated according to the different occasions such as 'festival, marriage, worship etc. The names of percussion instruments found in the ancient Sangam works are as follows : Muracu or panai, mulavu, tannumal, kinai, tatari, patalai, parai, tattam, tontakam, Pampai tuti, akuli, paoripparai, manror sirnparai, mattari etc.

Morasu

Murasu was a big drum which had unique honour in royal "lnalaces. During village festivals also murasu was used. The urasu was considered an important feature of war, camp and he battlefield This gave encouraging sensation to soldiers in heir progressive expeditions. Generally-the murasu sign.fied be honour of kings and chieftains in T amilagarn. The unique place it had in royal palace is already mentioned. It's sound was compared with the rainfalls and the roar or he sea, and it was used as a simile for the sound of Waterfalls rid thunder bolt. There are references to the high pitched, odaimurasu for announcing chat ities. This drum was used, Dot only for the mass feeding of gallant soldiers but also for the poor people. In Paripada l the sound of manamurasu (marriage drum) produced at Madurai was like the roaring sound of the sea and that of lndras thunderbolt. Its echo was beard in Tirupparankuodram, the temple of Murugan.

Mulavu

Mulavu can be identified with the modern mattalarn in shape only. From Malaipadukadam and Ahananuru it is known

that a stick (mulavin ta laik k.rl or rnulaviu errkurnil) was used for playing on mulavu; this stick was helpful for 'travelling artists on slippery path. Mulavu might have been - played on one side of it With fingers and on the other side with . stick. The Mulavu appears to be a big 'Udakkai' or Pampai. played with' stick and hand in local temp- les. The identification of it with Mattalam appears to be improbable. Mulavu is. given a central and important place to draw the minor muslcaj , defects of other instruments. This is evident from Madurark- kanchi, When the devotees of Lord Muruga holding in their bands their offering to tne Deity, the choicest offering among them was Mulavu,

Tannumai

As regards Tannumai there is no clear definition or shape about it. The term Tanuumai was used by the Sangam Tamils, in different meanings. It is referred to in Padirruppattu as makkattannumai (Tannumai with black spot, i.e., the black substance (Man) applied on the face of it, In that context there is also reference or note that it was played on by hand (Kaiyalai aluka). According to the commentaries of Padirrup pattu tannumai is interpreted as murasarn in this contexts.' orppuratannumai arppelunto muvala'. In Narrinai it is noted as 'palavai tannum d' In Ahananuru and Kuruntogai it is mentioned that tannumai was used by the Vcttakkavalar of Vetar clan especially whilst lifting cattle. In Purananuru here is an imagery about the honey bees alarmed by the sound of this drum (tannumai) flyaway from their honey combs bamboo tree. From MulJaikkali we infer that tannumai was considered as a marriage drum during the Sanga m age There is a reference to 'pookkoleya tannumai' in Ahananuru, and Purananuru. They speak of this instrument played for gallant warriors to select the flowers or symbols suitable to the situations of warfare.

Kinai and Tatari

The Kinai and tatari are different kinds of drums that give the sound syllabus-'kin kin' and 'tata tata' respectively. Kinai is a double faced drum since the old commentary Oil Purananuru identifies this as Udukkai. The movement Kinai is compared with that of turtle. This was also play with both sticks and hands. A Ceylonese scholar S.Vidyananthan identifies this Kinai with tatari. There are al references to show that kioai and tatari are one and the sum It may be said that kinai, tatari and udukkai are synonyms.

Patalai

Patalai is identified with single faced large drum called! 'Orukan Makkinair, fhere are references to 'Orukan Makkinai'' and 'PlItatai Orukan' in Purananuru. The musical souad *or* patalai was belpful to note the time measure. So it was called 'Dotitaru paniya patalai' in Malaipadukadam. Mayilai Seeni Venkatasami suggests that the modern term ‘tabla' (tapalai) is only the word patalai suffering metathesis.

Tattai

Nachinarkkiniyar says that tattai is an instrument made of bamboos and adds that it is called Tattai since it resembles the clapping of hands. It was used to scare away the birds coming towards the corn fields. Tattai is identified with Karadikai having the sound of bear.

Tontakam

Tontakam is a small drum played by the people of the hilly tracts to scare away the birds coming to eat millet in the fields. Ahananuru speaks of a folkdance participated by both males and females to tbe musical accompaniment or tontakam in the hilly streets. The Tirumurukarruppadai describes kuravaikkuttu performed by drunken jungle people with their relatives to the musical beat of tontakam *Manror Siruparai* mentioned in Malaipadugadam may be identified with tontakam since the description are alike.

Akuli and ElIari

Akuli is described in Maduraikkanchi as 'Nunnirakuli' Malaipadukadam says that the sound of owls was just like the sound of Akuli. Ellari is also a small drum mentioned in Malaipadukadam, According to Nachinarkkiniyar it is called 'Calli' since it has the sound of - Cal', Purananuru speaks of ellari' in the sense of ‘Calli’.

Tudi or Udukkai

In Porunararrupp::tdai, the side of rudi when beaten is compared with the circular foot of an young elephant. Tudiyan was one who played on Tudi. Tudi was played when offerings were made to the deities like ‘nadukal'. Paripadal mentions the use of tudi during the dance perfor- mances. It was useful to give caution to the agriculturists against sudden floods. Tolkappiyam explains a situation Tudinilai,

Pampai

Narrinai mentions about Pampai a, kind of drum which IS still in use in village festivals. Makuli and Mattarai are mentioned in Paripadal,

Parai

The term parai was used in a broad sense in the Sangam period. Kalittogai mentions about the sound of parai as a caution for the people to guard themselves from the ruttish elephants coming along the streets. The ancient poets speak about a peculiar animal called a cunama which could not tolerate the harsh sound of parai.

TULAIKKARUVI OR WIND INSTRUMENTS

Wind instruments are considered by the scholars as the earliest musical instruments of Tamils. In these instrumens sound is produced by setting in vibration a column of air inside th'e tube-like middle part. They are either mouth

blown or bellows blown. The antiquity of the wind instruments is explained by Captain Day in his book" The Musical instruments of Southern India and eccan." The following are the wind instruments mentioned ill the 'Saogam works: Flute, conch, Neduvankiyam or tumpu and Horn or trumpet.

Flute

Flute is the most universally common wind instrument amongst all musical instruments. The commentary on Paripadal speaks of 'Pakarkular' as a keynote instrument. The standard tonic note was set by the flute according to 'which the Yal was tuned. Kalittogai speaks of flute as coni . rolling the musical timbre of 'Yal.' In Perumpauarruppadal and its commentary some points regarding the process of making a flute are mentioned. In Paripadal there is a reference to flutes with seven and five holes. Ba-roboo. ampal stem konrai fruit were used for making flutes, The musical sound produced by the shepherds and cowherds during the evening hours was considered inducing pathos in the minds of' sepa rated 'lovers is picturised in Kurinchippattu, In' Pattinappala there is a detailed-description ofYelan Veriyadal, a kind of dance in which mention is made of flute as being one of the musical instruments to that dance. There is ample' reason to believe that it is a divine musical instrument as it is associated with Lord Muruga in Tirumurukarruppadai.

Tumpu or Neduvankiyam

In the world of music instruments, flute and turnpu are interpreted as Vankiyam and Neduvankiyam by the commentators of the Sangam works. The Tumpu should also be a flute of larger size with sligbt difference. As the term tumpu is also meant for the trunk of an elephant, and the sound of the tumpu or the appearance of an elephant is noted as resembling elephants sighting it seems that tumpu might have been a vertically blown pipe .

Horn or Udu Kompu

It should have been made of animal horn, whereas might have been made of the cone of strong wood •

Valai

The Valai or conch was also another musical instrument used during the festivals and war times. The conch was regarded as a sacred instrument. Its blowing indicated specially a success in the battle field; it might be a precursor of the trumpet.

NARAMPUKKARUVI OR STRINGED INSTRUMENTS

Yal (Yazh) is considered the oldest Tarnil musical instrument which paved the way for the emergence of a number of stringed instruments-plucked, bowed and struck varieties, Regarding the origin of this instrument Prof. P. Sambamurthy says, “When the primitive man shot an arrow he heard the fascinating sound emanating from the string of the bow. The bow string or Vil Yazh is the earliest stringed instrument in the history of human culture.”

The TamiIs had for every Tinai special instruments Vil, Yal and Parai suited to these tinais. In this connection there were Kurunchi Yal, Mnllai Yal, Marudbam Yal, Neydal Yal and Palai Yal. In Paripadal the term -Kuttam' is used for Yal in general. Four of the Pattuppattu works, Porunararruppadai, Sirupanarruppadai, Perumpanarruppadai and Ma la ipadukadam or Kootharar ruppadai have fine descriptions of Yal (Yazh). While describing, the shape and other observation of things and imagination. In the midst of differences of opinion regarding the real shape of the 'Yal' Swami Vipulanandar has thrown some light on this in his -Yalnul', ,

In Porunararruppadai there is a hyperbole that even the highway robbers of desert region are renouncing their robbery when they hear the charming music of the Palaiyal. Kalittogai has got a reference to point out that even wild elephant was brought under control by the music of YaL In Narrinai tltil sound of Yal is used as a simile for the sweet voice of Kuruku, (a kind of bird). The comparison that the sweet voice of a woman is like the music of Yal indicates that the Yal should have been very popular musical instrument among the highly. artistic minded people. The Panars were called Yalppanar.

KANCHAKKARUVI OR BELL METAL INSTRUMENTS

In the Sangam age, tala or rhythm held an important place in music -Iogy. In the opening stanza of Malaipadu kadarn there is a list of various musical instruments that were used by ancient musicians. In that list, there are two kinds of Cymbals, viz Pantil, and ElIari mentioned vividly. Pantil was made of well melted bronze and was circular in shape as to produce a ringing sound. While describing elari, the large cymbal, Per un Kaucikanar author of Ma1aipadukadam uses the attributed attributive words (that which is being bright and loud) signifying subtly the features of Cymbals i.e. sound and shining. In. Ahananuru, the cymbal 'is-mentioned. The large cymbal was made of gold. Though it is mentioned here so gold should be taken -a ,broad .rerm for-metals in general, since it is not possible to get the ringing or musical sound from genuine gold.

Bells

.Tbe sound of bells also was required as one of the musical accompaniments for the dance performances for the dance performances. In Ahananuru the dancer Attanatti has been described as wearing a belt of small bells around his hip in order to have the musical sound keeping time measure with his dance. In Kuruntogai it is described that the musical sound produced from the small bright bells was like the Vilarippan. In Purananuru it is mentioned that -Iraimanl' was

during the sentimental offerings to the deity in the hope of healing a hero's wounds and scaring way the ghosts. God Muruga is described as bolding a bell in one of his twelve hands in Tirumurukarruppadai,

Musicians

In the Sangam age musicians of high repute were patronised and gifts were given to them by Kings and other affluent persons. Lotus flowers made of gold as well as flowers knitted together with a silver string were presented to them. Occasionally lands and entire villages; too, were bestowed on them as gifts. Among the rulers of Tamilagam Pari, Nalankilli, 'Palai Padia Perunkadungo and the Pandian Nambi were some of the well known patrons of poets and musicians.

DANCE

Dancing was. developed with great enthusiasm during the Sangarn age. It attained a high degree of excellence in the peried of tbe post Sangam. The kings and Chieftains patronised "-dancing no less than music. Verses sung in praise of Kopperuncholan and Pari testify to this. The poet, Uraiyur Mudukannan Sattanar adverts to tbe patronage of dance by Nalam Killi.

Dancing was known by several names like 'Attam', 'Koothu; and Kunippu', Tolkappiyam shows' that dancing was resorted to by all classes of people. Tolkappiyam mentions Vallikkoothu and Kalanilaikkoothu. Vallikkoothu was the representation of the supposed dance of Valli the consort of Lord Muruga. The second one was held in honour of those soldiers who firmly stuck to their posts, relentlessly fighting the enemy even after many of their compatriots had retrated. Another pattern of dance is described in the section on the Puratrinai Iyalof Tolkappiyam. It was dance held by the fellow kings in honour of a ruler who was killed in the battle. The references to ritual dance was found in Kuruntogai and Maduraikkanchi, There is an interesting dance description in Kuruntogai held' in honour of Murugan.

Dance could be performed by men as well as women. Adi Mandi, the daughter of Karikalan's husband Attan Athi was a dancer. Madurai Tamila Kuttanar was a dancer from Madurai who bad specialised in the kind of dance peculiar to Tamilagam. A koothan or a porunan was a male dancer or actor and a Kootti, a femall dancer. The male dancer was called attan, the dance was attam and the stage aderkalarn. Anion the Sangam works, the Malaipadukadam and Porunararruppadai in particular describe the skill of these professional dancers.

Kuravai and Tunangai were group dances. The Kuravai though common *in* the Marudam region was also adopted the Kurinchi and Mullai. A ferocious type of Kuravai was the Verikkuravai, commonly resorted to by Kuravar when in a wild temper. This dance was common among the kurava soldiers. Adorning themselves with palmyra garlands these Kurava used to do dance in a frency. Tunangai generally to place in the open theatre of the village. In was a dance which men women participated. The women used to embraced each other in the course of the dance.

Apart from this associated with the battlefield there another type of' Tunangai ' when the victory was won, the or the leader of the triumphant army used to lead this dance in the midst of the corpses lying all around. On festive occasion groups of women performed the Tunangai dance. The Malaipadukadam shows that there was dancing at festivals and that, at other times, too, hillmen and their wives danced in order to amuse themselves. Kalittogai describes the attention devoted to pose and facial expression during dance.

How far the Tamilian technique of dance was influenced by the North Indian pattern has become a matter of controversy. "Whether the Tamil system of dance was indebted to. Bharatha or not one thing is clear, that is, that Bharata himself acknowledges the highly developed nature of South Indian music and dance."

"Chitra Dakshina Vrtte tu saptarupe prakirtita Sopohane sanirgite devastutyabhinandite Naradadyais tu gandharvaih sabhayam Devadanavah

Nirgitam sravitah samyag Iayatalasemanitam". (Natyasastra, v.31-2)

"Now when songs in seven forms and in Chitra and Dakshina Margas together with the Upohana and Nirgita were started by musical experts like Narada in praise of Gods, all the Gods and Danavas in the assembly were made to hear the Nirgita performed with proper tempo and time beat." The above, translation is given by Manmohan Ghosh(Bib. Indi, 1951, p. 81). This shows that the Dakshina Marga of the southern pattern of music had attained a high position when Bharata wrote his work. There is another reference in chapter XIV of Bharatha's Natya Sastra shows that the South Indian dance too bad attained high measure of development.

The host of pure Tamil terms occurring in the early literature of the Tamils indicates the indigenous origin and development of music, dance and other fine arts. Such are words like Isai, Koothu, Tunangai, Kuravai, TalaikkoI, Porunan, Yal,' Pan, Kannul, Ulai, Ili and Oviyam. During the post Sa ngam period due to Aryan influence there seems to have occurred a combination of Sou rh with North. The division of 'Ariyakkootu' (Northern Dance) and 'TamiI Koothu' (Southern Dance) is an indication of the distinction between the exotic and indigenous form. In certain cases the Tarnil patterns seem to bave been adopted by the Northern system and Sanskrit names. Ahakkoothu and Purakkoothu became "Nritya" and Nritta' in the aspects of Bharatha dance. These varieties of dance mentioned in Silappadikararn might have developed from certain types of Sangam age. It is agreeable to accept that basically the dance was that of the Tamils but it seems to have had some influence in details at the hands of the Arvan settlers.

DRAMA

Reference to Natakam are found in the Tolkappiyam and other early works. 'Nataka Valakkilum, Ulakiyal Valakkilum' (Tol. Porul, 53) Though the interpretation in' this contex had varied with writers, it seems to denote drama.

The Maduraikkanchi states that dramas were enacted night during festive occasions. It is unfortunate that no early dramatic composition has survived barring no doubt the Silampu which is as much a work of drama as of literature. Even with regard to Silappadikararn a scholar Madurai University Tamil Department points out that Silappadikararn was only a Therukkoothu or street drama. The various aspects like Kattiyankaran etc made him to come to the above conclusion.

The section of the Tolkappiyam which is immediately striking as concerns the dramatic arts is the meypattiyal. Even though it appears that nurpa 251 which enumerates eight *meypadukal* would seem to contain the most relevant information in this section, nurpa 249 is of vital importance this discussion here in that it gives us Tolkappiyar's idea of how these meypattu originates Nurpa 251 of this same section of the Tolkappiyam is giving us a list of the **meypadukal** makes the level of development of dramatic performances during the Sangarn period. '

“Nakaiye alukai I1ivaral marutkai accam perumitam Vekuli uvakaiyenru appal ettam meypadenba".

(They say laughter, weeping. desnisedness, wonder. Rear fortitude, anger and delight are the eight meipadukal)

Richard A. Frasca says that the primary importance of this nurpa is that it indicates the sophistication of the Tamils' concept of the theatre during this period. The fact that they nalysed and classified these varied emotional manifestations is ample proof that dramatic performance had a very important place in this society. The eight meypadukal clearly had to be the central concept around which ancient Dravidian theatrical traditions developed.

Professor George L. Hart of the U.S.A. in his detailed study of Sangam literature has given a discussion of the various performers of this ancient period but has certainly missed the point in describing them only as poets or musician). Many of the Sangarn poems are 'dramatic utterances'. The dancing girls were called ‘nataka makalir’ and the performance conducted by them was spoken of as Natakam, Drama was definitely an important aspect of the Sangtrn culture. But Tolkappiyam does not specifically mention Koothu or Nada , Kam in its list of compositions (Yappu), Prof. V. R. R. Dikshitar in his valuable translation with notes of the Silappadikaram makes a direct equivalence between the pattu of the Aham and Puram and drama.

PAINTING

Painting was known by the pure Tarnil word 'Oviyam'. the class of painters was called "Oviyar ' or "Oviya Makkal. painters were also described by the significant expression .Kannul Vinainar, Nachinarkkiniyar explains this term by stating that skillful painters had the gift of captivating the onlooks by their art.

It is learnt from Maduraikkanchi that figures of god as well as scences of Nature were painted-on walls as well as on Canvas, Tamil works like the Paripadal reveal that there existed some treatises on painting. Nedunalvadai calls the outline drawing : which was not painted as Punaiya Oviyam. The pictures on the walls of the temple at Kavirippumpattina are referred in the Pattinappalai. Palai Padia Perunkadunko stated to have compared the brush employed for painting with a kind of soft flower called' Padiri' in Narrinai.

The reference to the Pandyan King**, 'Chittira Madattuttunjiya Seranmaran'** indicates that the royal palace had a hall or a picture galIery containing art exhibits. The temple of Lord Murugan on the hill of Tirupparankundram contain painted pictures on the walls. We learn from the Madurail kanchi about the existence. of painting probably on the wall of Jain monasteries in Madurai, It is learnt that the canopi of the royal cot on which the Pandyan ...ing Nedunchelia usedto sleep as welI as the walls and- ceilings of the room halS~, drawings of astronomical drawings representing the positiel of planets. We are not able to get any archaeological evidences old painting to estimate the quality of paintings. The litera references, however tend to show that paintings of high m ..were found. The poet andarattanar compares a handso damsel to the painting of a girl executed by a skillful painte As far as the available information goes the sculpture the early Tamils does not seem to have attained high stag development.

CONCLUSION:

The age of the sangam in the extreme South India was one of cultural transformation. At the turn of the first century B.C. South India moved from pre-historic period. That South India was absorbed into the cultural development of the sub-continent, which was taking place at the time. Thus the sangam age constituted a glorious era in the history of South India.

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THIRUKURAL - TANAVARNAMS

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Abstract: *Thirukural is composed by Thiruvalluvar and considered as one of the greatest works ever written on ethics and morality, it is widely acknowledged for its universality and secular nature, called as "Ulagapothu marai"(Common veda for the world) in Tamil. Tānavarṇam is one of the most important musical forms belong to modern period of carnatic music. It is the first item figured in traditional music recitals. Varṇams cultured the voice and make it perfectly fit for performances. Varṇams are like a bridge between abhyāsa gāna and sabha gāna. All of the nuances and essential features of the rāga is imbibed in a Varṇa. The idea of rendering Thirukural as the first item of a carnatic concert aroused in the mind of Sri V.S. Gomathisankara Iyer who was working as a Professor in veena in the Department of music and also involved in the assignment of collecting rare Tamil compositions for the Annamalai University music series publications. This idea of using Thirukural as a carnatic music composition was inculcated into Iyer by the great Tamil Scholar Dr.Mu.Varadharajanar. 11 Thirukural varna-s tuned in raga Todi and its janya-s published in a book entitled " Tanavarna Kadal vol.1 published and authored by Prof. V.S. Gomathisankara Iyer. This paper intended to highlight the various aspects of Thirukural Varna-s.*

Key words: *Tanavarnam, Thirukural Varnam, Sahithya bhava, Vowel extensions*

INTRODUCTION

Thirukural is composed by Thiruvalluvar and considered as one of the greatest works ever written on ethics and morality, it is widely acknowledged for its universality and secular nature, called as "Ulagapothu marai"(Common veda for the world) in Tamil. The text of Thirukural consists of 1,330 short couplets, or kurals, of seven words each. Ten kurals written under one Athikaram and there are 133 Athikarams are in Thirukural. This work is divided into 3 main sections which are named as 'Arathupal,(Virtue) Porutpal, (Wealth) and kamathupal (Love). Content of Thirukural is considered as more literary than musical. In recent times Thirukural is tuned and used as songs for various musical and dance performances. Thirukural was the only non religious work which has been translated into about 41 world languages. Thirukural translated in Gujarati language on 16th January 2015 by our Prime minister Sri Narendra Modi ji

TANA VARNAMS

Tānavarṇam is one of the most important musical forms belong to modern period of carnatic music. It is the first item figured in traditional music recitals. Varṇams cultured the voice and make it perfectly fit for performances. Varṇams are like a bridge between abhyāsa gāna and sabha gāna. All of the nuances and essential features of the rāga is imbibed in a Varṇa. This is considered to be the most complex item for vocal exercises. Varnams played a vital role in providing rhythm control. Practising Varṇa in second and third speed is helpful to gain control on rhythm and tempo. Swara phrases of various lengths and range is the main identity of Tānvarṇam hence it is melodic oriented. Tānavarṇam has two major segments i.e Purvangam and Uttarangam. Purvangam comprises of pallavi, anupallavi and mukthāyiswaram, and uttarāngam comprises with caraṇam and caraṇa swara-s. Sāhityam (text) is simple and less in Varṇa and it has plenty of vowel extensions. It has at least three or more Caraṇa swara-s. Pallavi, anupallavi and Caraṇa of Varṇam has Sahitya (text) and chittaswara/ mukthāyiswara and Caraṇaswara have no lyrics. Tāna Varṇams are normally composed in Ādi tāla and kandajāti Ata tāla.

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The idea of rendering Thirukural as the first item of a carnatic concert aroused in the mind of Sri V.S. Gomathisankara Iyer who was working as a Professor in veena in the Department of music and also involved in the assignment of collecting rare Tamil compositions for the Annamalai University music series (Isai Kovai) publications. This idea of using Thirukural as a carnatic music composition was inculcated into Iyer by the great Tamil Scholar Mu.Varadharajanar.

PROF. GOMATHISANKARA IYER: THE MUSIC COMPOSER

Prof. Gomathisankara Iyer was born on August 21st 1908. His father Vasudevanallur Subbiah Bhagavathar (popularly known as "Pallavi" Subbiah Bhagavatar) was a well accomplished musician and Primary disciple of Sri Mahavaidyanatha Iyer . Gomathisankara Iyer initially trained in vocal music under his father's guidance. He later switched to veena and underwent advanced training under Karaikudi Subburama Iyer (the elder of the Karaikudi brothers) with whom he stayed for a period of 3 years. In 1931, only 23 years old, the young Gomathisankara Iyer joined Annamalai University as a veena teacher. Gomathisankara Iyer was associated with Annamalai University for the next 48 years until his retirement in 1979, as the Head of the Department of Music. In 1980, he moved to Madurai Kamaraj University with a UGC fellowship and retired from the University in 1983.

COMPOSING TUNE TO THIRUKURAL AS VARNAM

In general, Varnam is a 'Dhatu Prathana'(melody oriented) composition and lyrics/text are having less importance, vowel extensions in lyrics is commonly seen. Thirukural is not much suit for a musical composition like varnam because of its high literary value, especially the vowel extensions, the brand identity of Varnams, may obliterate the meaning of the text, however some kurals are carefully examined and identified by V.S.G. Iyer and he set tune for that kural-s in Varnam format. Mr.Iyer select two kurals from the same Athikaram of same concept and set it as purvanga of a Varnam and because of the requirement of short lyrics requirement for the charana, Mr. Iyer himself composed a single line text on par with the meaning of the selected kural-s for charanam.

Sri V.S. Gomathisankara Iyer published a book consists of 60 varnams in the name Thanavarna kadal vol.1 in December 1973 in which he has published around 11 following Tirukural varna-s. Mr.Iyer, mentioned in his book that the text is by Thiruvalluvar and only music set by him. During 1973, Annamalai University was very much involved in propagating Tamil Pann-s and Tamil Music. The idea of propagating Thirukural through Varnam musical form was very much received and appreciated.

SN	Starting word of the Varnam	Raga	Tala	Numbers of Thirukural-s used
1	Anbirkum Undo Adaikkum Thaazh	Todi	Adi	71 & 72
2	Irunthombi il Vazhvathellam	Dhanyasi	Adi	81 & 83
3	Ezhu Pirappum Theeyavai	Hindolam	Adi	62 & 66
4	Aravaazhi Anthanan	Asaveri	Adi	8 & 10
5	Nanri Marappathu	Suddha Dhanyasi	Adi	108 & 110
6	Serivarinthu seermai	Punnagavarali	Adi	123 & 126

7	Vaanninru ulagam	Revagupti	Adi	11 & 13
8	Arulilarku	Jayanthasri	Adi	247 & 249
9	Sirappu eenum Selvamum	Suddhaseemanthini	Adi	31 & 39
10	Naduvinri nanporul	Nagavarali	Adi	171 & 172
11	Purankuri Poithuyir	Ghanta	Adi	183 & 185

Around 22 Thirukural-s are tuned as Tanavarna-s in the 1st volume. All the 11 Varna-s are set to Adi tala . Among 1330 Thirukural-s, 22 Thirukural-s are very carefully selected for the above mentioned 11 varna-s as the tune didn't disturb or split the text, meaning and Thirukural's structure.

MUSICAL APPRECIATION

In general Varnam-s are taught to increase the knowledge of the student in rhythm, swara , and raga aspects of music. Rare raga-s like Suddhaseemanthini , Nagavarali, Revagupti, Ghanta, etc are used to compose Thirukural Varna-s. This shows the composer's interest in propagating Thirukural varnam-s among music society.

The first varnam is composed in Raga Todi which comprises 2 Thirukurals from the 7th athikaram 'Anbudaimai'(Loving- kindness)

"Anbirkum Undo adaikkumthaal Aarvalar
Punkanneer pusal tharum"

(What bolt can bar true love in fact the tricking tears reveal the heart.)

Todi is the 8th Melakartha raga which is very much suitable for the meaning of Thirukural-s selected. The core rasa of this raga is Karuna rasa as it is very much suits for the kural-s advocating the importance of Love and Kindness.

Thirukural is of 7 words in which the first line consists of four words and 3 words are in the second line. Thirukural is filled very much with meaning full text and it is really challenging to set tune for the lyrics without disturbing its structure. Adi tala is having 32 pulses per avartam. It is easy to distribute 4 words to 32 pulses but it is a bit difficult to distribute 3 words to 32 pulses by using vowel extensions without disturbing the meaning of the sentences. In the Thodi raga varna this problem is brilliantly handled by Prof. V.S. Gomathisankara Iyer

Raga – Thodi

Tala – Adi

Composer : Thiruvalluvar and tuned as varna by Prof. V. S. Gomathisankara Iyer

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Pallavi

X	1	2	3	X	√	X	√
p , ,d	p m g m	d p p m	g r s n	s , , s	r g m,	p d n d	n d p m
An –bi	-rkum	undo	adaik	Kum -- tha	--zh	a- r va	la -r
d p m g	m, p d	n d p ,	d n ṡ ,	ṙ ṡ n d	ṡ n d p	n d p ṡ	n d p m
Pun - -	--kan	- - - -	nee- r	poo---	sal ---	tha--ru	m- - -

It is beautifully tuned in a manner that it is not disturbing the sentences and meaning but also have vowel extensions.

Next Thirukural is also selected from the same Athikaram for tuning as anupallavi

X	1	2	3	X	√	X	√
d , n ,	ṡ , , ,	d n ṡ ṙ	ġ ṙ ṡ ,	n ġ ṙ ṡ	n d ṡ n	, d p m	g m d n
An –bi	lar---	ella -	m -thamak	Kur iya-	-r an	Puda	ya -r
s ṙ ġ ṙ	ġ ṁ ġ ,	ṙ ṡ ṙ n	d n ṡ ṙ	ġṙ ṡ ,	, , p d	n d p ,	m g m p
en - -	--- bum	- - - -	u- - -	ri yar	Pi-	ra--r	-ku--

In this Thirukural also the vowel extension is brilliantly infused without disturbing the meaning of the words like Enbum, Uriyar…etc . Anupallavi followed with a brisk Mukthayiswara.

Charanam of this varnam is composed by Prof.VS. Iyer along with the meaning of the above Thirukural-s

X	1	2	3	X	√	X	√
p, d n	d p m ,	p g m ,	d , , ,	p d n d	p, m p	d p m ,	, p g m
An –--	--- bin	peru -	mai --	Ari ---	thal -ni	r ----	ma i

CONCLUSION

In the book Tanavarna kadal vol.1 consists of 60 varnams and all the varnams are selected for compilation is in raga Todi and its janya-s. Thirukural varnam-s is a genius idea to propagate Thirukural through carnatic music. Unfortunately these varnams are not popularly performed by Carnatic musicians on stages now. Muthamizh included Literature, Music, and Drama. Thirukural is very popular among the Tamil community as a piece of Literature. It is not reached much to the

audience in the form of Tanavarna as much as the literature reached. However the effort of tune it in Tanavarna style is an appreciable innovative idea. The flow of Tamil Varnams, during 1970s into the music arena by various composers like Koteeswara Iyer, L.R. Neelamegam pillai, T.V. Lakshmi Narasimhan, K. Ponniah Pillai, Kunnakudi Venkatarama Iyer, Varahoor K. Muthukumaraswamy, Pathamadai Krishna Iyer, C.S. Natarajasundaram pillai, Nerur Srinivasachariar , V.S. Gomathisankara Iyer, etc…may be the another reason for the desertion from carnatic music stages of these Thirukural Varnams.

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భావవీణ

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శ్రీ త్యాగరాజస్వామి వారి అపూర్వరాగాలు

– డా॥ టి. గిరిజా శేఖరాంబ, అధ్యాపకులు, అకడమిక్ కన్సల్టెంట్ డిపార్ట్‌మెంట్ ఆఫ్ పెర్‌ఫార్మింగ్ ఆర్ట్స్,
ఎస్.వి. విశ్వవిద్యాలయం, తిరుపతి.

పరిచయం :

దక్షిణ భారతదేశ చరిత్రలో ముగ్గురు వాగ్గేయకారులు, శ్రీ త్యాగరాజస్వామి వారు, శ్రీ శ్యామశాస్త్రివారు, శ్రీ ముత్తు స్వామి దీక్షితులు. వీరు ముప్పురూ కర్ణాటక "సంగీత రత్నత్రయం"గా వెలుగొందడమే గాక వీరి రచనల ద్వారా కర్ణాటక సంగీతము ఒక మహోత్కృష్టమైన, మహోన్నతమైన స్థానాన్ని అధిరోహించింది. అందుచేతనే '18' వ శతాబ్దం కర్ణాటక సంగీత "స్వర్ణయుగంగా" చెప్పబడుచున్నది.

Key Words (ముఖ్యాంశాలు) : Performing Arts, Music, Contribution life sketch.

వివరణ :

త్రిమూర్తులలో ముఖ్యంగా శ్రీ త్యాగరాజస్వామి వారు ప్రథమ స్థానాన్ని అధిరోహించడానికి వీరి రచనలు అని చెప్పవచ్చు వీరి రచనలు అన్నీ కూడా "పండిత పామర" రంజకంగా ఉండటమేగాక వీరి రచనాశైలి 'ద్రాక్షపాకంగా' ఉండటం ఒక విశేషము.

త్యాగరాజ స్వామి వారు అనేక రకాలైనటువంటి రచనలను మనకు అందించారు. వీటిలో దివ్యనామ సంకీర్తనలు, ఉత్సవ సాంప్రదాయ కీర్తలను, జోలపాటలు, లాలి పాటలు, గేయనాటకాలు, మేలుకొలుపు పాటలు, పంచరత్నాలు ఇలా అనేకం.

సంగీత సేవ :

ఇక రాగాల పరంగా చూచినట్లయితే స్వామి వారు "200" రాగాలు వరకు ఉపయోగించి రచనలు చేసినట్లు తెలుస్తున్నది. ప్రసిద్ధి చెందిన రాగాలు.

ఉదాహరణకు :

శంకరాభరణం, కళ్యాణి, కాంభోజి వంటి రక్తిరాగాలలోనేకాక, జన్యరాగాలైన మోహన, సావేరి, హంసధ్వని రాగాలలోను, అలాగే 'నాట' లాంటి వివాది రాగాలలోను అనేక రచనలు చేసారు.

అపూర్వ రాగాల గురించి వివరణ:

కర్ణాటక సంగీతంలో మొట్ట మొదటి సారిగా ఈ "అపూర్వరాగాలు" అందించినటువంటి ఘనత త్యాగరాజ స్వామి వారిదే. ఈ అపూర్వరాగాలు వీరి ద్వారానే ప్రచారంలోకి రావటం జరిగింది.

ముఖ్యంగా వీరు చేసిన అపూర్వ రాగ కృతులు ఎంతో అపురూపమైనటువంటి రచనలుగా చెప్పవచ్చు. '80' అపూర్వ రాగాలలో రాగనామాన్ని, సాహిత్యాన్ని అందించటమే కాక కృతి పల్లవిలోనే ఆ రాగ ఆరోహణ, అవరోహణని, రాగ పరిచయాన్ని ఒక్క సాహిత్య పాదంలోనే పొందుపరచటం స్వామి వారి ఘనతని చెప్పవచ్చు. ఈ 80 అపూర్వ రాగాలలో ఒక రాగంలో ఒక కృతి ఉన్నటువంటి రచనలు '60' రాగాల వరకు ఉండటం విశేషం.

ఏక రాగ కృతి – కొన్ని అపూర్వ రాగాలు :

రాగము	కృతి	తాళము
1. అమృతవాహిని	శ్రీరామ పాదము	ఆది
2. ఆందోళిక	రాగసుధారస	ఆది
3. బిందుమాలిని	ఎంతముద్ద	ఆది
4. చాయానాట	ఇదినమయము రా	ఆది

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4. చాయావాటు	ఇదినమయము రా	ఆది
5. గంభీర వాణి	నదామదిని	ఆది
6. జయంత సేన	వినతాసుత	ఆది
7. జింగ్ల	ఆదితమ గాను	ఆది
8. సింహవాహిని	నెనయంచరా	ఆది
9. సిందుకన్నడ	ననుగన్న తల్లి	ఆది
10. విజయశ్రీ	వరనారద	ఆది

రెండు కృతులు ఉన్న కొన్ని అపూర్వరాగాలు :

రాగము	కృతి	తాళము
1. చంద్రజ్యోతి	అ) బాగాయనయ్య	ఆది
	ఆ) శివపదనా	ఆది
2. జయమనోహరి	అ) ఏ భక్తి భాగ్య నుదా	రూపకం
	ఆ) శ్రీరమ్య చిత్రాలంకార	రూపకం
3. కళ్యాణ వసంతం	అ) నాదలోలుడై	రూపకం
	ఆ) కనులుశాకని	రూపకం

మూడు కృతులు ఉన్న కొన్ని అపూర్వరాగాలు :

రాగము	కృతి	తాళము
1. బంగాళ	అ) గిరిరాజసుతా	ఆది
	ఆ) మునుపే తెలియక	ఆది
	ఇ) సాక్షిలేదనుచు	ఆది
2. జనరంజని	అ) విదజాలదురా	ఆది
	ఆ) స్మరణే సుఖము	ఆది
	ఇ) నాదానినమాట	ఆది
3. శుద్ధబంగాళ	అ) రామభక్తి	ఆది
	ఆ) తాలిచేజేసిన	ఆది
	ఇ) తప్పకనే వచ్చునా	ఆది

రచనా శైలి :

కర్ణాటక సంగీతములో 'సంగతులు' అనే అంశాన్ని ప్రవేశపెట్టినవారు త్యాగరాజస్వామివారు ఈ సంగతుల ద్వారా పూర్తి రాగ పరిచయాన్ని అందించటమేకాక కృతి వల్లవి సాహిత్యంలోనే ఈ సంగతులను చొప్పించటం స్వామివారి రచనా పాటవాన్ని తెలుపుతున్నాయి.

ఈ అపూర్వ రాగ కృతులలో చేసిన విశేష అంశాలు:

1. వ్యాకరణాలు : కృతి 'అలంకారికాలు' అయిన ఈ

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స్వరాక్షరం అనే అంశాన్ని త్యాగరాజస్వామివారు శ్రీరామ పాదమా" అనే కృతిలో

పాదమా
శ్రీరామ పాదమా } పాదమా అంటు ఇటు సాహిత్యం, అటు స్వరం రెండూ కూడ పాదమా అంటూ రచన చేసారు శుద్ధ స్వరాక్షరముతో ఇది ఒక విశేషము.

2. చిట్టి స్వరము : వరరాగల యజ్ఞలు - చెంచు కాంభోజి రాగ కృతిలో- నపామాగామదనిసా" అనే చిట్టి స్వరాన్ని రచించారు.

3. నిషాదాంత్య రాగము : ఈ అపూర్వ రాగాలలో నిషాదాంత్య రాగము "చిత్తరంజని రాగంలో నాదాతనుమనిశం శంకరం అనే కృతి ఆరోహణ నిసరిగమపదని - నిదపమగరినని మంద్ర స్థాయి నిషాదం నుండి - నిషాదం వరకు మాత్రమే ఈ రాగ నిడివి ఉన్నటువంటి రాగం. తార స్థాయి షడ్జమ సంచారం రాదు.

4. అపూర్వ రాగాలలో కొన్ని వివాదిరాగాలు :

రాగము	కృతి	తాళము
అ) గంభీర వాణి	నదామదిన్ దలతు గదరా	(షట్‌శ్రుతి దైవతం)
ఆ) శ్రీమణి	ఏమందునే	(శుద్ధ గాంధారము)
ఇ) కృతిరంజని	ఏదారి సంచరింతు	(శుద్ధ నిషాదం)
ఈ) ఛాయానాట	ఇదినమయమురా	(షట్‌శ్రుతిరుషభం)

5. ప్రతి మధ్యమ అపూర్వ రాగాలు :

రాగము	కృతి	తాళము
మందారి	పరలోక భయము	ఆది
సరస్వతి	అనురాగములేని	రూపకం

6. మేళకర్త అపూర్వ రాగాలు :

రాగము	కృతి	తాళము
గానమూర్తి	గానమూర్తే	ఆది
వాగధీశ్వరి	పరమాత్ముడు	ఆది

7. అమ్మవారి రచన :

ననుగన్న తల్లి నాభాగ్యమా- సిందు కన్నడ రాగం ఆదితాళంలో చేసిన ఈ అపూర్వ రాగ కృతి సాహిత్యం పరిశీలించిన నారాయణి, ధర్మాంచికే అంటూ అమ్మవారిని స్తుతిస్తూ చేసిన రచనగా చెప్పవచ్చు.

8. గణపతిని కీర్తిస్తున్నటువంటి రచన :

గిరిరాజసుతా తనయ సదయ- బంగాళ రాగ కృతిలో - గిరిరాజసుతుడు - తనయుడు అంటూ గణపతిని కీర్తిస్తు, అలాగే తన వంశం గురించి కూడ వివరించారు స్వామి వారు వారి తాతగారు 'గిరిరాజకవి' వారి తనయుడు రామబ్రహ్మం గారు అని వారి తనయుడు త్యాగరాజు అని రెండు విశేషణాలతో ఈ రచన సాగటం గమనార్హం.

9. శివకీర్తనలు :

రామాంకితంగా రచనలు చేసిన త్యాగరాజు కొన్ని శివకీర్తనలు కూడ రచించారు. ఈ అపూర్వ రాగాలలో

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అ) గంభీర వాణి నదామదిన్ దలతు గదరా
అ) చిత్తరంజని నాదాతను మనిశం

స్వామివారు. అలాగే 'ప్రతాపవరాళి' రాగ కృతిలో -
సీతారమణితో 'ఓమనగుంట' లాడి గెల్చుట - వేత వొకరి

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అ) గంభీర వాణి నదామదివ్ దలతు గదరా
అ) చిత్తరంజని నాదాతను మనిశం

10. సప్తస్వర వివరణ :

నాదాతనుమనిశం అనే కృతిలో సద్యోద్యాతాది పంచవక్త్రజ "సరిగమపదని" వరనప్తస్వర అంటూ సప్తస్వరాలు 7 అని వాటి ప్రాధాన్యత గురించి కూడ ఈ అపూర్వ రాగ కృతిలో వివరించారు స్వామివారు.

11. సాంఘికపరమైన అంశాలు :

వినవే ఓ మనసా వివరంబుగనే తెలిపెద - అంటూ 'విపర్వని' రాగ కృతిలో మనిషి మానసిక స్థితిని తెలుపుతూ చివరిగా రామ సాన్నిధ్యాన్ని ఎలా చేరాలో వివరించారు స్వామివారు. అలాగే 'ప్రతాపవరాళి' రాగ కృతిలో - సీతారమణితో 'ఓమనగుంట' లాడి గెల్చుట - చేత నొకరి కొకరు చూచి ఆ భావమెరిగి అంటూ ఒక ప్రక్క 'ఓమన గుంటలు' అనే ఒక వినోద క్రీడ గురించి చెప్పు. మరోక ప్రక్క ఒక చిన్న శృంగార భావాన్ని కూడ చెప్పటం ఒక విశేషంగా చెప్పవచ్చు వీరి రచనలలో.

ముగింపు :

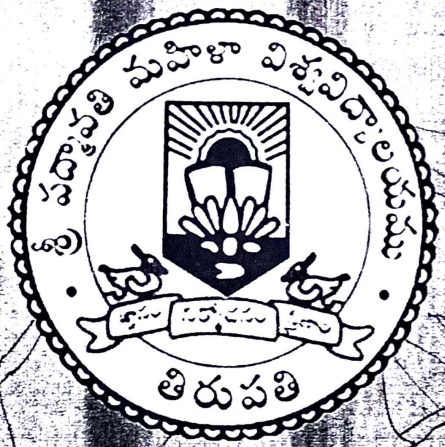
ఇలా అనేక అపూర్వ అంశాలను - ఈ అపూర్వ రాగకృతులలో పొందుపరచారు త్యాగరాజస్వామివారు. కర్ణాటక సంగీతానికి ఎనలేని సేవచేసిన త్యాగరాజ స్వామి ధన్యులు, వారి సేవ అనిర్వచనీయం.

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2) త్యాగరాజు రామకథాసుధ - ఇలపావులూరి కామేశ్వరరావు
3) Apurva Ragas of Saint Thyagaraja's compositions - Ph.D. thesis of Dr. Girija Seshamamba.

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TIRUPATI

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Contribution of women composers to South Indian Music

- Dr T. Girija Seshamamba *

Abstract :

Womens' Contributions through the centuries to South Indian Classical will be acknowledged and honoured. Many women composed many compositions in Telugu, Tamil and in Kannada towards south Indian music. Introducing such women composers and highlighting their contributions towards south Indian music, is the intention of presentation of this article.

Introduction:

In the God's creation creature of human is very miracle. Among human men and women are travelling putting hand in hand. Very latest, we found the vital role playing in all the fields by women. There are more opportunities today and women are overcoming inhibitions in every sphere of work. The same way women role in music also increased drastically. Undoubtedly the future of the music industry is going to fill with female singers and / or composers.

Women today are slowly but steadily being given their place no matter what field they are in and are being taken seriously. At this juncture, we are beginning to see female **composers** in the Indian music industry as well. As they are given their contributions irrespective of their gender, allowing their work to speak for themselves, female music creators are entering this erstwhile male dominated industry. We can find numerous female composers from the 1st century of sangam period from the southern states. Most of women from the 1st century CE Sangam period to the present day, there have been numerous female composers from the southern-most states.

Women Composers of South Indian Music:

1. Andal:

Andal is also known as Kothai, Nachiyar and Godadevi, was the any female Alwar among the twelve Hindu poet saints of south India. She was affiliated with the Sri Vaishnava tradition of Hinduism. Active in the 8th century Andalis created with two great Tamil works, "Tiruppavai and Nachiyar Tirumalai, which are still recited by devotees during the winter festival season of margali. Andal is a prominent figure for women in south India and has inspired several womens groups as Goda Mandali.

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Tiruppavai : Andal's first work is the 'TIRUPPAVAI' a collection of 30 verses in v Andal imagines herself to be a gopika, one of the cowherd girls known for unconditionaldevotion to Krishna. In these verses she describes the yearning to serve V and achieve happiness. Tiruppavai is the nector of Vedas and teaches philosophical va moral values, ethical values and the ultimate goal of life.

Nachiayar Tirumalai : The second work by Andal is the 'NACHIAR TIRUMA a poem of 143 verses. This is a classical Tamil poetic conventions and interspersing s from the Vedas and puranas.

2. Karaikkal Ammayiar :

Karaikkal Ammaiyar is one of the three women amongst the 63 nayanmars and c the gratest figures of early ?Tamil literature. She was born in Karaikkal, South India. Amm was a great devotee of Lord Siva, Karaikkal Ammaiyar produced 2 works Arputha Tiruva and Tirugattaimani malai.

3. Helavanakatte Giriyamma :

She was born in Rane bennoour. In kannada Dasa sahitya she was a first womı poser. She wrote many literatures in kannalda. She wrote 'CHITRAPATA R NAYANAM' IS ONE OF THE FORMOST LITERARY WORKS IN Kannada. She more than 40 songs in kannada language. Most of her literary works "Ankita Helavanakatte Ranga". She worte 5 narrative poems, all these poems are composed on her daily routines. Thebest known among which is the devotional 'CHANDRAHASANA KATHE".

. Akka Mahadevi :

Akka Mahadevi, a renowned poet. Saint from Karnataka. Shelives in 12th ce er 430 extant vachana poems and the two short writings called mantrogopya gangatrividhi are considered her most notable contribution to kannada literature. She an inspirational women in kannada literature and in the history of Karnataka. She u ne Chenna Mallikarjuna to refer to the Lord Shiva. Based on the use of her ankita lyric poems or vachanas are attributed to Akka Mahadevi.

Akka Mahadevi's works, like those of many other female bhakti poetstouch on enation, bothy from the material world and from social expectations and moves con en.

5. Tallapaka Tirumalamma :

Tallapaka Timmakka or Tirumalammma was a 15th century telugu poet. She worte 'SHUBADRA KALYANAM' in telugu. Timmakka was considered as the first telugu woman composer. Timmakka's main work, subhadra kalyanam with 1170 poems, is about the marraiage of Arjuna and Subhadra.

6. Molla :

Atukuri Molla (1440-1530) was a telugu poet who authored in telugu language 'RAMAYANA'. Molla is the second telugu poet of note after Tallapaka Timmakka. Her work is known as 'MOLLA RAMAYANAM' and is still one of the simplest of many Ramayanas written in Telugu.

Conclusion :

All above women are composers in Telugu, Tamil and Kannada literature. With the remarkable compositions of all these great women composers our South Indian Music and literature reached heights in the literature field.

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3.అన్నమాచార్య సంకీర్తనలు: రామాయణ, భారత ఇతివృత్తాంశాలు



డా. టి. గిరిజాశేషమాంబ

అధ్యాపకురాలు, అకడెమిక్ కన్సల్టెంట్,
సంగీత విభాగము, శ్రీ వేంకటేశ్వర యునివర్సిటి,
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వ్యాససంగ్రహం:

తెలుగు సాహిత్యచరిత్రలో అనేకమంది వాగ్గేయకారులు వివిధ రకాలైన సాహిత్య రచనలను మనకు అందించారు. సంగీతం, సాహిత్యం, భక్తి మూడింటిని మేళవించి భగవదర్పితంగా రచనలు చేసి కృతకృత్యులైన మహోన్నతులు తెలుగు సారస్వతప్రపంచంలో ఎందరో వాగ్గేయకారులున్నారు. ముఖ్యంగా పదకవితా పితామహుడు, వాగ్గేయకారుడైన అన్నమయ్య భక్తి, శృంగారం, వైరాగ్యం, వేదాంతసంబంధవిషయాలు, రామాయణ భారతేతిహాస పూర్వకమైన అంశాలను తన రచనలలో పొందుపరచి, వీరికి ముందు లేనటువంటి సాహిత్య రీతులను వీరి రచనల ద్వారా అందించడం ఒక విశేషంగా చెప్పవచ్చు. అన్నమాచార్య సంకీర్తనలలో రామాయణ, భారతేతివృత్తాలు ఏవిధంగా ఉన్నాయనే విషయాన్ని పరిశీలించి, విశ్లేషించడం అందించడం ఈ పరిశోధనావ్యాసం ముఖ్య ఉద్దేశ్యం. ముఖ్యగ్రంథాల ద్వారా, వివిధలక్షణగ్రంథాల ద్వారా అంతర్జాలంలో లభించిన ప్రామాణికవిషయాల ద్వారా ఈ వ్యాసం రూపుదిద్దుకుంది. అన్నమాచార్య రచనాప్రాభవాన్ని అర్థంచేసుకోవడానికి ఒక ముఖ్యసాధనంగా ఈ వ్యాసం ఉపయోగపడుతుంది.

Keywords: సాహిత్యము, సంకీర్తనలు, రామాయణము, భారతము, జీవితచరిత్ర.

1.ఉపోద్ఘాతం:

అన్నమయ్య వేదవిజ్ఞానం, శాస్త్రవైదుష్యం, పౌరాణిక జ్ఞానం అనంతం. సంకీర్తనా రచనా నైపుణ్యం అనుపమానం. చూసే చూపునుబట్టి అన్నమయ్య సంకీర్తనలు మనకు సమాచారాన్ని అందిస్తాయి. అన్నమయ్య ప్రతిభ అమోఘం కావడంలో ఆయనకు సమస్తవిషయాలు కరతలామాలకాలై సంకీర్తనల్లో ఒదిగిపోయాయి. అన్నయమ్య సంకీర్తనలు ఐతిహాసకులకు ఇతిహాసాలుగా స్ఫురిస్తాయి. రామాయణ, భారతాలు మన ఇతిహాసాలు. వాస్తవసంఘటనలకు అక్షరరూపమే ఇతిహాసం. అన్నమయ్య సంకీర్తనల్లో ప్రతిబింబించిన రామాయణ, మహాభారతాలకు సంబంధించిన అంశాల్లోని విశిష్టతను, తాత్వికతను అధ్యయనం చేయడం ఇటు సాహిత్యకులకు, సంగీతజ్ఞులకు ఎంతగానో ఉపయోగకరం.

2. రామాయణ, భారత ఇతివృత్త కీర్తనలు:

రామాయణము, మహాభారతం ఏవిధంగా చెప్పబడినాయో వివరిస్తూ అన్నమాచార్యుల వారు రచించిన ఒక కీర్తన ఈ విధంగా సాగింది.

2.1 రాగం - చారుకేసి; తాళం - ఆది

పల్లవి:

పేరు నారాయణుడవు బెంబాడి చేతలు నీవి

నోరు మూసుకున్న బోదు నున్నవి నీ సుద్దులు ॥

చరణం:

వేసులు మాకు జెప్పి విన భారతముగాగ

మోస నీపాల ముచ్చమి మొదలుగాను

రంతుల వాల్మీకి చెప్పి రామాయణముగాను

చెప్పి రామాయణముగాను

సంతగా తాటకాదుల జంపినడెల్లా (అధ్యాత్మ సంకీర్తనలు - సంపుటం 2)

మహాభారత కథాంశాన్ని, రామావతారంలో రాముడు ప్రదర్శించిన లీలలను, తాటకాదులను చంపిన విధానాన్ని అన్నమాచార్యులవారు ఈ కీర్తనలో వివరించారు. [6]

3. రామాయణసంకీర్తనలు:

అన్నమయ్య రామాయణ సంబంధిత సంకీర్తనలు ఎన్నింటిలో రచించారు. ఒక సంకీర్తనలో రాముని గుణగణాలను రామునిబాణ ప్రాశస్తి, కొన్ని సంకీర్తనలలో ఆంజనేయుని ప్రస్తావన ఇలా రచనలు చేసారు.[7]

రామకథనంతటిని ఒకే ఒక్క సంకీర్తనలో వివరించారు అన్నమయ్య.

3.1 రాగం - శుద్ధసావేరి; తాళం - ఆది

పల్లవి:

రాముడిదే లోకాభిరాముడితడు

గోమున పరశురామకోపమార్చె

చరణం(1):

యీతడే తాటకి జంపె యీపిన్నవాడా

ఆతల సుబాహు గొట్టి యజ్ఞము గాచె

చేతనే యీ కొమారుడా శివునివిల్లు విరిచె

సీతమ్మ బెండ్లాడె చెప్ప గొత్త కదవె ॥

చరణం(2):

మన కౌసల్య కొడుకా మాయామృగము నేసె

దనుజుల విరాధుని తానె చెరిచె

తనుమాడె నేడుదాళ్ళు తోడనే వాలి నడచె

చరణం(3): రావణు జంపి సీత మరల దెచ్చెను... (అధ్యాత్మ సంకీర్తనలు-సంపుటి 3)

శ్రీరాముడు అయోధ్యనాధుడైన దశరధుని పుత్రుడు. విశ్వామిత్రుని కోరిక మేరకు రామ లక్ష్మణులని యాగ సంరక్షణార్థం దశరథుడు పంపించాడు. విశ్వామిత్రుని సూచన మేరకు రామ లక్ష్మణులు మారీచ సుబాహులని సంహరించారు. ఆ తరువాత తాటకిని సంహరించాడు. శివుని విల్లు విరిచి సీతను పెండ్లాడినాడు. తరువాత వనవాసంలో మాయామృగాన్ని కొట్టినాడు. విరాధుడనే రాక్షసుని బాణంతో కొట్టి శాపవిమోచనం కలిగించాడు. (విరాధుడు పూర్వజన్మలో తుంబురుడు. కుబేరుని శాపంవల్ల రాక్షస రూపాన్ని పొందాడు. రామబాణంలో పూర్వరూపాన్ని ధరించాడు) తరువాత వాలిని సంహరించాడు. వారధికట్టి రావణుని జంపి సీతను తీసుకువచ్చాడు.

''రామాయణ''గాథ మొత్తాన్ని రామావతార విశేషాన్ని, రాముని తత్వాన్ని ఈ సంకీర్తనలో వివరించారు అన్నమయ్య. ఇలా ఈ ఒక్క సంకీర్తనలో రామగాథను మొత్తం ప్రస్తావించటం అన్నమయ్య సాహిత్య వైదుష్యాన్ని తెలుపుతున్నది. ఒక్కో సంకీర్తనలో రామాయణంలోని కొన్ని కొన్ని ప్రత్యేక ఘట్టాలని పొందుపరుస్తూ అన్నమయ్య పలు సంకీర్తనలు రచించారు. ప్రతీ సంకీర్తనలునూ శ్రీరాముని అవతారతత్వాన్ని ప్రతిబింబింప చేశారు అన్నయ్య.

ఈ సంకీర్తనలో అన్నమయ్య మరి కొన్ని విషయాలను ప్రస్తావించాడు.

3.2 రాగం - ద్విజావంతి; తాళం - ఆది

పల్లవి:

కౌసల్యా నందనరామ కమలాప్తకులరామ.. - అనే కీర్తనలో

చరణం(1):

''మునుపు దశరథరాముడవై తమ్ములు నీవు

జనించి తాటక జంపి, హరివిల్లు విరచి

సీత, పెండ్లాడి అనుమతి పరశురామునిచే గైకొంటివి''

చరణం(2): నుప్పనాతి శిక్షించి సొరిది రుషులగాచి

అపుడే ఖరదూషణాదుల గొట్టి

చొప్పుతో మాయామృగము సోదించి హరియించి

ప్పి హనుమంతు బంటుగా నేలుకొంటివి

చరణం(3):

సొలసి వాలి నడచి సుగ్రీవు గూడుక

జలధి బంధించి లంక సాధించి

వెలయు రావణు గెల్చి విభీషణుని మన్నించి

చెలగిత వయోధ్యలో శ్రీవేంకటేశుడా ॥ (అధ్యాత్మ సంకీర్తనలు - సంపుటి 1, 2)

ఈ సంకీర్తనలో పరశురాముని వృత్తాంతాన్ని పొందుపరచారు అన్నమయ్య. [6]

శ్రీరామ, పరశురాముల వృత్తాంతాన్ని ఈ సంకీర్తనలో ప్రస్తావించాడు. శూర్పణఖను శిక్షించిన విషయాన్ని హనుమంతుని బంటుగా చేసుకొన్న అంశాన్ని, సుగ్రీవునితో మైత్రిని, విభీషణుని మన్నించిన విషయాన్ని ఈ సంకీర్తనలో పొందుపరచారు అన్నమయ్య.

మరొక సంకీర్తనలో అన్నమయ్య శ్రీరాముని శరణాగత వాత్సల్యాన్ని వివరిస్తూ-

3.3 రాగం - హిందోళ; తాళం - ఆది

''కాకాసురు దోషము కడకుపరిహరించి

చేకొంటివి శరణంటే చేరి మడుగు

యీకడ మా నేరములు యింతకంటే నెక్కుడా

నీకే నే శరణంటి నీవు మమ్ము గాతువు'' (అ. సం.1 నుండి 4 సంపుటి)

అని రచించారు. తనపట్ల తప్పుచేసిన వారిని కూడ శ్రీరాముడు రక్షిస్తాడనటానికి కాకాసుర వృత్తాంతం నిదర్శనంగా నిలుస్తుంది.

మరొక సంకీర్తనలో అన్నమయ్య-

3.4 రాగం - ఖరహరప్రియ ; తాళం - ఆది

''అంటరాని గద్దకుల మంటి జటాయువుకు నీ

వంటి పరలోక కృత్యములు సేసితివి

యిరవైన శబరి రుచులివియె నైవేద్యమై'' (అ. సం.1 నుండి 4 సంపుటి)

అని రచించారు. జటాయువుకు శ్రీరాముడు అపకర్మలు గావించిన వృత్తాంతాన్ని, శబరి రుచిచూసి సమర్పించిన పళ్ళను స్వీకరించిన విషయాన్ని ఈ సంకీర్తనలో వర్ణించటమే గాక శ్రీరాముని భక్తవాత్సల్యాన్ని ప్రకటింప చేశారు అన్నమయ్య.

శ్రీరాముని సర్వలక్షణ తత్వాన్ని వివరిస్తూ అన్నమయ్య రచించిన మరొక సంకీర్తన.

3.5 రాగం - ముఖారి ; తాళం - ఆది

పల్లవి:

''రాముడు లోకాభిరాముడు త్రైలుక్య

ధాముడు రణరంగభీముడు వాడే''

చరణం 1:

వరుడు సేతకు ఫలాధరుడు మహాగ్రపు

శరుడు రాక్షస సంహరుడు వాడే

స్థిరుడు సర్వగుణాకరుడు కోదండ దీక్షా

గురుడు సేవక శుభకురుడు వాడే ॥ (అ. సం. సంపుటి, 1 నుండి 4)

''అంత్యాను ప్రాస'' విన్యాసంలో సాగిన ఈ సంకీర్తనలో శ్రీరాముని విశేషణాల ద్వారా, శ్రీరాముని తత్త్వాన్ని ప్రతిబింబింపజేశాడు అన్నమయ్య. రణ రంగంలో భయంకరుడని చెప్పడం ద్వారా యుద్ధభూమిలో తిరుగు లేనివాడని, అలాగే ''మహాగ్రపుశరుడు'' అనే విశేషాన్ని ప్రయోగించడం ద్వారా అమోఘమైన రామబాణం యొక్క గొప్పతనాన్ని స్పష్టపరచారు అన్నమయ్య ''రాక్షస సంహరుడు'' అనటం ద్వారా దుష్టశిక్షణ తత్త్వాన్ని, ''సేవక శుభకరుడు'' అని చెప్పడం ద్వారా తనను సేవించే శిష్యులకు మేలు చేకూర్చుతాడనే విషయాన్ని ఇలా ఈ సంకీర్తనమంతా శ్రీరాముని విశిష్టగుణాలని వివరించటం జరిగింది అన్నమయ్య.[5]

రామకథను పలు సంకీర్తనలలో వర్ణించిన అన్నమయ్య రామభక్తుడైన ఆంజనేయుని గూర్చి కూడ ఎన్నో సంకీర్తనలలో వివరిస్తారు.

3.6 రాగం - మలహరి ; తాళం - ఆది

పల్లవి:

నేల మిన్ను నొక్కటైననీబంటు వొక్క

వేలనే యక్షుని తెగవేసెగా నీబంటు

చరణం 1:

ఉంగరమెగరవేసి యుద్ధంలో పడకుండ

నింగికి చేయిచాచే నీబంటు

చెంగున జలధిదాటి జంటుమాలి నేలమీద

కుంగదొక్కి పదముల గుమ్మెగా నీబంటు

చరణం 2:

వెట్టగా రావణు రొమ్ము విరంగ చేతనే గుద్దె. (అ. సం. సంపుటి, 1 నుండి 4)

ఆంజనేయుని తత్త్వాన్ని వర్ణిస్తూ ఉంగరాన్ని పైకి ఎగురవేసి సముద్రంలో పడకుండా చేతితో పట్టుకొన్నట్లు వర్ణించాడు. జంబుమాలిని హనుమంతుడు కుంగదొక్కాడని అన్నమయ్య అచ్చతెలుగు పదాల్లో వర్ణించాడు.

అలాగే వివిధ వైష్ణవక్షేత్రాలలో వెలసిన హనుమంతుని అన్నమయ్య పలు సంకీర్తనలలో వర్ణించాడు. కలశాపురంలోని హనుమంతుని తత్త్వాన్ని అన్నమయ్య ఈ సంకీర్తనలు ఈ విధంగా ప్రస్తుతించాడు.

3.7 రాగం - అమృతవర్షిణి ; తాళం - ఆది

పల్లవి:

కలశాపురముకాడ గంధపుమాకులనీడు

అలరేవు మేలు మేలు హనుమంతరాయ (అన్నమయ్య సం. సంపుటి 1, పీటికలు-18)

4. మహాభారత ఇతివృత్తకీర్తనలు:

మహాభారత కథ అత్యంత విస్తృతమైనది. బహుపాత్రయుతమైనది కావటం వల్ల అన్నమయ్య ఒక సంకీర్తనలో మహాభారతాన్ని ఇమడ్చకుండా ఆయా సంకీర్తనలలో మహాభారత సన్నివేశాల్ని, పాత్రల్ని ప్రస్తావిస్తారు.

శ్రీకృష్ణుని జన్మను వర్ణిస్తూ అన్నమయ్య శ్రీకృష్ణుడు ఏయేపాత్రలతో ఎలాంటి బంధుత్వాన్ని కలిగి ఉన్నాడో ఈ విధంగా వర్ణించారు.

4.1 రాగం - హంసధ్వని ; తాళం - ఆది

పల్లవి :

అదర శ్రావణబహుళాష్టమి నేడితడు

నదురేయి జనియించినాడు చూడుగదరే ॥

చరణం 1:

గొంతిదేవి మేనల్లుడు గోపసతులమగుడు

పంతపు పాండవులకు బావమరిది

వంతుతో వసుదేవ దేవకుల కుమారుడు

ఇంతటి కృష్ణుడు జనియించి నీడుగదరే

చరణం 2:

బలరాముని తమ్ముడు పంచసాయకుని తండ్రి

మలసి మేలైన అభిమన్యుని మామ

లాలి సాత్యకి సుభద్రకు తోబుట్టినయన్ని" (అన్నమయ్య సం. సంపుటి 1, పీటికలు-18)

శ్రీకృష్ణునికి ఇతర పాత్రలతో ఉన్న బాంధవ్యం ఈ కీర్తనలో వివరించారు అన్నమయ్య. [4]

శ్రీకృష్ణునికి భక్తులపట్ల ఉండే పక్షపాతాన్ని వివరిస్తూ ఆయనకు దాస్యం చేసేవారిపట్ల ఆయనే దాసుడై ఉంటాడని అన్నమయ్య ఒక సంకీర్తనలో స్పష్టం చేశారు.

4.2 రాగం - మోహన ; తాళం - ఆది

''యిందరి పాలిటికిని ఈశ్వరుడ వేలికవు

వందవై యర్జును బండి బంటవైతివి

వందనకు నేలే దేవతలకే దొరవు (అధ్యాత్మ సంకీర్తనలు సంపుటి 4)

అందపు నీదాసులకు నన్నిటా దాసుడవు'' - అని అర్జునుని రథసారథ్య విషయాన్ని, శ్రీకృష్ణుని భక్త వాత్సల్యతను అన్నమయ్య ప్రస్తావించాడు.

ద్రౌపదీ వస్త్రాపరణ వృత్తాంతాన్ని స్మరిస్తూ అన్నమయ్య ఒక సంకీర్తనలో ''ద్వారకా నగరములో తగ నెత్తమాడే నీకు బీరాన ద్రౌపది మొరవెట్టిన యట్టు'' అని ద్రౌపది తనను రక్షించమని వేడుకొన్నట్లు ఈ కీర్తనలో వివరిస్తారు.[1]

శ్రీకృష్ణుని అవతారం దుష్టశిక్షణ, శిష్టరక్షణ అని తెలుపుతూ అన్నమయ్య ఒక సంకీర్తన రచించాడు.

4.3 రాగం - హిందోళం ; తాళం - ఆది

పల్లవి :

''ఎంతకత నడిపితి వేమి జోలి బెట్టితివి

చింతించ లోకములు నీ చేతివే కావా''

చరణం:

కౌరవుల పాండవుల కలహము వెట్టనేల

నేరిచి సారథ్యము నెరపనేలా

కోరి భూభార మణచే కొరకైతే నీచే చక్ర

మూరకే వేసితే దుష్టు లొక్కమాటే తెగరా । (అధ్యాత్మ సం. సంపుటి 1,2,3) [3]

శ్రీకృష్ణుని గూర్చి అన్నమయ్య ''ఎంత కత నడిపితివి'' అని అద్భుతంగా చెప్పారు. కౌరవ పాండవులకు కలహం పెట్టిదుష్ట శిక్షణ, శిష్టరక్షణను చేసినట్లు భావించిన అన్నమయ్య ప్రతిభ అనన్య సామాన్యం.

శ్రీకృష్ణుని విశ్వరూపాన్ని గూర్చి వివరిస్తూ అన్నమయ్య ఈ విధంగా రచించారు.

4.4 రాగం - కాపీ; తాళం - ఆది

''అనంత సూర్యచంద్రులు అనంతవాయువులును

అనంత నక్షత్రములనంత మేరువులు

కొనలు సాగేనన్నిటి కూటువ గూడుకొన్నట్లు

అనంతుడొక్కడే మించీనాది మూరితి'' (ఆధ్యాత్మిక సం. సంపుటి 1 నుంచి 4) [2]

అని వర్ణించారు.

5. ముగింపు:

- ప్రపంచసాహిత్యచరిత్రలోనే ప్రజల భాషలో పదకవిత్వం వ్రాసి ప్రపంచానికి అందించిన ప్రయోగశీలుడు అన్నమయ్య. భగవంతుని ఉనికిని, సమాజపు ఉనికిని విస్మరించకుండా తాను నమ్మిన సిద్ధాంతాన్ని బహుముఖీనంగా వ్యాఖ్యానిస్తూ సాధించిన ఫలితాలను సమాజానికి, దేవునికి సమర్పించిన దార్శనికుడు.
- ఈ వ్యాసంలో చర్చించిన రామాయణ, భారతాంశ ఇతివృత్త రచనలు ప్రతి ఒక్కటీ ఒక ప్రత్యేక రచనగా నిలుస్తాయి. భక్తి, శృంగార, వైరాగ్య రనచలు చేసిన అన్నమయ్య పురాణ, ఇతిహాసాలను కూడా తన రచనలలో ఇమిడ్చి రచించారు అని ఈ వ్యాసంలోని విశ్లేషణాంశాల ద్వారా తెలుస్తుంది.
- మొట్టమొదటగా వివరించిన రామాయణ సంకీర్తనలలో రామకథ ఇతివృత్తం మొత్తాన్ని ఒక సంకీర్తనలోనే పొందుపరచారు అన్నమయ్య. అలాగే ఆయా కీర్తనలకు ఉపయోగించిన రాగాలు, చారుకేసి, శుద్ధసావేరి, ముఖారి, వంటి రాగాలు కర్ణాటక సంగీతంలో ఎంతో ప్రాదాన్యత కలిగిన రాగాలని ఆయా సాహిత్య రీతులకు అనుగుణంగా కూర్చటం జరిగింది.
- తరువాత విశ్లేషించిన మహాభారత ఇతివృత్తకీర్తనలు కూడా శ్రీకృష్ణుని లీలలను, క్రిష్ణతత్వాన్ని కీర్తనల రూపంలో మలచారు అన్నమయ్య. ఆ కీర్తనలకు ఉపయోగించిన హంసధ్వని, మోహన, హిందోళ రాగాలలో కూర్చడం వలన సాహిత్యం మరింత సోభాయమానంగా ప్రకటితం అవుతుంది.
- అన్నమయ్య రనచలు ఎంత విశ్లేషించినప్పటికీ వారి రచనలలోని భక్తిని, భావాన్ని అర్థంచేసుకున్నప్పుడే ఆ సాహిత్యం మనకు అవగతం అవుతుంది.
- అన్నమయ్య కీర్తనలలో సాహిత్యం పరిపూర్ణంగా వ్యక్తం అయ్యేందుకు అవసరం అయిన మాధ్యమం సంగీతం. ఇటు సంగీతసాహిత్యాలను రెండింటిని మేళవించి పాడినట్లయితే అన్నమయ్య రచనలలో భావం, సంగీతం సుస్పష్టంగా అవగతం కాగలదు.

6. పాదసూచికలు:

1. శ్రీ మహాభారతం 2-35.
2. తాళ్ళపాక అన్నమాచార్య అధ్యాత్మ సంకీర్తనలు 2-469.
3. తాళ్ళపాక అన్నమాచార్య అధ్యాత్మ సంకీర్తనలు 3-355.
4. భాగవతం 7-169
5. అధ్యాత్మ సంకీర్తనలు పీఠికలు - 18.
6. అన్నమయ్య సంకీర్తనలు సంపుటి 1 పీఠికలు - 18.
7. తాళ్ళపాక పదసాహిత్యం - ఆధ్యాత్మిక సంకీర్తనలు - (1 నుండి 4 సంపుటాలు)
8. అన్నమాచార్య జీవిత చరిత్ర ద్విపద - పుట - 11.

7. ఉపయుక్తగ్రంథసూచి:

1. ఆనందమూర్తి, వేటూరి. తాళ్ళపాకకవుల పదకవితలు- భాషాప్రయోగవిశేషాలు. తి.తి.దే., తిరుపతి, 1976
2. కృష్ణమూర్తి, సాళ్వ. సంకీర్తనాలక్షణం. ఇనిస్టిట్యూట్ ఆఫ్ ఏషియన్ స్టడీస్, చెన్నై, 1996
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6. దక్షిణామూర్తి,శర్మ. పదకవితాపితామహస్య తాళ్ళపాక అన్నమాచార్యస్య సంస్కృతసంకీర్తనాः ఏకమధ్య-యనమ్. తి.తి.దే., తిరుపతి, 1997.
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8. విజయభారతి, బి. (పరి.) తెలుగు సాహిత్యకోశము, తెలుగు అకాడమీ, హైదరాబాదు, 1980.
9. వాణి, కేశర్ల. శ్రీ తాళ్ళపాక అన్నమాచార్యులు జీవిత చరిత్ర. తి.తి.దే., తిరుపతి, 2000.
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12. సుబ్రహ్మణ్యశాస్త్రి, శ్రీపాద. రామాయణం. విశాలాంధ్ర పబ్లిసింగ్ హౌస్, హైదరాబాద్, 2007.

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గమనిక: ఈ పత్రికలోని వ్యాసాలలో అభిప్రాయాలు రచయితల వ్యక్తిగతమైనవి.
వాటికి సంపాదకులు గానీ, పబ్లిషర్స్ గానీ ఎలాంటి బాధ్యత వహించరు.

GROUNDWATER SURVEY REPORT

A. Location details of the area:

1. **Name of the Land owner** : **Sri Balakrishna Garu**
1. **Village** : Guthivaripalle
2. **Mandal** : Erpedu
3. **District** : Tirupatidistrict
4. **State** : ANDHRA PRADESH
5. **GPS Coordinates** :

S.No	Location no.	Latitude	Longitude
1	Location 1 (P1)	N 13.667556°	E 79.544580°

B. General Details of the area:

1. **Purpose of Investigation** : Water for Agriculture
2. **Name of the Groundwater Investigator** : Dr. M.Venkata Subba Reddy & Mr.V.Ramamohan
3. **Type of Investigation** : Hydrogeological Survey & PQWT instrument
4. **Date of Survey** : 17-04-2024

C. Hydrogeological details of the area:

1. **Physiography (Hilly area / Slope area/ Plain area)** : **Plain**
2. **Soil Type and Thickness** : Black soil, 2- 4m
3. **Geology** : Gneisses
4. **Geomorphology** : Deeply weathered pediplain
5. **Average weathered zone thickness** : **20** m to 25 m
6. **Drainage details** : Sub-Dendritic drainage
7. **Water Body within 500m radius (Canal/Tank/Stream/River)** : River is flowing in the North to south side
8. **Well inventory within 500m** :
   - **a) Type of wells** : Bore wells
   - **b) Average Depth of wells** : 350ft
   - **c) Average Yield in LPH** : 3750 LPH

D. Recommendations:

S.No	VES no. / Loc.no.	Depth (Feet)	Diameter (mm) of bore well	Depth of Casing Pipe (Feet)	Expected Yield (LPH)	Type of Well
1	Location1	400	165	80-90	3500-3750	Bore well

Google image of the site:



Fig. 1 Location maps of Surveyed point for deep bore wells

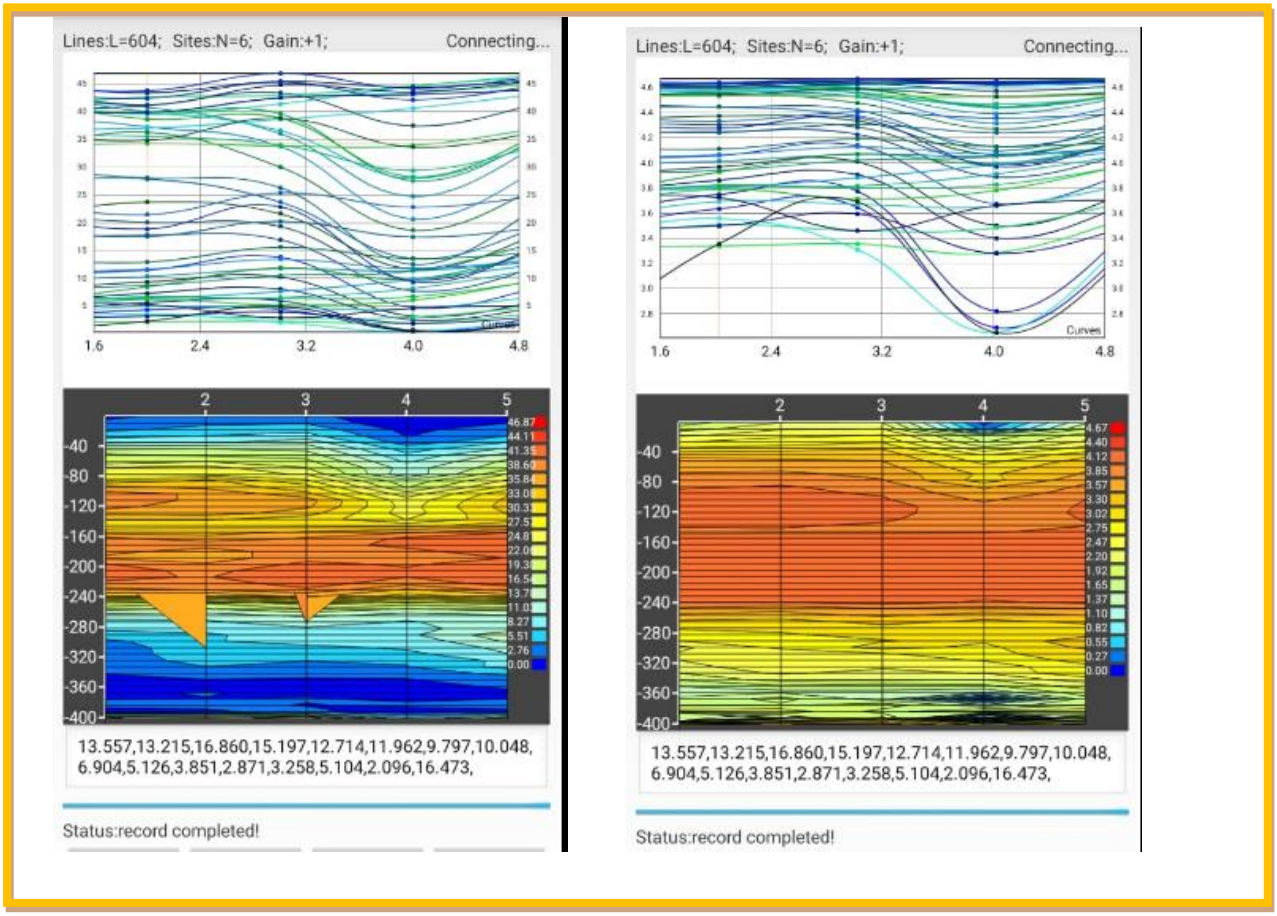


Fig. 2 Subsurface profile of Recommended Location no. 1

(M.VENKATA SUBBA REDDY)

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Selected Tanavarnam-s in Apoorva Raga-s

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ABSTRACT

Varnams are generally composed in popular raga-s which helps the learner to understand the nuances of that particular raga. There are number of varna-s are composed in raga-s like Todi, Kalyani, Sankarabharanam, Bhairavi, Dhanyasi, Begada, Abhogi, Purvikalyani, Sahana, Nattakuranji, etc. Post Trinity period was emerged with several new composers. Musicians shown their enthusiasm in doing experiments such as creating new raga-s, trying to sing rare raga-s mentioned in the various ancient Musical Treatises. Some of them composed music to varnam-s by tuning old poetry or literature and render it as varnam-s. Some musicians, who are get trained in both Carnatic and Hindusthani music systems, introduced Hindusthani raga-s to Carnatic music and composed varnam-s in it. This paper is intended to highlight some Apoorva raga'Tana Varnam-s', which is composed in rare or apoorva raga-s.

Keywords: Apoorva ragas, Tana Varnam, Thirukural Tana Varnam, Carnatic music.

Introduction

Tanavarṇam is one among the musical forms belong to modern period of carnatic music. It is the first item figured in traditional Carnatic music concerts. In general, Carnatic music compositions are divided into two major sections i.e 'Abhyasagana' and 'Sabhagana'. Abhyasa gana is for learners and Sabhagana is for performers after mastered in Abhyasagana. Varṇams are like a bridge between abhyasa gana and sabha gana. All of the nuances and essential features like sancharas, ranchaka prayogas, apoorva prayogas of the raga is glimpsed in a Varṇa. This is considered as most intricate and crucial item for vocal exercises. Varnams played a very important role in providing rhythm control to the music learner and practitioner. Practicing and performing Varṇa in second and third speed is helpful to gain control on rhythm, tempo and voice control over various sthayi-s. Hence it is melodic oriented, Swara phrases of various lengths and range is the main aspect of Tanvarṇam. Varnam, being a 'dhatu pradhana' composition, Sahityam (text) is simple, less in Varṇa and it has plenty of vowel extensions. These vowel extensions help to express the ragabhava by the performer through vocal cord. Tanavarṇam has two major segments i.e Purvangam and Uttarangam. Purvangam comprises of pallavi, anupallavi and mukthayiswaram, and uttarangam comprises with charaṇam and charaṇa

swara-s. Varnam is a unique composition only available in Carnatic music system and cannot be seen in any other music system in the world.

Varnams are generally composed in popular raga-s which helps the learner to understand the nuances of that particular raga. There are number of varna-s are composed in raga-s like Todi, Kalyani, Sankarabharanam, Bhairavi, Dhanyasi, Begada, Abhogi, Purvikalyani, Sahana, Nattakuranji, etc. Post Trinity period was emerged with several new composers. Musicians shown their enthusiasm in doing experiments such as creating new raga-s, trying to sing rare raga-s mentioned in the various ancient Musical Treatises. Some of them composed varnam-s are tuned old poetry or literature into varnam-s. Some musicians, who are well trained in both Hindusthani and Carnatic music systems introduced Hindusthani raga-s to Carnatic music and composed varnam-s in it. This paper is intended to highlight some of the Varnam-s which composed in rare or apoorva raga-s.

The idea of rendering Thirukural as the first item of a carnatic concert aroused in the mind of Sri V.S. Gomathisankara Iyer who was working as a professor in veena in the Department of music and also involved in the assignment of collecting rare Tamil compositions for the Annamalai University music series publications. This idea of using Thirukural as a carnatic music composition was inculcated into Iyer by the great Tamil Scholar Dr.Mu.Varadharajanar. Some of the Thirukural Varnam-s are tuned in rare ragas by V.S. Gomathisankara Iyer.

Raga-s : The epicenter of Indian Music

Music is the finest among the Fine arts. Music is a language of emotions. Music is the soul of Indian art and culture. It can influence all kinds of human emotions and feelings. Art music is bound by a System 'raga ' and 'tala'. Raga -s are vital to Indian music, especially to the Carnatic music, a music system of south India. Raga -s which originated centuries ago still have its refreshing beauty. The very heart of Indian music is ‘raga’. It is a melodic form upon which the musician improvises. A raga, is much more than a technical rule. Each raga in Indian music system depicts a mood. Some raga -s are suitable to be played during sun rise, some during sunset, some produce a devotional feeling, some raga produces a romantic feeling, and so on… The outstanding feature of Indian music system, then any other music system in the world, is raga system. Carnatic music system has 72 Mela Kartha raga -s. Raga -s have endless scope for variations and creations. Musical compositions are concrete form of raga -s. The beauty lying in raga is very subtle and delicate to elucidate and comprehend. A Musical composition can present only certain beauty aspects of a raga but a detailed alapana can expose the beauty of a raga to some extent.

After the emergence of 72 Melakartha systems into Carnatic Music many raga-s which were previously in vogue before the 72 Melakartha scheme assigned according to their

swarasthana-s or Characteristic features, under a Melakartha i.e Janaka ragas as Janya raga. These Janya ragas, classified mainly into two ie 'Upanga and Bhashanga'.

Upanga raga-s has the following classifications

1. Shadava – Sampurna
2. Audava – Sampurna
3. Sampurna – Shadava
4. Sampurna- Audava
5. Shadava - Shadava
6. Shadava - Audava
7. Audava - Shadava
8. Audava – Audava

Apart from the above classifications, classifications like the following Vakra ragas, Bhashanga Ragas, Nishadantya, Dhaivadantya Panchamantya, Madyamantya raga-s, Ghana, Naya, Desya Ragas, Karnataka – Desya ragas, Suddha, Chayalaga, Sankeerna Ragas, Common ragas and parallel ragas etc…are seen in the modern music. Among the above-mentioned classifications Prasiddha and apoorva raga-s is one classification. Prasidda means Popular and Apoorva means rare.

Some Apoorva Raga Varna-s

A raga, in which only one or a very few compositions composed, which is performed rarely in concerts is called apoorva raga or rare raga. Some Apoorva raga Varna-s is listed below

Sl.No.	Varnam	Raga	Tala	Composer
1.	Egan Aagi Anegan Agi	Nagavarali	Adi	Varagur. K. Muthukumaraswamy
2.	Naduvintri (Thirukural Tana Varnam)	Nagavarali	Adi	Thiruvalluvar Music Composed by V.S.Gomathi Sankara Iyer
3.	Sri Durga Lakshmi Saraswathi	Nagavarali	Adi	Pathamadai Krishna Iyer
4.	Thondanukku Kuraiyethum	Veenadhari	Adi	V.S.Gomathi Sankara Iyer
5.	Adi nathane Azhagiya Velane	Veenadhari	Adi	Varagur. K. Muthukumaraswamy
6.	Veenadhanda Kamandala	Veenadhari	Adi	V.A.Dandayutha Dikshitar
7.	Varuvanodi vanna malar	Veenadhari	Adi	S.Srinivasa Iyengar
8.	Sondamum bandamum	Megaranjani	Adi	V.S.Gomathi Sankara Iyer
9.	Maa Karunai pozhi	Megaranjani	Adi	Varagur. K. Muthukumaraswamy
10.	Sevikunavillatha pozthu (Thirukural Tana Varnam)	Megharanjani	Adi	Thiruvalluvar& Music Composed by V.S.Gomathi

				Sankara Iyer
11.	Megharanjani Ganamrutha	Megharanjani		Pattamadai Krishna Iyer
12.	Sevadi Tharuvai	Vahini	Adi	Varahur. K. Muthukumaraswamy
13.	Parinil nee kameswari	Vahini	Adi	Kshirapthisastri Thiruvananthai
14.	Aimkara Hrimkara	Omkaraswarupini	Adi	Adi Sankarar Music composed by TK Govindarao

Nagavarali

Aro : Ṇ S R G M P M D,,

Ava : N D P M G R S Ṇ D Ṇ S

Upanga janya of Todi, 8th Melakartha. Swarasthanas are Suddha Rishabam, Sadharana Gandharam, Suddha madhyamam, Suddha dhaivatham and Kaisiki Nishadam.

Raga Nagavarali also called as 'Nagadvani' in ancient Tamil music. In Tamil Pann System this pann comes under Marutha Yazh under thiram 'Nivir' evolved from Perugiyal. It ranges from Mandra stayi nishadam to Madhyasthayi nishada. But according to old tradition it has been performed Mandra stayi Dhivatham to Tara sthayi Gandharam. This raga, the swaras have to be sung without gamakas. Vakra swara prayogas like 'nrsgrmgsrns', 'gmdpg,rs', nsmm', 'gmdnrs' are raga ranjaka prayogas of Nagavarali raga.

'Eagan Agi Anegan Agi' is a Tamil Tana Varnam composed in Nagavarali raga set to Adi tala composed by Varagur. K. Muthukumaraswamy is a beautiful example for the ragalakshana of Nagavarali discussed above. Prayogas like the following exhibits the nature and raga ranchaka prayogas of this raga.

In pallavi prayogas like- ' ndmp, gmdp', 'rsrg mgmp- dpd- mpgrs'

In Anupallavi Prayogas like –'g,d, pmgr mndp, mpm', 'mpdmgr srgm'

In Muktayiswaram prayogas like- 'gmgrsrg,m', 'pndp ndpm', gmrg srgm n,d n, smg , nddpm grn

The above 'thaatu' prayogas are frequently occurs in this raga and these are also the raga ranchaka prayogas of raga Nagavarali. Apart from the above 'Thaatu prayogas' janta prayogas nddppmgr, nddpm, without gamakas also a special feature of this raga which is perceptible in this varna.

Veenadha

Aro : S G P D N Ṡ

Ava : Ṡ N D P M G R S

This raga is Janyam of 16th Mela Chakravaham. The swarsthanas are Suddha – Rishabam, Antara- Gandaram, Suddha- Madhyamam-, Chathusruthi- Dhaivatham, Kakali- Nishadam

Name of this raga mentioned in the book Sangitaswara prastara sagaram (p.425). Apart from the book Sangita Swaraprastara Sagaram, Sangita Chandirikai, Ragakosa, Palaiyali, Sangitakaumudi, and Pudiya Ragangal are a few grandhas mentioned this raga with same arohana and avarohana. A kriti 'Girija Deviya Bhajiselo' is composed by Sri Muthiah Bhagavathar in this raga, which is one among the Chamundamba Ashtotharasata Kirtana-s.

Tamil Varna-s ' Adi nathane – set to Adi tala composed by Varahur K. Muthukumaraswamy , Thondanukku Kuraiyethum –Adi composed by V.S. Gomathisankara Iyer, Veenadandakamandala – Adi composed by V.A. Dandayutha Dikshithar, Varuvanodi Vannamalar – Adi composed by S. Srinivasa Iyengar, Idikkuth thunai yarai –A' Thirukural' Tana varnam composed by Thiruvalluvar and music composed by V.S. Gomathisankar Iyer and A Tana Varnam in Telugu, Sari Evvarunnarura- Adi Composed by Pathamadai Krishna Iyer are perceptible in this raga.

In the Varnam 'Sari Evvarunnarura-Adi – Pathamadai Krishna Iyer , in pallavi the following phrases are ragachaya and raga ranjaka prayogas can be seen.

'grs, gpd ndpm',- 'm,grsgp,'- 'grsgpgp,'- 'dn,dpmgr'

In Anupallavi, the melody move up to tarastayi panchama 'dṅṡ,ġ,ṗṁġṙ', through this prayoga . In charanaswaras ,Janta swara prayoga like 'ṡṡnnddppmmgg'is used. Through the melodic structure of this varna the Swarasanchara-s , Ragaranchaka prayogas, Tarasthayi Sancharas, and Thatuprayogas has been observed.

Megharanjani

Aro: S R G M N Ṡ

Ava: Ṡ N M G R S

This is upanga Janya raga of 15th Mela Mayamalava Gowla. Swarasthanas figuring in this raga are Suddha rishabam, Antara Gandharam, Suddha Madhyamam, Kakali Nishadam. Panchama and Dhaivatha are varja. This raga is mentioned in many lakshanagrantha-s with note of its capability in stimulating rain when it was properly sung. A very few compositions are perceptible in this raga. Venkateswara Yadava – Rupaka – Muthuswamy Dikshitar and Karunato Nannu- Adi – Ramnad Srinivasa Iyengar is noteworthy. This raga also mentioned with the name 'Megharanji' in some texts.

Pallavi of the Tana Varnam ‘ Sondamum Bandamum’ –Adi , composed by V.S. Gomathisankara Iyer, begins with Madhyashayi Madhyama with the prayoga ‘mgm, n,; ṡnṡṙṡ, ;’ melody ranges up to tarastayi madhyama in the prayoga ‘ṡnṡ, ṙġṁ-ṁġṙṡ’ .

In the anupallavi of this varnam melody ranges up to tarastayi madhyama ‘ ṙġṁ,ġ, n, ṁ, ġ ṙṡnṡ,’

Vakra prayogas like ‘ṡ, nṙṡ-nġṙṡ’,and in mukthayiswara, Thatu prayogas like ‘gmrgsrns’and Srotovaha yati pattern with vakram like ‘ ṙnṙ - mnṙ- gmnṙ are perceptible. The varjam of Panchama and dhaivatha gives a western tint and swift swing effect to this raga.

Vahini

Aro : S G M P D N Ṡ

Ava: Ṡ D P M G R S

This raga is a upanga janyam of 16th Mela Chakravaham. This raga is mentioned with the name ‘Nabomargini’ with same arohana and avarohana in the book ‘ Ganavidya Prakasini’ authored by Perungulam Srinivasa Iyengar. ‘Sangeetha Swara prastara Sagaram’Authored by Nadamuni Pandithar and ‘Sangeetha Raga kadal’ written by Mahadevan in Tamil also mentioned this raga as Nabomargini. In this raga Thirukural Tana Varnam ‘ Kadanarinthu’ – Adi – Composed by Thiruvalluvar and music composed by V.S. Gomathisankara Iyer, and a Tamil Tana Varnam ‘Sevadi Tharuvai- Adi , composed by Varagur K. Muthukumaraswamy is perceptible in this raga.

In the Varnam ‘Sevadi Tharuvai’ by Varagur Muthukumaraswamy, the pallavi has following sancharas ‘dnṡd p,mg,’ ‘pmdpmgrs,’ ‘sḍṇs,’ ‘mgr, sgmg, mpm,’. In anupallavi melody ranges upto tarasthayi panchama ‘ṡ, ġṁṗṁġṙṡ,,,,’ ‘ṡġ, ṁġṙṡ’ the phrases are showing the tarasthayi sanchara-s of this raga. Janta swara prayogas like ‘ggrrss, pm gg rr ss’, are perceptible in the Charana swaras of the Tana Varna ‘Parinil nee Kameswari’ – Adi Composed by Thiruvananthai Ksheerabdi Sastri.

Omkaraswarupini

Aro : S R G M P N S

Ava : S NP M G R S

This is Janya raga of 62nd Mela Rishabapriya. The Swarasthana-s are Chathusruthi Rishabam, Antara Gandharam, Prati Madhyamam, and Kaisiki Nishadam . Tana Varnam ‘Aimkara Hrimkara’ is a Sloka composed by Adi Sankaracharya and music composed by Sri T.K. Govindarao. This raga is mentioned in ‘Palai Yazhi’ written by Dr. B.M. Sundaram. No other composition is seen in this raga except this varna.

In pallavi the melody ranges up to mandrastayi madhyama in the prayoga 'sṇ̲pṃp̲s, ṇ' Prayogas like 'srg –grs , rgm –mgr, are perceptible in the pallavi. In Anupallavi the melody glides up to Tarasthayi Gandhara in the prayoga ' ṡpṅṡṙ, ṙġ ṙ ṡn' In the Muktayiswaram Prathyagatha prayogas like 'rs-gr-mg-pm-np-mg',and Thatu prayogas like 'sr-sg-rm-gp-mn-pṡ' are interesting to observe.

Conclusion

In general Varna-s, taught to students to understand the framework, structure, and melodic movement of a raga. The sanchara-s and prayoga-s helps the learner to understand the melodic nature of that particular raga. Varna-s in apoorva ragas certainly helps the learner's to understand melody and nature of that raga. In general Tana Varna-s are having less text and plenty of vowel extensions to emphasis the melody.But closely observing to the above Varnas , the Thirukural Tana varnam and the Varnam tuned for the sloka of Sri Adisankaracharya is surprisingly match exactly to the music and set in Varna format without disturbing it's text. This shows the mastery of those composers who all are set music to that literature piece and change it into beautiful music composition 'Tana Varna'.

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THE MODERN ANDHRA VAGGEYAKARAS: THEIR CONTRIBUTIONS TO CARNATIC MUSIC

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Abstract: *Indian classical music is believed to be a divine art form which originated from the origin of Vedas. The Samaveda which is believed to have a laid the foundation for Indian classical music, consists of hymns from the Rigveda. In Rigveda time 3 notes were existed that was vudatta, anudatta, swarita. Carnatic music based on samaveda.*

"Samavedadidam geetam sanjagraha pitamahaha"

In Bhagavad Geeta – Sri Krishna also says

'Vedanaam samavedosmi"

The Yajnavalkya smriti mentions

"Veena vadana tatvagna sruti jati visaradha"

Talagnascha prayasena moksha margam niyaschati"

The one who is well versed in veena, one who has the knowledge of sruti, and one who is adopt in tala, attains moksha without doubt. Sruiti, Ragam, Talam the most elements in our carnatic music. Raga is the pivotal concept of in our carnatic music. There is no carnatic music without ragam and swaram.

This papers is intended to highlight and to promote 19th, 20th centuries and some modern Andhra vaggeyakaras. In the development of carnatic music.

Key words: *Performing arts, Music, Raga, Art forms, Composers, Fine arts.*

INTRODUCTION

Carnatic music, known as carnataka sangeetam in the south Indian languages, is a system of music commonly associated with south India, including the modern Indian states of Andhra Pradesh, Karnataka, Kerala, Tamilnadu and Telangana. It is one of two main subgenres of Indian Classical music that evolved from ancient Hindu texts and traditions, particularly the 'Samaveda'. Carnatic music based on the 3 elements of Sruti, Raga, Tala. Carnatic music is mainly sung through compositions, especially the kriti or kirtanam. Carnatic music is as usually taught and learned through compositions. Telugu language predominates in the evolution of carnatic music. Carnatic music is based as it is today on musical concepts raga, tala and swara that were described in detail in several ancient works, particularly the 'Bharata's Natya Sashtra. The18th century golden age of carnatic music, three gems of the canatic music – they are saint Thyagaraja, Shyamastry and Deekshitar were composed and created many compositions. In this time music was established many ways. After trinity period in the10th,20th century many telugu composers also came to vogue. This contribution was also tremendous. The new composers of the 19th, 20th centuries are introduced many new ragas (apoorva raga) and many new creations to carnatic music. Example: Dr Nookala China Satyanarayana garu, K.V.N. Sastry garu, Sri Hari Nagabhushanam garu etc. Like this many composers have given marvelous contribution towards carnatic music.

MODERN ANDHRA VAGGEYAKARAS: THEIR CONTRIBUTIONS TO CARNATIC MUSIC

1. SRI HARI NAGABHUSHANAM

"Vaggeyakara Ratna" Sri Harnaga Bhushanam garu hails from Krishna district Machilipatnam. He lives in the years 1884 to 1959. He was exponent in Music, literature English and violin. Also expert in Harikatha Kalakshepam. Not only expert in all these aspects he is an advocate.

Nagabhushanam was one of the sishya parampara of saint Thyagaraja. He composed many compositions like kritis and keertanams. In his compositions insted of his mudra saint Thyagaraja mudra occurs more of the compositions. He composed kritis in the raga Bilhari, Saranaga were popular ragas in carnatic music and also he created new ragas like Suddha Bhairavi and Madhava priya.

In the apoorva raga Madhavapriya was his creations.

Some of his compositions like:

Raga - Saranga - Kriti - Vinayakamu vighna - Aditala

Raga - Bilhari - Ninne nammi yunnavada - Rupaka tala

Apoorva Raga:

Raga - Madhavapriya – Madhava priye - Aditala

2. SRI MAHENDRAVADA BAPPANNA SASTRY

Sastry garu hails from Injamuru village Yanam district in Andhra Pradesh state. He was one of the modern Andhra composers. He lived in the years 1904 to 1979. He composed many tana varnas, kritis and javalis. He was a great exponent in manodharma sangeetam of swarakalpana part. He composed 195 compositions in our carnatic music. In these 150 kritis, 30 tana varnams, 15 javalis are there. His compositions are kept in the book "Harihara kriti manjari". He used the mudra "Vijaya gopala, Injaram in his compositions.

Some of his compositions like:

Raga - Mayamalava goula - Kriti - Vinnanura - Kandachapu tala

Raga- Sahana - Kriti - Bharamayana - Adi tala

3.SRI PATRYANI SEETA RAMA SASTRY

Sastry garu hails from Manapullam town near Gudivada, Vijayanagaram distirct. . He lived in the years 1900 to 1957. He was one of the modern Andhra composers. Actually sastry's surname was "sannidhi" but his fore fathers were worked in Navy. In navy soldiers the higher authority people was called "patrayadu" because of that sastry's surname was changed to "patrayani". In his child hood Sastry garu spent with his grand father, at that time he learned "Bala Ramayanam" and by-heart the Balaramayanam. This is only the Sastry gari preliminary education. His father was a well known musician. His father taught to sastry garu. He shifted to barampuram. At the age of 16 years sastry garu started writing his own compositions. After 16 years of age Sastry garu settled in saluru. He father Narasimha sastry garu called as "pedda guru of saluru and Sastry garu was a small guru of saluru. His father and sastry garu both are popularize the saluru gurus. He composed 30 kritis in is compositions some of swarajatis, kritis, varnam and javalis also.

Some of his compositions like:

Raga - Hamsadhwani - Kriti - Gananada smarana - Adi tala

Raga - Smurti ranjanai - Kriti - Ihapara sadhaname - Adi tala

Raga - Mukhari - Kriti - Nanda nanda - Adi tala

4. SRI TADEPALLI VENKATA SUBRAHMANYA SASTRY

He hails from "Peravali" village. He lived in the years 1918 to 1989. Professionally he was a teacher and also a graded artist in All India Radio. He composed 700 compositions on different Gods and Goddess. Sastry garu introduced 500 new ragas to carnatic music. He composed 72 melakarta ragas also. He wrote 2 harikatas namely "Thyagaraja Vijayam" and "Kusuma Haranatha Charitram".

Some of his compositions:

Raga - Naata - Kriti - Vighna nivarana vinayaka - Adi tala

Raga - Todi - Kriti - Yenni Nallaku Kaligeno - Rupaka tala

Rare Raga:

Raga - Vimali – Kriti - Visuddha chakra nilaya - Rupaka tala

One of his compositions he has created Rare raga (Apoorva Raga) name "Vimali

5. SRI MANUGANTI VENKATA RAO PANTULU

He hails from Kakinada town at Andhra Pradesh state. He lives in the 1902 to 1964. He started music at very early age. He was exponent in concerts. He composed many compositions in carnatic music.

Some of his compositions:

Raga - Pravrutti - Kriti - Neeve gati bhavaneepathi - Adi tala

The "pravrutti" raga is the one of the apoorva ragas in carnatic music. This raga is one of his creations.

6. SRI TUMARADA SANGAMESWARA SASTRY

Sastry garu hails from Bobbili. He lives in the years 1874 to 1931. He was exponent in veena. He was a great vidwan in veena. He attended regular concerts in madras and Thanjavur also. Sastry garu was not only exponent in veena and he was expert in nadaswaram, violin also. He composed many tana varnams also. The Pithapuram asthanam felicitated Sastry garu for his great playing of veena. Sastyi's life was spent in the Maharaja of Pithapuram. He composed many compositions in carnatic music. He was a great guru and he trained music to many students. He used mudra "Sangameswara" in his compositions.

Some of his compositions:

Raga - Kalyani - Kriti - Gananayakam subha gayakam - Adi tala

7. SRI VINJAMURI VARADARAJA IYENGAR

He hails from Guntur. He lives in the years 1915 – 1991. He was a disciple of Sri Tiger Varadachari". He has given many tunes to Annamacharya kirtanas, Sadasiva Bhahmendra, Tumu Narasimha Dasu. He composed varnams, Kritis, Javalis, Tillanas also.

Some of his compositions :

Raga – Manirangu - Javali - Kante Saiga chesenu - Adi tala

8. SRI DR. NOOKALA CHINA SATYANARAYANA

He hails from Visakhapatnam – Anakapalli village. He lives in the years 1927 to 2013 He was a great guru and also Maha Vidwan in CArnatic music. He was one of modern 20th century's telugu vaggeyakaras. He got the greatest award "Padma Bhushan" in the year 2010. He worked as a teacher, Principal in different colleges and universities like S.V. Music College, Tirupati, Telugu University , Hyderabad, Vijayawada – Govt. College as a principal also. He got many awards like Hamsa from Govt. of Andhra Pradesh, Saptagiri Sangeetha Vidwanmani, Sangeeta Nataka Academy awards. He was given performance in all over India. He wrote many books like "Sangeeta Sudha," "Ragalakshnana Sangraham", "Thyagaraja Pancharatna kritis etc. He has released some CDs also in carnatic music.

Some of his composition:

Raga – Madhuvanti - Kriti – Ramakadha sudha - Adi tala

9. M. S. BALASUBRAMANYA SARMA

He hails from Rajahmundry. He lived in the years 1929 to 2002. He was a exponent in carnatic music. He started his performances at the age of 10. He was a All India Radio graded Artist. He worked as a Music teacher in S.V. Music College, Tirupati, Sri Padmavati Mahila University, Tirupati. He got many awards like Saptagiri sangeeta Vidvanmani and Sangeeta Nataka Academy awards also. He has given tunes to many Annamacharya Kirtanas . In these "Kondalalo nelakonna" song was very popular.

Some of his compositions:

Raga - Saraswati - Kriti - Saraswati Namosthute -Rupaka Tala

Raga - Rasikapriya - Tillana -Adi tala

Raga - Vijaya sankari - Kriti - Sri Vijayasankari - Adi tala

Raga - Saveri - Kriti - Karunachudave - Adi tala

10. SRI K. V. N. SASTRY GARU

He hails from Hindupur district the village of Kodipalli. Sastry's childhood he shifted to Kurnool. He completed his preliminary education in his elder brother. He composed varnams, Kritis to carnatic music. In his compositons he used the mudra "Sastry nuta". He preserved his composition in the book "Ragalapana Chandrika".

Some of his compositions Like:

Ragam	- Valaji	- Kriti	- Maruvakanamova	- Adi tala
Ragam	- Sucharitra	- Kriti	- Mahaganapatim	- Khanda Triputa
Ragam	– Amritavarshini	- Kriti	- Bramarambana	- Adi Tala

CONCLUSION

Many modern telugu composers are composed brilliant compositions to our carnatic music. Their contributions and compositions are marveours to carnatic music. This is the effort to have knowledge of these composers and their compositions to the present generations.

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JAVALI: A CARNATIC MUSIC COMPOSITION OF ECSTASY

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Abstract: *There are many musical forms enriching Carnatic Music genre. Some Musical forms, still performed through centuries, which belong to medieval period are Tevaram, Prabhanda-s and Divyaprabhanda-s. During Ancient and Medieval period, Musical forms used for devotional purposes to spread Bhakthi culture. Generally, Musical forms used as a part of temple rituals. Raga, the epicentre of Indian music kept alive through centuries through musical compositions. Later centuries many musical compositions were developed. Musical forms belong to modern period are Sanchari Gita, Lakshana Gita, Swarajathi, Jathiswaram, Tanavarna, Padavarṇa, Kriti, Nottuswara, Utsavasampradaya kirtana, Divyanamakirtana, Padam, jawali, and Thillana. The above-mentioned musical forms composed in Sanskrit, Telugu, Tamizh, Kannada, languages and Manipravala enriched carnatic music heritage. However, Javali belongs to Carnatic Music composition group; it is consider under the category of exotic songs or Light songs. This paper is an attempt to bring out the special features and intrinsic magnificent aspects of the musical form 'Jawali'.*

Keywords: *Javali- Sringara rasa- Nayaka – Nayaki – Sakhi- Mysore Patrons –Urdu Jhali*

INTRODUCTION

There are many musical forms enriching Carnatic Music genre. Musical forms are still performed which belongs to medieval period are Tevaram, Prabhanda-s and Divyaprabhanda-s. During Ancient and Medieval period, Musical forms, used for devotional purposes to spread bhakthi culture. Generally, Musical forms used as a part of temple rituals. Raga, the epicentre of Indian music kept alive through centuries through these musical compositions. Later centuries many musical compositions were developed. Musical forms belong to modern period are Sanchari Gita, Lakshana Gita, Swarajathi, Jathiswaram, Tanavarna, Padavarṇa, Kriti, Nottuswara, Utsavasampradaya kirtana, Divyanamakirtana, Padam, jawali, and Thillana. The above-mentioned musical forms composed in Sanskrit, Telugu, Tamizh, Kannada, languages and Manipravala enriched Carnatic music heritage. However, Javali belongs to Carnatic Music composition group; it is consider under the category of exotic songs or light songs. C.R.Day in his book 'Music and Musical Instruments of the Southern India' (published 1891) says that Javali-s are songs of light and pleasing nature such as love songs, cradle songs, sung during the performance of a peculiar dance called karwar. These songs are comparatively recent introduction first sung by Kanarese musicians of the court of Sivapuri a petty state near celebrated Hampi ruins." According to Day's statement, the Javalis , mostly sung only in the Telugu language in the deep south of India known then as Madras Presidency.

JAVALI AS A MUSICAL COMPOSITION

Javali is one form of musical composition rendered both in music and dance concerts. Javali-s corresponds to the 'Ghazal' of Hindustani music. Javali-s are highly pleasing compositions with a lilting gait and catchy music and over the past 200 years, they have gained wide currency as songs expounding Sringara rasa. They characterized by their relative brevity and amorous themes. Because of their musical excellence and lively rhythm they have become popular not only in dance

music but also as pieces of art music and acquired the status of a much sought after item on concert platform s in the last portion of a concert. The music, although classical, is still of a lighter variety and hence Javali-s are invariably rendered towards the closing stages of concerts. Singing of a Javali at the end comes like a flash and imports on enlivening charm to the entire recital. Composing of Javali shows the talent and aesthetic sense of a composer. There are almost 1,000 Javali-s existing today though only about 50 are popularly performed, renowned musicologist Dr. Pappu Venugopal Rao opined, "Many of them are openly erotic with some even using obscene language accounting for their gradual disappearance from concert platforms as musicians probably felt squeamish about rendering them in public performances.

List of Some Popular Javali-s

SN	Javali	Raga	Tala	Composer
1	Celi Nenetlu	Pharas	Adi	Chinnaya (Tanjore Quartret)
2	Saramaina	Behag	Rupaka	H.H.Swathi Thirunal Maharaja
3	Emi Mayamu	Khamboji	Rupaka	Pattabhiramayya
4	Samayamide	Behag	Rupaka	Patnam Subrahmanya Iyer

JAVALI AS A DANCE COMPOSITION

As an item of dance, the Javali is quite welcome after the long drawn out heavy Music & Dance performance of the Padam. The evolution of Javali traced to the various compositions depicting different shades and patterns of love that over the years emerged on the scene from time to time. Javalis are usually in praise of deities, patrons and rulers. Javali-s are songs of exotic nature composed in lighter vain, they are sensuous in concepts of spirit. The characters -Nayaka, Nayaki and Sakhi- often indulge in banter and good-natured wit and Sarcasm. The characters -Nayaka, Nayaki and Sakhi- often indulge in banter and good-natured wit and Sarcasm. Unfaithful Nayakas are common. Most of the Javalis are composed in the voice of Nayaki or Sakhi and those composed in the voice of Nayakas are rare. In general, unfaithful Nayaka is in the themes of many Javali-s. The Nayika and the Nayaka may be of the Uttama, Madhyama or Adhama type. The nayika may be 'Sveeya', 'Parakeeya' or 'Samanya'. The depiction of the eight varieties of Nayika known as the 'Ashtanayika', based on their expressive form, become integral in the presentation of the Javali-s. Javali-s, mostly portraying three varieties of Nayika, they are,

- The 'vipralabdha', (the betrayed one),
- The 'virahotkanthita' (yearning in separation) ,
- evoking viyoga shringara rasa, 'khandita' (the angry one).

The nayaka involved in the lyrics would often be

- The 'upapati' i.e. married to one and seeking another woman,

- A ‘vaisika’ i.e. who may or may not married, but seeks a woman for a price. He may also a ‘shata’ or a liar.

Unfaithful Nayakas are common in Javali-s. Nayaki or Sakhi sings most of the Javalis and those sung by Nayakas are rare. Javali-s is portrayed diverse moods in different depending on the type to which the Nayaki belongs. The dancer found immense scope to perform Nritta and Nritya for Javali-s.

ORIGIN OF JAVALI

Javali had its roots in the numerous lyrics composed by Giriraja Kavi and other poets in honour of their royal Maratha rule and flowered at the court of the Mysore Maharajas and the palaces of many chieftains’ and Zamindars. It has believed that Javali had its birth in the nineteenth century. While considering the language of Javali, it is worthy of mention that this musical form has been composed in all the south Indian languages apart from Hindi and English. The simple and following language is colloquial bordering on obscenity and sometimes couched in double meaning.

There are different opinions are prevailing about the name Javali assigned to this musical form. From region to region, environment, culture and local language were the reasons for the name differences.

- It is believed that the word ‘Jhavali’ to have been derived from of the word ‘ Jhali’ of the Urdu language.
- In Marathi, the word ‘Jhavali’ means a gesture of the eyes in the language of love.
- The word Javali also be related to the Telugu term ‘Java’, means speed of quickness.
- The term ‘Jhamvali’ was current in the Hindustani music and popular in Mysore during the reigns of Chikkadevaraja Wodeyar and Tippu Sultan and this might have been the forerunner of the name Javali.
- In Kannada ‘Jhavadi’ or ‘Javali’ connotes a piece of poetry. Javala is a kannada term figuring in the BasavaPurana to denote a lay person. Kittel’s Kannada Dictionary, mentions that Javali as a kind of lewd poetry.
- The Conjecture is therefore possible that Javali refers to a musical form liked by the lay people. In this language, Java refers to dawn time. As such, the word Java may imply a love song requiring the Nayaki to come at dawn.
- Jya in Sanskrit connotes the bowstring and its Kannada equivalent is je. "Pode" or "vode" is striking. Jevode is striking a bowstring or danushtankara. As the appeal of the Javali may compare to the danushtankara of Kamadeva, the God of love, it is possible that the rasikas of earlier times called these compositions "Jevode" which later became Javadi or Javali.

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STRUCTURE OF JAVALI-S

Several Javali-s have been composed on the pattern of kriti. Just like kriti, Javali too possesses 3 Anga-s namely Pallavi, Anupallavi and Charanam. ln some Javali-s multiple charanams are observed. In few Javali-s, Anupallavi is omitted. Sahithyas of Javali-s conform to the rules of prosody and are replete with different literary beauties. There are exceptions to this rule. For example the Javali "Sariga Kongu" by Ghanam Krishna Iyer is of two lines, one pallavi and one charanam.

MUSIC OF JAVALI-S

The bright and attractive music is the main uniqueness of Javali-s. The fast rhythm and catchy tunes attracted the people and gain popularity. Javalis have been composed in popular Desi and Bhashanga ragas. Several Javalis are composed in Desi ragas like Behag, Darbari kanada, Desi Todi, Yamunakalyani, Hamirkalyani, Sindhubhairavi, HindusthaniKapi, Pharaz, Jenjhutti, Kamas etc. There are also many Javali-s composed in well-known rakti ragas like Athana, Darbar, Bilahari, Saveri, Kamboji, Bhairavi, Surutti, Kalyani amd Mukhari. Javalis have been set to different thala-s such as adi, roopaka,chapu etc. and rarely we can find Javali-s in Vilomachapu,Tisralaghu,Misralaghu and Tisragathi.

Javali-s composed in several grahams. The Javali 'Sariyemi' in Rupaka tala Composed by Sri Pattabhi Ramayya , Anupallavi and Charnam commenced in Athitha graham. In the Javali 'Chalamela' in raga Nattakurinji set to Rupaka tala composed by Chinnaiah (Tanjore Quartet) Pallavi is in 'Athitha Graha', Anupallavi is in Anahatha (1/2) beat after tala commeneces, and charnam is in Sama graham. In the Javali ' Elaradayane' in Bhairavi raga set to Adi tala composed by Chinnaiah, pallavi is in Athitha graha, Anupallavi is in samam and charanam is in Anagatam. Rhetorical beauties like Swaraksharas, Dwitiakshara prasa, Anuprasa, Antya prasa, Yati, Prasa Yati, etc are figuring in Javalis. Vadi Samvadi aspect is found in many Javali-s i.e. Samayamide- Behag –Rupaka- Pattnam Subrahmanya Iyer , Pallavi commences with Madhyasthayi Shadjam, Anupallavi begins with Madhyasthayi Madhyama and Charanam commences with Madhyasthayi panchama. In 'Vaddaninne – Kapi –Rupaka - Pattnam Subrahmanya Iyer, Pallavi begins with Madhya sthayi panchama and Anupallavi begins with Tarasthayi rishaba.

COMPOSERS OF JAVALI-S

The most prominent composers of Telugu Javali-s were Darmapuri Subbarayar, Pattabhiramayya, Swati Tirunal Maharaja, Tanjore Quartet, Patnam Subramania Iyer, Ramanad Srinivasa lyengar, Karur Chinnadevudu and Dakshinamoorthy, Tirupati Narayanasamy, Tacchur Singracharyulu Brothers, Veena Krishnamachari and Chandrasekhara Sastri, etc.. 90% of total Javali-s is composed in Telugu language. Some Popular Telugu Javali-s

SN	Javali	Raga	Tala	Composer
1	Kanukondini	Subhapanthuvarali	Adi	Pattnam Subrahmanya Iyer
2	Era Rara	Khamas	Adi	Pattnam Subrahmanya Iyer
3	Parulanna Matta	Kapi	Rupaka	Dharmapuri Subbarayar
4	Mosamu jesene	Todi	Rupaka	Chinnayya (Tanjore Quartet)
5	Vani bonthu	Kanada	Rupaka	Dharmapuri Subbarayar
6	Vagaladi	Behag	Rupakam	Tirupati Narayanaswami
7	Entani ninune	Khamboji	Misrachapu	Karur Dakshinamurthy
8	Sari Yemi	Atana	Rupaka	Pattabhiramayya
9	Itu sahasamulu	Saindavi	Adi	H.H.Swathi Thirunaal

Prominent Tamil Javali Composers - Dharmapuri Subbarayar, Pattabhi Ramayya, Periyasami Thooran, Tanjore Sankara Iyer, Velur Kuppusamy Mudaliar, Sri Vijayaraghavan, Madurai Muralidharan, Madurai N. Krishnan, Chithrvina Ravikiran, Karur Sivaramaya , Smt. D. Pattammal..etc

Some Popular Tamil Javali-s

SN	Javali	Raga	Tala	Composer
1	Adi endan	Mohana	Adi	Vellore Narayanaswami Pillai
2	Sanditta Pozhuthu	Saranga	Adi	Chitravina Ravikiran
3	Andarangam	Nalinakanthi	Adi	Madurai R. Muralidharan
4	Vandavazhiyai	Begada	Adi	Vijayaraghavan
5	Ninaindurugum	Mandari	Adi	Chitravina Ravikiran
6	Arivenayya un	Athana	Rupaka	Ghanam Krishnaiyer
7	Undanai Manam	Behag	Adi	Mangam Venkataswami

Prominent Kannada Javali composers – Mysore Sadasiva, Srinatha Vittala, Ananda Dasa, Aliya Lingaraja arsinavaru, Mummadi Krishna Raja Wodeyar, Venkatagiripati, Venkataramanaya, Sri Vasudeavathilavaru, Kavi Nanjundalingana, Sri Guru Chinna viraru, Guru Siddalingaru, Guru Lingaru, Guttalavanadu, Tirupati Saradu, Hallahalli Ramanna, Panduranga, Sri Datta Yatiraja, Basavahosalli vira, Santakavigalu, Sri Ranganatha, etc...

Some popular Kannada Javali-s

SN	Javali	Raga	Tala	Composer
1	Matada baradeno	Khamas	Chapu	Srimati & Sri Parthasarathy
2	Vratavetake	Behag	Adi	Anandadasa
3	Tore Sundarangana	Chenchuruti	Adi	Hullahalli Ramanna
4	Baruvano Barano	Sindhubhairavi	Adi	Srinatha Vithala
5	Idhene Sakhi	Behag	Adi	Venkatadri Samarao
6	Priya matada	Kedara	Adi	Surapurada Anandadasa
7	Manamohana	Mukhari	Adi	Kavi Nanjundalinga

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JAVALI-S IN OTHER LANGUAGES

Some Javalis composed in Hindi and other languages but unfortunately, the name of the composer not found in the book 'Prachina Navinalu' that is published in 1890

SN	Javali	Raga	Tala
1	Giridhara julate	Behag	Ata
2	Manavale gade	Hindustani	Adi
3	Bebabe (Bengali)	Todi	Adi
4	Chalabala Nahi	Hindustani	Adi
5	Galidina re	Hindustani	Adi
6	Digen	Bhairavi	Ata
7	Mohana Rasiya	Behag	Adi

JAVALI-S IN 'MANIPRAVALA' INCLUDING ENGLISH

It is interesting to find out some Javali-s is composed in English and in Manipravala with a mixture of Telugu , English and Tamil.

SN	Javali	Raga	Tala	Composer
1	Oh my lovely lalana	Kharaharapriya	Adi	Karur Sivaramayya
2	My dear come			Karur Sivaramayya
3	What has become of thy Promise*	Purvikalyani	Adi	Pattabhiramayya

*English translation of Telugu Javali 'Nee matale Mayanura'

CONCLUSION

Though Most Javali-s composed in Telugu, oldest Javali-s belongs to Kannada language by Kappani from 18th Century. These Javali-s composed in praise of Lord Nanjundeswara of Nanjunguda. This Javali-s are called as Vairagya Javali-s and manuscripts are preserved in Kannada Research Institute, Mysore University. Javali, considered as an important dance form for 'Sathir' Dance recitals in Temples. However after 'Sathir' developed as Bharathanatyam, Javali is continuing its placement in dance and as a musical form. Role of Veenai Dhanammal and her disciples has mentioned in particular for the procurement and propagation of Javali-s to the present music community. Vina Dhanammal's family learned from Subbarayar about 60 javalis. Dhanammal's sister had a repertoire of Dharmapuri javalis even richer than Dhanammal's. The direct disciples and indirect disciples called Dhanammal School propagated rare padams and Javali-s. Veena Dhanammal made his Javali-s famous through her concerts and her grand-daughter T. Balasaraswati made them the most sought after items in her dance programmes exploring its scope for abhinaya through her expertise.

A large amount of confusion regarding authorship of some Javali-s is perceptible because of the fact that in some cases the same composer had employed different mudras, in other way the same mudra used by different composers. Some Javalis have sangathis. A few musicians occasionally

sing kalpanasvaras for this amorous form. However, in general Javali-s, are Mathu Pradhana Compositions lyrics oriented compositions. Chitta svaras are out of place in Javali-s although Ramnad Srinivasa Ayyangar has introduced a Chitta svara to his javalis "Vega nivu vani rammanave" in Surati raga. There are more than 1000 Javali-s and its lyrics are available now in all four languages including Sanskrit in websites.

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Performing Arts: A significant frontier of the development of India –Africa Relations

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Abstract

International relationship is inevitable for any country and the consequences of international relations reflect on the social and economical growth of a country. The all round development of a realm can be achieved through joined ventures more effectively. Globalization of economy has major impacts on the sphere of human life and it generates the demand of maintaining good international relations. International relations are maintained through multifaceted activities like sports, summits, industrial collaborations and business conferences. Cultural exchange is a universally accepted remarkable technique for maintaining international relations. All the artistic outcome of a society is named as cultural activities or art forms. Performing arts includes music, dance, theatre arts, mime, mimicry, martial arts etc are the natural emphasizes of humanity. The performing art forms are more powerful in delivering the feelings through its efficient method to communicate the expressions than any other medium. It has no boundaries and reflects the social and chronological enormity of a country. Performing art form includes dance, music, drama, mime, martial arts etc… is very much successful in manifesting the cultural and traditional strength of a nation it belongs to. In recent times these performing art forms are playing a vital role in cultural exchange activities. This paper is intended to highlight some key aspects of performing art forms in the development of bilateral relationship between India and Africa

Key Words: Performing Art forms – Dance –Music- Theatre- Bilateral relationship – African culture – African dance music and theatre.

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Introduction

International relationship is essential for any country and the results of maintaining good international relations reflect on the social and economical growth of a country. The all round development of a country can be achieved through joined ventures more effectively. Globalization of economy has major impacts on the sphere of human life and it generates the demand of maintaining good international relations for every nation. During covid -19 disaster and post covid-19 era proved the importance of upholding good International relations. Maintaining good relationship with other nations becomes a crucial requirement for countries like African countries which are in the set course of rapid development. International relations are maintained through multifaceted activities like sports, summits, industrial collaborations and business conferences.

'A Nation's culture resides in the heart and in the soul of its people'

-Mahatma Gandhi

Culture is the reflection of every civilization and it illustrates the style and deeds of life in the past and present. Development of a country is graded through the agenda and policies dedicated for its cultural intensification. Cultural heritage confers face value to a nation. All the artistic outcome of a society is named as cultural activities or art forms. It includes music, dance, theatre arts, sculptural and painting works which are known as the natural emphasizes of humanity. These art forms are more powerful in delivering the feelings through its efficient method to correspond the expressions than any other medium. In recent times these performing art forms are playing a vital role in cultural exchange activities. This paper is intended to highlight some key aspects of performing art forms exercised in the development of bilateral relationship between India and African countries

Cultural Exchange

Cultural exchange is a universally accepted remarkable technique for maintaining international relations.

""Culture is this thing that we can exchange among ourselves as human beings to knock aside our differences and build upon our similarities. Cultural exchange is the ultimate exchange."

-Chuck.D.

Cultural relations and exchange programs are frequently discussed in regional, national and international platforms on various distinctive themes and modes. Top priority is given to cultural exchange activities in the agenda of every nation. Different forms of cultural exchange activities are in practice to facilitate the understanding of social and cultural background of two different countries and to communicate the benevolence. In recent times core theme of cultural aspect performing art forms are given top priority in cultural exchange activities.

Significance of performing art forms

"If we danced and shared music, we'd be too busy en-joy-in' life to start a war."

E.A. Bucchianeri, Brushstrokes of a Gadfly,

An art form which is suitable to perform on the stage in group or in solo, capable to stir a kind of emotion in the mind of the audience is called Performing arts. Performing art forms are the mirror of creativity and inheritance of a society. It has no boundaries and reflects the social and chronological enormity of a country. It is one of the most powerful medium capable to reach the mind of people without any discrimination. Performing art form includes dance, music, drama, mime, martial arts etc… is very much successful in manifesting the cultural and traditional strength of a nation it belongs to. It is the only art form competent to address and attract the attention of entire society from mass to class. Performing art forms are universally used to carry sociable messages to maintain good relationship between nations.

Role of Performing arts in cultural exchange activities

Performing art forms are inseparable from the history and traditional influence of a country. Through the presentation of performing art forms the significance of cultural and historical ethnicity can be straightforwardly conveyed to the audience more successfully than any other means. The bilateral performance of performing art groups' helps both people to understand the cultural heritage of each other's and it is the simplest way to transmit a depiction of the conventions of both countries. The presence of performing art forms in cultural exchange activities brings proximity among people and societies. Example: India – Japan, India – Singapore, etc…

Performing art forms are powerful mediums in conveying messages to the heart of people. It is capable to change the character and attitude of a person from his heart. (Example: Mahatma Gandhi developed a habit of telling truth by the influence of a drama on the story of Harishchandra). Performing art forms are having cultural linkage towards others since every society has its own performing art forms on their pride. Learning of any performing art form is an endless journey which offers additional understandings on its spiritual and religious connections, concepts and values to the learner.

'I regard the theatre as the greatest of all art forms, the most immediate way in which a human being can share with another the sense of what it is to be human being'

- Oscar Wilde

Language is one of the most significant barriers commonly observed in maintaining international relations since every region has its own languages and any communication in other than the regional languages may successful as statement but habitually fails to bring proximity in hearts. But every performing art form is accomplished to convey the communication in a unique manner direct to the hearts. The communication transmitted through feelings involves and administer the feelings of the audience and the message is successfully delivered to the hearts.

Performing arts performances perpetually made the minds of the people to evaluate the idea with the art forms of their own region. It leads to further interest in comparative cram, and further analysis to explore the performing arts of other's. Exchange of themes figuring in theatre, dance and music arena is tentatively exercised mutually and got a massive appreciation. Music dance and theatre arts are common assert for all the nations and every country feels proud for the possession of various art forms in their stride with their own pinch. Aspiration of cultural exchange is not accomplished without the presence of performing arts in it.

Indian cultural Tradition

India has an incredible cultural heritage. A country like India is standing for the plurality and individuality of its ethnicity. India has one of the world's largest collection of songs, music, dance, theatre, folk traditions, performing arts, rites and rituals, paintings and writings that are known as the 'Intangible Cultural Heritage' (ICH) of humanity. India has a lot of classical

performing art forms. These art forms are originated and developed into classical art forms from the different regions of this country. '*Bharathanatyam'* (Tamilnadu) , '*Mohiniattam'* (Kerala), '*Kathakali'* (Kerala), '*Odissi'*(Orissa) , '*Kuchipudi'* (Andhrapradesh), *kathak* (Northern regions), '*Manipuri*' (Manipur) and '*Sattriya'* (Assam) are popular classical dance forms of India. These dance forms are unique and having its own different styles and traditions. The modus operandi of thematic movements, expressions, makeup costumes, accompaniment and mode of presentation differs from each other. Classical Music of India is divided into two major divisions which is *Carnatic music* and *Hindusthani music*. *Carnatic music* is practiced in South Indian states and *Hindusthani music* is in northern region of India. A large number of folk art forms are in practice in India and every region has its own. *Kolattom, Bihu, Aliai –ligang , Bagurumba, Garbha, Tippani, Yakshagana, Kavadiattam , Puliyattom, Mayilattom, Dollukunitha, Cheraw, Girida, Bhanjara, Karagattom,* etc…, are some of the popular folk dance forms of India.

African cultural tradition

"The curious beauty of African music is that it uplifts even as it tells a sad tale. You may be poor, you may have only a ramshackle house, you may have lost your job, but that song gives you hope". *-Nelson Mandela*

African tradition and culture is expressed through many different art forms, such as music, dance, art, sculpture and beadwork. Many African languages are not scripture but "tonal languages. Oral tradition plays a vital role in African culture. The passage of cultural practices like tunes, folk songs, folk traditional stories from one generation to another mostly passed through oral tradition. Listening is an equally important skill, which has been perfected by the traditional oral practices.

Dance and music are the integral part of African culture and tradition. As like in India songs and music accompany in marriages, birth and death rites, hunting and congregations for various occasions. Dance with different masks and dresses used to communicate anger sorrow and joy. The mask in dance is very significant in African society. It is believed that the Holy Spirit will possess the dancer as they wear the holy mask.

India – Africa cultural exchange program

India has more than a three thousand year history of cultural and commercial relations with Africa. Today, Indian communities in Africa constitute 12.37 per cent of the total strength of India Diaspora and they reside in 46 countries of Africa. As a part of Incredible India campaign, India signed a Bilateral Agreement-Cultural Exchange Program with Algeria in October 2003 to strengthen the cultural relations between the countries, under which cultural troupes of both countries exchange their visits.

The **djembe** drum is said to have been invented in the 12th Century by the Mandinke tribe in what is now Mali, in West Africa. It has been played by West Africans for generations forming an integral part of ritualistic life in Mali, Guinea, Senegal and other neighboring West African countries. Algeria sent their cultural troupe named 'Djembe Africa' a cultural group of drummers and dancers to India during the India-Africa Forum Summit in New Delhi in April 2008, another 32-member ballet troupe in December 2010 and an Algerian classical music group participated in the India-Africa Forum Summit held in Addis Ababa in May 2011.

The significant role of exercising Performing art forms in summits is clearly perceptible in the India- Africa Forum Summit conducted in New Delhi in the year 2015. It's a union of cultures, shared histories and entwined dreams. Blend of the ancient sounds of African drums and sufi songs from Egypt with classical Indian dance, Vedic chants and Bollywood music, the India-Africa Forum Summit pulsated with creative energies of Indian and African artistes. It is mentioned in the summit report that the summit kicked off with a magnificent multi-media cultural programme, which included 'Chants of Faith', seeking blessings for the revitalization of India and Africa.

Vedic recitations mingled with African song Kealebog, expressed India's diversity and Africa's awakening. The show concluded with One Beat, One Rhythm and One Vision of a radiant future of Africa and India. The Rashtrapati Bhavan shone with a captivating spectacle of Indo-African fusion music and dance at the end of the summit on October 29. The gala show, which artistes from Africa and India in a celebration of shared culture, was staged before the leaders of African countries at the presidential banquet, and elicited a rapturous applause.

In the run-up to the summit, a host of cultural events were organized that brought out ancient and modern cultural connections between Indians and Africans. The cultural synergy rippled forth at the music-and-dance shows staged at the dinners hosted for senior officials and ministers ahead of the summit. The utilization of Performing art forms of both the countries help to change the mindset positively and respect towards the others.

India celebrated the carnival spirit of Africa at the 'Welcome Africa' concert in Nehru Park in Delhi on 2015, As a Part of Delhi International Arts Festival, in the evening with an enthralling performance of Sufi rock and Ghana-based musicians, who effortlessly mingled traditional African percussion music with Hindi songs. Ghanaian performers had the crowd dancing with their renditions of popular Hindi songs. The dance group from Ethiopia wove a magic spell, with many in the audience joyously joining in.





Indian performing arts in Africa

In African countries especially in South Africa to understand and appreciate Indian dance as we know it today, it is essential to precede this with a brief discussion on the living conditions of Indians during and after the indenture period. The accommodation Indians were offered was extremely primitive. The “coolie barracks” were overcrowded and soon became slums. Working hours extended from 6am to 5pm. On Saturdays work stopped at 1 pm, after which rations were handed out.

Suffering and unhygienic living conditions gave rise to a “high degree of diseases and illnesses”. Because of the drudgery experienced in their daily lives the early immigrant hungered

for diversion and recreation. Although the Indentured labourers were considered illiterate by the British colonialists, they certainly did not lack a quest for religion, music, song and dance.

Indian dance, particularly Bharatha Natyam and Kathak, was not introduced in South Africa for many decades following the arrival of the early Indian settlers. The early dance forms that did exist then were known as North Indian Nautch (a light lilting dance style) and the South Indian dance drama, the Therukoothu. Performances were presented in open grounds, under shaded trees and under crudely constructed shelters with only a demarcated area for a stage.

The Therukoothu or "street dance" had its beginnings in the ancient popular mode of story-telling. During the post-harvest period in the rural areas there existed a "lull" in the lives of the early Indians, and religious education in the form of storytelling was pursued fervently. The performers were only men who also played the roles of women. The earliest performances of this dance form began in Mount Edgecombe along the North Coast of KwaZulu Natal, and were part of the annual religious celebrations known as Thirunaal, which means "Festival Day"

Since the first batch of Indentured labourers were mainly from South India, and from an agricultural background, Therukoothu. This folk art form made its appearance in almost all Indian settlements on sugar estates in South Africa.

However, before the pursuance of the ancient classical dance styles of Bharatha Natyam and Kathak in South Africa, many folk styles emerged during Hindu festivals, highlighting socio-religious festivals such as Navarathri, Deepavali, Krishna Asthami. At the popular social events like Harvest festivals (Pongal) and wedding celebrations, folk dances such as the South Indian Kummie, Kolattam and and the Gujarati Garbas were performed respectively. Since Natal had the largest Indian population, localities such as Pentrich, Pietermaritzburg, and the suburbs of Clairwood, Overport, Mayville,Cato Manor, Stella Hill, Puntans Hill, Riverside, Seaview and Central Durban became centres of cultural activities. Further afield, Indian Culture thrived in regions like Port Elizabeth, East London, Kimberly, Fordsburg,Vrededorp, Benoni, Germiston and Pretoria.

Classical dance forms particularly Bharatha Natyam and Kathak were not introduced into South Africa for many decades following the arrival of the early Indian settlers. Between 1860

and 1940 these classical forms were virtually non-existent. Based on the premise that Bharatha Natyam suffered a decline in status in India and that only after the 1930s was there a resurgence of this ancient temple art, could be a reason for the interest and subsequent introduction of this art form to this country,

Today, classical dance, both Kathak and Bharatha Natyam, has evolved into a fine art form and can claim a status of its own amongst all other performing arts both nationally and internationally. There are numerous schools where Indian dance is being taught and the interest has continuously gained momentum since its inception .It must be noted that in the face of numerous obstacles experienced by Indians in South Africa, they fervently pursued an art form that was beyond the boundaries of the host country. It would appear that a shift in place and time would not deter their quest in maintaining and perpetuating a cultural heritage so steeped in religious-ritual and aesthetic character. Perhaps this is one of the reasons for the classical dance Bharatha Natyam to have successfully earned the reputation of being the most popular in African countries.

On seeing the dance recital by Kalakshetra organized by ICCR in South Africa, Ms. Verushka Pather, a Bharatanatyam dancer from South Africa impressed at her age of five and started learning Bharathanatyam at the local dance school under the tutelage of Smt Savitri Naidu. She had her ‘arangetram’(first stage performance) in 1998 and family members from South Africa and Japan came India to watch her dance recital. Verushka has got the golden opportunity to perform at the Tirumala Tirupati Devasthanam for the Brahmotsavam. A few years ago, she showcased her own production Sri Krishna Leela in India and she also revived the tradition of temple dancing. She organized a temple dance tour (with the help of Tamil Nadu government) in South India. Verushka is also collaborating with an African dancer for a show that will be a fusion of Bharatanatyam and African contemporary dance. Verushka is one of the finest example to understand the status of Indian performing art forms in African countries.

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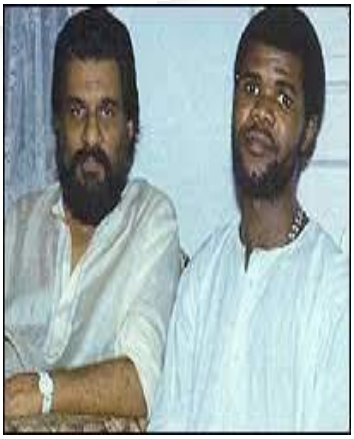


In 1994 the Surialanga Dance Company of Durban was invited to present 'a gift of art' to the first democratically elected pren sident of South Africa. The cultural part of the inauguration celebrations took the form of a programme entitled 'Many Cultures, One Nation'. The theme was welcomed by the company whose prime objectives included intercultural experimentation and empowerment through dance. The company consisted of trained Indian classical dancers, most of whom had graduated from different schools of dance from Durban and its surrounding areas in KwaZulu - Natal. Those members of the company who had been through a full training programme were entitled to teach the ancient art of Bharathanatyam, one of the four main classical dances of India.

Patrick Ngcobo was another classic example for influence Indian performing art forms on African countries, Mr. Patrick born in Durban, and was a Zulu Singer, He learned classical music from Padmasri Dr.K.J.Jesudas and performed and organized many programs in South African Lotus FM Radio.







In July 2016, our Indian Prime Minister, Sri Narendra Modi Visited a 5 day tour to African countries. In this picture it is evident that Indian Prime minister playing drums to pay respect to the traditionalistic aspect and culture of Tanzania. This is a typical example for exercising of Performing arts in cultural exchange and bilateral relations.





Conclusion

"For Africa and India, diversity is our lifeblood; it enriches us and makes us even stronger. It ensures that we value coexistence, dialogue, mutual understanding and peace. These are perspectives on the human development that India and Africa share, these are perspectives that we can together contribute to the rest of the world for handling conflicts and crises."

-Ex-President Pranab Mukherjee

International cultural policy focuses on cultural diplomacy: using art and culture to benefit international relations. To participate in the formulation and implementation of policies and programmes relating to India's external cultural relations, to foster and strengthen cultural relations and mutual understand between India and other countries. It is also intended to promote cultural exchange with other countries and peoples; to establish and develop relations with national and inter-national organizations in the field of culture;

After three successful summits, India extends its hand to strength the relationship with Africa by opening of 18 embassies in 18 African countries including Rwanda, Republic of the Cango, Eritrea, and in Liberia. The bilateral trade value reached 100 billion in the FY 2022-23.

India and African countries have vast history and tradition. They both have various diversities in tradition, language culture and ethnicity. Both are having their own traditional dance, music, art and sculptures. The friendship among these two countries is now closely observed by the global giants. It is clearly perceptible both the countries are trying to get closure to each other by exposing their cultural strength and vast historical ethnicity by exercising their own performing art forms in cultural relation programs and summits keeping the successful development in vision.

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THE CONCEPTION OF MIND IN INDIAN PHILOSOPHICAL PERCEPTIVE

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Abstract : In this paper I would like to discuss the place of mind in philosophical systems of India is briefly discussed. The philosophies selected are - Upanishads, Six systems of philosophies (saddarsanas), That mind is only an instrument of knowledge it is the internal sense-organ directed by the *Atman It is full of its content such as struggle, unhappiness and misery. Mind is full of symbols and images. It has collected its content through its experience. It is completely under the pressure of greed, jealousy, fear, imitation and obedience. So the mind is deformed and damaged. It is the storehouse of knowledge and memory.*

Keywords : Upanisads, saddarsanas, *Atman* and Indian Philosophy

The nature of mind and its constituents have been agitating the minds of philosophers for a long time. There have been various theories about the mind. But there is no doctrine that is completely satisfactory. Each theory conflicts with the other. Often the point of difference centre round the relation between mind and body. There are theories which are not only different from each other, but contradict each other. Either the mind is made subservient to matter or vice versa. Consequently many problems of perception and will are still being debated. Many thinkers have differentiated mind from body on the one hand and equated mind with the self on the other. If mind is pure body then the problem of will cannot be solved. If it is pure self, the problem of physical perception remains unsolved. Mind and body, as Ryle says, do not lend themselves to disjunctive treatment.

The Upanisads maintain that what are the necessary for knowledge is neither mere senses nor their proper functioning in conjunction with *manas*, but the Self which perceives through these. The self is often called either *prana* (breath) or *prajna* (intelligence). This is given in the form of a story. There is a dispute between the senses, *manas* and life as to superiority. The principle formulated is that which is most essential for existence is supreme. Each sense in turn leaves the body, and finds that for the existence of the body, it is

not essential. Finally, when the turn came for breath to leave the body, it was established that all others could not be without breath.

The mind is the internal sense-organ directed by the *Atman.* The mind directs the other sense-organs. This is revealed in the parable of the chariot in the Katha-Upanishad. A comparison is drawn between the chariot and man. *Atman* is the lord of the chariot. It is the enjoyer of the fruits of activity. Devoid of the *Atman*, the body has no meaning. This body is drawn into various channels of activity by the senses which are comparable to the horses. But the charioteer is the *buddhi* or intellect. It holds the reins which is *manas* and thus controls the horses. Here the word *manas* is used in a very restricted sense to mean only the characteristics of volition and doubt. And *buddhi* is used to mean intelligence.

According to Krishnamurti' *manas* is only an instrument of knowledge. The Self in Indian psychology has taken a different line of development than that of western psychology. The Self is that which is beyond the workings of the mind. So the aspects of *manas* and its working are described in great detail in the Upanisads. The cognitive aspect of mental life receives a great deal of attention. It is by the mind that one attains knowledge. Aitareya Upanisad says that the heart is the seat of the mind. We have various references to this in the Upanisads. If we examine some of the theories given by western thinkers regarding the seat of the mind, such as the Cartesian pineal gland, and the more common identification of the brain with the mind, this theory of the Upanisads does not at all sound absurd. The heart is the central organ on which the life of an organism depends. Without the heart there is no life, and similarly without mind there is no knowledge. The bodily functions such as movement and sensation are dependent on the working of both heart and mind. Hence the Upanishads maintain that the heart and the mind are fundamentally one. Because of the essential unity of the heart and the mind, they act together and perception is made possible.

The Nyaya and Vaisesika theories of *manas* are to a large extent similar and also identical. Although the Vaisesika Sutras lay their emphasis on the ontological aspect, the Nyaya Sutras emphasise, the epistemological aspect. Both these systems reflect the ideas of *manas* that are given in the Upanishads. As in the Upanishads, they do not regard *manas* the same as soul or *Atman*. They strengthen this idea by logical arguments. They prove that *manas* is material. According to the Vaisesikas *manas* is one of the categories, *dravyas* or substances. *Draya* is one of the categories or *padarthas*. A substance is that which has qualities. Soul or *Atman* is a substance, though spiritual in nature having spiritual qualities like intelligence. *Manas* is similarly one of the substances. The interest in *Atman* is here twofold. Negatively, it is shown that mind is the internal organ serving as the instrument of knowledge for the soul. Both the Nyaya and the Vaisesika systems maintain that *manas* is different from *Atman*.

Kanada gives us reasons which seek to prove the existence of *manas*. Both Nyaya and Vaisesika rely on the important factor of "attention" in their proof for the existence of *manas*. The dependence of intellectual activities, whether they be perceptual or conceptual, on attention is stressed and from this the instrument of intellection is inferred. The Vaisesikas have been led to acknowledge the existence of manas, because of the fact that though the sense organs are functioning, the self does not get any knowledge of the object. *Manas*

must be in contact with the object through the medium of the sense organ on the one hand, and with the self or the atman on the other hand. The sense-organs might be in contact with the object and the *manas* with the soul: still, if there is no contact between *manas* and the sense-organ, no knowledge can arise. That is why, though objects are before us, we do not see them: though sounds are heard we do not hear them i.e., get their meaning and understand them. *Manas* is occupied elsewhere and that the object on which the *manas* is concentrated or attending that alone is cognized by the Soul.

The Prabhakara Mimamsaka proves the existence of mind by pointing out that the qualities of the self such as buddhi, pleasure, pain, etc., would never become manifest but for the activity of the mind. The contact of the mind with the soul is necessary before cognition can take place. This mind along with the other five organs of perception constitute the six sense-organs. Internal organ of sense acts as the co-ordinator for the functions of the other external senses. It is the only way of perceiving mental states such as pleasure, pain, etc. The Mimamsa proves that the mind is atomic by arguing in the following way. Everything requires two kinds of causes, the material and the immaterial or the effective cause. The immaterial or effective cause always takes the form of either circumstances or qualities which by contact with the material cause produces the given effects. In the case of cognition, soul is the material cause because cognition is a specific quality of the soul. This atomic substance or the mind must also reside in the body, as otherwise no contact with the soul is possible. Mind is such an atomic substance. It by itself has no color or smell, but can bring into existence these things by contacting the organs such as the eye and the nose on the hand and the Atman on the other hand.

The Samkhya and Yoga theory says that there are three fundamental characteristics which are seen in everything that is experienced and they are *sttva* (intelligence stuff), *tamas* (mass and interia), and *rajas* (energy). *Prakrti* is defined in the Samkhya Sutras as "Primal matter which is the state of equipoise of *sattva*, *rajas* and *tamas*" (*Sattva-rajas tamasam-samya-vastha prakrtih*). Primal matter of *Prakriti* is nothing else but these three. But it does not mean that these are qualities which are to be found in a substrate which act as their receptacle.

The primal matrix, because of the proximity of Purusa who is pure intelligence, begins to create. The first product of creation is *mahat* or mind. This consciousness stuff, satta-matra, is the pure *sattva* where as *rajas* and *tamas* exits as subordinate elements. This is that which in its course creates two different aspects of our experience, viz. the material and mental. Vijnana Bhikshu characterizes this *mahat* as mind or *manas* in the sense that its function is thinking which is determinative in character. Thinking here means *niscaya* or judging.

In the Samkhya karika, we find a verse which not only says that "ascertainment is intellect" but also differentiate between two varieties of it. The Gaudapada Bhasya on the first part of this Sutra says,…"as in the seed the future germinating shoot is contained, so is determination (in intellect). This is a jar, this is cloth: that intellect which will so determine is to be so defined".

For Sankara the two words *manas* and *antahkarana* are interchangeable but due to division of functions, the same *manas* is referred to by various names as *manas, buddhi, ahamkara* and *citta. Manas* or *antahkarana* by itself is that which refers to the past, present and the future. This internal organ is that which controls and rules over the other organs of sense-perception. It is the apperceptive agent. In support of this Samkara says that *budhi*, which is the determinative aspect of *antahkarana*, is understood in five ways, corresponding to the cognitive organs. These along with the five *karmendriyas* are under the control of *manas* which is the chief indriya. It is problematic here whether Samkara meant the *manas* to be a sense-organ since *buddhi*, an aspect of the *antahkarana* is involved with the *jnanendriyas* during the process of perception, or whether he meant *manas* to be merely a co-ordinating factor, not having anything directly to do with the sense activities. *Manas* may be considered as that which co-ordinates the organs of perception and the organs of action. This would be something like the theory of the western physiological-psychologists who say that the motor and sensory impulses are controlled and directed by the brain which is the seat of the mind. The different aspects of the mental activities as given in the *Brhadaranayaka Upanishad* are here accepted by Samkara.

According to Krishnamurti mind is conditioned by past. It is full of its content such as struggle, unhappiness and misery. Mind is full of symbols and images. It has collected its content through its experience. It is completely under the pressure of greed, jealousy, fear, imitation and obedience. So the mind is deformed and damaged. It is the storehouse of knowledge and memory. Memory is material structure built in the brain by thought. A mind that is burdened with memory cannot possibly understand that which is real. Krishnamurti says, “Reality is not a thing which is knowable by the conditioned mind because the mind is the result of the known. Therefore the mind must understand itself and its functioning. Only then is it possible for the unknown to be.

Mind has to be free the past from at the psychological level. The understanding of the complications of the mind is the only factor of freedom. Freedom happens to be when there is the fundamental change in the psyche. It is the liberty of the mind from inner contradiction. Freedom liberates the mind from all formulas, from all constraints. It belongs to the realm of the unknown. Thought is useless to understand the unknown. It should realize the fact that it cannot work in the area of the unknown. It works only in the field that is already known to it. Thought has to realize that it cannot operate in the areas of the unknown. This is the only Truth that brings about a radical revolution in the brain cells, truth is the only liberating factor. The mind that does not perceive this will ever be in bondage. The panaceas, disciplines, sacrifices have no value in relation to truth.

Thought arises out of the past. It is a material process. Thought is the source of pleasure and fear. It records the past events and gives validity to them by giving them continuity. It is a measurement and comparison in terms of high or low, good or bad. Thought as measurement is a movement in time. It creates time by creating the picture of tomorrow. Thought having registered the biological pleasure or pain creates tomorrow of having or not having it again. Thought meets everything with a forced conclusion. It wants to

become something psychologically in time. Since thought implies time, the result of the past, it cannot know the truth which is ever new.

Thought is the cause of human predicament. It invents an ideal, the 'what should be' in order to be free from predicament. But the ideal is never obtained, since it is the result of desire. Mind must celibate itself without having any end in view. It must shed its hopes, knowledge, fears and all the content that is built by thought. It has to wipe away all the psychological accumulations. It must be unique by itself. Actual uniqueness lies in the discovery of what is true. This real individual uniqueness is not to be found in possessions either material or spiritual. It is to be found in understanding oneself by oneself. This uniqueness which is freedom comes through self understanding. Celibacy is to have a mind that is free from all images. It means understanding the whole process of fear and pleasure.

The mind is a store-house of memory. It is full of its attachments. It is dead with the weight of the past. One has to brush aside all the marks that experience has left on the brain cells. Then there comes an immense space in the mind. Death is the ending of all attachments to things, ideas and people. Death means the ending of the known, the cessation of all images. It is the ending of all the memory at the psychological level. It is possible only by submitting oneself to what is. One has to end the memory everyday that is acquired. According to Krishnamurti it is only when we die each day to all that is old that there can be the new. The new cannot be there where there is continuity. The new is the creative, the unknown, the eternal, or God. The conditioned mind cannot be the abode of freedom. It cannot meet the psychological death, the Unknown. The conscious part of the conditioned mind is at work in all daily activities. The conscious part of it is full of images. We try to bring transformation at the conscious, superficial layers of the mind. Our mind is keeping on with our hidden motives and formulas. The conscious mind is accustomed to respond according to the intensions of the unconscious mind.

In freedom the old mind with all its burden of knowledge comes to an end and so there is the beginning of the new mind which is spacious and empty. The empty mind is an innocent and sensitive mind. The new mind knows the art of observing, listening and learning. Art means putting everything in its right place. The new mind is not occupied with anything. The new mind is a perceptive mind. Perception is seeing the fact with one's whole being. It is seeing with a heart and mind which are completely cleansed of the past. The new mind is an attentive mind. Attention means the cessation of the psychological distance between the observer and the observed. Gandhiji's says that attention means complete attention, of the body and the psyche. The free mind is a religious mind which is not conditioned by its environment. The religious mind creates a holistic world, not the world of the Communist or the Capitalist, not of Brahmins or Roman Catholics. Religious mind demands a great honesty and a great sense of humility. It is not caught in experience and does not work for a belief or ritual. Religious mind has neither motive nor an end in view. It is an orderly mind which is true in itself. Being factual the religious mind understands the total quality of thought. So it is devoid of conflict, fear and authority. The religions mind is full of love in its true sense. Life devoid of true love is like a flower without fragrance. It is like the earth that has never grown a tree, a bush or a flower.

Religious mind does not belong to any cult, group or organized religion. It is not the Hindu mind, the Christian mind, the Buddhist mind or the Muslim mind. It is not the mind that goes to churches, temples or mosques. It does not entertain any from of belief or dogma. It does not belong to any group, sect, belief or church. Therefore it is capable of looking at things directly and understanding them immediately. It is a light to itself.

The religious mind is not fragmentary. It deals with facts, with what is actually happening in the world. It is capable of creating the true human being. A true human being is one in whom the scientific spirit and the true religious spirit go together. A true human being is one in whom there is a great honesty and a great sense of humanity. The religious mind is an orderly mind which is true in itself. It does not have any type of goals. It is utterly attentive to all outward and inward action. It is something entirely different from the mind that believes in an organized religion. It has a great sense of beauty which forms the basis for right relationship. Like a mirror it reflects the world within and the world without any distortion. Whereas the conditioned mind distorts the actuality according to the dictates of its own conditioning. The conditioned mind is full of images, hidden fears, urges and frustrations. It works like a photographic plate on which images have been permanently impressed. Whereas, the liberated mind works like a mirror in two way. Firstly, there is no distortion in its perception. It sees things exactly as they are. Secondly, there is no pathological accumulation of images in it. There is neither the thinker nor the images. It does not consciously eliminate the images. But the images eliminate themselves of their own accord instantaneously and effortlessly. The liberated mind is characterized by this quality of dying.

Conclusion

According to Indian Philosophical perceptive the human mind does not confine the human being to the conditioned mind. The human mind is limited to consciousness as we know it to be. The conditioned mind constitutes only a limited part of the brain. He is against the idea that there is nothing beyond the conditioned mind which is in utter confusion. He holds that there is an absolutely free mind beyond the conditioned mind. A radical transformation of the limited mind brings about the free mind. He says, “I realize that thought and thinker are very limited and I do not stop there”.

Transformation of the mind is possible when the conditioned mind is aware of itself without choice. Awareness should be devoid of choice, for choice is the product of the conditioned mind; choice is the movement of thought; there is no choice without the past. Awareness is observation in which the mind observes its nature without the observer.

Awareness is to be without the observer since the observer is the residue, the refuge, of the mind only; the observer is the thinker ‘who’ is thought itself; the thinker is only a modified continuity of thought. Awareness is alert passivity wherein the mind ‘holds’ the totality of the content without any remnant. In awareness the mind perceives the actuality of itself and realizes its truth. “Awareness is a state of being, in which truth can come into being, the truth of ‘what is”.

Radical transformation of the mind happens to be only when the mind directly faces the fact of its being totally. It takes place when the mind comprehends the fact of its being totally. An absolute observation of the fact of its structure brings about a radical transformation in the mind. He says, that the "Facts, if one observes carefully, in themselves bring about a change". But the mind always avoids the "understanding" of the fact of itself by verbalizing, justifying or condemning it: it prevaricates through the process of agreeing, disagreeing, affirming or denying. It deviates itself from the 'what is' of itself by interpreting, comparing or concluding it; it distorts the fact by suppressing, modifying or resisting it. The mind does not realize but only moulds the fact by identifying or recognizing it according to its own conditioning. The activities of verbalizing, justifying condemning and so on are only the movements of the mind in a modified from. Instead of bringing about a real change in the mind they merely manifest the mind in several different ways. They are the subtle means through which the mind chooses to continue itself endlessly.

The intelligent mind is a perceptive mind it does not experience but perceives the 'what is'. The conditioned mind experiences the 'what is' through knowledge, thought and time. Whereas the perceptive mind 'sees' the 'what is' from moment to moment. Its perception is without knowledge, thought and time. Perception is not experience. Experience is continuous whereas perception is momentary, without beginning and end. The first perception is the last perception. There is a total gap between two moments of perception. The one is not the continuity of the other. 'Perception, is like the light of a candle which has been put out and relit. The new light is not the old, though the candle is the same". The perspective mind 'sees' clearly the truth or the falsity of the 'what is' and dies to it completely. It does not reduce the moment of perception to memory by verbalizing it. It does not translate it in terms of thought. It does not create the continuity of the causal chain of the moments.

Only two things are significant for the free mind – intelligence and biological survival. Intelligence uses the factual thought strictly for biological survival. It guides thought in a proper direction and confines it to the physical realm. It does not allow thought to enter the 'psychological' world. It does not disturb the emptiness which is the foundation for harmonious human relations. It also forms the basis for peaceful so-existence of humanity. In freedom thought works 'though' intelligence, just as the sound of the drum is produced out of emptiness. Thought confines itself to technological realm. In freedom thought functions in the world with sanity, without going astray. It promotes a sustainable development of humanity. Intelligence is the only way of living a meaningful life. Bereft of intelligence life is absurd, full of problems. Intelligence is bliss which knows no sorrow. It is not touched by any of the human emotions or qualities which the conditioned consciousness is subjected to. So there are only two things left. The highest from of intelligence and survival which is entirely different from animal survival. Only then will humanity be good both at the technological and at the psychological level.

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The Historical Background of Patanjali Yoga

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Abstract

In this paper we discuss historical background of yoga, The science of Yoga is a psychology of a philosophical nature. The very introduction of the system of Yoga by Patanjali is by way of an instruction that the mind has to be controlled – Yogahs-chitta-vritti-nirodhah. Patanjali does go into the details of the philosophical background of the necessity to control the mind, the background that comes in Samkhya Indian philosophy. Simply explains that Yoga is control of the mind, restraint of the mind-stuff. Yoga is an experiential science. The most important benefit of yoga is it balances our physical and mental conditions.

Keywords : *yogah cittavritti nirodhah, Indian philosophy and Astanga-marga*

Yoga is one of six schools of Indian philosophy. These are Nyaya, Visheshika, Mimasa, Sankhya, Yoga, and Vedanta. A brief review of those six schools or systems will easily clarify the true nature of authentic Yoga being a system of spiritual pursuit. The word Yoga, in Sanskrit, has the meaning of "yoke", from a root yuj, to unite. To unite the body, mind, and soul to become one. Yoga is a physical work out with the mental benifits of calming and relaxing the mind. Together with the work of the body using asanas, (postures) connecting with our breath using the practice of pranayama.

As per Yogic scriptures the practice of Yoga leads to the union of individual consciousness with that of the Universal Consciousness, indicating a perfect harmony between the mind and body, Man & Nature. According to modern scientists, everything in the universe is just a manifestation of the same quantum firmament. One who experiences this oneness of existence is said to be in yoga, and is termed as a yogi, having attained to a state of freedom referred to as mukti, nirvana or moksha. Thus the aim of Yoga is Self-realization, to overcome all kinds of sufferings leading to 'the state of liberation' (Moksha) or ‘freedom’ (Kaivalya). Living with freedom in all walks of life, health and harmony shall be the main objectives of Yoga practice."Yoga” also refers to an inner science comprising of a variety of methods through which human beings can realize this union and achieve mastery over their destiny. Yoga, being widely considered as an ‘immortal cultural outcome’ of Indus Saraswati Valley civilization – dating back to 2700 B.C., has proved itself catering to both material and spiritual upliftment of humanity. Basic human values are the very identity of Yoga Sadhana.

Historical development of Yoga

Yoga is one of the oldest sciences of the world originated from India, which is very useful for both getting and maintaining the physical, mental and moral health. This yoga was started with the development of civilization. According to one of the classical texts of yoga known as Hatha yoga pradipika, Lord Shiva is the first teacher of yoga, where as Bhagavad-Gita tells Lord siva is the first teacher of yoga. Some historical researchers have proved that yoga was present during the time of Vedas. After the period of Vedas, a great sage Maharshi Patanjali systematized yoga, its meaning and its related knowledge through his Patanjali yoga sutras. After the Patanjali, many sages contributed greatly to the field through their practices and literatures.

*" **yogah cittavritti nirodhah** "*

"Yoga is the cessation of movements in the consciousness"

Yogameans union or integration from the outermost layer to the innermost self, that is, from the skin to the muscles, bones, nerves, mind, intellect, will, consciousness and self.

Cittameans consciousness, which is made up of three factors: mind (manas), intellect (buddhi) and ego (ahamkara). Citta is the vehicle of observation, attention, aims and reason; it has three functions, cognition, conation or volition, and motion.

Vritti means state of mind, fluctuations in mind, course of conduct, behaviour, a state of being, mode of action, movement, function, operation.

Nirodhahmeans obstruction, stoppage, opposition, annihilation, restraint, control, cessation.

Yoga is defined as restraint of fluctuations in the consciousness. It is the art of studying the behaviour of consciousness, which has three functions: cognition, conation or volition, and motion. Yoga shows ways of understanding the functioning of the mind, and helps to quieten their movements, leading one towards the undisturbed state of silence which dwells in the very seat of consciousness. Yoga is thus the art and science of mental discipline through which the mind becomes cultured and matured.

This vital sutra contains the definition of yoga: the control or restraint of the movement of consciousness, leading to their complete cessation.

Citta is the vehicle which takes the mind (manas) towards the soul (atma). Yoga is the cessation of all vibration in the seat of consciousness. It is extremely difficult to convey the meaning of the word citta because it is the subtlest form of cosmic intelligence (mahat). Mahat is the great principle, the source of the material world of nature (prakriti), as opposed to the soul, which is an offshoot of nature. According to Samkhya philosophy, creation is effected by the mingling of Prakriti with Purusa, the cosmic Soul. This view of cosmology is also accepted by the yoga philosophy. The principles of Purusa and prakriti are the source of all action, volition and silence.

Words such as citta, buddhi and mahat are so often used interchangeably that the student can easily become confused. One way to structure one's understanding is to remember that every phenomenon which has reached its full evolution or individuation has a subtle or cosmic counterpart. Thus, we translate buddhi as the individual discriminating intelligence, and consider mahat to be its cosmic counterpart. Similarly, the individuated consciousness, citta, is matched by its subtle form cit. for the purpose of Self-Realization, the highest awareness of consciousness and the most refined faculty of intelligence have to work so much in partnership that it is not always useful to split hairs by separating them. The thinking principle, or conscience (antahkarana) links the motivating principle of nature (mahat) to individual consciousness which can be thought of as a fluid enveloping ego (ahamkara), intelligence (buddhi) and mind (manas). This 'fluid' tends to become cloudy and opaque due to its contact with the external world via its three components. The sadhaka's aim is to bring the consciousness to a state of purity and translucence. It is important to note that consciousness not only links evolved or manifest nature to non-evolved or subtle nature; it is also closest to the soul itself, which does not belong to nature, being merely immanent in it.

Buddhi: possesses the decisive knowledge which is determined by perfection and experience. Manas gathers and collects information through the five senses of perception, jnanendriyas, and the five organs of action, karmendriyas. Cosmic intelligence, ego, individual intelligence, mind, the five senses of perception and the five organs of action are the products of the five elements of nature – earth, water, fire, air and ether (prthvi, ap, tejas, vayu and akasa) – with their infra-atomic qualities of smell, taste, form or sight, touch and sound (gandha, rasa, rupa, sparsa and sabda).

In order to help man to understand himself, the sages analysed humans as being composed of five sheaths, or kosas. They are annamaya, pranamaya, manomaya, vijjnanamaya, anandamaya.

The first three sheaths are within the field of the elements of nature. The intellectual sheath is said to be the layer of the individual soul (jivatman), and the blissful sheath the layer of the universal Soul (paramatman). In effect, all five sheaths have to be penetrated to reach emancipation. The innermost content of the sheaths, beyond even the blissful body, is purusa, the indivisible, non-manifest One, the 'void which is full'. This is experienced in nirbija Samadhi, whereas sabija Samadhi is experienced at the level of the blissful body.

The sadhaka is influenced by the self on the one hand and by objects seen, so that it does not become enmeshed by them. Through yoga, he should try to free his consciousness from the temptations of such objects, and bring it closer to the seer. Restraining the fluctuations of the mind is a process which leads to an end: Samadhi. Initially, yoga acts as the means of restraint. When the sadhaka has attained a total state of restraint, yogic discipline is accomplished and the end is reached: the consciousness remains pure. Thus, yoga is both the means and the end.

"*Vrttayah pancatayyah klishta aklistah***"**

The movements of consciousness are fivefold. They may be cognizable or non-cognizable, painful or non-painful. Fluctuations or modifications of the mind may be painful or non-painful, cognizable or non-cognizable. Pain may be hidden in the non-painful state, and the non-painful may be hidden in the painful state. Either may be cognizable or non-cognizable. When consciousness takes the lead, naturally the seer takes a back seat. The seed of change is in the consciousness and not in the seer. Consciousness sees objects in relation to its own idiosyncrasies, creating fluctuations and modifications in one's thoughts. These modifications, of which there are five, are explained. They may be visible or hidden, painful or not, distressing or pleasing, cognizable or non-cognizable.

It also explains that the consciousness involves the seer with the objects seen by it, and invites five types of fluctuations which can be divided and subdivided almost infinitely.

"*Pramanaviparyayavikalpanidrasmrtayah***"**

Pramana valid knowledge, experienced knowledge which is studied and Verified, proof, or evidence. They are caused by correct knowledge, illusion, delusion, sleep and memory. These five - fold fluctuations or modifications of consciousness are based onreal perception, or correct knowledge based on fact and proof; unreal or perception, or illusion; fanciful or imaginary knowledge; knowledge based on sleep; and memory. Consciousness has five qualitative types of intelligence: mudha (silly, stupid, or ignorant), ksipta (neglected or distracted), viksipta (agitated or scattered), ekagra (one-pointed or closely attentive) and niruddha (restrained or controlled). Since conscious intelligence id of five types, fluctuations are also. Wrong perceptions (viparyaya) are gathered by the senses of perception and influence the mind to accept what is felt by them (as in the story of the six blind men and the elephant). Fanciful knowledge (vikalpa) causes the mind to live in an imaginary state without consideration of the facts. Memory (smrti) helps one to recollect experiences for right understanding. Sleep (nidra) has its own peculiarity. As a jar when empty is filled with air, so consciousness is empty in sleep. It exists in space, without a place, and is filled with dormancy. In sleep, one has a glimpse of a quiet state of mind, manomaya. This dormant state of mind is felt only on waking. Just as a flower when at rest is in its bud, so the consciousness rests in its bud, the conscience. Correct knowledge (pramana) is direct knowledge from the core of the being. It is intuitive, therefore pure, and beyond the field of intellect. Direct knowledge leads man beyond the conscious state. This state of consciousness is called amanaskatva.

"*Abhyasavairagyabhyamtannirodhah***"**

Practice and detachment are the means to still the movements of consciousness. The fluctuations of consciousness, painful or non-painful, are to be controlled through repeated yogic practice. Mental strength must also be developed, to attain detachment and freedom from desires. Practice is involved in all the eight limbs of yoga. Evolutionary practice is the onward march towards discovery of the Self, involving yama, niyama, asana, and pranayama. The evolutionary path of renunciation involves pratyahara, dharana, dhyana and Samadhi. This inward journey detaches the consciousness from external objects. To be adept in yoga, yama and niyama must be observed carefully throughout the yogic sadhana. This is abhyasa. The discarding of ideas and actions which

obstruct progress in sadhana is vaIragya. Vairagya is a practice through which thesadhaka learns to be free from desires and passions and to cultivate non-attachment to things which hinder his pursuit of union with the soul. A bird cannot fly with one wing. It needs two wings to fly. To reach the highest spiritual goal, the two wings of yoga, abhyasaandvairagya are essential.

"*tapahsvadhyayaisvarapranidhananikriyayogah***"**

Burning zeal in practice, self-study and study of scriptures, and surrender to God are the acts of yoga. Tapas is the blazing desire to burn away the impurities of body, senses and mind.

Svadhyaya is the repetition of sacred mantras and the study of spiritual sacred texts in order to comprehend one's own self.

Isvarapranidhana is surrender of one's body, mind and soul to God through love for him.

Kriyayoga has come to have a wider connotation than the path of action, the path knowledge, or even the dedication of all actions to the Divine (karma, jnana, and bhakti-marga). This is because Isvarapranidhana means not only the surrender of the fruits of actions, but of all actions themselves to the Divinity. Love of God and the act of surrender to Him, is the path of bhakti. Hence, bhaktimarga too is encompassed by kriyayoga. The path of action (karma –marga) is the discipline (tapas) of body, senses and mind. The path of knowledge (jnana-marga) is the study of the self (svadhyaya) from the skin to the core and back again. The path of love of God (bhakti-marga) is surrender (pranidhana)of all to God. The first represents life, the second wisdom. The third, through the surrender of ego, brings the humility that leads to the effulgent, sorrow less light of Isvara, God

"*tasyavacakahpranavah***"**

He is represented by the sacred syllable aum. He is represented in aum. Aum is considered to be the symbol of divinity. It is a sacred mantra, and is to be repeated constantly. Aum is called pranava, which stands for praise of the divine and divinity. Sound is vibration, which, as modern science tells us, is at the source of all creation. God is beyond vibration, but vibration, being the subtlest form of his creation, is the nearest we can get to Him in the physical world. So we take it as His symbol. The letters a, u, m symbolize speech (vak). Mind (manas), and breath of life (prana). As leaves are held together by a twig, all speech is held together by aum. Aum is the ever last ring spirit, a symbol of serenity, divinity, majestic power, omnipotence and universality. They also represent the triad of divinity: Brahma the creator, Visnu the sustainer, and Siva the destroyer, of the Universe.

Yama	self- restraint, vows of abstention, control
Niyama	fixed observance, fixed rules, precepts, established order, law
asana	sitting in various postures, seat in general, a posture
pranayama	regulation of breath, restraint of breath
pratyahara	retreat, withdrawal of the senses
dharana	the act of concentration, act of holding, keeping the mind collected
dhyana	meditation, contemplation, reflection, attention

Samadhi	putting together, collection, composition, profound meditation, absorption, superconciousness

Moral injunctions (yama), fixed observances (niyama), posture regulation of breath (pranayama), internalization of the senses towards their source (pratyahara), concentration (dharana), meditation (dhyana) and absorption of consciousness in the self (Samadhi), are the eight constituents of yoga. In Pantanjali's system of duality, reality consists of two separate dimensions: purusha and prakriti. Purusha is pure consciousness, the transcendental Self, the immutable, eternal, attribute-less essence of life. Prakriti is creative energy-essentially everything else, not only physical matter in all its myriad manifestations but ideas, thoughts and subtle energy patterns. All is Prakriti. The world as macrocosm and the mind as microcosm both belong to prakriti, though the essence of both is purusha. The mind-as everything else in the three worlds-has both purusha and prakriti aspects. Because purusha is without attributes, it is difficult to say much about it. It is absolutely beyond the grasp of our senses and intellect, not to mention language. Prakriti, however, can be described in precise detail, and is in the Yoga Sutra. As purusha is pure consciousness, so prakriti is absolute insentience. All consciousness or awareness is the light of purusha shines upon the patterns of prakriti, making them luminous and apparent. As creative energy, prakriti is always moving, all manifestation never ceasing its dance of change and transformation. But despite this, the forms of prakriti in themselves remain devoid of consciousness. Prakriti is pure object, a shimmering mirror that the light of purusha illuminates with endlessly changing forms.

Yoga practice inverses this process. It is evolution in reverse. In yoga, one begins with the physical body and grosser forms of mind and works back through the subtler layers of prakriti to the ultimate source in purusha. Purusha is our true identity-at the core of all manifestation lies the absolute of pure awareness, the true nature of the mind. Vedanta calls this Atman, identical to Brahman, the Ultimate Transcendental Reality.(Atman in the microcosm, Brahman in the macrocosm, but this is only perspective. The Self is everywhere one.) Yoga calls this transcendental reality the purusha, but it is the same thing. The goal of yoga is total realization of this purusha nature, of pure bliss consciousness-our True Identity. This necessarily involves a detachment from all that is finite, temporal and limited, from all that is prakriti.

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Legal Rights of Girl Child: Indian scenario

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Abstract

International Day of the Girl Child increases awareness of issues faced by girls around the world. International Day of the Girl Child is an international observance day declared by the United Nations; it is also called the Day of Girls and the International Day of the Girl. October 11, 2012, was the first Day of the Girl Child. In 2022, we commemorate the 10th anniversary of the International Day of the Girl (IDG). In these last 10 years, there has been increased attention on issues that matter to girls amongst governments, policymakers and the general public, and more opportunities for girls to have their voices heard on the global stage. Yet, girls' rights remain limited and girls around the world continue to face unprecedented challenges to their education, their physical and mental wellness, and the protections needed for a life without violence. The paper aims at discussing Legal Rights of Girl Child and their situation in Indian scenario based on secondary data.

Keywords

Female Foeticide, Education, Safe environment, Abusive, Stridhan, Child marriage, Sexual harassment and Work place

Introduction

India's population of the girl child and adolescents is 253 million as per UNICEF report and the sex ratio at birth is 929 per 1000 male children as per NFHS-5. Girl is considered of no value in her parental home. Out of 12.5 million children married in India, 8.9 million are girls as per UNICEF report. India is the only large country in the world where more baby girls die than baby boys. The gender differential in child survival is currently 11 per cent, states UNICEF. A woman gives birth to a daughter the new mother risks being shamed and abused by her own family. A daughter may be considered a financial burden and likely not be able to support her and her husband in their older age. A strong preference for sons is a consequence of patriarchal and 'patrilineal' societies that favour men in both power and status. It can be most pronounced in highly agricultural and subsistence societies. These systems value sons over daughters because family assets are passed through male family members (patrilineal), and the greater earning potential of men in patriarchal societies leads

households to rely on boys as future supports as parents age. Though there are many laws in favour girl children in India, practices, such as, female foeticide, female infanticide, child marriage, malnutrition, exploitation, child trafficking, neglect and discrimination, child mortality and child abuse. In addition, opportunities need to be promoted to facilitate education and employment opportunities among them.

Objective and method

The main purpose of this research paper is to acquire an understanding of status of girl child in India. The paper aims at discussing the legal rights of girl children and examines the prevailing situation in India based on secondary data collected through various sources. It will helpful to create awareness on the legal rights of girl children and their situation in India.

Discussion

The legal rights of girl children in India and their prevailing situation briefly discussed hereunder.

Right against female Foeticide

Female foeticide refers to a practice which removes the female foetus after 18 weeks of growth in the uterus. It has been still practicing at high rate all over India though the government of India banned pre-natal sex determination under the PC-PNDT Act 1994. It was enacted on 20 September 1994, amended and effectively implemented in 2003 and strictly amended in 2011with the intent to prohibit prenatal diagnostic techniques for determination of the sex of the foetus leading to female feticide. Therefore, one cannot find out the sex of their unborn child till birth. Though it has been illegal in India since 1996, at least 9.0 million (0.9 crore) female births went “missing” between 2000 and 2019 because of female-selective abortions, as per Pew Research Centre. However, the average annual number of baby girls “missing” in India fell from about 480,000 (4.8 lakh) in 2010 to 410,000 (4.1 lakh) in 2019, the Center’s analysis finds (Yunping Tong, 2022). According to Amartya Sen (1990) around 37 million females missing from the Indian population, caused by a deepening crisis of gender inequality that had led to the widespread practice of sex selective abortions, female infanticide and neglect of girl-children. Gender-biased sex selection is a profound form of discrimination that results from the combination of three factors: strong preferences for sons within a society, the rising use of modern technologies, and generally declining fertility rates.

Right to Education

The Right to Education Act, 2009, provides all children between the ages of 6 and 14 years the right to free and compulsory elementary education. Although this law is gender-

neutral, it gives a push to the education of girl children, by giving them enhanced access to schooling. Further, the recent National Education Policy (NEP) 2020 envisages equitable and inclusive education for all, with special focus on children and youth, especially girls, from socially and economically disadvantaged groups. The policy's focus is important because despite effort to educate women, the dropout rate for girls is still high after secondary education. The enrolment ratio too dips at the secondary and higher secondary levels. Among many reasons, the onset of menstruation and the lack of availability of hygienic toilets are responsible for girls leaving school without completing education. The National Family Health Survey-5 (2019-21) indicates that over 21,800 girls who had dropped out of school before the 2019-20 school year, just over 13% girls did so as they were required for house work and almost 7% did so as they were married off even though child marriage is illegal. UNICEF's U-Report poll (2022) reveals that 38% of respondents knew at least one female student to have dropped out of school.

Right to be raised in a safe environment

All children, including female children, have the right to be brought up in a safe and protected environment. The Juvenile Justice Act, 2015 makes it illegal for parents and guardians of children to abuse, assault, neglect, or abandon a child. Study on Child Abuse: India (2007), out of the total working children, 23.2% was child domestic workers. Among these 81.16% were girls. Out of all child domestic workers, 44.19% were in the age group of 5-12 years followed by 33.27% in the age group of 15-18 years and 22.54% in the age group of 13-14 years. Further, the study reveals that majority of the girl child respondents (70.57%) reported neglect of one form or the other by family members. 48.4% of the girls reported having gone through such feelings as less attention, less food, less time for recreation, more household work, etc. an overwhelming majority 68.99% reported physical abuse, out of which most of the respondents (54.68%) were boys. UN Women supported survey, 2013 in Delhi shows 95 per cent of women and girls feel unsafe in public spaces.

Right against abusive family members

The Domestic Violence Act, 2005 protects all females from any kind of physical, emotional, sexual, or financial abuse by family members. The protection extends to all family members with whom the female shares a house-including her own family members like parents, siblings, uncles, aunts, etc. Therefore, this law protects female children from being abused at home. But, the Ministry of Women and Child Development (MWCD, 2007) released a study report on child abuse. Of the young adults (ages 18-24)

interviewed, almost half of them reported having been physically or sexually abused as children.

Right to stridhan

'Stridhan' is the property of a female, both movable and immovable, which is her own. It can be a gift, inheritance, maintenance, or even her own earnings. Only she has rights over her 'stridhan' and she can exclusively decide what she wants to do with it. This law applies only to Hindus. Since 2005, Hindu women have equal rights as men to inherit property. Therefore, a girl can inherit the same amount of property as her brother. Inheritance can be through a Will or through succession (if the deceased person does not leave a Will, the property will pass on to legal heirs according to the law). Supreme Court of India passed a landmark judgement declaring that all gifts made over to a woman at the time of her marriage remained her absolute private property till the end; and that her husband, or any other, had no right to them without her sanction.

Right against child marriage

The minimum age of marriage for girls is 18 years (and for boys, it's 21 years). Any adult responsible for marrying a female child under the age of 18 can be punished by law. Interestingly, the Parliament is now looking to increase the marriageable age for girls to 21 years now (on par with boys). In spite of the Prohibition of Child Marriage Act (2006), the practice of child marriage remains pervasive due to factors spread across the socio-ecological spectrum, including structural inequalities and regressive social norms in India. Girls with either no or below primary level education have experienced higher levels of child marriage. As per theNFHS-5, 23.3% women got married before attaining the legal age of 18 years from 26.8% reported in NFHS-4 and 48% of girls with no education were married below 18 years of age as compared to only 4% among those who attained higher education

Right against sexual harassment

Sexual harassment broadly means any kind of unwelcome physical contact, sexual gestures, comments, sexual advances, requests for sexual favours, etc. by a man to a woman. Indian law protects all women from sexual harassment by men. By virtue of this law, every girl child in India is protected against sexual harassment. Sexual violence is a major problem faced by women and girls in India. It is already a challenge for survivors to obtain justice in the Indian legal system, and those from the country's marginalized communities face even more major barriers. According to official crime data, there were 3,486 reported cases of rape against Dalit (Scheduled Caste) women and girls in 2019, and 1,110 reported rape cases against Adivasi women and girls (Scheduled Tribes). According to the latest National Family

Health Survey (NFHS-5), nearly 1 in 3 Indian women age 18-49 have suffered some form of spousal abuse; and around 6% have suffered sexual violence. Study on Child Abuse: INDIA 2007 reveals that among respondents, 48% of boys and 39% of the girls faced sexual abuse. The prevalence of sexual abuse in upper and middle class was found to be proportionately higher than in lower or in lower middle class. Sexual abuse was found to be prevalent in both joint and nuclear families.

Right against sexual harassment at work place

It is common for young girls these days to intern or work in offices, while they are still studying. The Prevention of Sexual Harassment at Workplace Act 2013 protects all female workers, whether they are full-time, part-time, consultants, or even interns, against any kind of sexual harassment at work. It defined sexual harassment; lay down the procedures for a complaint and inquiry, and the action to be taken. It broadened the Vishaka guidelines, which were already in place. As per NCRB Report 2020, total cases of sexual harassment reported stood at 17,003 in 2020, down by 1,331 cases from 2019's 18,334. With most people working from home in the last year, only 485 incidents of workplace sexual harassment were reported, down marginally from 2019's 505 cases.

Right to abortion

Abortion was legalized in the country in 1971. A female child has the right to abortion to terminate an unwanted pregnancy. The Medical Termination of Pregnancy Act, 1971 permits a minor girl to have an abortion, with the written consent of her guardian. However, abortion is only permitted under special conditions like if the pregnancy is 'likely to cause injury to the physical or mental health of the pregnant women'. At least 7% of all women aged 15-19 years began child-bearing in 2019-21, as per National Family Health Survey-5. Teenage pregnancies are higher in rural India (8%) than urban (4%). UNFPA's State of the World Population in 2008 suggested that teen pregnancy in India is high with 62 pregnant teens out of every 1,000 women. In 2015, abortions among teenage girls had seen an alarming rise at 67 per cent. Abortion among girls under the age of 15 in Mumbai has risen by 144 per cent over the last three years as per BMC (The Times of India, 2015).

Conclusion

India is home to 20 per cent child population of the world. Here, nearly 100 million children fall in the poorest wealth quintile. Though the girl children has legal rights, they facing many problems such as Female infanticide and Foeticide, Early Marriage, better education, health, Neglect and Discrimination, Trafficking, Abuse , exploitation and Violence etc. However, The opportunity to be born, opportunity to grow in a safe and secure

environment, opportunity to develop ones' full potential are some of the major issues concerning the girl children in India must be taken into account for giving girl children their due position in India.

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Women's Empowerment in India:A critical analysis based on NFHS-5

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"You can tell the condition of a nation by looking at the status of its women."

- Jawaharlal Nehru

Abstract

Women's empowerment refers to the process of enabling women to have greater control over their lives and to be able to make their own decisions. This can include empowering women to participate fully in the economy and in the political process, as well as empowering them to make decisions about their own health and well-being. It is the key to improving their participation in decision-making, which is the most crucial factor in socio-economic and cultural development. India is a developing country, has a very poor economic status of females due to its male-dominated nature. Women constitute roughly 50 per cent of the country's population, and most of them are still economically dependent, unemployed, and in many ways inferior to men. However, women's empowerment is very necessary to create a bright future for the family, society and country. Empowering women would mean encouraging women to self-sufficiency, financial independence, positive self-esteem, creating confidence in difficult situations and active participation in various socio-political development endeavours. The paper aims at examine the six key indicators on women empowerment, based secondary data collected from NFHS-5 by taking descriptive research design and suggestions are made to empower women in India.

Key words

Women Empowerment, Household Decisions, Work Participation, Own of Property, Access to Bank & Mobile Phone, and Health withHygienic

Introduction

Women's empowerment can be defined to promoting women's sense of self-worth, their ability to determine their own choices, and their right to influence social change for themselves and others. It means increasing and improving the social, economic, political and legal power of women, ensuring equal rights and sufficient self-confidence for women to claim their rights and develop independently. Women's empowerment equips and allows women to make life-determining decisions through the different societal problems.The empowerment of women is a key aspect in achieving gender equality, where men and women

have equal power and opportunities for education, health, economic participation and personal development. The empowerment of women is essential for the health and social development of families, communities and countries. Panda (2017) opined that the empowerment of women is not a necessary fact for our country, but it is necessary for the sustainable development of the nation. When women live safe, satisfied and productive lives, they can reach their full potential. In addition, they contribute their skills to the workforce and can raise happier and healthier children. Women are key factors in the economy and play an important role in the workforce and contribute to the growth and development of the family, society and nation. India's journey towards women empowerment has its ups and downs.

Seema Singh and Antra Singh (2020) concluded that while thinking about improving educational attainment and political participation, the downward trend in economic participation and opportunity and health and survival segment has been quite significant.Women empowerment refers to women's ability to make strategic life choices that were previously denied themAs India progresses economically, the country is encouraged to pay more attention to social and human development, including women's empowerment. The equal rights of men and women are enshrined in Articles 14 to 16 of the Constitution of India, which came into force on 26 January 1950 (Constitution of India, 2020). Empowerment refers to a situation where the powerless gain greater control over resources and ideologies. It is associated with concepts such as autonomy, power, status and agency. The empowerment of women in India is highly dependent on several variables which include geographical location (urban/rural), social status (caste and class), educational status, marital status, religion and age. As a traditional patriarchal society, women have been given a secondary status, which is reflected economically, socially and politically. However, women's equality and empowerment has always been a priority and taken very seriously by stakeholders (Seema Singh and Antra Singh, 2020).

Review of Literature

Shettar (2015) concludes that access to education; employment and changes in the social structure are only factors contributing to the empowerment of women. Khatri (2016) focuses on the impact of literacy and education on the empowerment of women and a proposal to improve the changes considered for the empowerment and economic development of women. Suresh and Sivakumar (2017) found that the empowerment of women is essentially a process that raises the economic, social and political status of

traditionally disadvantaged women in society. It is a process to protect them from any kind of violence. A study by Banashri Mandal (2018) shows that women empowerment means increasing and improving the social, economic, political and legal power of women to ensure equal rights for women and make them confident enough to demand their rights.SangeethaMenon et al (2020) examined at indicators of women's empowerment such as women's decision-making power in domestic affairs, economic autonomy, also freedom of movement and access to education. Sobha Rani (2023) states that the empowerment of women would mean giving women financial independence, self-confidence and positive evaluation so that they can face difficult situations and participates in development activities.

Objective

1. The paper examines the six key indicators of women empowerment in India and
2. Suggest measures to improve women status in India.

Methodology

The paper is descriptive in nature also based on secondary data collected from NFHS-5 (National Family Health Survey-2019-21) for India and 14 States /UTs included in two Phases of the Survey and gathered information from 6,36,699 households covering 7,24,115 women of aged 15-49 years. The six key indicators of women empowerment considered in paper are:1. Currently married women who usually participate in three household decisions (Decisions about health care for herself, making major household purchases, and visits to her family or relatives), 2. Women who worked in the last 12 months and were paid in cash 3. Women owning a house and/or land (alone or jointly with others) 4. Women having a bank or savings account that they themselves use, 5. Women having a mobile phone that they themselves use and 6. Women age 15-24 years who use hygienic methods of protection during their menstrual period (Locally prepared napkins, sanitary napkins, tampons, and menstrual cups are considered to be hygienic methods of protection.)

Results and Discussion

The women empowerment aspects such as participation of women in household decision, paid work, Ownership of house/land, Access to mobile phone and bank and Practice of Menstrual Hygiene are briefly discussed hereunder.

Women in Household decision

One of the characteristics of women's empowerment is decision-making. The participation of women in household decision-making can reduce the perceived gender inequality. Nowadays, married women reveal their position in the family, usually involved in making three household decisions (e.g. self-care, important household purchases, and

visitingfamily or relatives).Acharya,et al. (2010) found that almost half (47.1%) of ever-married women made their health care decisions alone or with their spouse. This proportion is 52.8% for large household purchases, 57.6% for everyday household purchases and 56.6% for family/friends.

Table-1: Currently married women who usually participate in three household decisions

S. No	India/ State/ Union Territory	NFHS-5 (2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	91.0	87.7	88.7	84.0
2.	Arunachal Pradesh	89.2	86.6	87.0	89.1
3.	Chhattisgarh	96.5	91.6	95.7	90.5
4.	Haryana	90.7	86.2	87.5	76.5
5.	Jharkhand	94.6	89.8	91.0	86.6
6.	Madhya Pradesh	91.7	84.1	86.0	82.8
7.	Odisha	89.9	90.3	90.2	81.8
8.	Punjab	93.3	90.3	91.4	90.2
9.	Rajasthan	90.6	86.8	87.7	81.7
10.	Tamil Nadu	91.8	93.7	92.8	84.0
11.	Uttar Pradesh	90.1	86.8	87.6	81.7
12.	Uttarakhand	91.8	90.6	91.0	89.8
13.	Chandigarh	94.6	-	94.6	96.6
14.	NCT Delhi	92.0	94.3	92.0	73.8
15.	Puducherry	98.4	96.6	97.9	85.1

Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)

Table-1 depicts that currently married woman (aged 15-49) who usually participate in three household decisions like health care for herself, making major household purchases, and visits to her family or relatives has been slightly increased from NFHS-4 to NFHS-5. Further, women who reside in urban areas have more involved in household decisions than their rural counterparts. Women who participated in household decisions were differing by states and union territories.

Participation in paid works

Paid work is still the privilege of few women around the world, although it can be said that all women work. One of the main factors preventing women from controlling household decisions is the value of the work they do. There is substantial evidence that women in India have limited opportunities to participate in paid work outside the home (Mehrotra et al., 2016).

Table-2: Per cent of women who worked in the last 12 months and were paid in cash

S. No	India/ State/ Union Territory	NFHS-5 (2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	25.0	25.6	25.4	24.6
2.	Arunachal Pradesh	23.0	23.6	23.5	17.2
3.	Chhattisgarh	28.4	42.6	31.1	36.8
4.	Haryana	22.6	17.0	18.8	17.6
5.	Jharkhand	18.8	17.7	18.0	24.8
6.	Madhya Pradesh	23.2	28.0	26.8	29.9
7.	Odisha	26.3	25.6	25.7	22.5
8.	Punjab	25.6	20.2	22.3	18.5
9.	Rajasthan	17.0	17.5	17.4	18.6
10.	Tamil Nadu	35.4	45.5	40.8	30.5
11.	Uttar Pradesh	17.7	14.8	15.5	16.6
12.	Uttarakhand	20.2	22.2	21.6	15.5
13.	Chandigarh	22.0	-	22.0	32.6
14.	NCT Delhi	25.0	17.2	24.9	21.1
15.	Puducherry	35.4	44.8	38.2	21.2

Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)

Table-2 portrays that currently married woman (aged 15-49) who worked in the last 12 months and were paid in cash has been meagrely increased from NFHS-4 to NFHS-5. Further, women who reside in urban areas have worked in the last 12 months and were paid in cash than their rural counterparts. Women who worked in the last 12 months and were paid in cash were more or less similar in many states and but differ in union territories.

Ownership of house/land

Women's access to and control over productive resources, especially ownership of agricultural land, is key to their economic empowerment, social status, physical security, and their own and their families' overall well-being. It also analyses intra-gender gaps, and identifies the factors–individual, household and regional–affecting a woman's likelihood of owning land. Despite significant advancement towards equality in inheritance laws, women are found to constitute barely 14% of landowners owning 11% of agricultural land in rural landowning households, averaged across states. (Agarwal, B., et al, 2020).

Table-3: Percent of women owning a house and/or land (alone or jointly with others)

S.No	India/ State/ Union Territory	NFHS-5(2019-21)			NFHS-4 (215-16)
		NFHS-5(2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	38.3	45.7	43.3	38.4
2.	Arunachal Pradesh	69.8	70.3	70.2	59.7
3.	Chhattisgarh	46.1	45.5	45.6	26.4
4.	Haryana	35.7	41.0	39.3	35.8
5.	Jharkhand	57.4	66.5	64.2	49.7
6.	Madhya Pradesh	35.8	41.3	39.9	43.5
7.	Odisha	35.4	45.5	43.5	63.5
8.	Punjab	58.0	67.1	63.5	32.1
9.	Rajasthan	26.5	26.6	26.6	24.1
10.	Tamil Nadu	43.2	52.0	47.9	36.2
11.	Uttar Pradesh	46.8	53.5	51.9	34.2
12.	Uttarakhand	23.3	25.1	24.6	29.2
13.	Chandigarh	30.4	-	30.4	21.6
14.	NCT Delhi	22.6	27.4	22.7	34.9
15.	Puducherry	36.8	38.3	37.2	40.3
Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)					

Table-3 reveals that women owning a house and/or land (alone or jointly with others)have been significantly increased from NFHS-4 to NFHS-5. Further, significantly higher per cent of rural women owned a house and/or land (alone or jointly with others) than women reside in urban areas. Women who owning a house and/or land (alone or jointly with others)were significantly varied in many states and but differ in union territories.

Access to Bank

Financial inclusion is essential for economic growth and sustainable development; for women, it is a pathway to economic and social empowerment. Expanding financial access for women is proven to have a positive impact not only on the women themselves but, consequently, on household incomes. Banks as part of their programs facilitate women by providing personalised banking services which are designed specially according to their needs and preferences. Jan DhanYojana is an initiative towards financial inclusion which also paves way for women financial empowerment. ShrutiJha (2019) stated that various initiatives are being implemented and more to roll out, Indian women is on the way of empowerment, socially and financially, to reach towards the goals of gender equality and empowerment.

Table-4: Per cent of women having a bank or savings account that they themselves use

		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	80.9	77.4	78.6	53.0
2.	Arunachal Pradesh	86.0	76.7	78.2	56.6
3.	Chhattisgarh	77.9	81.1	80.3	51.3
4.	Haryana	76.3	72.4	73.6	45.6
5.	Jharkhand	79.2	79.8	79.6	45.1
6.	Madhya Pradesh	78.5	73.3	74.7	37.3
7.	Odisha	82.8	87.4	86.5	56.2
8.	Punjab	86.9	82.1	81.6	58.8
9.	Rajasthan	81.7	79.0	89.6	58.2
10.	Tamil Nadu	92.7	91.7	92.2	77.0
11.	Uttar Pradesh	79.8	78.1	75.4	54.6
12.	Uttarakhand	81.3	79.8	80.2	58.5
13.	Chandigarh	87.1	-	89.1	79.6
14.	NCT Delhi	72.3	84.8	72.5	64.5
15.	Puducherry	90.9	96.6	97.9	85.0

Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)

Table-4 shows that women having a bank or savings account that they themselves use have been significantly increased from NFHS-4 to NFHS-5. Further, significantly higher per cent of urban women having a bank or savings account that they themselves use than women reside in rural areas. Women who women having a bank or savings account that they themselves use were significantly varied in many states and but differ in union territories.

Access to mobile phone

Many have heralded mobile phones as promising new tools for women's empowerment in the Global South. The mobile phone revealed the opportunities and freedom of women to make their own choices, improve their social network, change attitudes and change their lives. The mobile phone is changing the general socio-economic, political and psychological life of women. Only 28% of all 612 million women own mobile phones, compared to 43% of men. The gender gap in mobile phone ownership is as high as 114 million. "Gender inequality is relatively large and widespread in India, affecting women's access to and use of mobile phones.Ashim Nandi (2021) found that mobile phone use generally facilitates women's empowerment, but mobile phone use does not support women's empowerment in a male-dominated economy.

Table-5: Per cent of women having a mobile phone that they themselves use

S.No	India/ State/ Union Territory	NFHS-5(2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	69.4	46.6	54.0	45.9
2.	Arunachal Pradesh	81.9	75.3	76.4	59.8
3.	Chhattisgarh	61.2	34.0	40.7	31.0
4.	Haryana	65.1	43.4	50.4	50.5
5.	Jharkhand	65.2	43.7	49.0	35.2
6.	Madhya Pradesh	58.8	31.4	38.5	28.7
7.	Odisha	58.8	48.0	50.1	39.2
8.	Punjab	71.0	54.9	61.2	57.2
9.	Rajasthan	65.5	45.3	50.2	41.4
10.	Tamil Nadu	81.2	68.9	74.6	62.0
11.	Uttar Pradesh	59.9	52.4	46.5	37.1
12.	Uttarakhand	73.1	55.7	60.9	55.4
13.	Chandigarh	70.0	-	70.0	74.2
14.	NCT Delhi	73.7	81.0	73.8	66.6
15.	Puducherry	85.5	86.6	82.9	67.3
Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)					

Table-5 illustrations that women were having a mobile phone that they themselves use have been significantly increased from NFHS-4 to NFHS-5. Further, significantly higher per cent of urban women having a bank or savings account that they themselves use than women reside in rural areas. Women who women having a mobile phone that they themselves usewere significantly varied in many states and but differ in union territories.

Practice of Menstrual Hygiene

Poor menstrual hygiene,however, can lead to serious health risks, such as reproductive and urinary infections, which in the future can lead to infertility and birth complications. Not washing your hands after changing menstrual products can spread infections such as hepatitis B and thrush. Dasgupta and Sarkar(2008) found that 78 (48.75%) girls knew how to use sanitary napkins during menstruation. Of the practices, only 18 (11.25%) girls used sanitary napkins during menstruation. When cleaning, 156 (97.5%) girls used both soap and water. Singh, A., Chakrabarty, M., Singh, S. jt 2022)

Table-6: Per cent of women age 15-24 years who use hygienic methods of protection during their menstrual period

S.No	India/ State/ Union Territory	NFHS-5 (2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	89.4	72.3	77.3	57.6
2.	Arunachal Pradesh	93.5	91.4	91.8	73.4
3.	Chhattisgarh	83.2	64.8	68.8	47.1
4.	Haryana	96.7	91.6	92.2	78.3
5.	Jharkhand	88.2	70.8	74.9	49.6
6.	Madhya Pradesh	81.9	53.4	60.5	37.6
7.	Odisha	91.7	79.5	81.5	47.4
8.	Punjab	95.4	91.1	93.2	84.4
9.	Rajasthan	92.2	81.9	84.1	55.2
10.	Tamil Nadu	98.6	98.0	98.3	91.4
11.	Uttar Pradesh	86.7	68.4	72.6	419.1
12.	Uttarakhand	94.5	89.7	91.2	69.9
13.	Chandigarh	93.3	-	93.0	92.1
14.	NCT Delhi	96.9	98.4	96.9	90.0
15.	Puducherry	99.1	99.1	99.1	96.5

Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)

Table-6 depicts that women age 15-24 years who use hygienic methods of protection during their menstrual period (Locally prepared napkins, sanitary napkins, tampons, and menstrual cups are considered to be hygienic methods of protection) have been significantly increased from NFHS-4 to NFHS-5. Further, significantly higher per cent of urban women having a bank or savings account that they themselves use than women reside in rural areas. Women who women having a mobile phone that they themselves use were significantly varied in many states and but differ in union territories.

Conclusion

Most of the currently married women (aged 15-49 years) have usually participated in three household decisions. But, only about one-fourth of currently married woman (aged 15-49) had worked in the last 12 months and was paid in cash. On an average, less than half of women were owned a house and/or land (alone or jointly with other). Nearly four-fifths of women had a bank or savings account that they themselves used. Nearly half of the were having a mobile phone that they themselves used and nearly four-fifths of women aged 15-24 years had used hygienic methods of protection during their menstrual period by way of locally prepared napkins, sanitary napkins, tampons, and menstrual cup. However, the six

empowerment aspects examined have been increased from NFHS-4 to NFHS-6 period, but rural-urban differentials were observed. Based on the findings, it is suggested that gender discrimination can be reduced by creating awareness on need of women empowerment and their benefits. Further, apart from new programmes, existing women empowerment policies should strengthen in rural areas, where in more women are residing. Women empowerment helpsthe women to handle their issues in better.It can direct them towards progress and development by channelizing their energies and efforts into productive purposes, thus creating gender equality and accelerating the speed of development of the Indian economy.

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Determinants of the performance achieved by the Auxiliary Nurse Midwifes under MCH Services in National Rural Health Mission - A study

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Abstract

India's Primary Health Care and the Family Planning Programs have come a long way after the independence in improving health indicators in general, yet it has high 'maternal' and 'under five' mortality rates. However, a lot of ground still needs to be covered to complete the demographic and epidemiological transition and improve Maternal and Child Health Indicators in a country which is as big as a continent. It is important to understand why the role of Auxiliary Nurse Midwifes (ANMs) changed from primarily a Midwife in 60s to a Preventive Health Worker with focus on Family Planning and Immunization. Changes in Program Priorities - emphasis on Preventive Services, lack of focus on Curative/Midwifery Services, changes in monitoring mechanism, lack of supervision/training, weak management, neglect by International Agencies and NGOs are major factors associated with this change. The present study aims at examines the Determinants of the performance achieved by the Auxiliary Nurse Midwifes under MCH Services in National Rural Health Mission. It is based on primary date by covering the sample size of 175 Auxiliary Nurse Midwifes with simple random sampling technic and suggestions are made for policy implications

Keywords

Auxiliary Nurse Midwifes The National Rural Health Mission, Maternal and Child Health, Health Care System, Performance and Rural Areas.

Introduction

The National Rural Health Mission (NRHM) launched by the Hon'ble Prime Minister on 12th April 2005 throughout the country with special focus on 18 states, including eight Empowered Action Group (EAG) states, the North-Eastern states, Jammu & Kashmir and Himachal Pradesh seeks to provide Accessible, Affordable and Quality Health Care Services to Rural Population, especially the Vulnerable Sections. The NRHM operates as an omnibus broadband programme by integrating all Vertical Health Programmes of the Departments of Health and Family Welfare including Reproductive & Child Health Programme and various Diseases Control Programmes. The NRHM has emerged as a Major Financing and Health Sector Reform Strategy to strengthen States Health Systems. The National Rural Health

Mission (NRHM) has been launched with a view to bringing about dramatic improvement in the Health System and the health status of the people, especially those who live in the Rural Areas of the Country. The Mission seeks to provide Universal Access to Equitable, Affordable and Quality Health Care which is accountable at the same time responsive to the needs of the people, reduction of Child and Maternal Deaths as well as Population Stabilization, Gender and Demographic Balance. In this process, the Mission would help achieve goals set under the National Health Policy and the Millennium Development Goals during the Mission Period i.e., 2005-2012. Later, the Mission Period has been extended up to 2017. To achieve these goals NRHM will:

- ✓ Facilitate increased Access and Utilization of Quality Health Services by all.
- ✓ Forge a partnership between the Central, State and the Local Governments.
- ✓ Set up a platform for involving the Panchayat Raj Institutions and Community in the management of Primary Health Programmes and Infrastructure.
- ✓ Provide an opportunity for promoting Equity and Social Justice.
- ✓ Establish a mechanism to provide flexibility to the States and the community to promote Local Initiatives.
- ✓ Develop a framework for promoting inter-spectral convergence for Promotive and Preventive Health Care.

The Objectives of the NRHM Mission

The influences of major determinants like a) Socio-Demographic Characteristics viz., Age, Marital Status, Religion, Caste, Education, Income b) Awareness on NRHM Goals and c) Professional Factors like Experience and Transfers on the performance rendered under MCH Services by the ANMs were presented. MCH Services viz., 1). ANC Registration, 2). IFA Tablet Distribution, 3). TT(PW), 4). Total Deliveries, 5). Institutional Deliveries, 6). BCG, 7). OPV, 8). Hepatitis-B, 9) Fully Immunized and 10). Family Planning Cases of the ANMs for the last two years have been taken as the dependent variable, and the influence of different factors like Socio-economic, demographic, knowledge and professional factors on it have been analysed.

Review of Literature

A study on Factors governing the performance of Auxiliary Nurse Midwives in Pune district, India by Pyone T et al concluded that focusing on the tasks of ANMs with technical inputs alone is insufficient to achieve the full potential of ANMs in a changing context. Systematic efforts tackling factors governing ANMs in their workplaces can produce a useful cadre that can play an important role in achieving universal health coverage in India. Razee

.H et al (2012) focussed on 'Listening to the rural health workers in Papua New Guinea-the social factors that influence their motivation to work'. Sunder Gujral (1991) studied the determinants of community health workers' performance in India. Bhombe, Ishwari et al (2019) studied the workload and work pattern of ANMs and identify the causes for improving work efficiency of ANMs and conclude that clarity about job responsibilities of ANMs is lacking and available working time is not effectively utilized. Time spent on supporting tasks such as travel and waiting is maximum and training to manage time for priority tasks and to improve skills is required. Factors influencing ANMs in their practices, scope of work and the mechanisms that influence ANMs' performances remain understudied. According to Zahra Hadizadesh Talasaz, Shahla Nourani Saadoldin et al, Mashhad, Iran, (2014), the mean age of the participants was 39.63±6.92 years. Spearman Correlation Test showed a direct correlation between Job Satisfaction and the Total Score of Job Performance ($P<0.001$, $r=0.490$). A direct relationship was also found between Job Satisfaction and the quality of Educational Performance ($P<0.001$, $r=0.415$), Care Performance ($P<0.001$, $r=0.335$), and Communicative Performance ($P<0.001$, $r=0.510$). There was a positive correlation between Job Satisfaction and Job Performance of Midwives. Ch. Platis, P. Reklitis, S. Zimeras et al, (2014**):** Relation between Job Satisfaction and Job performance in Healthcare Services

Objective

The paper aimed to study Determinants of the performance achieved by the Auxiliary Nurse Midwifes under MCH Services in National Rural Health Mission in Krishna District, Andhra Pradesh, India.

Methodology

The study is based on primary data consisting of 170 Auxiliary Nurse Midwives working in 18 PHCs covering a total of all the 109 Sub-Centres were interviewed with a semi structured questionnaire. There are ten MCH services of the ANMs during 2014-15 & 2015-16, weightages have been to MCH services rendered by ANMs. Basing on the performance under MCH services of the ANMs, the average performance of the each ANM per year was calculated and all the ANMs under study have been categorized into three groups based on the individual achievements under each service' are categorized in three as "high performance, average performance and poor performance".

Results and Discussion

These changes will require sustained and careful planning and resource allocation. Increasing resources along with systemic reforms will improve health status of the women

and children who are the focus of Reproductive Child Health programs. Nurses' Job Satisfaction is an important indicator of Nurses' Job intent to stay, provide quality of Nursing Care and Professional Performance, which therefore needs a greater focus of Administrators or Managers. The determinants such as Job-satisfaction, Attitude and Awareness about the programme those are likely to influence the performance of the Auxiliary Nurse Midwives (ANMs).

Table-1: Association between the Type of appointment of ANMs and their performance under MCH Services

Type of Appointment	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
2nd ANM	20	21.74%	42	45.65%	30	32.61%	92	100.00%
Regular ANM	18	23.08%	44	56.41%	16	20.51%	78	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
3.28	2		> 0.05				Not Significant	

From Table-1, slightly more proportion of Regular ANMs (23.08%) recorded 'High Performance' as against (21.74%) among 2nd ANMs. (56.41%) of Regular ANMs manifested as 'Average Performance' as against (45.65%) among 2nd ANMs. (32.61%) of 2nd ANMs recorded under 'Poor Performance' as against (20.51%) among Regular ANMs. The difference observed is statistically not significant at $P > 0.05$.

Table-2: Association between the Religion of the ANMs and their performance under MCH Services

Religion	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Hindus	34	21.25%	82	51.25%	44	27.50%	160	100.00%
Christians	4	40.00%	4	40.00%	2	20.00%	10	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
1.91	2		> 0.05				Not Significant	

From the table-2, out of total 170 ANMs (both Regular and 2nd ANMs), only meagre number i.e., only 10 ANMs are recorded under 'Christians'. However, slightly more proportion of 'Christians' category ANMs recorded 'High Performance' as against 21.25% of 'Hindu' category ANMs. 51.25% of 'Hindu' ANMs recorded 'Average Performance' as against 40.00% of 'Christian' ANMs. 27.5% of 'Hindu' ANMs recorded 'Poor Performance' as against 20.0% of 'Christian' ANMs.

Table-3: Association between the Income of the ANMs and their performance under MCH Services

Income (per month)	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
< Rs. 15,000/-	20	21.74%	42	45.65%	30	32.61%	92	100.00%
Rs. 15001/- to Rs. 30,000/-	0	0.00%	4	100.00%	0	0.00%	4	100.00%
> Rs. 30,001/-	18	24.32%	40	54.05%	16	21.62%	74	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%

From the table-3, It is evident that slightly more proportion (24.32%) of ANMs whose income is more than Rs: 30,001/- recorded 'High Performance' as against (21.74%) among ANMs whose Income is less than Rs: 15,000/-. No one is recorded 'High Performance' among ANMs whose Income is in between Rs: 15,001/- & Rs: 30,000/-. Though, meagre number 100 % (4) ANMs whose Income is in between Rs: 15,001/- & Rs: 30,000/- recorded 'Average Performance as against 54.05% among ANMs whose Income is more than Rs. 30,001/- and 45.65% among ANMs whose Income is less than Rs. 15,000/-. More proportion (32.61%) of ANMs whose Income is less than Rs: 15,000/- recorded 'Poor Performance' as against (21.62%) among ANMs whose Income is more than Rs: 30,001/-. No one is recorded 'Poor Performance' among the ANMs whose Income is in between Rs: 15,001/- & Rs: 30,000/-.

Table-4: Association between the Education of the ANMs and their performance under MCH Services:

Education	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Up to 10th Class	22	19.64%	48	42.86%	42	37.50%	112	100.00%
Inter/PUC	14	29.17%	30	62.50%	4	8.33%	48	100.00%
Degree & above	2	20.00%	8	80.00%	0	0.00%	10	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%

Education is an important influencing factor in rendering better services in any sector. From the table-4, also it is quite evident that better the education higher the performance. 'High Performance' is recorded in high proportion i.e., 29.17% of ANMs who studied 'Inter/PUC' as against 20% among ANMs studied 'Degree & above' and 19.64% among ANMs studied 'Up to 10th Class'. However, out of total 172 ANMs, only 10 ANMs studied 'Degree & above'. 'Average Performance' is recorded in high proportion i.e., 80% of ANMs who studied 'Degree & above' as against 62.5% among ANMs studied 'Inter/PUC' and

42.86% among ANMs studied 'up to 10th Class'. High proportion (37.5%) of ANMs studied 'up to 10th Class' recorded 'Poor Performance' as against 8.33% of ANMs studied 'Inter/PUC'. No one from ANMs studied 'Degree & above' recorded 'Poor Performance'.

Table-5: Association between Total Length of Service of ANMs and their performance under MCH Services

Length of the Service of the ANMs (Yrs)	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Up to 10 Yrs	26	23.21%	56	50.00%	30	26.79%	112	100.00%
> 10 to < 20 Yrs	8	30.77%	12	46.15%	6	23.08%	26	100.00%
> 20 Yrs	4	12.50%	18	56.25%	10	31.25%	32	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
2.93	4		> 0.05				Not Significant	

From the table-5, slightly more proportion (30.77%) of ANMs whose service is in between '10 Years & 20 Years' recorded 'High Performance' as against (23.21%) of ANMs whose service is 'Up to 10 Years' and (12.5%) of ANMs whose service is '> 20 Years'. High proportion (56.25%) of ANMs with '> 20 Years' of service recorded 'Average Performance' as against (46.15%) of ANMs with service 'between 10 & 20 Years' and (50%) of ANMs with service 'Up to 10 Years'. (31.25%) of ANMs with '> 20 Years' of service recorded 'Poor Performance' as against (23.08%) of ANMs with service between 'between 10 & 20 Years' and (26.79%) of ANMs whose service is 'Up to 10 Years'. The said difference is statistically not significant at P > 0.05.

Table-6: Association between Preferences of ANMs to join in the present post and their performance under MCH Services:

Preference to join in the present post	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Interest and desire to serve the people	36	25.00%	66	45.83%	42	29.17%	144	100.00%
Economic Necessity/ Shifted from the other department	2	7.69%	20	76.92%	4	15.38%	26	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
8.71	2		< 0.01				Highly Significant	

From the table-6, it is evident that the ANMs who joined in the present post with 'Interest and desire to serve the people' have performed better MCH Services. 25% of ANMs who joined with 'Interest and desire' recorded 'High Performance' as against only 7.69% of ANMs who joined with 'Economic necessity'. 76.92% of ANMs joined with 'Economic Necessity' recorded 'Average Performance' as against 45.83% of ANMs joined with 'Interest and Desire'. 15.38% of ANMs joined with 'Economic Necessity' recorded 'Poor Performance' as against 29.17% of ANMs joined with 'Interest and Desire'. The said difference is statistically highly significant at $P < 0.05$.

Table-7: Association between ANM's present Sub-Centre happens to be her native place and their MCH Services:

Present Sub Centre whether native place or not of the ANM	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Yes	8	12.90%	32	51.61%	22	35.48%	62	100.00%
No	30	27.78%	54	50.00%	24	22.22%	108	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
6.48	2		< 0.05				Significant	

From the table-7, it is evident that the performance of ANMs who's present Sub-Centre is not her Native Place recorded 'high' when compared with the performance of ANMs who's present Sub-Centre happens to be her Native Place. Slightly more proportion (27.78%) of ANMs who's present Sub-Centre is not her native place recorded 'High Performance' as against (12.9%) of ANMs whose present Sub-Centre happens to be her native place. The difference observed is statistically significant at $P < 0.05$.

Table-8: Association between the Transfers of the ANMs and their performance under MCH Services:

No., of Transfers in the service	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
No Transfers	28	25.93%	50	46.30%	30	27.78%	108	100.00%
One Transfer	2	9.09%	16	72.73%	4	18.18%	22	100.00%
Two & more Transfers	8	20.00%	20	50.00%	12	30.00%	40	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
5.76	4		> 0.05				Not Significant	

From the table-8, slightly more proportion (25.93%) of ANMs who have not been transferred in their service recorded 'High Performance' as against (20%) of ANMs who

have 'Two & more transfers' and (9.09%) of ANMs who have 'No Transfer'. 46.3% of ANMs with 'No Transfer', 72.73% of ANMs with 'One Transfer' and 50% of ANMs with 'Two & more Transfers' recorded 'Average Performance' where as 27.78% of ANMs with 'No Transfer', 18.18% of ANMs with 'One Transfer' and 30% of ANMs with 'Two & More Transfers' recorded 'Poor Performance'. The difference is statistically not significant at P > 0.05.

Conclusion

The findings of all these major aspects related Determinants of the performance achieved by the Auxiliary Nurse Midwifes under MCH Services to may be very useful for the administrators and decision makers of health sector in identifying the shortfalls in National Health Mission and to change its administrative policies accordingly, to get good results in terms of principles of Primary Health Care namely Equitable Distribution, Community Participation, Intersect oral Co-ordination and Appropriate Technology. Therefore, it is recommended that Health Care Administrators provide organizational supports for Midwives to improve their Professional Performance.

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GEOGRAPHICAL ANALYSIS

RESEARCH ARTICLE

A Perspective on Ecological View and Ecodevelopment Approach for Land Use Planning in The Drought Prone Areas: A Case Study of United Anantapur District, Andhra Pradesh

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Abstract

Land is a basic natural resource. It forms the basis for all the biological, human and economic activities. In the developing countries like India, where agriculture is the main source of economy and livelihood for more than two-thirds of the working population, proper utilisation of land resource is vital.

Introduction

In recent years, serious concern has been shown on ecological management and optimum utilization of land resources for the benefit of mankind. Hence the use of land resource is "central to all discussions of land problems and policies [(1)] . Land use at any region is a complex, diversified and dynamic concept. It is due to the operation of whole range of environmental factors but modified by socio-economic and historical elements. In dry areas, the use of land resources is virtually associated with climatic and edaphic conditions, besides the socio-economic needs of the mankind. Undoubtedly, the erratic behaviour of the monsoon, frequent occurrences of drought and prolonged dry spells have had a devastating and debilitating effect on land use pattern and as a result, the landscapes in dry areas gets continuously varied and modified. Since land itself is one of the important components of the ecosystems, a critical study on landscape ecology and its planning calls for greater attention to be paid to the drought prone areas to keep the ecological balance between the environment and the socio-economic needs of the region.

Ecological View of Landscape

In the sense of ecology, land carries ecosystems, but is itself also a part of these ecosystems. Although the use of land resource may be considered from abroad view of human welfare, its use is always a process of modifications of ecosystem. The idea that land use is a process of modification of ecosystem was well explored by Simmons [(2)] .

He suggested that land use ecology might form a central theme in biogeography. It is also mentioned that the ecosystem concept provides the necessary modern scientific framework to the study of land use. The form and function of land use is a human enterprise, while the development of landscape is the continuous efforts of man for his needs and sustenance under every possible combinations of terrain, climatic, edaphic and vegetative conditions. By all means, it suggested that any scientific and rational land use planning should see that the ecological balance was not disturbed and that proper equilibrium between the environment and the socio-economic needs of the area be maintained.

Ecological Problems of Land Use

In the process of land use management and optimisation, ecological problems are becoming a most serious concern. The ever increasing pressure of population and decreasing man-land ratio are posing challenging problems to the land-use planners. Structurally, a land-use system consists of three interacting spheres namely, ecological (environmental), economic and social. Each sphere has its own unique set of human-ascribed goals. Ecological problems are those, which appear in connection with human socio-economic needs, change the quality of the physical environment and indiscriminate use of natural resource base. Ecological problems appear in different types of physical environment and various socio-economic, technological and political conditions.

The negative ecological effects like degree of decertification, land degradation, soil erosion, soil salinisation, chemical contamination and water pollution are frequent in the dry areas but taking place in different intensities and degree of criticality. The other problems related to land use are under-utilisation, over-utilisation and mis- utilisation of land resources. So the question is what are the reasons for the appearance of negative ecological effects in different environmental and socio- economic conditions. Off all, undoubtedly, man's indiscriminate use of land resources has resulted in the creation of negative ecological effects. His failure to recognise the long term implications of deforestation, faculty methods of cultivation, overgrazing, massive application of fertilisers and pesticides, practice of single crop monocultures, imbalances in the input and output factors and large scale exploitation of land and soil resources throughout an entire ecosystem. Results in widespread degradation.

The practice of monoculture was accompanied subsequently by great losses of genetic varieties in the fields, involving high risks of large hectarages being destroyed by single drought or pest. To cultivation of the same crop continuously and their synthetic fertilisation year after year has resulted in the disruption of the soil balance. With diminishing organic matter in the soil, its ability to retain moisture is also reduced and as a consequence, the soil becomes sterile and dry. To circumvent some of these problems a critical examination of landscape ecology is essential for a more rational approach to land use planning and conservation of resources.

Eco-development and Ecological Planning of Land Use

Generally speaking, ecological planning is a fundamental tool for landscape and regional planning, such that many landscape ecological studies are now done as integral parts of landscape and regional planning projects[3] . It offers an effective means of helping mankind to adapt to the dynamic changing environment of which he is but one integral part. Mc Harg[4] has defined ecological planning as "an instrument for revealing regions as interacting and dynamic natural systems having intrinsic opportunities and constraints for all human uses.

The goals of such planning are derived from the region and its people as proffered by locations where all or most advantageous (safe, healthy and beautiful) factors exist with none or few detrimental factors for any and all anticipated future uses. What constitutes 'detrimental' or 'advantageous' is derived from the use itself and the value system of the initiating person or group. The concept of eco-development forms the main strategy of 'Habitat Ecology'. It helps in explaining the form of planned growth which is concerned with the development of local available land resources within the constraints of local environment with a view to optimise the local capacities of the biosphere to support the welfare of life. The eco-development approach is very close to ecological and environmental planning to balance and harmonise the various enterprises of land use which man for his own benefit has superimposed on physical environment.

The eco-development approach related to land use rests on (i) rational utilisation, (ii) development of mankind pertaining to their well-being rather than in economic sense, and (iii) advancing a true symbiosis between man and environment. To activate and regulate the harmony between landuse development and environment both the demand and supply side of the equation must be acted upon. In the eco-development and ecological planning sense, any land use planning should not be considered merely from the agricultural point of view and bringing more land under the plough making it viable for cultivation, but should include rational utilisation of land resource, conservation of land from erosion, development of nutrients and soil cover through multiple vegetative systems, improving the potential capacity of land, application of modern scientific technology and lastly the preclusion of over exploitation of land.

Study Region

Anantapur district is one of the chronically drought-prone areas in the country. It is located in the rain-shadow region of

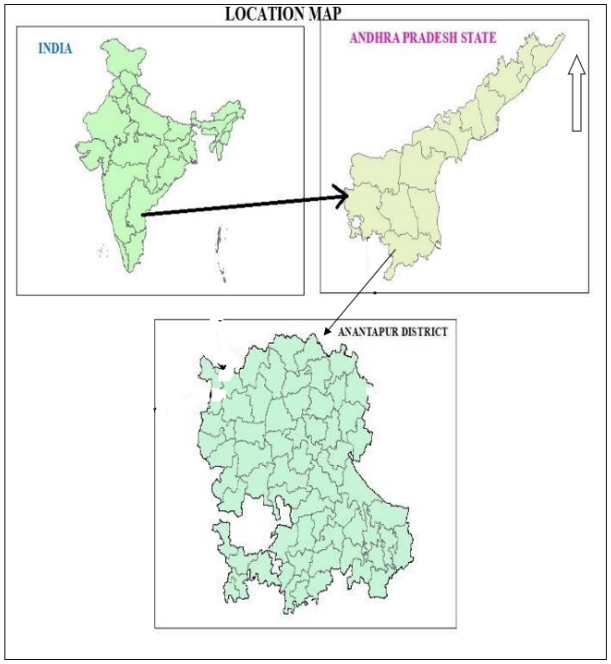


Fig. 1. Location map

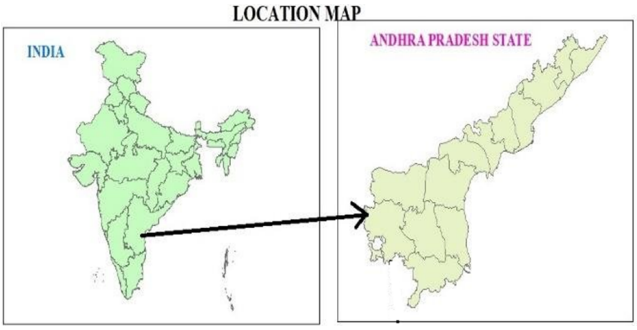


Fig. 2. Location map

the Western Ghats in Andhra Pradesh. It is the largest district in terms of area in the State. The population spread is very sparse with a density of population of 166 persons per Sq.Km. Agriculture is the predominant occupation of the people. The average annual rainfall of the district is 544 mm. with the lowest number of rainy days of 35 in the State. The district has been experiencing a drought once in every two years which is really serious and detrimental to stable agriculture.

Methodology

The spatial distributional pattern and changes in important land use types namely, forest land, fallow land and crop-land are examined and delineated with the help of both quantitative and cartographic techniques. The quantum of change is determined through percentages, regression trend and growth rates The impact of rainfall on land use types is measured with correlation testing.

Forest Land Use

Forests form distinct ecosystems. In fact, Anantapur district is very poor in forest cover with only 10.3% of the total geographical area of the district. The nature and character of forests in the district does not indicate any dense growth of tree population with different variety of plants. The forests of the district may be described as dry mixed deciduous and thorny open scrub types.

The distribution of forest-cover in the district is not only very low in proportion but also most uneven. Relatively, higher concentrations (15.1-20% and >20%) of forest-cover are found in southern, south-eastern and north-eastern parts of the district. In these areas, the amount of rainfall is comparatively higher than the other parts of the district. The western part of the district is found with very thin forest cover with discontinuous thorny thickets and scrub woodlands whose vegetative growth is stunted due to poor edaphic and very low isohyetal conditions.

During the three decades under consideration (1960-90) total area under forest has not shown any substantial change but showed a small increase of 0.1 per cent or 2000 hectares. The regression analysis has also revealed that the trend of forest land is marginally positive with 2 per cent of the goodness of fit. The annual compound growth rate has also shown a negligible rate of increase of 0.003 per cent.

Planning for the Development of Forest Land

In drought-prone areas, maintenance of ecological balance is one of the most important considerations to build-up the humus contents in the soil, avert soil erosion, increase the moisture in the atmosphere, raise the ground water level and heap in ground water recharge and storage besides other economic purposes. However, the poor quantity of forest cover in the district is too short to fulfil the requirement of ecological balance and is seriously jeopardizing the ecosystem of the region it is necessary to take up massive efforts on war-footing to develop forest-cover in the district

The development of forest-cover in the district heavily depends upon the (i) plantation of drought resistant species in large parts of the reserve forest areas, which are devoid of any vegetative cover, (ii) there are number of tanks in the district which are silted and do not fill up with meagre rainfall The foreshore of these tanks can be planted with eucalyptus and subabul plantations., (ii) depending upon the suitability of site and topography, particularly in the slopy agricultural lands and cultivable wastelands and all along the road sides the species like tamarind, neem, gulmohar, eucalyptus, fruit and flowering plants can be planted extensively. Agave species

can be planted in 'estate concept' mainly to yield raw material for fibre extraction and to put otherwise unproductive areas to productive use and (iv) pasture development can be taken up on the barren hills, slopy soils, community lands and village poramboke lands. Having all the afforestation schemes, it is utmost necessary to convert this dry belt gradually into a green belt for balancing the ecosystem.

Fallow Land Use

Land under fallows accounted for 17 per cent of the geographical area of the district. which is indeed a high proportion. More than one fifth of the geographical area under fallows is found in 17 mandals mostly located in western and north-eastern parts of the district.

During thirty years period, the proportion of fallow land has increased by 5.6 per cent amounting to about 106 thousand hectares. The increase is found in many parts of the district. The regression analysis has also confirmed this trend of increase of fallow land but is accounted by 22 per cent of co-efficient of determination. It indicates that the increase in the area under fallows is not perpetual from year to year but highly fluctuating. The annual average rate of increase is 0.6 per cent.

It is suggested that an increasing trend of fallow land should be controlled and utilised at optimum level through scientific land use management systems. If possible all the fallow lands should be brought under dry farming cultivation with suitable drought resistant rain-fed crops like millets, pulses, fodder crops and agro-forestry A considerable change in the outlook of farmers is to be brought out from traditional practices to new methods of dry farming for optimum use of fallow lands with multi-tier vegetations in different ecological systems and the sound management of Sylvi-Agri-Pastoral Systems.

Agricultural Land Use

The district has vast agricultural land resource base but suffers from instability due to vagaries of monsoon. The net area sown in the district accounted for 49.9 per cent of the total geographical area which is significantly. Higher than the average proportion of net sown area in Andhra Pradesh State (41.3 per cent)

The quantum of change in the proportion of net area sown during 1960- 1990 showed a significant decline of 5.5 per cent amounting to 105 thousand hectares. The trend of net area sown in the district has been negative. The goodness of fit of the regression trend states that the present negative trend is to the tune of 11 per cent only. It means that the negative trend of the net area sown is not exactly perfect but it is highly fluctuating from year to year depending on the variation of rainfall On an average, the annual compound growth rate declined at 0.03 per cent.

Impact of Rainfall on Arable Land

In the drought-prone region, where rain-fed farming is predominant and irrigation development is very low, it is a common assumption that the increase or decrease in either cropped area or fallow land will be in close association with the success or failure of monsoons. In the present study, the correlation analysis has revealed that there has been a positive correlation between rainfall and net area sown in the district to the tune of 0.55 Co-efficient value and negative correlation between rainfall and fallow land to the tune of 0.62 co-efficient value. A high negative correlation of 0.85 is found between net area sown and fallow land. It shows that if there is an increase in rainfall, the land under cropping may increase or if there is decrease in rainfall, the land under fallows may increase. It indicates that these two land use types are inversely correlated and functionally related with each other.

Strategy for the Development of Suitable Cropping Pattern

The present cropping pattern dominated by groundnut, cannot be treated as inappropriate and it appears to be a more or less natural consequence of the poor natural resource endowments of the district. Now that it required all the more is the optimisation and strengthening of present cropping pattern without further spatial extension of mon-crop groundnut. In view of varying drought conditions and agricultural drought which differs from one crop to another crop in an area, an extending monoculture groundnut farming to wider area may not be advisable, as a wide-spread drought may adversely affect the agricultural economy of the district. In such circumstances, all rainfed crops which are of high value and low water consuming must be preferred. The risks from droughts could be reduced by popularising suitable inter-cropping methods. If there is failure of rain, at least one of the component crops will yield something and thereby minimise the risk of total loss. The non-traditional crops like sunflower, safflower and castor etc. should also be grown in the suitable soil and moisture conditions.

Soil Characteristics and Problems

The soil is a dynamic layer which immediately reacts to the pattern of its use or changes in the soil forming environment. The district has 82 per cent of red soils and 18 per cent of black soils. The phosphorus and organic matter 3 content is poor in 82 to 90 per cent of the soils. But more than 90 per cent of the soils are moderately rich in potash more than 95 per cent of the soils are neutral or weakly alkaline. Less than 5 per cent of the soils are having severe saline and or alkaline problems.

The results of studies made by different organisations reveal that the soil characteristics are being changed in a short span of time by such activities of man like (i) removal of vegetation cover, (ii) application of heavy irrigation, (iii)

change of cropping pattern and (iv) change of morphology. The conclusions are that (1) in the undulating piedment regions where dry farming is practiced there is an increase of rill and gully erosion, (2) there is steady increase in the salinity and alkalinity problems in the canal irrigated mandals like Rayadurg, Gooty. Tadipatri and Anantapur, (3) there is a decreasing tendency in the potassium content of the soils particularly in the paddy cultivated areas and (4) with the shift from millet oriented to groundnut oriented cropping pattern, the soils have shown sulphur and zinc deficiency. Iron deficiency is also predicted in the near future.

Soil Management

The soil management programme in a semi-arid region like Anantapur district should be comprehensive and integrated one. First and foremost adequate importance should be given to the extension programmes to create the awareness in the farming community about the dangers of the mismanagement of the soil ecosystem and to motivate them to follow proper soil management 2 guidelines. The soil forming environment could be improved by managing catchments at t micro-level Construction of check dams and watersheds on small catchments serves as a multi-purpose schemes in this direction Both agronomic and engineering measures of soil conservation should be implemented in a complementary manner to achieve better results. The alkalinity and salinity problems of the soils have to be solved with suitable measures like zypsum application and leaching of excessive salts with suitable dosage of irrigation respectively Proper care should also be taken to minimise water sepage from the irrigation canals which will lead to the problems of salinity and alkalinity.

Conclusion

It has been observed that man, rather than the nature is bringing considerable change in the quality of land in a short span of time. The short- sighted and unplanned commercial and subsistence gathering of resources from the nature's bounty have caused considerable damage to the land system Many of his activities though fetching short-term gains, are causing long-term and sometimes irreversible damages to the quality of landscape system in this dry region. In view of very low proportion of forest cover, high proportion of fallow land, instability in agriculture land followed by mono-cultures and poor nature of soil cover, the landscape ecosystem of this region is delicate and is being easily disturbed.) The maintenance of ecological balance is one of the most important 4 considerations and is to be looked into it very seriously. To achieve the required goals, "Sustainable Land Use Development" is the way of environmental feature. Jacobs [5] has referred to sustainable development as "the offspring of ecological planning". To understand both and carry them out, environmental education is essential at all levels and in all sectors of the population.

It is also often emphasised that the transformation of rural habitat is the fundamental lead for the eco-development of the region the integrated Rural Development (IRD) is to be concerned with ecological and environmental issues in addition to the integration of sectors and policies in space-time dimensions. The IRD concept is also to be conceived as strategic design of problem solving planning process for the effective involvement of local human and physical resources to improve the socio-economic and ecological situation of the rural habitat.

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INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

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REGIONAL INEQUALITY IN LITERACY ASPECTS IN INDIA: AN ANALYSIS

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Abstract

Literacy forms an important input in overall development of individuals enabling them to comprehend their social, political and cultural environment better and respond to it appropriately. It acts as a catalyst for social upliftment enhancing the returns on investment made in almost every aspect of development effort, be it population control, health, hygiene, environmental degradation control, employment of weaker sections of the society. Literacy rate in India (Census of India, 2011) was found to be 74.04 percent. When compared to the adult literacy rate, the youth literacy rate was about 9 percent higher. During the last decade, the highest improvement in literacy rate was observed among rural females (24 percent). This paper is descriptive in nature and examines the regional inequality in literacy aspects in India based on 75th round of National Sample Survey data. This will be useful in decision support, frame policy measures to improve literacy rate among the regions.

Key Words

Literacy, Education, Region, Inequality, gender and Census of India

Introduction

Educational attainment is the first and foremost step towards improving quality of life, awareness level and also level of skill of people in the society. Considering the importance of education, India has enacted ‘ Right to Education Act,2009’ to ensure free and compulsory Education for children in the age group 6-14 years. Literacy and education are important indicators in a society and play a central role in human development that impacts overall social-economic development milieu. Higher levels of literacy and education lead to better attainment of health and nutritional status, economic growth, population control, empowerment of the weaker sections and community as a whole. Also, higher literacy rates improve

development indicators consistently. Census obtains information on literacy for every individual, as this is recognised as one of the most important social characteristics. In census, a person aged seven years and above who can both read and write in any language, is treated as ‘ literate’ . A person, who can only read but cannot write, is not considered as ‘ literate’ (Census of India, 2011).

Literacy is the main foundation for social and economic growth. Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society (UNESCO, 2018). Generally, literacy also encompasses numeracy, the ability to make simple arithmetic calculations. Literacy and education is also one of the main components of human development index (HDI), as it has direct impact on the per capita income, level of living and ultimately on life expectancy. There is a strong empirical co-relation between literacy and life expectancy (Khan, 2004). In international usages, literacy is defined as the ability to read write and at least a simple message in any language (Hassan, 2005). Education is the single best development investment and a powerful instrument to develop an economically prosperous society. The long term social and economic return from education is enormous. The level of development of any region or any area may be gauged through the socio-economic characteristics of people. Of the various elements of population characteristics, the level of literacy and education gives the best exposition of regional development because of its dual functions as cause and effect of modernization.

Review of literature

Gopala Krishan and Madhav Shyam (1978) describe and interpret the regional aspects of the urban-rural differential in literacy in India in relation to economic, society and educational history different of India on the basis of 1971 census data. Siddiqui Shafiqullah (2011) attempted to analyses the trends of differential in literacy rate, spatial patterns of urban-rural differential and the relationship between differential index and selected variables of development among the districts of Uttar Pradesh, India. Kalyan Sundar Som and Ramesh Prasad Mishra (2014) examined the literacy and their differential in West Bengal, India. Ghanshyam Prasad Jhariya and C.K.Jain (2014) attempted to study the trends and pattern and their differential (Male-female and urbanrural) of literacy in Madhya Pradesh. The male – female and rural – urban differential has been worked out. There are remarkable gaps between male and female and between rural and urban rates in the state. Jangra, Ravinder and Kaushik, Satya (2015) describe and interpret the regional aspects of the urban-rural differentials in female literacy during 1991, 2001 and 2011, identify the correlates of female literacy in an agro-based economy, the total female literacy rate has increased significantly during the study period, and there are wide gaps in urban-rural female literacy. Comparatively, the increase is more remarkable in rural areas and gap is narrowing down. Vachaspati Shukla and Udaya S

Mishra (2020) examined the progress in literacy among the Indian states are evaluated here from an age cohort perspective.

Objectives

1. To examine the inequality in literacy aspects in India, also its states and
2. To suggest measures to improve aspects of literacy

Method and Material

The paper is based on descriptive and data collected from 75th round of National Sample Survey conducted on Household Social Consumption: Education during 1st July 2017 to 30th June 2018. A stratified multi-stage design was adopted for the 75th round survey and covers whole of the Indian Union except the villages in Andaman and Nicobar Islands. In this survey, total number of persons of age 3 to 35 years surveyed was 2, 86,456 (1, 73,397 in rural areas and 1, 13,059 in urban areas). Percentage of literates among persons of age 7 years and above has been defined as literacy rate.

Analysis and Discussion

Literacy rate

Literacy and level of education are basic indicators of the level of development achieved by a society. Spread of literacy is generally associated with important traits of modern civilization such as modernization, urbanization, industrialization, communication and commerce. Literacy forms an important input in overall development of individuals enabling them to comprehend their social, political and cultural environment better and respond to it appropriately. Education is a human right. Education is essential for human emancipation and social development. It contributes to better health, higher productivity, greater income, human freedom, capability and esteemed living, increased participation in community life. Literacy is an important demographic element of human process. It is essential for human character, social and economic development. Education includes new ideas for a better building of the society and their personal life style. Table- 1 gives data on literacy rate (in per cent) among persons of age 7 years and above for different States and regions.

Table-1: Literacy rate (in per cent) among persons of age 7 years and above for different states and regions

State	Rural			Urban **(in per cent)**			Rural+Urban **(in per cent)**		
	Male	Female	Person	Male	Female	Person	Male	Female	Person
Jammu and Kashmir	84.9	66.0	75.8	88.5	75.7	82.6	85.7	68.0	77.3
Himachal Pradesh	92.3	79.2	85.6	97.8	93.0	95.5	92.9	80.5	86.6
Haryana	85.8	66.4	77.0	92.5	81.2	87.3	88.0	71.3	80.4
Punjab	85.5	74.0	80.0	93.8	86.7	90.5	88.5	78.5	83.7
Uttarakhand	93.1	79.0	86.1	97.4	85.9	92.0	94.3	80.7	87.6
Uttar Pradesh	80.5	60.4	70.8	86.8	74.9	81.2	81.8	63.4	73.0
Delhi	-	-	-	94.1	83.4	89.4	93.7	82.4	88.7
Rajasthan	77.6	52.6	65.5	91.1	74.6	83.5	80.8	57.6	69.7
North Region	**85.7**	**68.2**	**77.3**	**92.8**	**81.9**	**87.8**	**88.2**	**72.8**	**80.9**
Gujarat	85.7	68.0	77.0	95.2	86.3	91.1	89.5	74.8	82.4
Maharashtra	87.0	71.4	79.4	95.3	87.6	91.7	90.7	78.4	84.8
West Region	**86.4**	**69.7**	**78.2**	**95.3**	**87.0**	**91.4**	**90.1**	**76.6**	**83.6**
Chhattisgarh	84.0	65.6	75.0	91.8	82.3	87.2	85.4	68.7	77.3
Madhya Pradesh	77.9	61.0	69.8	91.4	79.5	85.8	81.2	65.5	73.7
Central Region	**81.0**	**63.3**	**72.4**	**91.6**	**80.9**	**86.5**	**83.3**	**67.1**	**75.5**
Bihar	78.6	58.7	69.5	89.3	75.9	83.1	79.7	60.5	70.9
Jharkhand	80.6	61.4	71.4	92.6	78.6	86.1	83.0	64.7	74.3
Odisha	82.0	67.3	74.9	94.4	85.9	90.2	84.0	70.3	77.3
West Bengal	82.0	72.6	77.4	91.4	84.7	88.1	84.8	76.1	80.5
East Region	**80.8**	**65.0**	**73.3**	**92.0**	**81.3**	**86.9**	**82.9**	**67.9**	**75.8**
Assam	89.4	79.9	84.9	96.1	91.4	93.8	90.1	81.2	85.9
Northeast Region	**89.4**	**79.9**	**84.9**	**96.1**	**91.4**	**93.8**	**90.1**	**81.2**	**85.9**
Andhra Pradesh	67.5	53.4	60.4	86.3	73.1	79.6	73.4	59.5	66.4
Telangana	70.6	53.7	62.1	91.7	79.0	85.5	80.5	65.1	72.8
Karnataka	78.2	63.1	71.0	92.5	83.7	88.3	83.4	70.5	77.2
Kerala	96.7	94.1	95.4	98.2	96.4	97.3	97.4	95.2	96.2
Tamil Nadu	84.2	70.8	77.5	92.3	85.9	89.0	87.9	77.9	82.9
South Region	**79.4**	**67.0**	**73.3**	**92.2**	**83.6**	**87.9**	**84.5**	**73.6**	**79.1**
All India	**81.5**	**65.0**	**73.5**	**92.2**	**82.8**	**87.7**	**84.7**	**70.3**	**77.7**

Note: Figures for rural Delhi is not presented separately. However, ' rural + urban' for Delhi includes, ' rural' also.
Source: NSS 75th Round, July 2017 – June 2018.

Table-1 depicts that higher literacy rate is found in the region of north-east followed west, north, central, east and south. Central and east region had lower literacy rate than all India level. Among the regions, lowest literacy rate registered Uttar Pradesh in north, Gujarat in west, Madhya Pradesh in Central, Bihar in East and Andhra Pradesh in South in order. In the regions and states, literacy rate was lower for females. The differentials in literacy rate in regions and states can be attributed to disparities in socio-economic, cultures, physical conditions, infrastructure facilities and education related policies.

Years of formal education

Number of years completed in formal education or levels of education and literacy lead to a greater awareness and also contributes in improvement of economic and social conditions. Also better literacy and educational level definitely have a positive impact on the health as well as other sectors that influences level of development. Data on average number of years completed in formal education among persons of age 15 years and above for different states and regions presented in table-2

Table-2: Average number of years completed in formal education among persons of age 15 years and above for different states and regions

State	Rural			Urban			Rural+Urban		
	Male	Female	Person	Male	Female	Person	Male	Female	Person
Jammu and Kashmir	9.9	9.3	9.6	10.8	10.8	10.8	10.1	9.7	9.9
Himachal Pradesh	10.3	10.0	10.1	12.6	11.7	12.2	10.6	10.2	10.4
Haryana	10.0	9.5	9.8	11.7	11.5	11.6	10.6	10.3	10.5
Punjab	9.4	9.2	9.3	11.0	11.1	11.1	10.0	10.0	10.0
Uttarakhand	10.4	9.7	10.0	12.5	11.7	12.1	11.0	10.2	10.6
Uttar Pradesh	9.6	9.2	9.5	11.2	11.0	11.1	10.0	9.7	9.9
Delhi	-	-	-	11.4	11.4	11.4	11.4	11.4	11.4
Rajasthan	9.3	8.5	9.0	11.1	10.5	10.9	9.8	9.1	9.6
North Region	**9.8**	**9.3**	**9.6**	**11.5**	**11.2**	**11.4**	**10.4**	**10.1**	**10.3**
Gujarat	8.9	8.0	8.6	10.8	10.2	10.5	9.8	9.0	9.4
Maharashtra	9.5	8.6	9.1	11.4	10.8	11.2	10.4	9.7	10.1
West Region	**9.2**	**8.3**	**8.9**	**11.1**	**10.5**	**10.9**	**10.1**	**9.4**	**9.8**
Chhattisgarh	8.9	8.0	8.5	11.1	10.6	10.9	9.4	8.7	9.1
Madhya Pradesh	8.7	7.8	8.4	10.9	10.4	10.6	9.4	8.6	9.1
Central Region	**8.8**	**7.9**	**8.5**	**11.0**	**10.5**	**10.8**	**9.4**	**8.7**	**9.1**
Bihar	9.1	8.2	8.8	11.1	10.2	10.7	9.4	8.5	9.0
Jharkhand	8.6	7.7	8.2	10.8	10.3	10.6	9.1	8.4	8.8
Odisha	8.5	8.0	8.3	11.1	10.4	10.8	9.0	8.5	8.8
West Bengal	8.3	7.8	8.1	10.3	9.8	10.1	9.0	8.5	8.7
East Region	**8.6**	**7.9**	**8.4**	**10.8**	**10.2**	**10.6**	**9.1**	**8.5**	**8.8**
Assam	9.1	8.3	8.7	11.5	10.6	11.1	9.4	8.6	9.0
Northeast Region	**9.1**	**8.3**	**8.7**	**11.5**	**10.6**	**11.1**	**9.4**	**8.6**	**9.0**
Andhra Pradesh	9.3	8.6	9.0	10.7	9.9	10.3	9.8	9.1	9.5
Telangana	9.8	9.1	9.5	11.9	11.3	11.7	11.0	10.4	10.7
Karnataka	9.2	8.7	9.0	11.8	11.0	11.4	10.3	9.7	10.1
Kerala	10.2	10.2	10.2	10.6	10.8	10.7	10.4	10.4	10.4
Tamil Nadu	9.6	9.0	9.3	11.0	10.2	10.6	10.3	9.7	10.0
South Region	**9.6**	**9.1**	**9.4**	**11.2**	**10.6**	**10.9**	**10.4**	**9.9**	**10.1**
All India	**9.2**	**8.6**	**9.0**	**11.2**	**10.6**	**10.9**	**9.9**	**9.4**	**9.7**

Note: Figures for rural Delhi is not presented separately. However, ' rural + urban' for Delhi includes, ' rural' also.
Source: NSS 75th Round, July 2017 – June 2018.

Table-2 reveals that the average number of years completed in formal education among persons of age 15 years and above has registered in region of north followed by south, west, north east, west and east region. Enteral and east regions registered lower literacy rate than national level. Among the regions, Uttar Pradesh in north, Andhra Pradesh in south, Gujarat in west, Madhya Pradesh in Central and West Bengal in east in order had lower average number of years completed in formal education among persons of age 15 years and above. Average number of years completed in formal education was lower for females. It is generally influenced by socio-economic status and cultural aspects along with parents' perception on importance of higher education.

Gross Attendance Ratio (GAR)

GAR is one of the important indices of literacy rate. For each level of education, GAR is the ratio of the number of persons attending in the level of education to the number persons in the corresponding official age-group. GAR is calculated as " Number of persons attending in particular Classes/ estimated population in the respective classes' age-group x100. Table-3 furnishes details of Gross Attendance Ratio (GAR).

Table-3: Gross Attendance Ratio (GAR) at different levels of education for different States and region (rural+urban person)

State	Level of education					
	Primary level	Upper primary/ Middle level	Primary and Upper primary/ Middle level	Secondary level	Higher Secondary level	Post higher Secondary level
Jammu and Kashmir	101.9	96.9	100.2	115.7	77.0	33.1
Himachal Pradesh	99.3	92.1	96.1	100.9	110.0	34.1
Haryana	106.3	93.8	101.3	96.7	70.3	25.2
Punjab	101.5	94.9	99.1	95.4	79.4	22.8
Uttarakhand	99.8	111.6	104.0	80.7	98.7	32.8
Uttar Pradesh	98.9	88.8	95.4	64.0	60.4	20.8
Delhi	100.2	90.6	96.8	93.6	86.2	29.6
Rajasthan	110.5	87.0	101.6	82.4	70.1	28.9
North Region	**102.3**	**94.5**	**99.3**	**91.2**	**81.5**	**28.4**
Gujarat	106.0	89.1	99.1	88.3	59.2	15.3
Maharashtra	101.1	96.5	99.5	104.0	74.3	29.3
West Region	**103.6**	**92.8**	**99.3**	**96.2**	**66.8**	**22.3**
Chhattisgarh	102.4	100.4	101.6	90.3	66.9	16.2
Madhya Pradesh	95.3	97.5	96.1	83.9	59.9	17.3
Central Region	**98.9**	**99.0**	**98.9**	**87.1**	**63.4**	**16.8**
Bihar	97.2	98.4	97.6	82.0	65.7	16.2
Jharkhand	112.4	91.4	105.3	90.0	51.3	16.8
Odisha	103.4	91.3	98.8	87.2	53.4	14.5
West Bengal	101.6	105.2	103.0	92.4	59.3	18.7
East Region	**103.7**	**96.6**	**101.2**	**87.9**	**57.4**	**16.6**
Assam	103.6	104.7	104.0	86.6	56.0	16.5
Northeast Region	**103.6**	**104.7**	**104.0**	**86.6**	**56.0**	**16.5**
Andhra Pradesh	99.3	81.9	92.2	114.1	73.0	26.1
Telangana	92.8	106.1	97.7	109.0	96.8	28.9
Karnataka	104.4	90.1	99.3	92.3	73.4	21.7
Kerala	103.6	97.2	100.9	97.3	99.9	37.6

Tamil Nadu	103.2	96.4	100.4	89.8	91.9	35.4
South Region	**100.7**	**94.3**	**98.1**	**100.5**	**87.0**	**29.9**
All India	**101.2**	**94.4**	**98.7**	**86.4**	**68.3**	**22.8**

Note: Figures for rural Delhi is not presented separately. However, ' rural + urban' for Delhi includes, ' rural' also.
Source: NSS 75th Round, July 2017 – June 2018.

Table-3 reveals that the gross attendance ratio in primary level was lower in central region and southern than all India. In upper primary/ middle level, least GAR was recorded in west region. In primary and upper primary/middle level, least GAR recorded in south. In secondary level, least GAR recorded in north-east. In higher secondary level, least GAR recorded in east region. In post higher secondary level, least GAR recorded in east and central region. In primary level, Telangana of south region had least GAR. In Upper primary/Middle level, Rajasthan of north region had lowest GAR. In Primary and Upper primary/Middle level, Andhra Pradesh of south region had lowest GAR. In Secondary level, Uttar Pradesh of north region had lowest GAR. In higher secondary level, Jharkhand of east region had lowest GAR. In post higher Secondary level, Odisha of east region had recorded lowest GAR. Thus, differential in Gross Attendance Ratio (GAR) at different levels of education for different States and region were recorded. It can be due to differential in socio-economic and cultural progress, access of education facilities and other factors.

Net Attendance Ratio (NAR)

Net Attendance Ratio is the better indicator than GAR and shows level progress in literacy rate .It is the ratio of the number of persons in the official age-group attending a particular level of education to the total number of persons in the age-group. NAR is calculated as " Number of persons currently attending in particular Classes/ estimated population in the age-group in those particular classes x100.

Table-4: Net Attendance Ratio (GAR) at different levels of education for different States and regions (rural+urban person)

State	Level of education					
	Primary level	Upper primary/ Middle level	Primary and upper primary/ Middle level	Secondary level	Higher Secondary level	Post higher Secondary level
Jammu and Kashmir	88.1	78.4	91.3	69.6	46.1	29.5
Himachal Pradesh	90.1	80.6	90.7	68.2	67.5	28.1
Haryana	89.9	77.2	90.6	63.2	47.5	20.9
Punjab	88.8	78.1	90.9	65.3	49.7	19.8
Uttarakhand	87.1	80.8	94.0	54.3	56.5	29.2
Uttar Pradesh	79.2	59.7	84.0	38.7	33.1	17.2
Delhi	89.8	73.1	87.3	62.4	54.0	23.4
Rajasthan	89.5	69.1	88.2	48.2	37.8	24.2
North Region	**87.8**	**74.6**	**89.6**	**58.7**	**49.0**	**24.0**
Gujarat	93.7	77.6	91.0	62.9	40.6	13.7
Maharashtra	90.8	79.9	91.6	71.9	54.1	25.9
West Region	92.3	78.8	91.3	67.4	47.4	19.8

Chhattisgarh	91.6	82.1	93.5	64.9	46.6	13.1
Madhya Pradesh	81.6	72.9	86.6	54.1	36.3	13.5
Central Region	**86.6**	**77.5**	**90.05**	**59.5**	**41.45**	**13.3**
Bihar	81.9	70.3	87.8	54.2	35.7	13.2
Jharkhand	87.7	61.3	91.2	50.0	29.0	13.8
Odisha	91.2	77.0	91.5	67.6	37.4	12.0
West Bengal	88.4	77.8	91.9	60.2	36.3	15.8
East Region	**87.3**	**71.6**	**90.6**	**58**	**34.6**	**13.7**
Assam	88.8	77.0	93.0	57.3	36.8	15.2
Northeast Region	**88.8**	**77.0**	**93.0**	**57.3**	**36.8**	**15.2**
Andhra Pradesh	86.5	64.6	84.5	70.7	51.8	22.4
Telangana	82.2	75.8	91.0	76.8	75.2	25.2
Karnataka	95.3	80.7	94.5	75.8	56.5	20.2
Kerala	94.4	86.3	93.6	76.9	78.5	33.2
Tamil Nadu	89.5	81.3	92.3	66.7	61.8	30.4
South Region	**89.6**	**77.7**	**91.2**	**73.4**	**64.8**	**26.3**
All India	**86.1**	**72.2**	**89.0**	**57.6**	**43.4**	**19.4**

Note: Figures for rural Delhi is not presented separately. However, ‘ rural + urban’ for Delhi includes, ‘ rural’ also.
Source: NSS 75th Round, July 2017 – June 2018.

Table-4 reveals that in primary level, a difference in net attendance ratio was meager. However, Uttar Pradesh in North, Madhya Pradesh in Central, Bihar in east, and Telangana in south region recorded lowest net attendance ratio. In upper primary/middle level, lowest net attendance ratio observed in east region. In primary and upper primary/middle level, north region recorded lowest. In secondary level, net attendance ratio was lowest in north-east region. Lowest net attendance ratio found in east region in higher secondary level and central region in post higher secondary level. Among the states, except post higher Secondary level, Uttar Pradesh recorded lowest net attendance ratio.

Dropouts

Inspite of huge expenditure spent by the national and states/UTs on education sector along with several education policies, dropout is still serious issue in India. Parent’ s attitudes, unwillingness of students, distance and lack of facilities, bad school environment and building are the few of causes for dropouts. A Study of Dropout rate of School Children in Punjab by Inderpreet Kaur (2018) highlights the alarming rate of school dropouts, find out the causes of students drop out rates and their impact on Indian economy also report that children within the rural areas drop out of school earlier than those in the urban areas. An ever-enrolled person was considered as dropped out if he/ she did not complete the last level of education for which he/she enrolled and currently not attending any educational institution for reasons other than ‘ completion of the desired level of education’ .

Table-5: Percentage of persons dropped out among ever enrolled persons of age 3 to 35 years for different States

State	Rural			Urban			Rural+Urban		
	Male	Female	Person	Male	Female	Person	Male	Female	Person
Jammu and Kashmir	10.4	13.9	11.9	7.9	10.2	8.9	9.8	13.1	11.3
Himachal Pradesh	5.4	4.8	5.1	3.8	3.9	3.8	5.2	4.7	5.0
Haryana	11.0	10.8	10.9	5.2	4.5	4.9	9.1	8.7	8.9
Punjab	5.3	3.0	4.2	4.6	2.5	3.7	5.0	2.8	4.0
Uttarakhand	3.4	3.2	3.3	4.7	2.4	3.7	3.7	3.0	3.4
Uttar Pradesh	6.8	6.7	6.8	6.1	4.6	5.4	6.7	6.3	6.5
Delhi	-	-	-	6.5	6.1	6.4	6.5	6.0	6.3
Rajasthan	12.3	16.0	13.9	10.0	11.4	10.6	11.7	14.9	13.1
North Region	**7.8**	**8.3**	**8.0**	**6.1**	**5.7**	**5.9**	**7.2**	**7.4**	**7.3**
Gujarat	21.3	19.5	20.5	13.7	13.9	13.8	18.2	17.3	17.8
Maharashtra	16.8	19.9	18.2	12.2	11.6	11.9	14.7	16.1	15.3
West Region	**19.1**	**19.7**	**19.4**	**13.0**	**12.8**	**12.9**	**16.5**	**16.7**	**16.6**
Chhattisgarh	11.3	13.2	12.2	7.7	9.4	8.5	10.7	12.4	11.5
Madhya Pradesh	14.6	14.3	14.5	8.9	10.3	9.5	13.1	13.3	13.2
Central Region	**13.0**	**13.8**	**13.4**	**8.3**	**9.9**	**9.0**	**11.9**	**12.9**	**12.4**
Bihar	9.1	13.1	10.7	4.6	7.3	5.8	8.6	12.4	10.2
Jharkhand	13.5	16.3	14.7	8.7	8.4	8.6	12.5	14.7	13.5
Odisha	22.5	23.5	23.0	10.4	14.1	12.2	20.6	21.9	21.2
West Bengal	24.9	24.7	24.8	19.9	20.4	20.1	23.5	23.5	23.5
East Region	**17.5**	**19.4**	**18.3**	**10.9**	**12.6**	**11.7**	**16.3**	**18.1**	**17.1**
Assam	18.6	23.8	21.0	13.0	15.9	14.3	18.0	23.0	20.3
Northeast Region	18.6	23.8	21.0	13.0	15.9	14.3	18.0	23.0	20.3
Andhra Pradesh	14.4	14.6	14.5	10.4	11.3	10.8	13.1	13.5	13.3
Telangana	11.2	13.9	12.4	6.5	6.3	6.4	8.9	10.3	9.5
Karnataka	15.0	18.4	16.5	7.9	9.2	8.5	12.3	14.7	13.3
Kerala	14.6	14.5	14.5	13.1	11.9	12.5	13.9	13.3	13.6
Tamil Nadu	10.8	9.4	10.1	6.9	6.6	6.7	8.1	9.0	8.5
South Region	**13.2**	**14.2**	**13.6**	**9.0**	**9.1**	**9.0**	**11.3**	**12.2**	**11.6**
All India	**13.2**	**14.7**	**13.8**	**9.5**	**9.7**	**9.6**	**12.1**	**13.2**	**12.6**

Note: Figures for rural Delhi is not presented separately. However, ' rural + urban' for Delhi includes, ' rural' also. Source: NSS 75th Round, July 2017 – June 2018.

Table-5 shows that percentage of persons dropped out among ever enrolled persons of age 3 to 35 years was east and west region. Rural of all regions recorded higher dropped out in rural than urban and higher for females than males. This clearly reveals some of the hurdles like poverty and social norms access to education in rural and for females. In northern region, highest dropout recorded in Rajasthan. Similarly, Gujarat in west region, Madhya Pradesh in central region, West Bengal in east, Assam in north east, and Kerala, Karnataka and Andhra Pradesh states in south recorded higher dropouts. Thus, significant differential in dropouts recorded among the regions, states, rural-urban areas and by gender.

Summary and policy implications

Among the regional and states, inequality in literacy rate, years of formal education, gross attendance ratio, net attendance ratio and dropped out among ever enrolled persons of age 3 to 35 years was found. Hence, tackle the inequality in examined literacy aspects, emphases should be given to special educations of New Education policy 2020 apart from strict implementation of free and compulsory education as per Right to Education Act, 2009 by considering the level of literacy, influencing obstacles such as geographical, socio-economic and cultural apart from other aspects that prevails at regional and states level.

Measures to improve Literacy Rate

- Encouraging every female to study
- Teaching in mother tongue
- Develop love for reading
- Use of technology in teaching and learning
- Encourage learning by doing
- Institutional Social Responsibility (ISR)
- Social Responsibility of every educated and employed citizen

Every citizen should be given a compulsory task to educate children in their own neighbourhoods. Local Governing bodies can target the area to analyse and formulate plan to cover up the population in bringing up the rate of literacy in India.

Limitation

The main limitation of the study is that for north-east region, data related to education aspects available for Assam state only.

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A Study On Socio-Economic And Demographic Characteristics Of HIV Positive Pregnant Women Attending ART Centre

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Abstract

The women are mostly engaged in the unorganised sector as labourers. They face the problems of job insecurity and exploitation on par with the male workers. In addition, they are subjected to wage discrimination and the nature of work assigned to them is usually drudgery in nature. They are also subjected to sexual exploitation at the work place. In the homes they are expected to do all the domestic chores. Therefore, the women with Human Immunodeficiency Virus (HIV) positive in lower starts of society need urgent and special attention. Moreover, the women in India are characterized by low status, low level of education, low level of health conditions and employment. They are suffering from insecurity, exploitation in addition to poverty. The paper aims at examines the Socio-Economic and Demographic Characteristics and based on primary data collected from HIV positive pregnant women attending Antiretroviral therapy (ART) Centre.

Keywords

Socio-Economic and Demographic Characteristics, Antiretroviral therapy and Human Immunodeficiency Virus

Introduction

India is one such Third World country which is characterized by poverty and unemployment. According to 2001 census 35 per cent of the population is living below poverty line and 25 per cent below poverty line huge are of developmental benefits are going in favour of a small section of the society, who have high socio-economic status. This has been resulting in the widening of income and wealth disparities. Consequently, the intensity of poverty has been rising and as a result, high incidence of poverty has been falling on women. Rural women are mostly engaged in the farms as agricultural labourers. They face the problems of job insecurity and exploitation on par with the male workers. In

addition, they are subjected to wage discrimination and the nature of work assigned to them is usually drudgery in nature. They are also subjected to sexual exploitation at the work place. In the homes they are expected to do all the domestic chores. Therefore, the rural women in lower starts of society need urgent and special attention. Msamanga, G.I et al (2006) examined the Socio-economic and demographic factors associated with prevalence of HIV infection among pregnant women in Dar es Salaam, Tanzania.

The women will face different problems for their existence depending upon the class to which they belonged to. Therefore, treating all the women as one category may not be helpful in proper understanding often phenomenon. The women belonging to the upper strata are relatively at some advantage, while women in poorer sectors are to wage struggles for their existence. The women in the upper strata of the society have the problem of leisure and the problems that go with the leisure, the middle class women are under the stresses and strains of deteriorating living standards. It is the middle class women who compete for the jobs in the organized sector and encounter stiff competition. The third category of women who belong to the poorer classes and are engaged in the basic struggle for existence, particularly in the rural areas face a different type of problems. Chauhan G (2014) HIV positive pregnant women were younger, primi and housewives. HIV positive antenatal women need to be followed rigorously to link them to ART services. Caroline Granberg (2015) found that higher level of education and belonging to a higher level of wealth quintile were significantly associated with having knowledge about PMTCT. All categories for education showed a significant difference.

The rural women are mostly engaged in the farms as agricultural labourers. They face the problems of job insecurity and exploitation on par with the male workers. In addition, they are subjected to wage discrimination and the nature of work assigned to them is usually drudgery in nature. They are also subjected to sexual exploitation at the work place. In the homes they are expected to do all the domestic chores. Therefore, the rural women in lower starts of society need urgent and special attention. The rural women in India are characterized by low status, low level of education, low level of health conditions and employment. They are suffering from insecurity, exploitation in addition to poverty. Socio-economic status (SES) is often measured as a combination of education, income, and occupation. It is commonly conceptualized as the social standing or class of an individual or group. When viewed through a social class lens, privilege, power and control are emphasized. Furthermore, an examination of SES as a gradient or continuous variable reveals inequities in access to and distribution of resources. The SES is relevant to all realms of behavioural and social science including research, practice, education and advocacy. Padmaja Y et al (2017) studied the demographic characteristics among pregnant and postpartum HIV positive women. Social class and educational status play a vital role in establishing awareness and ensuring the antenatal care and compliance. Empathetic, inclusive and responsive by health care providers in convincing women to get tested goes a long way.

Literature Review

Anne WanjaKibera et al (2017) found that HIV infections in Kenya were predominantly among the resourceful newly married,young educated adults. Gender distribution difference was insignificant (2.2%) in the numbers by sex it was at (2%). The youngest participant was 18 years old implying that the

mode of transmission in this population was sexual and or any other but unlikely to be mother to child. Ottop F. Manyi et al (2020) aimed to describe the socio-demographic profiles of naive to antiretroviral therapy (ART) HIV-infected pregnant women. A total of seventy (70) women were enrolled with age range varying between 15 and 40 years, the Muslim religion, education below secondary level and the profession of housewife were significantly associated. Unyime Patrick Udoudo et al (2021) examined the socio-economic characteristics such as age, marital status, employment status, place of residence, level of education. The result showed that the marital status, place of residence and level of education has a negative relationship with the probability of a pregnant woman having a positive HIV status. Feny Deya Virdausi et al (2022) found that women's age, education level, wealth quintile, residential area and region, access to information, owning cell phones and autonomy were significantly associated with positive knowledge and attitudes toward HIV/AIDS.

Objective

To study the Socio-Economic and Demographic Characteristics of HIV positive pregnant women attending ART Centre

Method and material

The paper is based descriptive research design and based on primary data collected with interview scheduled from 250 HIV positive pregnant women coming to Antiretroviral therapy Center at SVRR Government General Hospital, Tirupati, Andhra Pradesh.

Results and discussion

Age

Age is an important factor which determines the physical ability to work. Age is very important factor besides the active participation in innovative activities and risk taking ability. To understand the working age group, it is necessary to classify the respondents according to their age. Age shows understanding nature and shouldering the responsibility. The age of the respondents is presented in the table-1.

Table-1: Age of the Respondents

Sl. No.	Age	No. of Women	Percentage
1	Below 25 years	75	30.0
2	26 - 35 years	101	40.4
3	Above 35 years	74	29.6
	Total	**250**	**100.0**

The table-1 shows that 40.4 per cent of the respondents are in the age group of 26–35 years, 30 per cent are in the age group of below 25 years and 29.6 per cent are in the age group of above 35 years. Above all, it is concluded that more than 40 per cent of the respondents are in the age group of 26–35 years.

Marital Status

The marital status of the respondents is shown in the table-2.

Table-2: Marital status of the respondents

Sl. No.	Marital Status	No. of Women	Percentage
1	Married	248	99.2
2	Unmarried	2	0.8
	Total	**250**	**100.0**

The table-2 shows that 99.2 per cent of the respondents are married and mere 0.8 per cent is spinsters.

Caste

Caste is another variable to analyse and understand the socio-economic characteristics of the respondents. Caste has become very important in India, for meaningful study it is not possible and feasible without taking caste into consideration. The caste composition of the respondents is furnished in the table-3.

Table-3: Caste of the respondents

Sl. No.	Caste	No. of Women	Percentage
1	Forward Caste	52	20.8
2	Backward Caste	120	48.0
3	Scheduled Caste	60	24.0
4	Scheduled Tribe	18	7.2
	Total	**250**	**100.0**

The table-3 portrays that 48 per cent of the respondents belong to Backward Caste, 24 per cent to Scheduled Caste, around 21 per cent to Forward Caste and a little over 7 per cent belong to Scheduled Tribe.

Education

Education plays a very important role to empower women and for development of society. It gives analysing capacity and wisdom to thinking and decision making capacity. Education - formal and informal - improves awareness for better life and generates positive impulses for socio-economic advancement. It controls the attitudes, opinions and behaviour of the people and influences the economic destiny of the family. The educational status of the respondents is presented in the table-4.

Table-4: Literacy of the Respondents

Sl. No.	Education	No. of women	Percentage
1	Illiterate	106	42.4
2	Up to Primary	39	15.6
3	Up to 10th	85	34.0
4	Intermediate	11	4.4
5	Graduation	9	3.6
	Total	**250**	**100.0**

It is quite obvious from the table-4 that 42.4 per cent of the respondents are illiterates, 34 per cent have SSC qualification, around 16 per cent have primary education, 4.4 per cent have Intermediate and around 4 per cent are graduates.

Occupation

It is a common fact that the occupation of the individual determines his position in the society and standard of living. Table-5 reveals the occupational structure of the sample population. Most of the respondents in the sample are doing business and are in employment. Only a few persons are Involved in agriculture. Majority of the respondents from the employment and business categories show higher fertility and higher additional expected family size compared to the cultivators in the sample population.

Table-5: Occupation of the Respondents

Sl. No.	Occupation	No. of Women	Percentage
1	Housewife	128	51.2
2	Coolie	90	36.0
3	Petty business	11	4.4
4	Daily labourers	14	5.6
5	Private jobs	7	2.8
	Total	**250**	**100.0**

The table-5 shows that 51.2 per cent are housewives, 36 per cent are coolies, around 6 per cent are daily labourers, 4.4 per cent have petty business and around 3 per cent are working in private sector.

Financial Support

The financial support the respondents getting is shown in the table-6.

Table-6: Mode of financial support

Sl. No.	Mode of financial support having to live	No. of Women	Percentage
1	Family members	159	63.6
2	Friends	42	16.8
3	Relatives	49	19.6
	Total	**250**	**100.0**

The table-6 shows that around 64 per cent of the respondents have financial support from their family members to live, around 20 per cent have financial support from relatives and around 17 per cent have financial support from friends.

Conclusion

This study showed that as many women as men were equally vulnerable to HIV infections. Risk factors for HIV infections were being young adults, mostly backward and scheduled caste, illiterate or primary education and majority are being housewife, and receiving financial support from family members most are being married or cohabiting couples, a contrast with the notion that marriage was a protective institution against HIV infections. The high prevalence rate of HIV was attributed to low level of sexual health education and condom use. Low risk factors for HIV infections were associated with low level of education. As such, policy makers should review HIV programmes and consider the contribution of socio-economic and demographic factors done so that gaps in the prevention and control of HIV in could be sealed to reduce the negative impact of HIV infections.

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This study showed that as many women as men were equally vulnerable to HIV infections. Risk factors for HIV infections were being young adults, mostly backward and scheduled caste, illiterate or primary education and majority are being housewife, and receiving financial support from family members most are being married or cohabiting couples, a contrast with the notion that marriage was a protective institution against HIV infections. The high prevalence rate of HIV was attributed to low level of sexual health education and condom use. Low risk factors for HIV infections were associated with low level of education. As such, policy makers should review HIV programmes and consider the contribution of socio-economic and demographic factors done so that gaps in the prevention and control of HIV in could be sealed to reduce the negative impact of HIV infections.

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حضرت عبدالحق شہ میر ثالثؒ کی نعت گوئی

حضرت سید عبدالحق شہ میر ثالثؒ خاندانِ شہ میریہ کے چشم و چراغ ہیں۔ آپ کی ولادت ۱۸۷۱ء میں شہر کڈپا میں ہوئی اور ۱۹۳۵ء میں اس دارِ فانی سے کوچ کر گئے۔ آپ ایک صوفی باصفا اور عالم باعمل بزرگ تھے۔ آپ شاعر بھی تھے اور نثر نگار بھی۔ آپ کا شعری سرمایہ دیوان شاہ میر ہے جو ۱۹۲۱ء میں زیورِ طبع سے آراستہ ہوا تھا۔ اس دیوان سے متعلق حضرت محمود بخاریؒ اپنی تصنیف شہ میری اولیاء میں لکھتے ہیں:

''دیوان شاہ میر' حضرت شاہ میر کے کلام حمد و نعت' سلام و منقبت کا لاجواب مجموعہ ہے۔ دیوان کیا ہے! تصوف کا خزانہ' مُعارف کا گنجینہ' عشقِ حقیقی کا پیغام' حُبِ نبوی کا لبریز جام ہے۔'' (ص:۱۱۲)

دیوان شاہ میر میں حضرت شہ میر ثالثؒ نے وافر نعتیں کہی ہیں اور خوب کہی ہیں۔ بقول میر انیسؔ: ''ایک پھول کا مضمون ہو تو سو رنگ سے باندھوں'' کے مصداق حضرت نے حضور اکرم حضرت محمد صلی اللہ علیہ وسلّم کی تعریف و توصیف میں عقیدت کے رنگ برنگ پھول نچھاور کیے ہیں۔ آپ کے کلام کے مطالعہ سے بخوبی اندازہ ہوتا ہے کہ یہ ایک عاشقِ رسول کا کلام ہے۔ جس میں آمد ہی آمد ہے۔ اپنی نعتیہ شاعری پر آپ کو خود ناز تھا۔ کہتے ہیں:

گوہرِ نعتِ رسولِ عربی سے پُر ہے
مرے دیوان کا لے کر یہ خزانہ دیکھو
جتنی غزلیں ہیں سب نعتِ حضرت میں ہیں
قابلِ وصف میرا یہ دیوان ہوا

حضرت کا کلام اپنے اجداد کے کلام کے مقابلے میں کافی نکھرا ہوا ہے۔ انہوں نے کلاسیکی شعری روایات بالخصوص تغزل کی آمیزش سے اپنے نعتیہ کلام کو آراستہ کیا ہے۔ پروفیسر مظفر علی شہ میری نے اپنی تصنیف: حضرت عبدالحق شہ میر ثالثؒ۔ حیات' شخصیت اور فن'' میں یوں رقم طراز ہیں:

''انہوں نے اپنے خاندانِ صوفیہ کے مخصوص موضوعاتِ شاعری کے اظہار اور زبان و بیان میں جو جدت و ندرت پیدا کی ہے' اس کی حیثیت نعتیہ و ذوقیہ شاعری میں اجتہاد کیا ہے۔ ان کے نعتیہ کلام میں غزل کا لوچ اور مٹھاس رچ بس کر باہم شیر و شکر ہو گئے ہیں۔ یہ اپنی نوعیت کا جدید رنگ ہے جو ان کے شعرائے سَلَف کے یہاں نہیں ملتا۔'' (ص:۴۲)

حضرت شہ میر ثالثؒ کی صاف زبان' شائستہ بیانی' سادگی و سلاست' نرم و شیریں لہجے نے شہ میری اولیا کے کلام میں آپ کو منفرد مقام عطا کیا ہے۔ جس کا آپ کو خود احساس تھا۔ فرماتے ہیں:

میں نازاں ہوں رسول اللہ کی مدحت سرائی پر
کوئی شہ میر مجھ جیسا غزل خواں ہو نہیں سکتا

حضرت شہ میر ثالثؒ کے نعتیہ کلام میں سرکارِ دو عالم حضرت محمد مصطفیٰ صلی اللہ علیہ وسلّم کی عظمت و بزرگی کا بیان' اوصاف حمیدہ کا عقیدت سے بھرا اظہار، قد و قامت' صورت و سیرت کا ذکر' دیدار مصطفیٰ کی تمنا اور مدینہ منورہ کی سرزمین سے محبت کا والہانہ اظہار ملتا ہے۔ ان موضوعات کو حضرت نے نہایت عمدگی سے شعر کے قالب میں ڈھالا ہے۔ حضرت کا نعتیہ



اردو ادب کے فروغ میں مذہبی ادب کا کردار

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ستار فیضیؔ کی شاعری میں مذہبی عناصر

ڈاکٹر محمد نثار احمد

اسوسی ایٹ پروفیسر، شعبہ اردو ایس-وی-یونیورسٹی، تروپتی (آندھرا پردیش)

جناب ستار فیضی کا نام شیخ عبدالستار ہے۔ قلمی نام ستار فیضی اور تخلص فیضیؔ۔ یکم جون 1965 (انیس سو پینسٹھ عیسوی) کو کڈپہ میں پیدا ہوئے۔ اردو میڈیم سے تعلیم حاصل کی۔ انھیں اردو سے والہانہ محبت ہے۔ 1989ء (انیس سو نواسی عیسوی) میں اردو کے مدرس بنے۔ اُس وقت سے آج تک انھوں اردو درس و تدریس اور اردو شعر و ادب کے لیے اپنے آپ کو وقف کر دیا۔ اِن دنوں ستار فیضی کڈپہ ضلع میں میدکور کے ضلع پریشد اردو ہائی اسکول میں اسکول اسسٹنٹ کی حیثیت سے خدمات انجام دے رہے ہیں۔

ستار فیضی آندھرا پردیش کے اہم اور ممتاز شعراء میں شمار کئے جاتے ہیں۔ انہوں نے شاعری میں مختلف اصناف پر طبع آزمائی کی ہے۔ حمد، نعت، مناجات، منقبت، غزل اور نظم کے علاوہ انھوں نے کہانیاں اور مضامین بھی لکھے ہیں۔ ان کی کہانیاں اور نظمیں مختلف اخبارات، رسائل و جرائد میں شائع ہوتے ہیں۔ چند ایک کے نام یہ ہیں: گل بوٹے ممبئی، بچوں کی دنیا دہلی، الحیات رانچی، روشن ستارے حیدرآباد، دعوت دہلی، الہدیٰ نیپال، ندائے صالحات کڈپہ، قومی صحافت لکھنؤ، صدائے بسمل جارکھنڈ، تریاق ممبئی، ماہنامہ اردو دنیا، ماہنامہ تریاق، بدرِ کامل ناندیڑ کے علاوہ سالار و یکلی، روزنامہ سیاست، روزنامہ اعتماد اور روزنامہ رہنمائے دکن میں ان کے مضامین شائع ہوتے ہیں۔

ستار فیضی کا مجموعۂ کلام ''دھنک'' کے نام سے اردو اکیڈمی آندھرا پردیش کی جزوی مالی تعاون سے 2014ء شائع ہو چکا ہے۔ ان کے مضامین کا مجموعہ ''مہک'' اور شعری مجموعہ ''کسک'' زیرِ طبع ہے۔ سرورِ کونین کے نام سے ایک شراکتی نعتیہ مجموعہ بھی اردو اکیڈمی کے مالی تعاون سے منظرِ عام پر آ چکا ہے۔ اس کے علاوہ ''چھتیس حرکاتی نظمیں''، ''فیضی کے سو 100 شعر''، ''فیضی کی پچاس پہیلیاں''، ''ایکٹیوٹی بک''، ''لطیفوں کا مجموعہ ''مسکان''، بچوں کی نظمیں ''غنچہ غنچہ''، ''بھارت میرا مہان'' اور گذشتہ دنوں ان کی نعتوں پر مشتمل ایک مجموعہ ''شاہِ اُمَم'' کے نام سے شائع ہو چکا ہے۔ ستار فیضی صاحب نے تیلگو میں بھی چند کتابچے شائع کئے ہیں۔ اردو ساہتیہ نُو رتنالو، بھکتی مُکتی، بھارتیہ پرمُکھا مسلم مہیللو، وغیرہ شائع ہو چکے ہیں۔

ستار فیضی کی ادبی شخصیت کی کئی جہتیں ہیں۔ ستار فیضی نے اپنی شاعری میں مذہبی موضوعات کو مختلف جہتوں میں پیش کیا ہے۔ حمد و نعت اور دعا و مناجات کے علاوہ دیگر منظومات میں بھی دینی، اسلامی اور

Urdu Adab Ke Faroug [illegible]
Mazhabi Adab Ka [illegible]

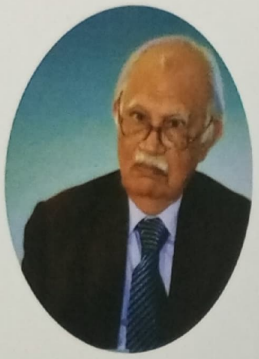
اردو زبان [illegible] کے ظرف میں بہت وسعت ہے۔ اسلامیات اور دیگر مذہبی لٹریچر کی اردو ادب میں بڑی اچھی کھپت ہوسکتی ہے، اس سے ہمارا ادب نہ صرف تازہ اور توانا بنے گا بلکہ زبان وادب سے عوام کی دلچسپی میں جو زبردست کمی دیکھنے کو مل رہی ہے یہ کمی بھی دور ہوجائے گی۔ آج مذہبی نظریات وتعلیمات میں عوام کی دلچسپی بڑھ رہی ہے، مذہب بے زاری کے بادل جو کمیونسٹوں کے گمراہ کن پروپگنڈہ سے عوام کے ذہنوں پر چھائے ہوئے تھے وہ اب چھٹنے لگے ہیں۔ اردو ادب کو بھی ان زنجیروں سے چھٹکارا حاصل کرلینا چاہیے۔

پروفیسر قاضی حبیب احمد

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Edited By:
Dr S. Mohamed Yassir
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"پروفیسر بی شیخ علی
حیات اور خدمات"



مرتب ڈاکٹر محمد نصر اللہ خان

اسسٹنٹ پروفیسر، شعبۂ اردو، کرناٹک اسٹیٹ اوپن یونیورسٹی، میسورو

ناشر

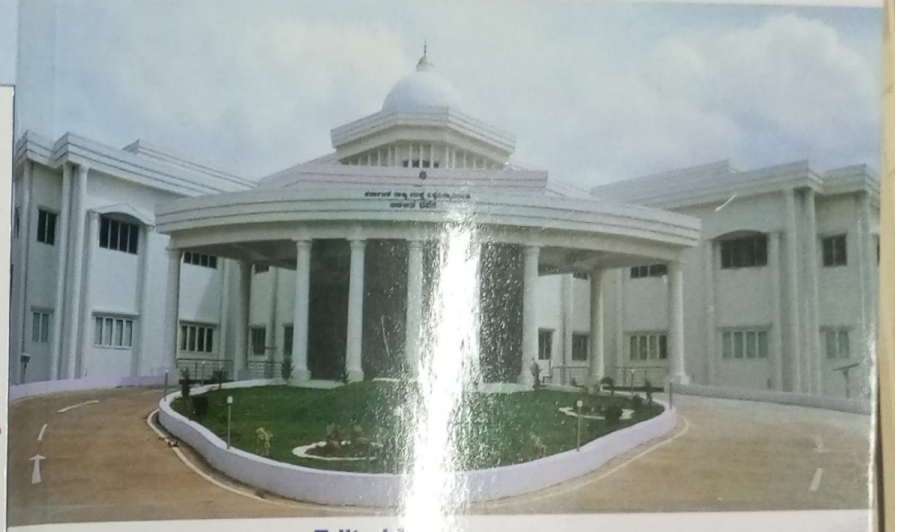
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مکتا گنگوتری، میسورو، 570006

2023

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"پروفیسر بی شیخ علی حیات اور خدمات"



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پروفیسر بی شیخ علی کی تعلیمی خدمات - ایک جائزہ

ڈاکٹر محمد نثار احمد

صدر شعبۂ اردو، ایس۔ وی۔ یونیورسٹی

تروپتی، آندھرا پردیش

پروفیسر شیخ علی کی شخصیت کرناٹک ہی نہیں بلکہ جنوبی ہند کی قد آور شخصیت تھی۔ انہوں نے ہندوستان اور بیرون ہند بھی اپنی تحقیقات اور تصنیفات کے ذریعے ایک بلند مقام حاصل کیا۔ پروفیسر شیخ علی ایک مشہور مؤرخ، فلسفۂ تاریخ کے رمز شناس، محقق اور مصنف تھے۔ ان کا دائرہ کار صرف تاریخ تک محدود نہیں تھا بلکہ مذہب، ادب، صحافت اور سماجیات و سیاسیات پر بھی انہیں گہرا عبور حاصل تھا۔ ان کی شخصیت ہمہ جہت شخصیت تھی۔ وہ مختلف عہدوں پر فائز رہے۔ ان کی تعلیم میسور یونیورسٹی، علی گڑھ مسلم یونیورسٹی اور لندن یونیورسٹی میں ہوئی۔ انہوں نے ان دونوں یونیورسٹیوں سے تاریخ میں پی ایچ ڈی کی ڈگری حاصل کی یعنی علی گڑھ مسلم یونیورسٹی اور لندن یونیورسٹی۔

انہوں نے اپنی مادر علمی میسور یونیورسٹی سے اپنی تدریسی خدمات کا آغاز کیا۔ تقریباً چالیس سال پروفیسر کی حیثیت سے خدمات انجام دینے کے بعد ملک کی دو مؤقر یونیورسٹیوں کے وائس چانسلر کی حیثیت سے شاندار کارنامے انجام دیئے۔ یونیورسٹی آف گوا اور منگلور یونیورسٹی میں ان کی گراں بہا خدمات کا اعتراف کیا جاتا ہے۔ یہ اعزاز بہت کم افراد کو حاصل ہوتا ہے۔

اعلیٰ تعلیمی اداروں میں اعلیٰ تعلیم حاصل کرنے اور شاندار تدریسی خدمات انجام دینے کی وجہ سے انہیں تعلیم کی اہمیت اور افادیت کا بخوبی اندازہ تھا۔ تعلیمی اداروں کے انتظام اور نظم و نسق کے سلسلے میں طویل ترین تجربہ ان کے ساتھ تھا۔ وہ ہمیشہ قوم و ملت کی تعلیمی ترقی کے لیے فکرمند رہتے تھے۔ ان کا ایقان تھا کہ تعلیمی ترقی ہی کے ذریعے قوم و ملت کی ترقی ہو سکتی ہے۔

پروفیسر شیخ علی تعلیم کی اہمیت اور علم کی فضیلت کے بارے میں ایک جگہ لکھتے ہیں:

''اسی لیے کہتے ہیں کہ قوموں کا مستقبل درسگاہوں میں ڈھلتا

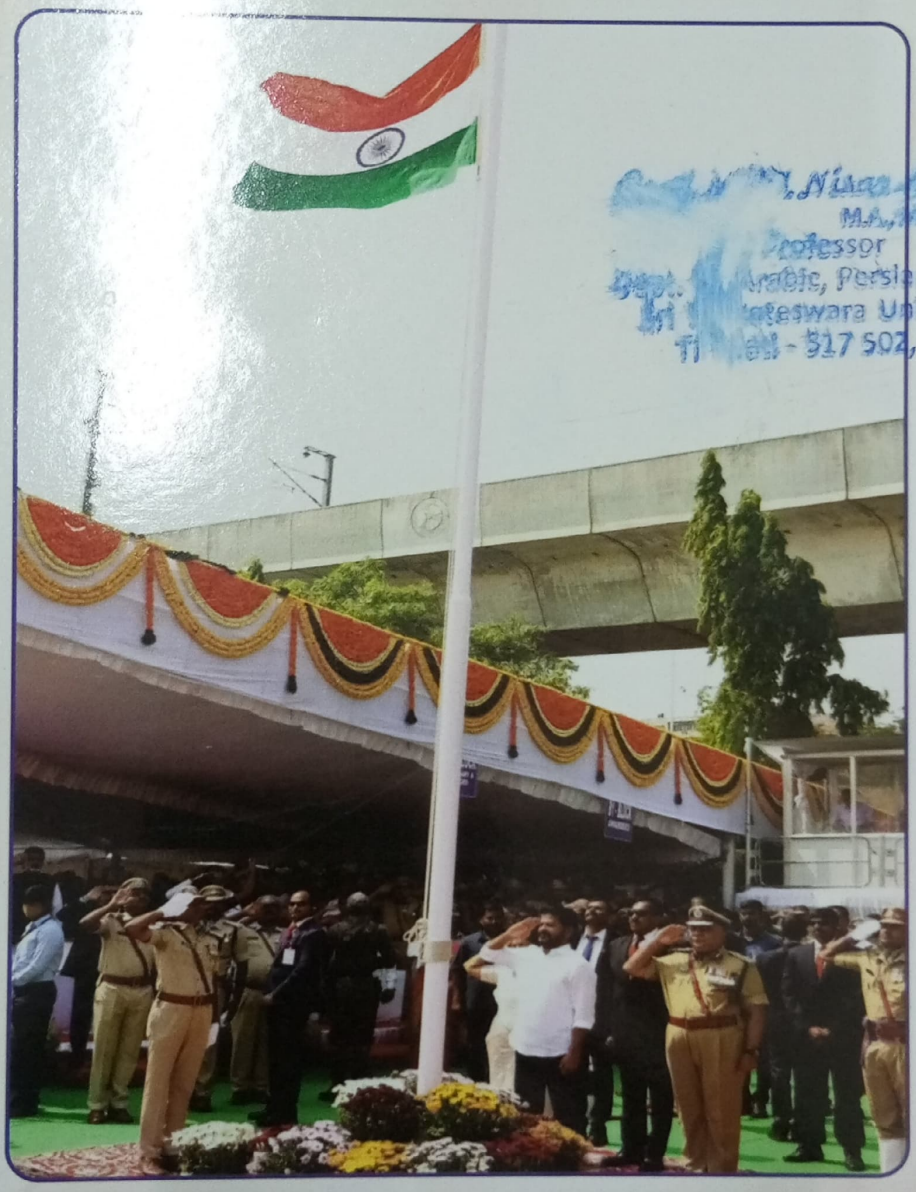
ہے اور قوموں کے معمار معلم ہوتے ہیں۔ علم ہی ایک ایسی واحد دولت ہے جو لٹانے سے بڑھتی ہے اور بچانے سے گھٹتی ہے۔ مذہب اسلام کی ابتداء اقراء یعنی پڑھنے کے حکم سے شروع ہوئی۔ یہ قرآن مجید کی پہلی وحی ہے۔ جو رسول اکرم صلی اللہ علیہ وسلم پر نازل ہوئی۔'' (ارمغانِ سالار، ص:68)

پروفیسر شیخ علی ایک ماہر تعلیم تھے۔ انہوں نے فلسفۂ تعلیم کی مشہور شخصیات کا گہرا مطالعہ کیا تھا۔ وہ خاص طور پر عالم اسلام کے مفکرین سے متاثر تھے جن میں مولانا رومی، حافظ شیرازی، امام غزالی، سرسید احمد خان، علامہ شبلی نعمانی، مولانا حالی، علامہ اقبال، مولانا ابوالکلام آزاد اور ڈاکٹر ذاکر حسین وغیرہ قابل ذکر ہیں۔ ان مفکرین کے افکار اور تعلیمی تصورات سے متاثر ہو کر انہوں نے ان افکار کو اپنے فکر و نظر میں شامل کر لیا تھا۔ وہ ان بزرگوں کی تعلیمی خدمات کے معترف تھے۔ انہوں نے اپنے مضامین میں خاص طور پر تعلیمی تصورات کا ذکر کیا ہے۔ انہوں نے ماہر تعلیم ڈاکٹر ذاکر حسین پر انگریزی میں ایک کتاب کرناٹک کے گورنر خورشید عالم خان کے ساتھ لکھی جسے ساہتیہ اکیڈمی نے شائع کیا۔ پروفیسر ابوالکلام قاسمی نے اس کا اردو ترجمہ کیا ہے۔ اس کتاب میں پروفیسر شیخ علی نے نہایت عمدہ اسلوب میں ڈاکٹر ذاکر حسین کے تعلیمی تصورات کو مبسوط اور مفصل پیش کیا ہے۔ اصلاحِ نصاب کے سلسلے میں سابق صدر جمہوریہ ہند ڈاکٹر ذاکر حسین کے حوالے سے ایک جگہ لکھتے ہیں:

''ایک اور اہم بات یہ ہے کہ ہمارے طرزِ تعلیم میں اصلاح چاہیے۔ ڈاکٹر ذاکر حسین صاحب ماہر تعلیم نے تعلیمی اسلوب کے جو طریقے سکھائے ہیں، ان کی تعمیل چاہیے۔ انہوں نے کہا کہ انگریزوں نے تعلیم کا جو مقصد قرار دیا تھا، وہ اب تک باقی ہے یعنی نوکری۔ اس کو بدل کر اخلاقی شخصیت کی تعمیر تعلیم کا مقصد ہونا چاہیے۔ مقصد کے تعین کی کسوٹی تہذیب ہے۔'' (ارمغانِ سالار، ص:76)

پروفیسر شیخ علی کی تعلیمی خدمات کے سلسلے میں قابل ذکر پہلو یہ ہے کہ وہ ایک طرف الامین تعلیمی تحریک سے وابستہ رہے۔ اس کے روحِ رواں اور سرپرست کی حیثیت سے ابتداء

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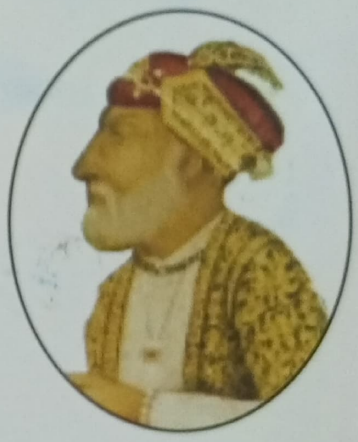
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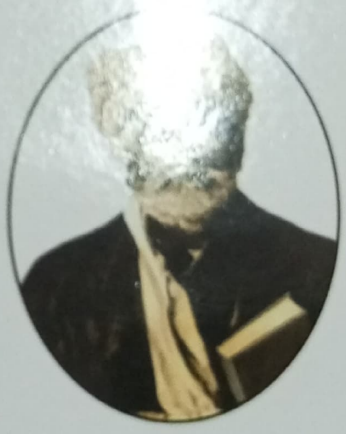
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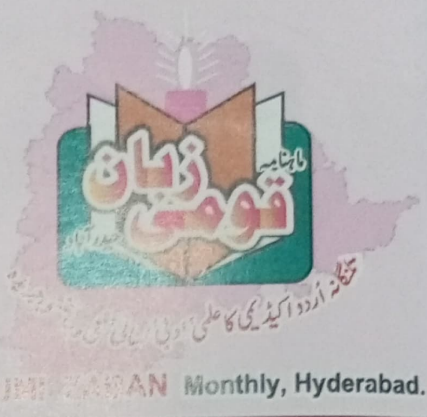
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میرؔ کے کلام میں سادگی اور پُرکاری

خدائے سخن میر تقی میرؔ (ولادت 1722 - وفات 1810) اردو کے ممتاز ترین شعراء میں سب سے نمایاں مقام کے حامل ہیں۔ ان کے کلام کی گوناگوں خصوصیات کی وجہ سے ان کی اہمیت آج بھی اردو دنیا میں امتیازی مقام اور اہمیت کی حامل ہے۔ مستقبل میں بھی ان کے کلام کو اہمیت دی جاتی رہے گی۔

میرؔ کے کلام میں بہت سی ایسی خصوصیات ہیں، جن کی وجہ سے میرؔ کو یہ مقام و مرتبہ حاصل ہوا ہے کہ ان کو خدائے سخن قرار دیا گیا۔ ان کے کلام کے بہتر نشتر تو مشہور ہیں ہی، اس کے ساتھ ساتھ ان کے کلام میں سادگی، سلاست، تاثیر اور اثر آفرینی کی خصوصیات ان کو اردو کے شعرا میں ممتاز اور منفرد مقام عطا کرتے ہیں۔

سادگی اور پُرکاری دراصل میرؔ کے کلام کی نمائندہ اور ممتاز خصوصیت ہے۔ میرؔ کے کلام میں الفاظ و معنی کی سطح پر پیچیدگی کے بجائے سادگی کا غلبہ زیادہ ہے۔ وہ سہل اور آسان الفاظ کے ذریعہ عام فہم اسلوب میں اپنے خیالات کو پیش کر کے متاثر کرنے کا گُر جانتے ہیں۔ میرؔ نے اسی سادگی کے ذیعہ اپنی پُرکاری کا جادو جگایا ہے۔ ان کا یہ جادو سر چڑھ کے بولتا ہے۔ تاثیر اور تاثُر کا وفور میرؔ کے کلام کی جان ہے۔ اسی خصوصیت نے ان کے کلام کو ایک نئی جہت عطا کی ہے۔

میر تقی میرؔ کا خیال ہے کہ ان کے اشعار اگرچہ کہ خواص کو پسند ہیں لیکن ان کے مخاطب عوام ہیں۔ گویا خواص اپنے طور پر پسند کرتے ہیں جب کہ خود انہوں نے عوام کو مخاطب کیا ہے۔ وہ خود کہتے ہیں:

شعر میرے ہیں گو خواص پسند
پر مجھے گفتگو عوام سے ہے

میرؔ کے کلام میں یہی وہ خصوصیت ہے کہ وہ خود خواص میں بھی مقبول ہیں اور عوام میں بھی۔ انہوں نے عوام سے گفتگو کرنے کو ترجیح دی اور خواص خود ان کے کلام کی جانب التفات کرنے پر مجبور ہیں۔ اس سے ان کے مزاج اور شعری رجحان کا بخوبی اندازہ لگایا جا سکتا ہے۔ میرؔ کو خود اس بات کا بھی احساس تھا کہ ان کے کلام میں جو روانی اور سلاست ہے، یہی ان کی شاعری کا کمال ہے اور اس کا اظہار انہوں نے اپنے ایک شعر میں یوں کیا ہے:

میرؔ، دریا ہے، سنے شعر زبانی اس کی
اللہ اللہ رے، طبیعت میں روانی اس کی

میرؔ کے کلام میں نہ کوئی ایہام ہے نہ ابہام ہے۔ ان کے یہاں صنائع اور بدائع یا پھر فنی مرصع کاری بھی نہیں لیکن ان کی سادگی اور سلاست نے ان کو مقبولیت عطا کی ہے۔ میرؔ کے شعر یوں متاثر کرتے ہیں۔ جذبات کی صداقت اور تجربات کی حقیقت بیانی کے ساتھ ان کے اظہار میں وہ دلکشی اور جاذبیت ہے کہ وہ متاثر کرتے ہیں اور تاثر بھی دیرپا

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غالبؔ دکن ۔یسیرؔ کرنولی

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دہلی کے بلّی ماراں محلّہ سے مرزا اسداللہ خاں غالبؔ کی شہرت کا سلسلہ شروع ہوتا ہے۔ جورفتہ رفتہ ہندو پاک اورایران کی سرحدوں کو پار کرتے ہوئے دنیائے ادب پر چھا گیا ہے۔ غالبؔ ایک آفاقی شاعر ہیں۔ان کی شاعرانہ عظمت کے چرچے صرف اردو اور فارسی تک محدود نہیں ہیں۔ بلکہ دنیا کی دیگر زبانوں کے ادیبوں اور شاعروں نے بھی غالبؔ کو بڑا شاعر تسلیم کیا ہے۔مختلف زبانوں میں غالبؔ کی شاعری کے ترجمے ہورہے ہیں۔اور روز بہ روز غالبؔ کے شیدائیوں اور پرستاروں میں اضافہ ہورہا ہے۔اُنہیں پرستاروں میں ایک نام امیر علی خاں یسیرؔ کرنولی کا ہے جو غالبؔ دکن کے لقب سے مشہور ومعروف ہیں۔

یسیرؔ کرنولی کی ولادت، غالبؔ کی ولادت کے سو سال بعد ۱۹۰۶ء میں جنوبی ہند کی ریاست آندھراپردیش کے شہر کرنول میں ہوئی۔ پٹھان گھرانے میں پیدا ہوئے۔ابا واجداد جاگیردار تھے۔یسیرؔ نے بی۔اے۔اور ایم۔اے۔کی تعلیم حاصل کی۔ بعد میں بی۔ایل۔بھی پاس کیا۔سرکاری ملازم ہوئے۔ ملازمت کو اپنی طبیعت سے ناموافق پاکر استعفی دے دیا۔وکالت کی۔یہاں بھی دل نہ لگا۔پیشۂ وکالت کو بھی خیرباد کہکر گھر پر رہنے لگے۔پھر کسی پیشہ یا ملازمت سے وابستہ نہ ہوئے۔اور شادی بھی نہیں کی۔وراثت میں جاگیر ملی تھی۔گزر بسر کے لیے یہی کافی تھی۔شعر کہنے میں اور شاگردوں کی اصلاح میں مصروف رہے۔ ۱۹۸۸ء میں وفات پائی۔

یسیرؔ کرنولی نے اپنا دیوان ''نفیر شوق'' بطور یادگار چھوڑا ہے۔ جو ۱۹۸۰ء میں کرنول سے شائع ہوکر منظر عام پر آیا۔اس دیوان کے مطالعہ سے بخوبی واضح ہوتا ہے کہ یہ غالبؔ کی پیروی میں لکھا گیا ہے۔اس دیوان کی بیشتر غزلوں کی زمینیں، ردیف وقافیے، موضوعات، زبان، انداز بیان دیوان غالبؔ سے مماثلت رکھتی ہیں۔اور یہ سچ بھی ہے۔اس کا اندازہ ہمیں اس بات سے بھی ہوتا ہے کہ انہوں نے اپنا دیوان ''نفیر شوق'' غالبؔ کے پرستاروں کے نام معنون کیا ہے۔ انتساب میں لکھتے ہیں:

''نجم الدولہ دبیر الملک نواب مرزا اسداللہ خاں غالبؔ کے پرستاروں کے نام۔'' (نفیر شوق، ص:۳)

یسیرؔ کرنولی نے شاعری کی ابتداء تحصیل علم کے زمانے میں ہی کی تھی۔ غالبؔ کی طرح یسیرؔ کے خاندان میں بھی کوئی شاعر گزرا ہے اور نہ ہی ان دونوں نے شاعری میں کسی کی شاگردی اختیار کی ہے۔بغیر کسی استاد کے عروض کی کتابیں پڑھیں۔استاذی شعراء میرؔ، غالبؔ، مومنؔ، ذوقؔ، نصیرؔ اور ناسخؔ کا مطالعہ کیا۔مزاج شاعرانہ تھا اور طبعیت میں روانی تھی۔ بہت جلد فن شعر پر دسترس حاصل کرلی اور شعر کہنے لگے۔ چوں کہ وہ غالبؔ سے بے حد متاثر تھے، لہذا غالبؔ ہی کے رنگ میں شعر کہنا اپنا شیوہ بنالیا۔ڈاکٹر یعقوب شریف لکھتے ہیں:

''یسیرؔ، غالبؔ سے بہت متاثر رہے ہیں۔انہوں نے نہ صرف غالبؔ کے طرزِ ادا اور اسلوب کی پیروی کی ہے بلکہ غالبؔ کی غزلوں کی بحریں، زمینیں، ردیف وقافیے بھی من وعن اپنا لیے ہیں۔'' (غالب دکن۔یسیر کرنولی، ص:۱۶۴)

یہی وجہ تھی کہ یسیرؔ کو ''غالبؔ دکن'' کہا جانے لگا۔غالبؔ دکن کے لقب سے متعلق ملک الشعراء اوج یعقوبی یورقم طراز ہیں:

''جب اُس مشاعرہ میں غالبؔ کی ایک سنگلاخ زمین میں یسیرؔ صاحب نے غزل سنائی تو خود میری ہمہ گوئی اور ہمہ دانی کا احساس متزلزل رہ گیا۔ میں سوچ بھی نہیں سکتا تھا کہ کرنول جیسے دور افتادہ مقام میں ایسا شاعر بھی ہوگا۔ میں اگر زیادہ صاف گوئی سے کام لوں تو بلا جھجک یہ کہہ سکتا ہوں کہ رفع شک کے طور پر میں نے ان سے کچھ سنانے کی خواہش کی۔ چنانچہ یسیرؔ صاحب نے غالبؔ ہی کی زمینوں میں مزید دو غزلیں سنائیں۔ نتیجہ کے طور پر مجھے کہنا پڑا کہ علامہ یسیرؔ کو غالبؔ دکن کا خطاب دینا چاہیئے۔ غالباً یہ بات میرے دل کی گہرائیوں سے نکلی تھی جس میں بھرپور خلوص تھا کہ آج سارا آندھرا پردیش آپ کو غالبؔ دکن ہی کے نام سے جانتا ہے۔'' (نفیر شوق' ص:۴ اور ۵)

اوج یعقوبی نے سنگلاخ زمینوں کے استعمال پر یسیرؔ کو غالبؔ دکن کہا تو مولوی سید افتخار احمد نے فکری اعتبار سے یسیرؔ کو غالبؔ دکن سے یاد کیا ہے۔ خود یسیرؔ کرنولی ''نفیر شوق'' میں لکھتے ہیں:

''میرے مکرم دوست مولوی سید محمد افتخار احمد صاحب بشرؔ نے پہلی بار مجھے غالبؔ دکن کے نام سے یاد کیا' اس بنا پر کہ میرے شعر غالبؔ کے اشعار کی طرح دعوتِ فکر دیتے ہیں۔'' (نفیر شوق' ص:۳۵)

اس میں کوئی شک نہیں کہ یسیرؔ کرنولی نے غالبؔ کی پیروی کی ہے۔ غالبؔ اور یسیر کے درمیان ایک صدی کا فاصلہ ہے۔ یسیرؔ کے زمانے میں اردو کی شعری روایات کافی بدل چکے تھے۔ تاہم یسیرؔ نے اپنی شاعری میں کلاسیکی روایات کی پاس داری کی ہے۔ عشقیہ واردات کی ترجمانی' فارسی تراکیب کا استعمال 'غزل کی لفظیات اور طرز بیان ان سب سے یسیرؔ کی غزل مزین ہے۔ کلاسیکی روایات کا لحاظ کرتے ہوئے غالبؔ کی سنگلاخ زمینوں میں غزل کہنا یسیرؔ کرنولی کا وصف خاص رہا ہے۔ غالبؔ پسندی کا ذکر کرتے ہوئے ڈاکٹر ابوالفضل سید محمود قادری لکھتے ہیں:

''غالبؔ اور یسیرؔ کے درمیان ایک صدی سے زیادہ عرصہ کا فصل موجود ہے۔ اس طویل عرصے میں ادبی اقدار نے طرح طرح کی کروٹیں بدلیں' لیکن یسیرؔ کے ذہن و شعور پر غالبؔ ہی غالب رہے۔ یہاں تک کہ ترتیبِ دیوان کے مرحلے پر بھی 'نقش فریادی ہے کس کی شوخیٔ تحریر کا' کی زمیں میں یسیرؔ نے بھی نفیرِ شوق کو کاغذی پیرہن میں پیکرِ تصور بنایا۔'' (نفیر شوق ایک جائزہ' ص:۷ اور ۸)

''نفیر شوق'' کی پہلی غزل ہی اس بات کی غماز ہے۔ جس میں دیوان غالبؔ کی پہلی غزل کی زمین' ردیف و قافیہ کی پیروی کرتے ہوئے نہایت خوب صورت شعر کہے ہیں۔ دیوان غالبؔ کے پہلے دو شعر ملاحظہ ہوں:

نقش فریادی ہے کس کی شوخیٔ تحریر کا — کاغذی ہے پیرہن ہر پیکر تصوری کا
کاو کاوِ سخت جانی ہائے تنہائی نہ پوچھ — صبح کرنا شام کا لانا ہے جوئے شیر کا

اسی طرز پر لکھے یسیرؔ کرنولی کے شعر ملاحظہ ہوں:

ہے یہ عالم اضطرابِ شوق کی توقیر کا — ضبط بھی صیدِ زبوں فتراکِ دار و گیر کا
اشکِ خوں میں بہہ گیا دل عاشقِ دلگیر کا — تشنہ لب رہ جائے گا پیکاں کسی کے تیر کا
جذبۂ ایثار کی گرمی کا عالم دیکھنا — دیر تک فتراک سے ٹپکا لہو نخچیر کا
یوں بھی غالبؔ کی زمینوں میں غزل لکھنا یسیرؔ — فکر کے کہسار سے لانا ہے جوئے شیر کا

غالبؔ اور یسیرؔ کی غزلوں کا تقابلی مطالعہ کیا جائے تو ان دونوں کے اشعار میں بحر' ردیف اور قافیہ کے علاوہ فکر اور احساس میں بھی مماثلت اور یکسانیت کو دیکھا جا سکتا ہے۔ چند شعر ملاحظہ ہوں:

غالبؔ: بازیچۂ اطفال ہے دنیا میرے آگے ہوتا ہے شب و روز تماشا مرے آگے
یسیرؔ : ایک وہم ہے رنگینیٔ دنیا مرے آگے یہ محو تماشا ہے ' تماشا مرے آگے

غالبؔ: ابن مریم ہوا کرے کوئی میرے دکھ کی دوا کرے کوئی
یسیرؔ : اک زحمتِ نظر تو گوارا کرے کوئی میرے غمِ دوراں کا مداوا کر ے کوئی

غالبؔ: کیا کیا خضر نے سکندر سے اب کسے رہنما کرے کوئی
یسیرؔ : جنابِ خضر کو بھی ہمسفر میں کر نہیں سکتا ابھی جو فرق کر نا ہے مجھے رہبر و رہزن میں

غالبؔ: کیوں جل گیا نہ تابِ رخِ یار دیکھ کر جلتا ہوں اپنی طاقتِ دیدار دیکھ کر
یسیرؔ : یوں کھو گئے جمالِ رخِ یار دیکھ کر ہم دیکھتے رہے انہیں سو بار دیکھ کر
غالبؔ: میں نے مجنوں پہ لڑکپن میں اسدؔ سنگ اُٹھایا تھا کہ سر یاد آیا
یسیرؔ : حالِ مجنوں پہ اڑے ہوش یسیرؔ سنگ یاد آیا نہ سر یاد آیا

غالبؔ کی طرح یسیرؔ نے بھی فارسی تراکیب کا بخوبی استعمال کیا ہے۔یسیرؔ' دکن کے شاعر ہیں۔تاہم انہوں نے اشعار میں فارسی تراکیب کو اس خوبصورتی سے برتا ہے کہ ایسا لگتا ہے کہ یسیرؔ شمالی ہند کے کلاسیکی شاعر ہیں۔جیسے :صیدِ زبوں' انیسِ شام' پروانۂ شتاب' چرخ نیلی فام' چراغِ سرِ مدفن' لباس حریر ضبط وغیرہ۔

مثال کے طور پر دو شعر ملاحظہ ہوں:

خیالِ یار کو میں نے انیس شام کیا طلوعِ صبح، تمنا کا اہتمام کیا
زندگی کانپتے گزری ہے شبِ فرقت میں ایک افسردہ چراغِ سرِ مدفن

مذکورہ بالا اشعار میں یسیرؔ کرنولی نے انوکھی اور دلاویز تشبیات سے شعروں میں معنوی دینا آباد کردی ہے جو کلام غالبؔ کی بھی ایک نمایاں خصوصیت ہے۔جیسے خیال یار کو انیس شام اور مشکل بھری زندگی کو چراغِ سرِ مدفن۔

غالبؔ اور یسیرؔ کے کلام میں دقیقہ رسی اور مشکل پسندی کے ساتھ ساتھ سہل الممتنع کی کیفیت بھی پائی جاتی ہے۔نفیر شوق کے مطالعہ سے ایسا محسوس ہوتا ہے کہ یسیرؔ نے بعض مقامات پر کلام غالبؔ کی تقلید و تتبع کرنے کی کوشش کی ہے۔ذیل میں یسیرؔ کے چند مطلعے ملاحظہ ہوں:

ان کا انداز نظر یاد آیا ساتھ ہی زخمِ جگر یاد آیا
یوں کھوگئے جمالِ رخِ یار دیکھ کر ہم دیکھتے رہے انہیں سو بار دیکھ کر
ایک وہم ہے رنگینیٔ دنیا میرے آگے ہر محو تماشا ہے تماشا مرے آگے
ملا ہے درد' حیاتِ رواں دواں کے لیے نفیر شوق ضروری تھی کارواں کے لیے

غرض یسیرؔ کرنولی کا شمار غالبؔ کے معنوی شاگردوں میں ہوتا ہے۔ انہوں نے من وعن غالبؔ کی پیروی کرنے کی کوشش کی ہے۔ غالبؔ کی طرح سنگلاخ زمینوں میں غزلیں کہی ہیں۔ بحر، ردیف اور قافیہ کا اہتمام کیا ہے۔ کلاسیکی روش کو اختیار کرتے ہوئے بہترین شعر کہے ہیں۔ اس میں شک نہیں کہ یسیرؔ کرنولی نے ''نفیرِ شوق'' کی شکل میں غالبؔ شناسی کا مبیّن ثبوت دیا ہے۔

حواشی:

۱۔ غالب دکن یسیر کرنولی۔ حیات اور شاعری، ڈاکٹر محمد یعقوب شریف، رام نگر کالونی، چتور، آندھرا پردیش، ۲۰۱۹۔

۲۔ نفیر شوق، امیر علی خاں یسیرؔ، کرنول، آندھرا پردیش، ۱۹۸۰۔

۳۔ نفیر شوق ایک جائزہ، شاہین جلد سوم، یکم مارچ ۱۹۸۴۔

☆☆☆

شہہ میریہ خانوادہ کے چند شعرا کا دکنی کلام

پروفیسر محمد نثار احمد
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ریاست آندھرا پردیش کے علاقۂ رائل سیما کے معروف صوفی خانوادۂ شہہ میریہ کو یہ امتیاز حاصل ہے کہ یہ ایک علمی وادبی خانوادہ ہے۔اس سلسلہ کے کئی شعرا کا کلام محفوظ ہے۔اس خانوادے کے شعرا نے دکنی میں کئی تصانیف یادگار چھوڑی ہیں۔اس خانوادے کا ادبی سرمایہ شاعری اور نثر دونوں میں موجود ہے۔

ہندوستان کے دیگر صوبوں کی طرح آندھرا پردیش میں بھی صوفیاء کرام کی آمد ہوئی اور یہاں کے مختلف خطوں میں انھوں نے اسلام کی تبلیغ واشاعت اور تلقین کا فریضہ انجام دیا۔رائل سیما صوبۂ آندھرا پردیش کا ایک اہم خطہ ہے اور یہ چار اضلاع پر مشتمل ہے، کرنول، کڑپہ، انت پور اور چتّور۔رائل سیما میں صوفیانہ شعروادب کی روایت حضرت خواجہ بندہ نواز گیسودرازؒ سے وابستہ ہے۔

خانوادۂ شہ میریہ کے بعض قلمی تصانیف سے بھی پتہ چلتا ہے کہ رائل سیما میں صوفیانہ شعروادب کی روایت حضرت خواجہ بندہ نواز گیسودرازؒ ہی سے وابستہ ہے۔حضرت جلال الدین اکمل فرزندِ حضرت شاہ کمال ثانی جامیٔ دکن کی تصنیف ''مقصود السالکین'' کے اس اقتباس سے بھی واضح ہوجاتا ہے کہ رائل سیما کے صوفیاء نے جب تصنیف وتالیف کا آغاز کیا تھا تو ان کے سامنے حضرت میراں جی شمس العشاق، حضرت برہان الدین جانم اور حضرت امین الدین اعلیٰ کی ادبی روایتیں موجود تھیں۔مقصود السالکین کا یہ اقتباس ملاظہ ہوں:

''حضرت شاہ برہان الدین جانم بیجاپوری والدِ ماجد حضرت امین الدین اعلیٰ قدس سرہٗ جو ہمارے پیروں کے پیر اور حضرت خواجہ سید محمد حسینی گیسودراز بندہ نوازؒ قدس سرہٗ کے سلسلہ اور خلفاء میں ہیں۔'' (مقصود السالکین۔ص۲۳)

رائل سیما میں شہ میریہ خانوادہ میں کئی علماء، شاعر، ادیب، صاحبِ تصنیف بزرگ گذرے ہیں۔شہ میریہ خانوادہ بخارا سے نکل کر شمالی ہند، گلبرگہ، بیجاپور ہوتے ہوئے حیدرآباد، کرنول، کڑپہ، گرم کنڈہ پہنچا۔رائل سیما میں یہ خانوادہ تقریباً چار سو سال کی تاریخ رکھتا ہے۔اس خانوادہ میں جو صاحبِ تصانیف بزرگ گذرے ہیں وہ یہ ہیں: حضرت شاہ میرؔ، حضرت شاہ نورؔ، حضرت شاہ کمالؔ، حضرت بیرنگؔ، حضرت سالکؔ، حضرت مقبلؔ، حضرت لامعؔ اور حضرت اکملؔ وغیرہ۔ان بزرگوں نے حقائق ومعارف کے ذریعہ تبلیغِ اسلام واحسان کی اہم خدمات انجام دیں۔

حضرت شاہ میرؔ:

حضرت شاہ میرؔ حضرت سید شاہ جمال الدین کے لڑکے اور حضرت سید شاہ کمال اول کے پوتے تھے۔آپ کا اسمِ گرامی سید محمد حسینی اور لقب شاہ میر تھا۔آپ حضرت مخدوم جہانیانِ جہاں گشتؒ کی اولاد میں سے تھے۔شاہ میر کے بھائی شاہ نوراللہ بخاری اپنی تصنیف 'تجلیٔ انوار' میں لکھتے ہیں ؎

حضرت سید محمد مرشد روشن ضمیر تاجِ سر سلطان کا' اور قطبِ حق دوران کا

ڈاکٹر رفیعہ سلطانہ لکھتی ہیں:

''ان کا نام سید محمد حسینی اور لقب شاہ میر تھا۔ والد کا نام سید شاہ جمال الدین تھا جو حضرت مخدوم جہانیان جہاں گشتؒ کی اولاد سے تھے۔'' (اردو نثر کا آغاز وارتقاء۔ص ۲۳۷)

نصیرالدین ہاشمی کے الفاظ ملاحظہ ہوں:

''شاہ میر دکن کے ایک صوفی بزرگ گذرے ہیں جو قادریہ اور حسینی طریقہ کی بیعت لیا کرتے تھے۔.....شاہ میر شاہ میاں کے لقب سے بھی موسوم تھے۔''

مندرجہ بالا تمام بیانات سے یہ بات واضح ہوجاتی ہے کہ بام سید محمد حسینی تھا۔ لیکن آپ نے اپنے تخلص شاہ میرؔ کے نام سے شہرت پائی۔ آج بھی دنیائے ادب اور خانقاہوں میں آپ شاہ میرؔ ہی کے نام سے جانے اور پہچانے جاتے ہیں۔

حضرت سید محمد حسینی میرؔ تخلص کیا کرتے تھے۔ کہیں کہیں شاہ میرؔ یا شہ میرؔ بھی تخلص کے طور پر باندھا ہے۔ ذیل کے اس شعر میں تخلص میر استعمال کیا ہے ؎

کر تلاوت رات دن اپنا وجود باتدبر میرؔ در ہر فصل و باب (شاہ کمال۔ کلماتِ کمالیہ۔ص۔۲۰۸)

حضرت شاہ میر نے اپنی رباعی میں اپنے مشہور نام کو بطور تخلص استعمال کیا ہے۔

شہ میر نہ کر فکر تو کچھ قوت کی واللہ
رازق تیرا قادر و قیوم ہے اللہ
چیرا ہے جنے منہ کو تیرے ولے رزق نہ دے وے
لاحول ولاقوۃ الا باللہ!!

حضرت شاہ میر کا نمونۂ کلام:

ذات کو ہر شئے کے نیں ہے انقلاب اور صفت کو انفکاک و انسلاب
جو کہ آب آتش نہ ہوئے عکس نیر سلب نہ ہوئے عرق آتش غرق آب
نا ہوےء صرفِ عدم محض وجود حال بیداری نہ ہوئے حال ِخواب
نا مبدل ذات نا متغیر صفات یہ عقائد سنت و راہِ صواب
ذات کو ہر دم تلبس ہے و لیک صورت ہر وصف سے اے کامیاب
اور صفت کو صورت افعال سے ہے تلبس ہر زماں بے ارتیاب
فعل کو آثار کے صورت سے ہے ہم تجلی ہم تلبس ارتکاب
ذات کو ہر شئے کے یوں ہے خلع بس اس کو کہتے ہیں تجدد ذولباب
گر نہ یوں ہو ذات کیونکر ہو بدیع بے بدیعیت کا یہ سارا حساب
خلع کو کہتے عدم در اصطلاح بس کو بولیں وہ وجود اے بہرہ یاب
مصطلح اہلِ حقایق کا سخن نیں لغت سے کام ان کو اے صحاب
کیا فنا اور کیا موت وحیات یا دو غفلت انکشاف و احتجاب
عینیت اور غیریت وصل و فراق ذوق و جدان و یقیں ریب ونقاب
کفر و ایمان راہِ منزل اور مقام سیر وطیر و جذب وسعی واکتساب

نفی و اثبات اورقرب و حضور بیخودی و باخودی کشف و حجاب
یہ مسائل اصطلاحی ہیں سمجھ یک بہ یک واللہ اعلم بالصواب
کر تلاوت رات دن اپنا وجود باتدبر میؔر در ہر فصل وباب
(کلماتِ کمالیہ۔ص۲۰۸)

حضرت شاہ نوؔر:

نام سید نوراللہ حسینی الملقب بہ سید شاہ نوراللہ بادشاہ بخاریؒ۔آپ کا نام خود آپ کی تصانیف میں اس طرح لکھا ہوا ہے۔حضرت شاہ نوؔر رسالۂ ارشادِ نوریہ میں اس طرح لکھتے ہیں:''ہندی زباں سوں سید نوراللہ بن جمال الدین آسان کرکر حضرت سید محمد حسینی شاہمیر صاحب قدس سرہٗ کی فیض ہورارشادِنوریہ کی برکت سوں ہورحق تعالیٰ کی عنایت ہور ہدایت کی اعانت سوں لکھتا ہے۔''(ارشادِنوریہ۔ص۷۶)

آپ نوؔر تخلص کیا کرتے تھے۔آپ اپنے فارسی واردو کلام کے کئی بیتوں میں تخلص نوؔر استعمال کیا ہے۔اس کی چندایک مثالیں ملاحظہ ہو:

محبوب ندا کند کہ اے نوؔر آنجا کہ توئی منم ہمیشہ (تجلیِ انوار۔ص۱)
بندی نورکونورایمان دے تیرادیدجنت منی دان دے (عقائدِنوریہ۔ص۵)

حضرت شاہ نوراللہ بخاری کے ہمعصروں میں کئی صوفیاء کرام اورعلماء وشعراء ہیں۔جن میں حضرت شہ میر اول،مولانا باقر آگاہ ویلوری،شاہ فی الحال کرنولی،وجدی کرنولی،سراج اورنگ آبادی کے علاوہ آپ کے بھائی حضرت سید شاہ کمال مصنف''مخزن العرفان''وغیرہ تھے۔

شاہ نوؔر کثیرالتصانیف بزرگ ہیں۔آپ کو عربی،فارسی اوراردو زبانوں پرعبور حاصل تھا۔شاہ نوؔر فارسی اوراردو میں کئی تصانیف اپنی یادگار چھوڑی ہیں۔جن میں عقائدِ نوریہ،تجلیاتِ نورانی اورمجموعہ التکسیر ہیں۔یہ تمام کتابیں قلمی ہیں اورکتب خانۂ کمالیہ،گرمکنڈہ،ضلع چتّور میں موجود ہیں۔

نمونۂ کلام:

ذاتِ رب کی جسم و جسمانی نہیں نفس بی نیں اور نفسانی نہیں
قلب و قلبی بھی نہ پہچانے اوسے بلکہ نیں ہی روح وروحانی نہیں
ذات وذاتی ذات اوراسکے صفات یوں جو نا سمجھے سو عرفانی نہیں
معرفت رب کی،ہر اک پرفرض ہے ہور عبادت انکی جس ثانی نہیں
ذاتِ مطلق ہے ہمہ باطن ہے لیک باہمہ ظاہر ہے پنہانی نہیں
منشائ ہر دوھے وحدت جمع توں او حقیقت احمدی فانی نہیں
بعد اس کے ہے الٰہیت سو کیا غیر نفس الامر انسانی نہیں
بعدہٗ ہے جان ارواح ومثال جاں اگن پانی پوں پانی نہیں
(تجلیِ انوار،ص۔۲۶)

حضرت شاہ کمالؔ:

حضرت شاہ کمالؒ(دوّم)۔حضرت سید شاہ کمال الدین بخاری رحمۃ اللہ علیہ اپنے وقت کے بلندمرتبت ولی کامل گزرے ہیں۔علم وعرفان کی دنیا میں آپ کی ذات قطعاًمحتاج تعارف نہیں۔درس وتدریس،تالیف وتصنیف،پندونصائح اورمجاہدہ وریاضت ایسے جملہ امور میں اپنی نظیر آپ تھے۔حضرت شاہ کمال اپنے عہد کے ایک قادرالکلام اور باکمال اور پرگو شاعرومصنف ہیں۔آپ ایک فطری اوروہبی شاعر تھے،بلا مبالغہ ہزاروں اشعار آپ کے نوکِ قلم سے تخلیق

پائے ہیں۔آپ کے اشعار کا موضوع تصوف واحسان ہونے کے باوجود آپ نے اس پامال مضمون کو اپنے قلمِ معجز رقم سے زندۂ جاوید بنادیا،اس کی نظیر اس دور کے دیگر شعرا میں ملنا بہت مشکل ہے۔آپ کو عربی، فارسی اور دکنی اردو تینوں زبانوں پر عبور حاصل تھا۔آپ نے عربی، فارسی اور دکنی اردو زبانوں میں تصانیف چھوڑی ہیں۔حضرت سلطان ٹیپو شہیدؒ نے آپ کو بجا طور پر ''جامیٔ دکن'' کے خطاب سے سرفراز فرمایا تھا۔بقول محمد سخاوت مرزا آپ کو اپنے تمام ہم عصروں میں اپنے طرز و رنگ کے لحاظ سے فوقیت حاصل ہے۔حضرت شاہ کمالؒ (دوم) کے علم وفضل وتقویٰ و بزرگی کا عالم یہ تھا کہ عوام تو عوام خواص الخاص بھی آپ کے عقیدت مندوں کی قطار میں نظر آتے تھے،جن میں جلیل القدر سلطان ٹیپو شہیدؒ کا بھی نام شامل ہے۔

آپ کا نام سید شاہ کمال الدین تھا۔آپ سید شاہ جمال الدین بخاریؒ کے تیسرے فرزند تھے۔شاہ کمال نے اپنے دیوان ''مخزن العرفان'' میں اپنا نام اس طرح لکھا ہے ؎

دیکھ اس کے حال پر اپنی نوازش کی نظر جم جم کمال الدین تیرا بندہ ہے کمتر یا جمال الدین

(دیوانِ مخزن العرفان۔ص۱۸۶)

رسالۂ اردو میں سخاوت مرزا نے بھی حضرت شاہ کمال کا نام کمال الدین ہی لکھا ہے۔سخاوت مرزا لکھتے ہیں:

''اسمِ گرامی کمال الدین سادات الحسینی الحسنی ابن سید جمال الدین۔۔۔۔۔'' (رسالۂ اردو۔بابت ماہ اپریل،۱۹۳۹ء ص۔۲۶۳)

ڈاکٹر زور نے بھی کتب خانہ اداریۂ ادبیات اردو،حیدرآباد کی وضاحتی فہرست جلد سوم میں حضرت شاہ کمال کا ذکر یوں کیا ہے:''سید شاہ کمال الدین ولد سید شاہ جمال الدین شاہنور (بیجاپور) کے رہنے والے تھے۔بعد کو کڑپہ اور کرنول میں مقیم ہوئے۔'' (وضاحتی فہرست جلد سوم۔کتب خانہ اداریہ ادبیات اردو ،ص۲۰۷)

نصیر الدین ہاشمی نے بھی حضرت شاہ کمال کے بارے میں اپنے خیالات کا اظہار کیا ہے۔وہ لکھتے ہیں:''شاہ کمال المتخلص بہ کمال کڑپہ آپ کا مولد تھا۔صاحبِ باطن بزرگ تھے۔'' (وضاحتی فہرست کتب خانۂ سالار جنگ میوزیم،ص۔۷۶۸)

حکیم محمود بخاری لکھتے ہیں:''اسمِ گرامی کمال الدین جامیٔ دکن لقب کمال تخلص فرماتے تھے۔آپ سید جمال الدین بادشاہ بخاری اول کے تیسرے فرزند اور سید محمد حسینی شاہ میر اول کے چھوٹے بھائی ہیں۔'' (شہ میری اولیاء،ص۔۱۱۳)

شاہ کمال الدین کمالؔ تخلص کیا کرتے تھے۔دکن کے پہلے صاحبِ دیوان شاعر محمد قلی قطب شاہ کی طرح آپ نے بھی کئی تخلص اپنائے۔شاہ کمال اپنے کلام میں کمالی،کمالا،کمال اللہ اور کمالیا کو تخلص کے طور پر استعمال کیا ہے۔کہیں کہیں پورا نام کمال الدین بھی تخلص کے طور پر باندھا ہے۔اس طرح انھوں نے اپنے نام اور تخلص کو کلام میں مختلف طرح سے لکھا ہے۔

دیوانِ مخزن العرفان (منظوم دکنی اردو)،معراج نامہ (منظوم دکنی اردو)،ضیافت نامہ (منظوم دکنی اردو)،حسن السوال وحسن الجواب (منظوم دکنی اردو)۔فارسی زبان میں بھی شاہ کمال نے کئی تصانیف قلم بند کی ہیں۔جن میں نصاب،کمال المعرفت،کلماتِ کمالیہ،معدنِ محاسن،رحیما اور دیوانِ کمال بہت مشہور ہیں۔

اول الذّکر تصنیف حضرت شاہ کمالؔ کا منظوم دکنی اردو دیوان ہے۔جس میں انھوں نے اپنے سارے تجربوں،مشاہدوں اور فنی وادبی صلاحیتوں کو اس دیوان کے ذریعہ اجاگر کیا ہے۔شاہ کمالؔ نے اپنے صوفیانہ نظریات کو بڑی حکمت و آسانی کے ساتھ سمجھایا ہے۔اس دیوان کے دو حصّے ہیں جس میں کئی غزلیات،رباعیات،مثنویات کے علاوہ منقبتی کلام بھی موجود ہے۔دیوان میں نعتیہ کلام سے زیادہ تصوف کے مسائل بیان کئے گئے ہیں۔اس کے علاوہ مختلف بزرگانِ دین کی مدح میں بھی کئی نظمیں لکھی گئی ہیں۔ساتھ ہی شاہ کمالؔ نے ریختی صنف پر بھی طبع آزمائی فرمائی اور انھوں نے اپنی ریختیوں کے ذریعہ صوفیانہ نکات کو واضح کیا ہے۔اس کے علاوہ شاہ کمالؔ نے ایک چکّی نامہ بھی اپنی یادگار چھوڑا ہے۔اس چکّی نامہ کو شاہ کمالؔ نے تمثیلی انداز میں پیش کیا ہے جو معرفت کے خزانے

سے مزین ہے۔حضرت شاہ کمالؔ نے اپنی صوفیانہ شاعری کے ذریعہ فصاحت و بلاغت کے دریا بہائے ہیں۔آپ کی شاعری میں آمد ہی آمد نظر آتا ہے۔شاہ کمالؔ کوالہامی شاعر کہا جائے تو بے جانہ ہوگا۔ذیل میں آپ کے کلام سے چند ایک نمونے ملاحظہ فرمائیں۔

جیئو مین پیئو عیان تھا مجھے معلوم نہ تھا آشکارا ہو نہاں تھا مجھے معلوم نہ تھا
میں سمجھتا تھا مرا پیئو ہے مرے سے جدا سربسر وہم وگماں تھا مجھے معلوم نہ تھا
پیئو کے ہی ذات وصفت باطن وظاہر ہے مرا میں تو نامی بہ میاں تھا مجھے معلوم نہ تھا
متلبس ہو وہ یک پیئو سدا جلوہ نما درلباسِ دوجہاں تھا مجھے معلوم نہ تھا
پیئو ہے ہست بجز نیست نہیں پیئو کا غیر عینِ ایمان یہ بیاں تھا مجھے معلوم نہ تھا
پیئو زمین پیئو زمان پیئو مکین پیئو مکان پیئو تن پیئو ہی جاں تھا مجھے معلوم نہ تھا
پیئو کو پیر سے پانا ہے وگر نئیں تو محال پیر یوں فیض رساں تھا مجھے معلوم نہ تھا
پیئو نے پیر کے گھنگٹ میں دکھایا ہے جمال یہ عجب رازِ نہاں تھا مجھے معلوم نہ تھا
پیئو نے پیر نما آپ ہوا ہے ورنہ پیئو بے نام ونشاں تھا مجھے معلوم نہ تھا
پیر نے پیئو کو ہر شئی میں بتایا ہے مجھے نئیں تو وہ پیئو کہاں تھا مجھے معلوم نہ تھا
پیئو کو پیئو سے دکھلانے مرے تئیں یہ کمالؔ پیر شہمیر ضماں تھا مجھے معلوم نہ تھا

(مخزن العرفان،ص۱۰۵)

حضرت شاہ کمال کی ایک ریختی کے چند شعر:

تجھ حُب کا جب سے لذت پائی ہوں اے دھنی میں
تب سے بندھی ہوں اپنی راحت سے دشمنی میں
قُمری نمن لگا کر سب تن کو راکھا اپنے
تجھ سرو قد کے کارن بن گئی ہوں جوگنی میں
چولے پہ تجھ برہ کے سینہ کے رکھ توے کو
دل اور جگر اُپس کا دھنیان نمن بھنی میں

حضرت شاہ کمال کے کلام میں صنائع اور بدائع کے مطالعہ سے پتہ چلتا ہے کہ آپ جملہ محاسنِ سخن کے رمز شناس تھے۔آپ نے اپنے کلام میں اسرارِ معرفت کے بیان اور اپنی غزلوں میں جہاں علوم ومعارف کے اسرار ورموز بیان کئے ہیں، وہیں آپ نے ظاہری محاسن اور جملہ کلام کے خصائصِ لفظی ومعنوی کا بھی بطورِ خاص لحاظ رکھا ہے۔

حضرت شاہ کمال کے کلام میں غزل،حمد ونعت اور مناجات کے علاوہ دیگر اصناف جیسے قصیدہ،منقبت،مرثیہ اور مثنوی کے ساتھ ساتھ مخمس،ترجیع بند، رباعی،سی حرفی اور ریختی پر بھی طبع آزمائی ملتی ہے۔

مخزن العرفان کی زبان اردو کی قدیم دکنی زبان ہے۔لیکن یہ دکنی زبان نہایت قدیم اور مشہور دکنی تصانیف کی طرح غریب لفظیات کی حامل نہیں ہے ،جیسا کہ قلیؔ،وجہیؔ،غواصیؔ،ابن نشاطی وغیرہ کے ہاں قدیم دکنی الفاظ ہی ملتے ہیں۔حضرت شاہ کمال کا زمانہ اس کے کافی بعد کا زمانہ ہے،جس کی وجہ سے زبان میں کافی اصلاحات ہوچکی تھیں اور زبان میں معیاری الفاظ کے استعمال کا رواج عام ہو چکا تھا۔یہی وجہ ہے کہ مخزن العرفان میں شامل کلام میں معرب اور مفرس

الفاظ کے ساتھ ساتھ معیاری زبان کے الفاظ بھی ملتے ہیں۔ یہ کہا جا سکتا ہے کہ اس عہد تک دکنی زبان نے کافی ترقی کر لی تھی۔ بھاشا کے الفاظ اور جنوبی ہند کے علاقائی زبانوں کے الفاظ بھی ملتے ہیں، بلکہ اگر یہ کہا جائے تو بیجا نہ ہوگا کہ حضرت شاہ کمال کے کلام میں مستعمل اردو زبان کافی معیاری اور معتبر لسانی ساخت کے ساتھ فصاحت و بلاغت کے تمام محاسن سے لبریز ہے۔

حضرت عبدالحق شاہ میرؔ:

سید عبدالحق نام عرف شاہ میر بادشاہ اور تخلص شاہ میرؔ تھا۔ آپ کی پیدائش ۱۲۸۷ھ میں محلّہ نبی کوٹ کڑپہ میں ہوئی۔ حکیم محمود بخاری نے شہ میری اولیاء میں لکھتے ہیں: ''اسمِ گرامی عبدالحق عرف شاہ میر بادشاہ، شاہ میرؔ تخلص فرماتے تھے۔ سن بارہ سو ستیاسی ہجری (۱۲۸۷ھ) مطابق اٹھارہ سو ایکہتر عیسوی میں بہ مقام کڑپہ (محلّہ نبی کوٹ) اپنے قدیم آبائی گھر میں پیدا ہوئے۔'' (شہ میری اولیاء، ص۔۱۷)

حضرت شاہ میر سن ۱۲۸۷ھ مطابق اٹھارہ سو ایکہتر عیسوی میں بہ مقام کڑپہ (محلّہ نبی کوٹ) اپنے قدیم آبائی گھر میں پیدا ہوئے۔

حضرت شاہ میر کے اکیسویں دادا حضرت سید جلال الدین حسین جلال اعظم سرخ بخاریؒ سلطان شہاب الدین غوری کے زمانہ میں ملتان تشریف لائے اور نویں دادا حضرت سید جمال الدین بخاریؒ نے ملتان سے گلبرگہ آکر حضرت سید محمد حسینی بندہ نواز گیسو درازؒ کی پڑپوتی سے شادی کی۔ سید جمال الدین بخاری کے پوتے حضرت سید کمال الدین بخاری نے گلبرگہ سے بیجاپور آکر چندے قیام فرمایا۔ پھر شاہ نور اور کرنول ہوتے ہوئے کڑپہ پہنچے اور گرمکنڈہ جا کر انتقال فرمایا۔ اس طرح یہ خاندان تقریباً تین سو سال سے علاقۂ رائل سیما میں آباد ہے۔

آپ کی تصانیف میں دیوانِ شاہ میر، حقیقتِ محمدیہ، گلدستہ اشرف العالمین، فضائلِ توبہ، منازل المصحف، نصابِ نصیحت قابلِ ذکر ہیں۔ آپ کا دیوان، دیوانِ شاہ میر کے نام سے طبع ہو چکا ہے۔

نمونۂ کلام کے طور پر حضرت شاہ میر کی ایک نعت پیش ہے:

آتش ہجر پیمبر میں ہوں جلتا جاتا — ہے دھواں آہ کا سینے سے نکلتا جاتا
دن قریب آئے ہیں طیبہ سے جدا ہونے کے — چشمۂ غم مرے دل سے ہے ابلتا جاتا
ذکرِ رخصت جو کیا کرتے ہیں زائر باہم — غمِ فرقت سے مرا دم ہے نکلتا جاتا
مجھ سے کیوں کہتا ہے زائر کہ چلو طیبہ سے — دل مرا ایسی ہی باتوں سے ہے جلتا جاتا
ہند کے رہنے سے حیراں و پریشاں تھا میں — اب مدینے میں جو ہوں دل ہے بہلتا جاتا
دل کو دیتی جو کبھی طاقتِ رفتار جواب — سر کے بل راہِ مدینے میں میں چلتا جاتا
دشتِ طیبہ کو جو جاتا ہوں تو ہر پتھر سے — مثلِ فرہاد سر اپنا ہوں کچلتا جاتا
خوابِ غفلت میں عبث عمر کی شب کٹتی ہے — شمع کی طرح ہوں اس غم میں پگھلتا جاتا
آرہا ہے مرے لب پر جو محمد کا نام — دل ِ بیتاب ہے سینے میں اچھلتا جاتا
غیرتِ گوہر ِ نایاب ہے وہ اے شہ میرؔ — سخن نعت جو منھ سے ہے نکلتا جاتا

حضرت سید جلال الدین اکملؔ:

حضرت سید جلال الدین نام اور اکملؔ تخلص ہے۔ آپ حضرت شاہ کمال الدین بخاری کے فرزند اور خلیفہ تھے۔ آپ نے درس نظامیہ کی تکمیل مدراس میں فرمائی۔ تحصیل علم ظاہری کے بعد آپ نے خرقۂ خلافت اور فیض باطنی والد ماجد سے حاصل فرمایا۔ آپ کے دو صاحبزادے تھے۔ سید مراد علی عرف علی مراد شاہ

افضلؔ اور سید فقیر محی الدین متقبلؔ۔ آپ کی وفات ۱۲۷۷ھ میں ہوئی۔ مزارِ اقدس محل، ضلع چتّور میں واقع ہے۔

اکملؔ کو نثر اور نظم دونوں پر قدرت حاصل تھی۔ آپ کی تصانیف میں مقصود السالکین اور چہل حدیث قابلِ ذکر ہیں۔ چہل حدیث اکملؔ کی منظوم تصنیف ہے جو آپ کے والد ماجد کی فارسی نظم چہل حدیث کا منظوم ترجمہ ہے۔ اس کے علاوہ آپ نے چند ایک حمد و نعت بھی کہے ہیں۔ نمونہ کلام ملاحظہ ہوں: ؎

کروں حمدِ خدا یہ دم ہے کہاں — یہ لب و لہجہ اور فہم ہے کہاں
کس طرح یہ رقم ہونا — دست و لوح اور قلم ہونا
ایسا دست اور دوات و خامہ کہاں — وہ سکت یہ سیاہ نامہ کہاں
ہے زبس یہ ثنا کا بام بلند — کیوں وہاں پہنچے فکر کا یہ کمند

حضرت جلال الدین اکملؔ کے چیدہ کلام سے دو غزلیں اور ایک رباعی بطورِ نمونہ پیش ہیں۔

رات دن پیچ و تاب ہے ہم کو — طلب آفتاب ہے ہم کو
اپنے چہرے سے تو اٹھایا نقاب — نے حجابی حجاب ہے ہم کو
حسنِ خلق اے فرشتہ خو تیرا — گلِ باغ گلاب ہے ہم کو
معنیٔ وجہ حق سمجھنے کو — تیری صورت کتاب ہے ہم کو
رات دن یاد بن نہ گزرے تری — اپنے دم کا حساب ہے ہم کو
ہم تو ہیں خاکسار اے اکملؔ — جد علیؓ بو تراب ہے ہم کو

حضرت اکملؔ نے مناجاتِ بجناب سرورِ کائنات علیہ التحیہ والتسلیمات کے عنوان سے ایک مناجات بھی لکھے ہیں۔ اسکے چند ابیات یہ ہیں ؎

عرض ہے یہ حضورِ انور سے — تیری درگاہِ پاک و برتر سے
شاق ہے مجھ پہ ہجرِ دلبر کا — چمنِ نازک کے صنوبر کا
سرور گلزار جس کی قامت ہے — جس سے اس دل پہ اک قیامت ہے
جب سے اس دل کو اس نے چھین لیا — دل لیا اور میرا دین لیا
آہ وزاری ہے بے قراری ہے — یا نبی وقت انتظاری ہے
یہ زمانہ تو ہے عجب الٹا — جس کو دیکھو تو ہے کہ ڈھب الٹا
ایسا کچھ کرئے یا رسولِ کریم — کہ ملے مجھ سے میرا یار قدیم
جس نے مجھ کو کیا فریفتہ ہو — یاد سے اس نے ہمارا شیفتہ ہو
آہنِ دل کو اس کے گرم کرو — موم کی طرح نرم نرم کرو
ماہِ رخ مہربان ہو جائے — ملتفت جانِ جان ہو جائے
یا محمد تم اس ستم سے چھڑاؤ — اپنے یوسف کو بند غم سے چھڑاؤ
میرے دلبر سے مجھ کو جلد ملاؤ — یا نبی میری التجا بر لاؤ

حضرت سید علی مراد شاہ افضلؔ:

آپ کا اسم مبارک مراد علی عرف مراد شاہ اور افضلؔ تخلص کیا کرتے تھے۔ آپ حضرت سید جلال الدین اکملؔ کے بڑے صاحبزادے اور شاہ کمال جامیؒ

دکن کے پوتے ہیں۔۱۲۴۹ھ میں آپ کی ولادت ہوئی۔ابتدائی تعلیم والد صاحب سے حاصل کی۔علومِ ظاہری کے بعد نعمتِ باطنی اور خلافت اپنے والدِ ماجد حضرت اکمل سے پائی۔

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نہ ورد میں ہے نہ لالہ میں نہ سمن میں ہے — بہار جو ترے رخسار کے چمن میں ہے
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ہو کس طرح نہ دل ہر کدام کا پروانہ — کہ شمع نور کی تیرے ہر انجمن میں ہے
ہے نور صدید ِبیضا کا ہر کف پا میں — اثر ہزار مسیحا کا ہر سخن میں ہے
فقط نہ روئے زمیں پر ہے تذکرہ تیرا — وظیفہ چرخ پہ شام وسحر عدن میں ہے
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صفات وذات میں تیرا عدیل اورمانند — نہ کوئی قدرت خلاق ذوالمنن میں ہے
نصیب کیجئے شاہا سفر مدینے کا — مزہ وہ رنج کا کب راحتِ وطن میں ہے
کبھی نہ بھول وظیفہ درود کا افضلؔ — کہ لفظ ِصلّ ِعلیٰ کاہراک دہن میں ہے

بہ اعتبارِ مجموعی کہا جاسکتا ہے کہ حضرات شہہ میری اولیاء نے علاقۂ رائل سیما اور آندھرا پردیش کے علاقوں کو اپنی صوفیانہ تعلیمات سے متاثر کیا۔اس عہد کی مقبول عام دکنی زبان کو اظہارِ خیال کا وسیلہ بنایا۔دکنی میں شہہ میری خانوادے کے شعرا کا کلام اہمیت کا حامل ہے۔آج بھی عوام وخواص اس سلسلہ سے جڑے ہوئے ہیں اوران صوفیائے کرام کی تعلیمات سے فیض حاصل کررہے ہیں۔شہہ میری سلسلہ کے دکنی رسائل اور کتابوں پر تحقیق کا سلسلہ بھی جاری ہے۔

☆☆☆

A Study on Xeno-Estrogenic Pesticides Effects on Steroid Hormones in Breast Cancer Patients

PDF (https://www.museonaturalistico.it/index.php/journal/article/view/309/238)

Keywords:
Organochlorines, Organophosphates, Endocrine Disruption, persistence, xenobiotics, disorders

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Abstract

In recent decades, "environmental xenobiotic-mediated endocrine disruption", especially by xeno-estrogens, has gained a lot of interest from toxicologists and environmental researchers. These estrogen-mimicking chemicals are known to cause various human disorders specifically triggering breast disorders in women. Pesticides are the most heavily used harmful xenobiotic chemicals around the world. The estrogen-mimicking potential of the most widely used organochlorine and organophosphate pesticides are well established. However, their effect is not as clearly understood among the plethora of effects these persistent xenobiotics are known to pose on our physiological system. Estrogens are one of the principal risk modifiers of various disorders, including cancer, not only in women but in men as well. Despite the ban on these xenobiotics in some parts of the world, humans are still at apparent risk of exposure to these harmful chemicals as they are still widely persistent and likely to stay in our environment for a long time owing to their high chemical stability. The present work intends to understand how these harmful chemicals may affect the risk of the development of estrogen-mediated human cancer.

Issue

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MERCURY INDUCED ALTERATIONS IN PHOTOSYSTEM-II PHOTOCHEMISTRY IN MAIZE PLANTS

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Abstract:

Mercury is a toxic heavy metal and it inhibited PS-II catalysed electron transport activity in a dose dependent manner. 50% loss was noticed with the treatment of 15μM $HgCl_2$. Spectral measurements clearly indicated that there is an enhancement in F_o value due to changes in LHC-II complex of PS-II in maize leaves. There is a positive correlation between the loss of PS-II and Chl a fluorescence which clearly demonstrates that the inhibitory site lies near PS-II reaction centre of maize thylakoids.

Key words: Electron transport; Fluorescence; Mercury;Maize plants; Photosystem II.

INTRODUCTION:

Heavy metals like Zn, Cd, Ni, Cu, Hg, Co and Pb can inhibit photosynthetic electron transport at multiple sites (Van Assche and Cl ijsters, 1980; Cl ijsters and Van Assche, 1986; Mohanty *et al.*, 1989). Photosynthetic organisms showed reduction in PS II supported electron transport activities when they were grown *in vivo* in the presence of supra optimal level of heavy metals like Cd (Baszynski *et al.*, 1980), Zn (DeFilippis *et al.*,1981b). Majority of the observations on the effect of heavy metal ions on partial photochemical reactions are made in isolated systems *in vitro*. The PS II supported electron transport activity is more susceptible to heavy metals like Zn, Ni (Tripathy *et al*, 1981), Co (Tripathy *et al.*, 1983), Cu, Cd and Zn, Cd (Bazzaz and Govindjee, 1974a) Cu (Cedeno- Maldonado *et al.*, 1972; Shioi *et al.*, 1978a; Shioi *et al.*, 1978b; Samuel son and Oquist, 1980; Renganathan and Bose, 1989; Mohanty *et al.*, 1959al Co, Ni, and Zn (Mohanty *et al.*, I 989b) Pb (Bazzaz and Gov i nd j ee, 1974b) and Hg^{2+}(Honeycutt and Krogmann, 1972; Samson and Popovic, 1990). In addition to this it was also shown that this heavy metal ion induced inhibition is dependent on the illuminating intensity (Zn, Cu: Cedeno- Maldonado *et al.*, 1972). At light limiting conditions, the extent of inhibition was found to be less than that at light saturating conditions. Sites of heavy metal action in PS II catalyzed electron transport. Restoration of Hill activity by semicarbazide in the heavy metal ion treated plant chloroplasts (Zn: Van Assche and Clijsters, 1980; Van Assche and Clijsters, 1986) and by $MnCl_2$ (Cd: Baszynski *et al.*, 1980) indicates that the water splitting site is the site of action of heavy metals. In Cd treated maize chloroplasts restoration of Hill activity by DPC suggests that OEC is the site of action (Cd: Bazzaz and Govindjee, 1974b). In this investigation the effects of mercury on PS-II photochemistry as been compared with spectral alterations in maize plants.

MATERIALS AND METHODS:

Healthy seeds of Maize (*Zea mays. L*) were obtained from Regional Agricultural research station, Tirupati. The seedlings were randomly placed in plastic trays and grown in a growth chamber providing with fluorescence light (Phillips, India) with a light intensity of 30- 35 μ moles m^{-2} s^{-1} at 25 ± 1^0C. Fully expanded 8th day leaf segments (4-5 cm long) were cut from apical region and used for treatment. Isolation of thylakoid membranes was done according to the procedure described by Sabat *et al.* (1986). PS II catalyzed electron transport assay (H_2O → *p*-BQ) activity was measured as O_2 evolution in the thylakoid membranes. The 2 ml reaction mixture contains reaction buffers [50 mM HEPES-NaOH (pH 7.5),100 mM sucrose, 2mM $MgCl_2$ and 5 mM KCl], 0.5 mM freshly prepared p-BQ and thylakoid membranes equivalent to 40 μg of Chl. Fluorescence emission and excitation spectras were recorded by using Jasco FP777 Spectrofluorimeter. PAM kinetic fluorimeter is used for measurements.Lipid peroxidation has been measured according to the method of Carmak and Horst (1991).

Chinese Journal of Evidence-Based Medicine

In-vivo and *In-vitro* rearing of Entomopathogenic Nematode (EPN) by Fermentation technology

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Abstract:

Entomopathogenic nematodes (EPNs) have been utilized in classical, conservation, and augmentative biological control programs. The vast majority of applied research has focused on their potential as inundatively applied augmentative biological control agents. Extensive research over the past three decades has demonstrated both their successes and failures for control of insect pests of crops, ornamental plants, trees and lawn and turf. So Production and application technology is critical for the success of entomopathogenic nematodes (EPNs) in biological control. Production approaches include *in vivo* and *in vitro* methods (solid or liquid fermentation). For laboratory use and small scale field experiments, *in vivo* production of EPNs appears to be the appropriate method. *In vivo* production is also appropriate for niche markets and small growers where a lack of capital, scientific expertise or infrastructure cannot justify large investments into *in vitro* culture technology. *In vitro* technology is used when large scale production is needed at reasonable quality and cost. Infective juveniles of entomopathogenic nematodes are usually applied using various spray equipment and standard irrigation systems. Enhanced efficacy in EPN

applications can be facilitated through improved delivery mechanisms (e.g., cadaver application) or optimization of spray equipment. Substantial progress has been made in developing EPN formulations, particularly for above ground applications, e.g., mixing EPNs with Talc, kaolinite and cocopeat. Bait formulations and insect host cadavers can enhance EPN persistence and reduce the quantity of nematodes required per unit area. This study demonstrated successful control of several other insects that affect production and application of EPNs and offers insights for their future in biological insect suppression by increasing the shell life.

Keywords: Entomopathogenic nematode, *heterorhabditis*, production, *steinernema,* biological control, commercialization.

1. INTRODUCTION:

Nematodes that parasitize insects, known as entomopathogenic nematodes (EPNs), have been described from 23 nematode families (Koppenhofer, 2007, 2020). Of all of the nematodes studied for biological control of insects, the Steinernematidae and Heterorhabditidae have received the most attention because they possess many of the attributes of effective biological control agents (Kaya and Gaugler, 1993; Grewal et al., 2005a; Koppenhofer, 2007) and have been utilized as classical, conservational, and augmentative biological control agents. Entomopathogenic nematodes (EPNs) of the families Heterorhabditidae and Steinernematidae are obligate parasites of insects and are used as biological control agents of economically important insect pests. The vast majority of applied research has focused on their potential as inundatively applied augmentative biological control agents (Grewal et al., 2005a).The two major genera are Heterorhabditis (Poinar, 1976), and Steinernema (Travassos, 1927), with 85 species described to date. These nematodes possess a symbiotic association with pathogenic bacteria from the Xenorhabdus and Photorhabdus genera, associated with Steinernema and Heterorhabditis respectively (Poinar, 1990). EPNs are parasites of arthropods in nature that are only horizontally transmitted and possess an infective juvenile (IJ) stage that actively invades the insect host. They are always associated with symbiotic bacteria that play an important role in host infection. The biology of the EPN-symbiotic bacteria complex has been extensively reviewed in Burnell and Stock (2000), Griffin et al. (2005), Lewis and Clarke (2012), Stock (2015), and Shapiro-Ilan et al. (2017, 2018). Infective juveniles (IJs), considered the only free-living stage of EPNs, enter the host insect through its natural apertures (oral cavity, anus and spiracles) or in some cases through the cuticle (Dowds and Peters, 2002). After penetrating the insect's hemocoel, IJs release their symbiotic bacteria, which are the primary agents responsible for host death and also provide the nematodes with nutrition and defense against secondary invaders (Poinar, 1990). The nematodes complete their development and live for two or three generations inside their host. When food is depleted, IJs exit from host cadaver searching for new hosts (Grewal and Georgis, 1999, Koppenho¨fer, 2020). The host range of most known EPN species remains mostly unknown to date (Peters, 1996; Shapiro-Ilan et al., 2017, 2018) because most species have been isolated from

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PREPARATION AND EVALUATION OF POLYHERBAL SCENTED CANDLE USING VOLATILE OILS EXTRACTED BY ENFLEURAGE METHOD

P. Kavya Sri[1], T. Usha Kiran Reddy*[2], B. Sony[3], A. Sandhya[4], K. G. Rajyalakshmi[5], G. Sindhu[6], Ch. Apparao[7], B. J. Divya[8]

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ABSTRACT

Background: Medicinal plants serve dual roles, offering remedies for various diseases and income-generation opportunities. Ancient Indian texts, including Ayurveda, extensively document plant use in healthcare. Globally, medicinal plants are vital resources in the fight against severe diseases. Essential oils in plants provide distinct aromas, flavors, and pathogen protection. Tithonia erecta flower oil boasts a complex composition with diverse beneficial properties. Exocarp extract from Citrus sinensis differs from juice or leaf extracts, containing more lipophilic compounds but fewer glycosylated compounds and lacking cyanidins and sterols. Eucalyptus globulus oil acts as an antiseptic and anti-spasmodic stimulant for respiratory issues. Scented candles are a popular relaxation method, promoting well-being through ambient lighting. This study aims to create practical scented candles using natural materials like soy wax, beeswax, and essential oils. The desired candle should offer a long burn time, be cost-effective, and pose no health risks to users. The candle composition includes gel wax, vegetable or animal fat, eucalyptus leaves, marigold petals, and orange peels. This study involves preparing and evaluating polyherbal scented candles using volatile oils extracted through the enfleurage method. **Results:** The phytochemical analysis of these extracts revealed the presence of volatile oils, alkaloids and proteins. The FTIR analysis reveals the presence of OH group in these extracts. **Conclusion:** This research successfully developed a natural polyherbal scented candle with extended burn time, cost-effectiveness, and user safety. Antioxidants prevent undesired

In-vivo and In-vitro rearing of Entomopathogenic Nematode (EPN) by Fermentation technology

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Keywords:
Entomopathogenic nematode, heterorhabditis, production, steinernema, biological control, commercialization.

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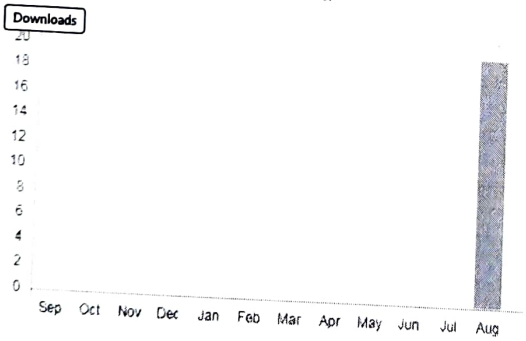
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Abstract

Entomopathogenic nematodes (EPNs) have been utilized in classical, conservation, and augmentative biological control programs. The vast majority of applied research has focused on their potential as inundatively applied augmentative biological control agents. Extensive research over the past three decades has demonstrated both their successes and failures for control of insect pests of crops, ornamental plants, trees and lawn and turf. So Production and application technology is critical for the success of entomopathogenic nematodes (EPNs) in biological control. Production approaches include *in vivo* and *in vitro* methods (solid or liquid fermentation). For laboratory use and small scale field experiments, *in vivo* production of EPNs appears to be the appropriate method. *In vivo* production is also appropriate for niche markets and small growers where a lack of capital, scientific expertise or infrastructure cannot justify large investments into *in vitro* culture technology. *In vitro* technology is used when large scale production is needed at reasonable quality and cost. Infective juveniles of entomopathogenic nematodes are usually applied using various spray equipment and standard irrigation systems. Enhanced efficacy in EPN applications can be facilitated through improved delivery mechanisms (e.g., cadaver application) or optimization of spray equipment. Substantial progress has been made in developing EPN formulations, particularly for above ground applications, e.g., mixing EPNs with Talc, kaolinite and cocopeat. Bait formulations and insect host cadavers can enhance EPN persistence and reduce the quantity of nematodes required per unit area. This study demonstrated successful control of several other insects that affect production and application of EPNs and offers insights for their future in biological insect suppression by increasing the shell life.

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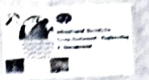
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Polymeric nanoparticles based treatment approaches for hepatocellular carcinoma (HCC)

Vothani Sarath Babu; Chittoor Pallavi; Gurvinder Singh; Rajesh Kumar ✉; Arun Sharma

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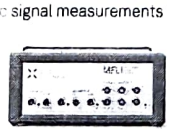
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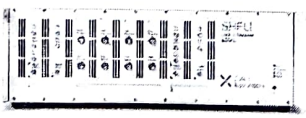
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Polymeric Nanoparticles Based Treatment Approaches for Hepatocellular Carcinoma (HCC)

Vothani Sarath Babu[1, 2, a], Chittoor Pallavi[3], Gurvinder Singh[1], Rajesh Kumar[1, b], Arun Sharma[1]

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Abstract. The conventional treatment strategies for hepatocellular carcinoma (HCC) are associated with some limitations viz. low aqueous solubility, higher drug doses, non-specific targeting towards HCC cells and associated toxicity or side effects. Biodegradable polymer-based nanomedicines offer a promising approach to augment the HCC cell uptake of the drug, by prolonging the drug blood circulation, increasing the retention time, and releasing the drug to specific target. The present review summarizes the recent advancements in designing of polymeric nanocarriers for HCC to overcome the persistent challenges associated with traditional HCC-chemotherapy. The different blueprints discussed here, will further provide an important lead in order to develop and formulate an effective nanomedicine-based treatment for the hepatocellular carcinoma.

Keywords. Nanoparticles (NPs), nanomedicine, drug delivery, biodegradable polymer, chemotherapy, hepatocellular carcinoma (HCC).

INTRODUCTION

Cancer is a significant health care problem, which is characterizes by abnormal and uncontrolled increase in cell proliferation, it is the most serious life-threatening disease worldwide. According to World Health Organization (WHO), it is expected that cancer death rates will increase to 12 million cases by 2030, whereas, the rate of cancer diagnosis is expected to reach 24 million globally by 2035 [1].

Despite recent advances in cancer diagnosis and treatment options, therapeutic interventions for several malignancies are still insufficient. For example, mortality rates of Hepatocellular Carcinoma (HCC) are increasing annually by 2.7% (women) and 1.6% (men) accounting for 3% or 6% of cancer related deaths in the United States [2]. The design and development of smart nanoplatforms represent an attractive and interesting direction in the field of cancer therapy. In contrast to nanocarriers, these nanoplatforms exhibit intelligent characteristics because they transport and control the release of cargo at a specific location. In order to facilitate the clinical transformation, the nano-drugs should be prepared by the simple process and the selected component should be approved by the FDA (U.S. Food and Drug Administration). Due to the complexity of these multifunctional systems, it is very important to ensure their reproducibility.

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FORMULATION AND EVALUATION OF ORNIDAZOLE FLOATING TABLETS FOR GASTRORETENTIVE DRUG DELIVERY

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ABSTRACT

During childhood stomach is infected with *Helicobactor pylori* and used to cause peptic ulcers, under normal conditions they are not detected. It is present in more than half of the world population. To cure these peptic ulcers and get protection from bacteria antibiotics are used. Ornidazole is one of the antibiotics used to get protection from H pylori bacterium and cure the ulcers of stomach. Ornidazole helps to prevent infection after surgery and is used to treat dental infections, ulcers and pressure sores. So, it is the most beneficial drug to human beings. Considering the significance of this principle we proposed a formulation of ornidazole in our laboratory.

INTRODUCTION

Conventional drug delivery system achieves and maintains the drug concentration within treatment only when taken several times a Day. It often results in damaging side effects and leads to poor control after therapy and there is a significant fluctuation in drug levels. In recent years, several advanced techniques have been made to result in the development of new techniques in administering required concentration of drug in a therapeutic range. The concept of sustained or prolonged release of biologically active agents has been well appreciated and rationalized for decades. Controlled release refers to the use of a delivery device within the objective of releasing the drug into the patient body at a predetermined rate or at specific times or with special release profiles (Gilbert and Christopher, 2005).

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Original Article

Nephroprotective Effects of Mycophenolate Mofetil and Glibenclamide on Streptozotocin-induced Diabetic Renal Injury in Rats: An Experimental Study

Sangeetha Lakshmi Boju[1], Peddanna Kotha[2], Nasreen A[3], Swapna Gurrapu[4], Estari Mamidala[4], Ram R[1], Srilatha Chintamaneni[3], Appa Rao Chippada[2], Siva Kumar Vishnubhotla[1]

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ABSTRACT. Diabetic renal injury is a microvascular complication associated with inflammation and oxidative stress, culminating in renal dysfunction. Conventionally, it is treated with hypoglycemic agents to address metabolic perturbations. However, the way to mitigate immunological, inflammation, and oxidative stress have seldom been studied. Hence, in the present study, the nephroprotective role of immunosuppressive and anti-inflammatory drugs, mycophenolate mofetil (MMF) in combination with the oral hypoglycemic agent glibenclamide, on streptozotocin (STZ)-induced diabetic renal damage was studied. Bodyweight, fasting blood glucose, and glycosylated hemoglobin levels were altered in the diabetic rats. Furthermore, renal injury was indicated by abnormal levels of urinary protein and creatinine and serum markers of renal function in diabetic rats. Hyperglycemia-induced oxidative stress and inflammation were also observed in the diabetic rats. The combination of MMF and glibenclamide treatment significantly attenuated the abnormal effects of hyperglycemia, oxidative stress, and inflammation-induced renal injury in diabetic rats. Histopathological studies confirmed the nephroprotective role of MMF and glibenclamide by reversing renal injury in diabetic rats. The present study suggests that MMF and glibenclamide have a protective role in STZ-induced diabetic renal damage.

Introduction

Diabetic renal injury, a microvascular complication of diabetes mellitus, is the leading cause of end-stage renal disease. Diabetic nephropathy (DN) is characterized by a progressive decrease in the glomerular filtration rate and increased urinary albumin excretion.[1] DN is characterized by the presence of hypertrophy of the glomeruli, thickening of the capillary basement membrane, the accumulation of extracellular matrix in the mesangium and the interstitium, and tubular injury in experimental

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Original Article

Asparagus gonoclados Baker (AGAF) Root Tubers Improve Glycemic Control and Hyperlipidemia in Streptozotocin-Induced Diabetic Rats

Allagadda Rajasekhar [1], Kotha Peddanna [2], Nalluri Vedasree [1], Yallanki Sireesha [4], Chinthirla Parthasarathi [3], Nagoji Nagaraju [5], Chippada Appa Rao [1]*.

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Abstract: This study aimed to investigate the antidiabetic and antihyperlipidemic activity of the active fraction of *Asparagus gonoclados* root tubers (AGAF) in streptozotocin-induced diabetic rats. After 45 days of treatment with the active fraction (AGAF) of *Asparagus gonoclados* at a dose of 50 mg/kg b.w.t., the levels of fasting blood glucose (FBG), hemoglobin, HbA1c, insulin, serum lipid profiles, and renal and hepatic function markers were measured in all experimental groups of rats. Treatment with AGAF remarkably normalized the FBG, insulin, and lipid profile levels. AGAF also normalized the hepatic and renal function markers in STZ-induced diabetic-treated rats. The findings from our current study confirm that AGAF successfully alleviates diabetes mellitus and its associated complications by improving insulin secretion and action with no apparent toxic effects on the liver or kidney.

Keywords: *A. gonoclados*, Antidiabetic activity, Streptozotocin, Insulin, Hyperglycemia.

Introduction

Diabetes mellitus is a disorder of abnormally high blood sugar (glucose) levels due to deficient production of insulin to meet its needs and is a leading cause of morbidity and mortality. Type 2 diabetes is characterized by low levels of high-density lipoprotein cholesterol (HDL-C) and high levels of triglycerides (TG). Increased serum concentrations of total cholesterol (TC), triglycerides (TG), and low-density lipoprotein cholesterol (LDL-c), as well as decreased HDL-C, are considered lipid parameters that

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BIOCHEMICAL STUDIES ON THE ANTIDIABETIC AND ANTIHYPERLIPIDEMIC ACTIVITY OF AQUEOUS SEED EXTRACT OF *PENNISETUM GLAUCUM* IN STZ INDUCED DIABETIC RATS

Venkata prasad Surtineni[1], Yallanki Sireesha[2], Rajasekhar Allagadda[1], Subhan Ali Mohammad[1], Appa Rao Chippada[1]

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ABSTRACT

The modern medicines available for the management of diabetes exert serious side effects, So the antidiabetic drug discovery has shifted its focus to natural plant sources having minimal side effects and high efficacy. The aim of the present investigation was to evaluate the antidiabetic and antihyperlipidemic activity of *Pennisetum glaucum* seeds in STZ-induced diabetic rats. Diabetes was induced in male wistar albino rats by a single intra peritoneal injection of STZ (50mg/kg bw). FBG levels were measured by glucose oxidase-peroxidase reactive strips. Aqueous extract of seeds of *Pennisetum glaucum* (AqSPG) at a dosage of 250 mg/ kg bw, was orally administered to diabetic rats along with normal rats up to 30 days. For comparison diabetic rats treated with a standard drug glibenclamide 20mg/kg bw. Serum biochemical parameters such as HbA1c, plasma insulin, total lipid profile, hepatic and renal functional markers were measured. Long term oral administration of aqueous extract of seeds of *Pennisetum glaucum* (AqSPG) resulted in significant reduction in FBG and HbA1c levels in diabetic rats, with the corrections of diabetic dyslipidemia, plasma insulin compared to untreated diabetic rats. There was a significant decrease in the activities of liver and renal functional markers in diabetic treated rats compared to untreated diabetic rats indicating the protective role of the AqSPG against liver and kidney damage and its non-toxic property. Based on results it is concluded that AqSPG have significant antidiabetic and antihyperlipidemic effects. Further studies are required to identify the active principle (s) from the extract.

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An International Open Access, Peer-reviewed, Refereed Journal

AN OVERVIEW OF ANTIDIABETIC MEDICINAL PLANTS AVAILABLE IN THE SESHACHALAM HILL RANGE

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Abstract

Diabetes mellitus is a syndrome characterized by hyperglycemia, metabolic changes in carbohydrates, lipids, and proteins. In the long term, DM causes eye, kidney, cardiovascular, and neurological complications. In the last few years, there has been exponential growth in the field of herbal medicine in both developing and developed countries. This review article was designed to report on some of the medicinal plants available in the Seshachalam hill ranges of the Rayalaseema region of Andhra Pradesh. India is the largest producer of medicinal plants and is called the Botanical Garden of the Globe." WHO establishes a global center for traditional medicine. "Ensuring all people have access to safe and effective treatment ´is an essential part of WHO's mission. Studies have been carried out globally to verify their efficacy, and some of the findings have led to the production of plant-based medicines. India trades 7,000 species of medicinal plants annually. The current review focuses on the antidiabetic effect of the medicinal plants available in the Seshachalam Hill range of the Rayalaseema region of Andhra Pradesh.

Keywords: Diabetes mellitus, medicinal plants, antidiabetic activity, Seshachalam hill range, Phytochemicals.

Introduction

Diabetes is a chronic endocrine disorder that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Diabetes mellitus, characterized by hyperglycemia, may over time lead to serious damage to the heart, blood vessels, eyes, kidneys, and nerves. Some reasons, like stress, the rapid development of cities, a substantial increase in purchase power, lifestyle ease, and metro life, have led to health issues. According to the WHO global report, the prevalence of diabetes is steadily increasing. By the year 2030, approximately 438 million people (7.8%) of the adult population are expected to have diabetes. Managing diabetes involves a series of cost-effective interventions, such as blood glucose control, through a combination of diet, physical activity, and, if necessary, medication. The cost of treating diabetes and associated complications exceeds $100 billion per year, and complications are far less common. The treatment of diabetes with synthetic drugs is generally not preferred because of their high cost and side effects. It is necessary to develop traditional and alternative medicine. Plant drugs are frequently considered to be less toxic and free of side effects than synthetic ones. Many herbs have been shown to have hypoglycemic action in animals and humans.

3.0.5

Antidiabetic effects *of Setaria italica* seeds aqueous extract in STZ induced diabetic rats. A Histopathological study

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[2,3]Department of Biochemistry, Sri Venkateswara University, Tirupati, 517502, Andhra Pradesh, India.
Corresponding Author: **Dr. Chippada Appa Rao**

Abstract-

Background: ***Setaria italica*** **is commonly known as Foxtail millet. In India it is chiefly cultivated in Andhra Pradesh, Telangana and Tamil Nadu. It can be taken as sweet or savoury food in all ways that rice is used. Due to the presence of high fibre content, it is suggested as a food for diabetic patients.**

Objectives: To evaluate the protective effects of SISAE on STZ induced diabetic rats.

Materials and Methods: The rats were divided into five groups (six rats in each group).

The animals in group 2 and 4 were given daily oral dose of 300mg of SISAE /kg b.w/day while groups 1 and 3 rats were given water alone and group 5 rats were treated with Glibenclamide at a dose of 20mg/kg b.wfor a period of 30 days. All the five groups were sacrificed on the last day of treatment by cervical dislocation and then blood, pancreas, liver and kidney were collected and stored in 10% formalin after washing 3 times with normal saline. Serum was separated and stored for further biochemical investigations. The tissues were washed, dehydrated with alcohol, cleared with xylene and paraffin blocks were made. Serial sections of 5 micrometres thickness were cut using a rotary microtone. The sections were then deparaffinised with xylene and hydrated in descending grades of alcohol. The slides were then transferred to haematoxylin for 10 minutes, followed by rinsing with water, differentiated in 1% acid alcohol, rinsed in water, blueing in running tap water or 1% lithium carbonate differentiated in 1% alcohol. Later they were counterstained with eosin, rinsed with water, dehydrated with ascending grades of alcohol, cleared with xylene and mounted on glass slides. These slides were examined under 10X and 40X using microscopes.

Results: In histopathological examination, Stained sections of pancreas of diabetic untreated rats showed destruction of beta cells with lymphocytic infiltrations and atrophy. Diabetic treated rats with SISAE showed regenerative changes with tissue architecture. Kidneys sections of diabetic untreated rats showed tubular damage and haemorrhage. But after treatment with SISAE damage of the kidney tissue was controlled. Stained sections of the diabetic untreated rats showed degenerative liver with severe congestion of central vein, haemorrhage in the sinusoidal spaces with hazy nucleus. Whereas, treatment with SISAE in diabetic rats showed improvement in histological structure of liver sections of diabetic rats with normal appearance of the liver lobules.

***Key words*: *Setaria italica*, seeds aqueous extract, (SISAE), Diabetes mellitus (DM), Streptozotocin (STZ), hyperglycemia, histopathology.**

INTRODUCTION

Diabetes mellitus is a metabolic disorder affecting a huge number of populations in the world. It is characterized by chronic hyperglycemia, resulting from defects in insulin secretion or insulin action. It is predicted that the number of diabetic persons in the world could reach 366 million by the year 2030. From the data available through literature, it was found that plant having antidiabetic activity is mainly due to the presence of secondary metabolite. Oxidative stress is involved in development of diabetes and a lot of other diseases. Diabetes mellitus is one of the oxidative stress conditions in which free radicals are increased and antioxidant mechanisms are inhibited. Plants impose their activity through this mechanism and can reduce the toxic effects of drugs. Ayurveda is an ancient Indian form of medicine which deals with plants and plant extracts. Plant drugs are frequently considered to be less toxic and freer from side effects than synthetic ones. Many herbs have been shown to have hypoglycaemic action in animals and humans. *Setaria italica* belongs to family Poaceae commonly known as Foxtail millet. The edible part of the plant is seed. The millet has protein and fiber content compared to other millets. In previous studies anti hyperglycemic and hypolipidemic activity of aqueous seed extract of *Setaria italica* in streptozotocin induced diabetic rats (Sireesha et al. 2011) was reported with improved activities of carbohydrate metabolic and antioxidant enzymes. (Sireesha, et al. 2023). In this paper, the protective effects of SISAE against diabetes induced damage are presented.

HISTOLOGY OF PANCREAS

Pancreas is a pistol shaped gland located inferior and deep to the stomach. It's about 6 inches or 15 cms long. It has both endocrine and exocrine functions. Its exocrine functions are to produce digestive enzymes. Its edoncrine functions pertain to regulating blood glucose. Pancreas produce insulin and glucagons, two hormones that regulate sugar levels in blood. Insulin and glucagons are secreted from pancreas directly into blood.

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Original Article

Nephroprotective Effects of Mycophenolate Mofetil and Glibenclamide on Streptozotocin-induced Diabetic Renal Injury in Rats: An Experimental Study

Sangeetha Lakshmi Boju[1], Peddanna Kotha[2], Nasreen A[3], Swapna Gurrapu[4], Estari Mamidala[4], Ram R[1], Srilatha Chintamaneni[3], Appa Rao Chippada[2], Siva Kumar Vishnubhotla[1]

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ABSTRACT. Diabetic renal injury is a microvascular complication associated with inflammation and oxidative stress, culminating in renal dysfunction. Conventionally, it is treated with hypoglycemic agents to address metabolic perturbations. However, the way to mitigate immunological, inflammation, and oxidative stress have seldom been studied. Hence, in the present study, the nephroprotective role of immunosuppressive and anti-inflammatory drugs, mycophenolate mofetil (MMF) in combination with the oral hypoglycemic agent glibenclamide, on streptozotocin (STZ)-induced diabetic renal damage was studied. Bodyweight, fasting blood glucose, and glycosylated hemoglobin levels were altered in the diabetic rats. Furthermore, renal injury was indicated by abnormal levels of urinary protein and creatinine and serum markers of renal function in diabetic rats. Hyperglycemia-induced oxidative stress and inflammation were also observed in the diabetic rats. The combination of MMF and glibenclamide treatment significantly attenuated the abnormal effects of hyperglycemia, oxidative stress, and inflammation-induced renal injury in diabetic rats. Histopathological studies confirmed the nephroprotective role of MMF and glibenclamide by reversing renal injury in diabetic rats. The present study suggests that MMF and glibenclamide have a protective role in STZ-induced diabetic renal damage.

Introduction

Diabetic renal injury, a microvascular complication of diabetes mellitus, is the leading cause of end-stage renal disease. Diabetic nephropathy (DN) is characterized by a progressive decrease in the glomerular filtration rate and increased urinary albumin excretion.[1] DN is characterized by the presence of hypertrophy of the glomeruli, thickening of the capillary basement membrane, the accumulation of extracellular matrix in the mesangium and the interstitium, and tubular injury in experimental

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No. 3/1/3(20)/Endo-fellowship/22-NCD-III

Date: 20/06/22

To,

Prof Ch Apparao,
Professor,
Dept of Biochemistry,
SV University Tirupati-517502

Sub: Award of Research Associate to Dr. Rajasekhar Allagadda, on project entitled, "Antidiabetic beneficial effects of Basella rubra L. whole plant in High fat-diet/STZ induced type 2 diabetic Male Albino Wistar rats"

Sir,

I am glad to inform you that the ICMR has awarded Research Associate to Dr. Rajasekhar Allagadda on a stipend of Rs. 47,000/- p.m. to carry out research on the project mentioned above under your guidance. H.R.A. and Medical reimbursement will be paid as per the rules of your Institute.

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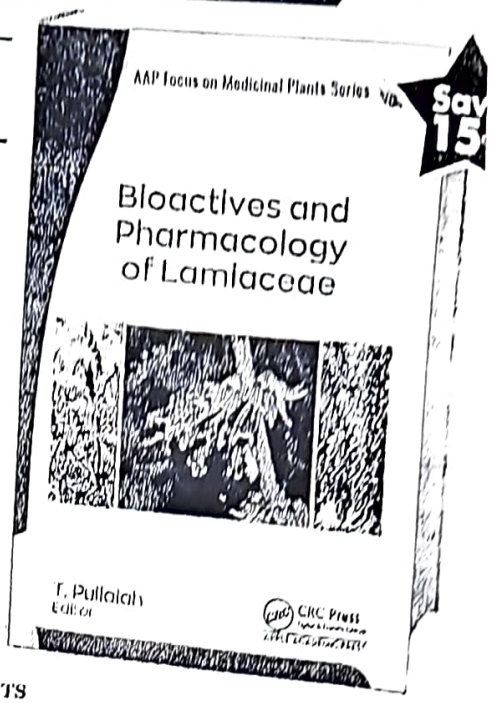
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REPORTS: The awardees shall submit one copy of the Ist annual report with original protocol & soft copy of both for the first 10 months on the prescribed standard Performa from the date of commencement of the fellowship giving complete factual details of the research work done through the Guide along with his/her appraisal. Subsequent annual report should be submitted through the Guide two months before the completion of fellowship tenure. Failure to submit reports in time may lead to termination of the award. One copy of the Final report with original protocol & soft copy of both in the prescribed form clearly shall be submitted one month before the date of termination of the award.

AAP **New Book Announcement**

Bioactives and Pharmacology of Lamiaceae

Available April 2023



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Editor: T. Pullaiah, PhD
Former Professor, Department of Botany, Sri Krishnadevaraya University, Andhra Pradesh, India

This new book, **Bioactives and Pharmacology of Lamiaceae**, provides a wealth of information on plants in the Lamiaceae family, noted for their essential oils bioactives, and pharmacological properties. The chapters investigate a wide variety of species, providing for each an introduction, characteristics, properties, distribution, traditional uses, and current and potential pharmacological applications.

Aiming to be a resource for the development of new drugs based on species within the Lamiaceae family, the volume includes 26 species discussed, including bungleweed (*Ajuga*), Malabar catmint (*Anisomeles malabarica*), beechwood (*Gmelina arborea*), Brazilian mint (Hyptis crenata), rosemary (*Rosmarinus officinalis* L.), holy basil (*Ocimum tenuiflorum*), and many more.

Edited by the noted botanist T. Pullaiah, PhD, this new volume under his AAP Focus on Medicinal Plants book series, will be a valuable reference for those in drug discovery, botany, and fragrance chemists.

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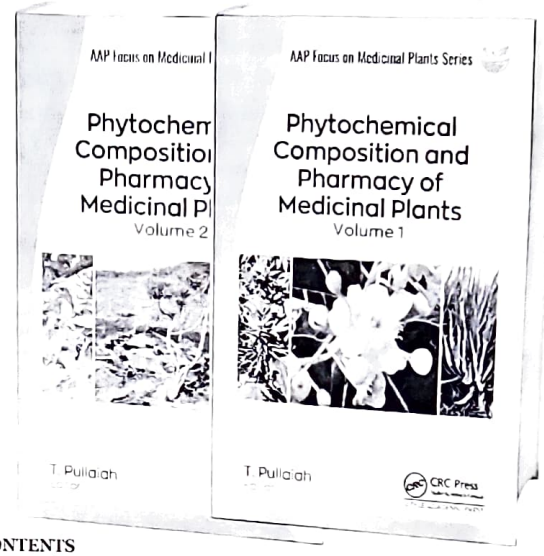
AAP **New Book Announcement**

Phytochemical Composition and Pharmacy of Medicinal Plants,

2-volume set

Forthcoming April 2023

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Editor: T. Pullaiah, PhD
Former Professor, Department of Botany,
Sri Krishnadevaraya University, Andhra Pradesh, India

This new 2-volume set offers a comprehensive review of more than 80 medicinal plant species, providing information on the bioactives and pharmacology of these beneficial plants. It describes the structures of the secondary metabolites found in these plants, the functions of these compounds in human and plant biology, and the biosynthesis of these compounds.

Each chapter begins with a brief introduction about the species. The chapters then delve into the bioactive phytochemicals from the plant along with its chemical structure. The published literature on pharmacological activities on that species is comprehensively reviewed. A wide array of the biological activities and potential health benefits of the medicinal plant (which include antiviral, antimicrobial, antioxidant, anti-cancer, anti-inflammatory, and antidiabetic properties as well as protective effects on liver, kidney, heart and nervous system) are given.

Phytochemical Composition and Pharmacy of Medicinal Plants aims to be valuable source book for scientists, researchers, industry professionals, faculty and students for the development of new and effective drugs from medicinal plants.

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About the Editor

T. Pullaiah, PhD, is a former Professor at the Department of Botany at Sri Krishnadevaraya University in Andhra Pradesh, India, where he has taught for more than 35 years. He has held several positions at the university, including Dean, Faculty of Biosciences, Head of the Department of Botany, Head of the Department of Biotechnology, and Member of the Academic Senate. He was President of the Indian Botanical Society (2014), President of the Indian Association for Angiosperm Taxonomy (2013), and Fellow of Andhra Pradesh Akademi of Sciences. He was awarded the Panchanan Maheshwari Gold Medal, the Dr. G. Panigrahi Memorial Lecture Award of the Indian Botanical Society, the Prof. Y.D. Tyagi Gold Medal of the Indian Association for Angiosperm Taxonomy, and a best teacher award from the Government of Andhra Pradesh. Under his guidance, 54 students obtained their doctoral degrees. He has authored over 50 books, edited 20 books, and published over 330 research papers, including reviews and book chapters. His books include *Advances in Cell and Molecular Diagnostics, Ethnobotany of India* (5 volumes), *Red Sanders: Silviculture and Conservation, Monograph on Brachystelma and Ceropegia in India, Flora of Andhra Pradesh* (5 volumes), *Flora of Eastern Ghats (7 volumes), Flora of Telangana* (3 volumes), *Encyclopaedia of World Medicinal Plants* (7 volumes, 2nd edition), *Encyclopaedia of Herbal Antioxidants* (3 volumes), *Global Biodiversity* (4 volumes), *Handbook of Research on Herbal Liver Protection*, among others. Dr. Pullaiah was a member of the Species Survival Commission of the International Union for Conservation of Nature (IUCN). He received his PhD from Andhra University, India, and attended Moscow State University, Russia.

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Higher Education Department – Universities - In-charge arrangements to the posts of Vice-Chancellors of various Universities – Orders – Issued.

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G.O.Rt.No.122 **Dated:18.07.2024**

Read the following:-

1. A.P. Universities Act, 1991 (Act No.4 of 1991) amended from time to time.
2. Jawaharlal Nehru Technological Universities Act, 2008 (Act No.30 of 2008)
3. Sri Padmavathi Mahila Visvavidyalayam (Women's University) Act, 1983 (A.P. Act No.16 of 1983)
4. Dravidian University Act, 1997 (Act No.17 of 1997)
5. Dr.YSR Architecture & Fine Arts University Act, 2008 (Act No.31 of 2008)
6. Dr. Abdul Haq Urdu University Act, 2016 (A.P Act No.13 of 2016)

****

O R D E R:-

In view of the acceptance of the resignations tendered by the present Vice-Chancellors of the following Universities, in exercise of the powers conferred under Section 12(3) of A.P. Universities Act, 1991 (Act No.4 of 1991), SCHEDULE-1 of the Jawaharlal Nehru Technological Universities Act, 2008 (Act No.30 of 2008); STATUTE 1 Section 26(1) of Sri Padmavathi Mahila Viswavidyalayam (Women's University) Act, 1983 (A.P Act No.16 of 1983), Statute-1 of Dravidian University Act 1987 (Act No.17 of 1997); SCHEDULE of Dr.YSR Architecture & Fine Arts University Act, 2008 (Act No.31 of 2008); and Section 11(10) of Dr. Abdul Haq Urdu University Act, 2016 (A.P Act No.13 of 2016), Government hereby made the following In-charge arrangements to the post of Vice-Chancellor to the respective Universities until further orders:-

Sl. No.	Name of University	Name of the person kept as Incharge Vice-Chancellor
1	Sri Venkateswara University, Tirupati	Prof. Chippada Appa Rao, Biochemistry Department, Sri Venkateswara University
2	Sri krishnadevaraya University, Ananthapur	Prof. B. Anitha, Management studies Department, Sri krishnadevaraya University
3	Andhra University, Visakhapatnam	Prof. Gottapu Sasibhushan Rao, Electronics & Communication Engineering Department, Andhra University
4	Acharya Nagarjuna University, Guntur	Prof. Kancharla Gangadhar, Computer Science Department, Acharya Nagarjuna University
5	JNTU, Anantapur	Prof. H. Sudarshan Rao, Civil Engineering Department, JNTU-Ananthapur

[P.T.O]

SRI VENKATESWARA UNIVERSITY : TIRUPATI

No.Estt/VDL/ALL CIR /2021

Date : 02.06.2021

PROCEEDINGS OF THE VICE-CHANCELLOR

Sub : S.V. University – Teaching Establishment – Appointment of Dean, College Development Council, S.V. University, Tirupati – Orders Issued.

Read :
1. Proceedings of the Vice Chancellor (EA/C) No.Estt/B1/ Dean CDC/2020, dated 17.01.2020.
2. Vice Chancellor's orders dated 02.06.2021.

ORDER :

In pursuance of the orders of the Hon'ble Vice Chancellor second read above, ***Prof. Ch. Appa Rao***, Department of Bio Chemistry, S.V.U. College of Sciences, Tirupati is appointed as ***Dean, College Development Council*** with immediate effect for a period of one year.

The above appointment is without prejudice to his normal duties as Professor in the Department of Bio Chemistry, S.V.U. College of Sciences, Tirupati.

He shall be paid an amount of Rs.500/- as honorarium per month for discharging the duties of Dean, College Development Council, an amount of Rs.500/- per month towards conveyance allowance and the same shall be met from the Development Account of the University.

Prof. B. Ramachandra Reddy, Retired, Department of Commerce, S.V.U. College of Commerce, Management and Computer Science, Tirupati is deemed to have been relieved from the duties of the Dean, College Development Council with effect from the afternoon of 31.05.2021.

He shall take over charge from Prof. B. Ramachandra Reddy, Retired, Department of Commerce, S.V.U. College of Commerce, Management and Computer Science, Tirupati.

(BY ORDER)

REGISTRAR

To

1) Prof. Ch. Appa Rao,
Department of Bio Chemistry,
S.V.U. College of Sciences,
Tirupati.

2) Prof. B. Ramachandra Reddy,
Retired, Department of Commerce,
S.V.U. College of Commerce,
Management and Computer Science,
Tirupati.

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No.E.II-(7)/Principal-SVUPC. Sci/2019 Date: 31.10.2019

PROCEEDINGS OF THE RECTOR

Sub:- S.V. University – Teaching Establishment - Appointment of In-Charge Principal, SVU College of Pharmaceutical Sciences - Orders - Issued.

Read :-
1. Proceedings of the Vice Chancellor No.E-II (7)/Principal/ SVUC of PCSciences/2017, dated 25.02.2017.
2. Rector's orders dated 31.10.2019

ORDER: -@-

Prof. K. THYAGARAJU, Department of Bio-Chemistry and Principal SVU College of Pharmaceutical Sciences, Tirupati is retiring from the University Service on the afternoon of 31.10.2019 on attaining the age of superannuation of 62 years.

Consequent on his retirement, ***Prof. CH. APPA RAO***, Department of Bio-Chemistry and Dean Faculty of Pharmaceutical Sciences, SVU College of Pharmaceutical Sciences, Tirupati, is appointed as ***In-Charge Principal***, SVU College of Pharmaceutical Sciences, Tirupati, on the afternoon of 31.10.2019 until further orders.

He shall take over charge of the Principalship from Prof. K. THYAGARAJU, and send a report of taking over charge in the format prescribed for the purpose i.e. Certificate of Transfer of charge.

Prof. K. Thyagaraju shall handover charge of Principalship to ***Prof. CH. APPA RAO***, on the afternoon of 31.10.2019.

Whenever, the In-Charge Principal goes on leave or on other duty, the Principal SVU College of Sciences, will act as Principal-In charge.

(BY ORDER)

REGISTRAR

To

Prof. Ch. Appa Rao
Department of Bio-Chemistry and
Dean Faculty of Pharmaceutical Sciences
Tirupati.

Prof. K. Thyagaraju
Dept. of Bio-Chemistry and
Principal, SVU College of Pharmaceutical Science
Tirupati.

Copy to:

The Principal, SVU College of Sciences, Tirupati, informed to make necessary entries in the Service Registers of the teachers concerned.
The Principal, SVU College of Arts/Commerce, Management & Comp Sci /

CAR
Membership

NSE INDIA

THE NATIONAL SOCIETY OF ETHNOPHARMACOLOGY, INDIA

Estd: 1985

Patron: Padma Shri Dr. P R Krishnakumar

This is to certify that

Ch. APPA RAO

has been admitted as a ~~Member~~ / Life Member

of

The National Society of Ethnopharmacology, India

with effect from

03/03/2017

Membership No. 320

President

General Secretary

Office: Amity Institute for Herbal and Biotech Products Development, 3 Ravi Nagar, Peroorkada P.O., Thiruvananthapuram - 695 005, Kerala, India

SOCIETY OF BIOLOGICAL CHEMISTS, INDIA

Life Membership No. 1898 Year 2007

NAME Dr. Ch. APPA RAO

ADDRESS DEPT. OF BIOCHEMISTRY
SRI VENKATESWARA UNIVERSITY
TIRUPATI

Please quote the above number in all correspondence with the society. Intimate change of address if any.

SAP
Membership

भारतीय विज्ञान कांग्रेस संस्था
14, डॉ० बिरेश गुहा स्ट्रीट, कोलकाता - 700 017, भारत
THE INDIAN SCIENCE CONGRESS ASSOCIATION
700 017, INDIA

107th ISC 2020 Bengaluru, F.Y. 2019-20

ई-मेल / E
आजीवन सद
LIFE MEMB
नाम / NAME
पता / ADDR
वर्तमान संब
PRESENT
हस्ताक्षर / SI

Sec : New Biol.(includ Biochem., Biophys. & Mol. Biol. & Biotech.)
Membership No. : L39371
Prof. Dr. Chippada Appa Rao
Professor
Dept. of Biochemistry
Sri Venkateswara Universit
Tirupati 517502
ANDHRA PRADESH

जारी करने का दिनांक /

20 NOV 2019

डॉ. एस. रामाकृष्णा / Dr. S. Ramakrishna
महासचिव / General Secretary
सदस्यता प्रभार / Membership Affairs

SAP

Membership

SOCIETY FOR ETHNOPHARMACOLOGY
(SFE-INDIA)

www.ethnopharmacology.in

This is to certify that

Chippada Apparao

Tirupati, Andhra Pradesh

Has been accepted as a member of the
Society for Ethnopharmacology, Kolkata, India (SFE-INDIA).
In witness whereof this certificate has been signed and
presented on November, 2019.

Membership No: SFE/19/I-1491 Valid till: December 30, 2024

President

Secretary

SOCIETY FOR ETHNOPHARMACOLOGY
A Registered Society under West Bengal Society Registration Act 1961)
Affiliated to International Society for Ethnopharmacology
[illegible] Jadavpur, Kolkata [illegible] India

SAR
Administration

ANDHRA PRADESH STATE COUNCIL OF HIGHER EDUCATION
(A Statutory Body of the Government of A.P)
3rd, 4th and 5th floors, Neeladri Towers, Sri Ram Nagar, 6th Battalion Road, Atmakur(V), Mangalagiri(M), Guntur-522503, Andhra Pradesh
Web: www.apsche.org. Email: acapsche@gmail.com

PROCEEDINGS OF THE CHAIRMAN, ANDHRA PRADESH STATE COUNCIL OF HIGHER EDUCATION :: GUNTUR

PRESENT: PROF.K.HEMACHANDRA REDDY
CHAIRMAN

Procs.No. APSCHE/AC/Online admns/OAC/2020 **Dt:02.11.2020**

Sub : APSCHE – Academic Cell - Introduction of Online admission process for admission into under graduate courses offered by the Degree Colleges in the State from the academic year 2020-21 - Constitution of Online Admission Committee- Regarding.

Ref: G.O.Ms.No.34 Higher Education Department dated 15-10-2020

-o0o-

ORDER:-

The Government of A.P, vide G.O under reference has issued orders introducing online admission process for admission into Undergraduate Programmes in Arts, Sciences, Social Sciences, Commerce, Management, Computer Applications and Social work etc. including Honours, in all faculties in Government Degree Colleges, Government Autonomous Degree Colleges, Private Aided Degree Colleges, Private Unaided Degree Colleges and Private-Autonomous Degree Colleges (Aided and Unaided).

As per rule 13 of the G.O under reference cited, the AP State Council of Higher Education is authorized to implement online admission process for admissions into under graduate courses ie BA, B.Com., B.Sc.,etc. offered by the Degree Colleges in the State from the academic year 2020-21.

In accordance with powers construed through the G.O under reference and in accordance with 13.3 of rule 13 of the G.O under reference, the A.P State Council of Higher Education constitutes the Online Admission Committee (OAC) for Online Admissions-2020 with the following members:

Sl No	Designation as per G.O	Member nominated for 2020-21
1	Convener of Admissions nominated by APSCHE	Prof.Ch.Appa Rao, Professor in Biochemistry, S.V University, Tirupati
2	Co-Convener of Admissions nominated by CCE, AP	Dr.Ch.Tulasi Mastanamma, Academic Guidance Officer, O/o CCE A.P
3	Nodal officer nominated by APSCHE	Dr.B.S.Selina, Academic Officer, Academic Cell, APSCHE
4	Nodal officer nominated by CCE, AP	Mr.Sridhar, Academic Officer, Academic Cell, O/o CCE A.P

GOVERNMENT OF ANDHRA PRADESH
ABSTRACT

Higher Education Department – Universities -In-charge arrangements to the posts of Vice-Chancellors of various Universities – Orders – Issued.

HIGHER EDUCATION (UE) DEPARTMENT

G.O.Rt.No.122 **Dated:18.07.2024**

Read the following:-

1. A.P. Universities Act, 1991 (Act No.4 of 1991) amended from time to time.
2. Jawaharlal Nehru Technological Universities Act, 2008 (Act No.30 of 2008)
3. Sri Padmavathi Mahila Viswavidyalayam (Women's University) Act, 1983 (A.P. Act No.16 of 1983)
4. Dravidian University Act, 1997 (Act No.17 of 1997)
5. Dr.YSR Architecture & Fine Arts University Act, 2008 (Act No.31 of 2008)
6. Dr. Abdul Haq Urdu University Act, 2016 (A.P Act No.13 of 2016)

****

O R D E R:-

In view of the acceptance of the resignations tendered by the present Vice-Chancellors of the following Universities, in exercise of the powers conferred under Section 12(3) of A.P. Universities Act, 1991 (Act No.4 of 1991), SCHEDULE-1 of the Jawaharlal Nehru Technological Universities Act, 2008 (Act No.30 of 2008); STATUTE 1 Section 26(1) of Sri Padmavathi Mahila Viswavidyalayam (Women's University) Act, 1983 (A.P Act No.16 of 1983), Statute-1 of Dravidian University Act 1987 (Act No.17 of 1997); SCHEDULE of Dr.YSR Architecture & Fine Arts University Act, 2008 (Act No.31 of 2008); and Section 11(10) of Dr. Abdul Haq Urdu University Act, 2016 (A.P Act No.13 of 2016), Government hereby made the following In-charge arrangements to the post of Vice-Chancellor to the respective Universities until further orders:-

Sl. No.	Name of University	Name of the person kept as Incharge Vice-Chancellor
1	Sri Venkateswara University, Tirupati	Prof. Chippada Appa Rao, Biochemistry Department, Sri Venkateswara University
2	Sri krishnadevaraya University, Ananthapur	Prof. B. Anitha, Management studies Department, Sri krishnadevaraya University
3	Andhra University, Visakhapatnam	Prof. Gottapu Sasibhushan Rao, Electronics & Communication Engineering Department, Andhra University
4	Acharya Nagarjuna University, Guntur	Prof. Kancharla Gangadhar, Computer Science Department, Acharya Nagarjuna University
5	JNTU, Anantapur	Prof. H. Sudarshan Rao, Civil Engineering Department, JNTU-Ananthapur

[P.T.O]

Prof M Balaji

1 – 10					
Seminar/Conferences/Workshops/Symposia wherein served as Resource person		50			
International	Keynote speaker / Chairman / Co-Chairman / Distinguished Guest / Key Speaker / Lead Discussant 1 – 20				
National	Keynote Speaker / Chairman / Co-Chairman / Distinguished Guest / Key Speaker / Lead Discussant 1 – 10		3 x10=30		
Membership in editorial boards 1- 5		20	4 x 5=20		
Membership in professional bodies 1- 5		25			
Training Programmes attended		30			
Outside the Country 1-20					
Outside the State 1-5					
Guest Lecturers delivered by faculty		75			
Industry 1-5					
Research Institutes 1-5					
Other Universities 1-3			1 x 3=3		
ACHIEVEMENTS AND EXTENSION ACTIVITIES		**150**	**100**	**10**	1000
Executive Positions in professional bodies 1-10		40			
Awards and Honours (only academic bodies and Govt.) 1-30		30	1 x 30=30		
Administrative positions in the University 1-30		30	1 x30=30		
Extension activities (participation in community service One programme – 10		50	4 x 10=40		
Total : 74..88		**750**		**100**	11982

Note: Details of Research, Academic Activities and Achievements and Extension Activities shall be furnished along with the report

Dr. M. BALAJI, M.Sc., Ph.D.
Professor
Dept. of Biochemistry
Sri Venkateswara University
TIRUPATI-517502, A.P. INDIA

Calculation of Performance Rate:

1. Ascertain performance score as per the points mentioned against each criteria
2. Calculate each parameter score such as scores of Student feedback, research, academic activities and achievements and extension activities
3. Multiply the parameter score with weight assigned to each parameter. eg. Student feedback X weight (50)
4. Add the weighted parameter score of all four parameters
5. Divide the total weighted score BY 16.000 (the maximum possible weighted score) and multiply with 100 to get performance rate of the faculty for the academic year.

3 Biotech (2023) 13:41
https://doi.org/10.1007/s13205-023-03461-x

ORIGINAL ARTICLE

Capparis zeylanica L. root extract promotes apoptosis and cell cycle arrest, inhibits epithelial-to-mesenchymal transition and triggers E-cadherin expression in breast cancer cell lines

Mallepogu Venkataswamy[1] · Reddy Sankaran Karunakaran[1] · Md. Shahidul Islam[2] · Balaji Meriga[1]

Received: 29 August 2022 / Accepted: 31 December 2022 / Published online: 10 January 2023
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Abstract
Capparis zeylanica L. is a climbing shrub distributed in Indian subcontinent and Mediterranean region. Almost all parts of the plant are used in folk medicine and traditional practices to treat several human ailments. The present study was aimed to investigate the role of *C. zeylanica* L. root extract in preventing cancerous cells growth and proliferation, as well as promoting apoptosis and cell cycle arrest in MDA-MB-231 and MCF-7 breast cancer cells. Methanolic extract of *C. zeylanica* L. (MECz) was prepared and characterized by LC–ESI–MS/MS analysis. In vitro cytotoxicity and anti-proliferative activity of MECz was evaluated by MTT assay, while cell viability, apoptosis and cell cycle progression by Muse Cell analyzer. Furthermore, the mRNA and protein expressions of EMT markers were assessed using qRT-PCR and western blotting techniques, respectively. The MECz was found to be rich in phenolic compounds including chlorogenic acid, 6-gingerol, and certain triterpenes like ursolic acid etc. The apparent anti-metastasis activity of MECz was evident from IC_{50} value of 19.12 and 24.22 µg/mL, respectively, on MDA-MB-231 and MCF-7 cells in MTT assay. An absolute decrease in cell viability (78.1–53.4% and 89.9–49.0%), augmented apoptosis (90.98–48.25% and 88.25–47.70%) and S phase, G_2/M phase cell cycle arrest was found by MECz treatment on MDA-MB-231 and MCF-7 cells. The gene expression studies revealed that MECz could significantly ($p < 0.001$) regulate the expression of EMT markers such as snail, slug, zeb-1, twist-1, fibronectin, vimentin and E-cadherin at molecular level. These findings demonstrate that *C. zeylanica* L. root extract inhibits breast cancer cells growth and proliferation through regulating the expression of key EMT marker genes and proteins. Thus, MECz may be suggested as a potential anti-metastasis agent in the treatment of breast cancer.

Keywords Apoptosis · Breast cancer · *Capparis zeylanica* · Cell cycle · Cytotoxicity · EMT markers

Abbreviations

C. zeylanica	*Capparis zeylanica*
MECz	Methanolic extract of *Capparis zeylanica*
EAECz	Ethyl acetate extract of *Capparis zeylanica*
AcECz	Acetone extract of *Capparis zeylanica*
AqECz	Aqueous extract of *Capparis zeylanica*
EMT	Epithelial-to-mesenchymal transition

Introduction

Cancer is the second most prominent cause of death worldwide in people with age of 70 or less and about 30% of cancer deaths are owing to breast cancer (Siegel et al. 2018). The high incidence of cancer is majorly owing to steady rise in life expectancy, increasing urbanization; changes in environmental conditions, food habits and lifestyle (Jemal et al. 2011). According to GLOBOCAN 2020, an estimated 19.3 million people worldwide were diagnosed with cancer in 2020, with 10 million deaths from cancer (Sung et al. 2021). It is predicted that, by 2040, the global prevalence of cancer will be doubled from its current prevalence (29–37%), with low- and middle-income countries (LMICs) account for two-thirds of the prevalence (Shah et al. 2019). Breast cancer is the most widespread cancer among women and in 2022, approximately 2.9 million female breast cancer cases were diagnosed worldwide, accounting for nearly one-fourth of

✉ Balaji Meriga
balaji.meriga@gmail.com

1 Department of Biochemistry, Sri Venkateswara University, Tirupati, Andhra Pradesh 517502, India

2 Department of Biochemistry, School of Life Sciences, University of KwaZulu-Natal, Westville Campus, Durban 4000, South Africa

Contents lists available at ScienceDirect

Scientific African

journal homepage:

Evaluation of the antidiabetic, antiobesity and antioxidant potential of *Anthophycus longifolius* ((Turner) Kützing)

S'thandiwe N. Magwaza [a], Ochuko L. Erukainure [a,b], Kolawole Olofinsan [c], Balaji Meriga [d], Md. Shahidul Islam [a],

[a] Department of Biochemistry, School of Life Sciences, University of KwaZulu-Natal, Westville Campus, Durban 4000, South Africa
[b] Department of Microbiology, School of Life Sciences, University of KwaZulu-Natal, Westville Campus, Durban 4000, South Africa
[c] Department of Pharmacology, University of the Free State, Bloemfontein 9300, South Africa
[d] Department of Biochemistry, Sri Venkateswara University, Tirupati, Andra Pradesh, India

ARTICLE INFO

Editor: DR B Gyampoh

Keywords:
Amylase
Diabetes
Glucosidase
Obesity
Oxidative stress
Pancreatic lipase

ABSTRACT

Obesity is a major public health problem that is associated with many metabolic disorders including diabetes, hypertension, and cardiovascular diseases. *Anthophycus longifolius* is a brown seaweed that have been shown to possess antioxidant, antibacterial and anti-inflammatory activities. The present study investigated the anti-diabetic, anti-obesity and oxidative stress ameliorating properties of cold water (CW) and ethanolic (EtOH) extracts of *A. longifolius* using *in vitro* and *ex vivo* experimental models. The extracts significantly inhibited the activities of carbohydrate and lipid digestive enzymes α - glucosidase (IC_{50} = CW: 176.9±2.1 μg/ml; EtOH: 179.8 ±1.9 μg/ml); α-amylase (IC_{50} = CW: 86.1±1.7 μg/ml; EtOH: 77.8±1.9 μg/ml); and pancreatic lipase (IC_{50} = CW: 184.3±1.7 μg/ml; EtOH: 534.1±2.3 μg/ml), and stimulated adipose glucose uptake (CW: 10- 50.5 mg/g adipose tissue; EtOH: 9 - 79 mg/g adipose tissue). Incubation of adipose tissues with $FeSO_4$ significantly depleted reduced glutathione (GSH) level, super oxide dismutase (SOD) and catalase activities, while concomitantly elevated malondialdehyde (MDA) level. These changes were significantly reversed following the treatment of *A. longifolius* extracts. Liquid chromatography-mass spectrometry (LC-MS) analysis of the extracts revealed the presence of rhodomycinone, salsolinol, 5-hydroxyconiferyl alcohol, 2-caffeoylisocitrate and demethylangiside in the cold water extract, while petromyzonol 24-sulfate, atractyloside, abyssinone VI and podecdysone B in the ethanolic extract. Molecular docking analysis revealed potent interactions of the phytochemicals with GLUT4 and leptin. These results indicate the possible antidiabetic, antiobesity and oxidative stress ameliorating potentials of *A. longifolius* extracts at *in vitro* and *ex vivo* experimental models. The identified compounds may be responsible for the observed biological activities.

List of abbreviations

6- HD	6-hydroxydopamine
DFFE	Department of forestry fisheries and environment

* Corresponding author.
E-mail address: islamd@ukzn.ac.za (Md.S. Islam).

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Available online 24 December 2023
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3 Biotech (2024) 14:16
https://doi.org/10.1007/s13205-023-03847-x

ORIGINAL ARTICLE

Thymoquinone mitigates obesity and diabetic parameters through regulation of major adipokines, key lipid metabolizing enzymes and AMPK/p-AMPK in diet-induced obese rats

Keerthi Ramineedu[1] · Karunakaran Reddy Sankaran[1] · Venkataswamy Mallepogu[1] · Devi Prasad Rendedula[2] · Ramesh Gunturu[2] · Sreedevi Gandham[3] · Shahidul Islam Md[4] · Balaji Meriga[1]

Received: 16 September 2023 / Accepted: 2 November 2023
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Abstract
The present study was designed to evaluate the anti-obesity and anti-hyperglycemic activity of Thymoquinone (ThyQ) isolated from *Nigella sativa* seeds. Male Wistar rats were randomly divided into five groups and fed either normal pellet diet or high-fat diet (HFD) for 18 weeks and water *ad-libitum*. Group I: normal pellet diet (NPD)-fed, Group II: high-fat diet (HFD)-fed, Group III: HFD-fed-ThyQ (20 mg)-treated, Group IV: HFD-fed-ThyQ (40 mg)-treated and Group V: HFD-fed-Orlistat (5 mg)-treated group. Intervention with ThyQ started from 12th week onwards to HFD-fed rats of group III and IV. ThyQ administration significantly ($p < 0.01$) mitigated body weight gain, blood glucose, insulin level, serum and liver lipids (except HDL) and improved glucose tolerance and insulin sensitivity as evaluated by oral glucose tolerance test (OGTT), homeostasis model assessment—insulin resistance (HOMA-IR) and insulin tolerance test (ITT). Furthermore, ThyQ significantly ($p < 0.01$) diminished serum aspartate transaminase (AST), alanine transaminase (ALT), acetyl-CoA carboxylase (ACC), plasma leptin, resistin and visfatin levels but enhanced lipoprotein lipase (LPL) and adiponectin levels. RT-PCR analysis demonstrated down-regulated mRNA expression of sterol regulatory element-binding proteins-1c (SREBP-1c), CCAAT/enhancer-binding protein—α (C/EBP-α) and fatty acid synthase (FAS) but upregulation of Insulin receptor substrate-1 (IRS-1).Western blot analysis displayed phosphorylation of adenosine monophosphate activated protein kinase (AMPK) in ThyQ-treated rats. Liver microtome sections of HFD-fed rats showed degenerated hepatocytes with high lipid stores while that of adipose tissue sections displayed large, fat-laden adipocytes, however, these histological changes were considerably attenuated in ThyQ-treated groups. Together these findings demonstrate that ThyQ can be a valuable therapeutic compound to potentially alleviate diet-induced obesity, hyperglycemia and insulin resistance.

Keywords Adipokines · Glycemic-lipid profile · *Nigella sativa* · Obesity rats · Thymoquinone

Abbreviations

AMPK	Adenosine monophosphate activated protein kinase
ACC	Acetyl-CoA carboxylase
AST	Aspartate transaminase
ALT	Alanine transaminase
CVDs	Cardiovascular diseases
FAS	Fatty acid synthase
HFD	High-fat diet
HOMA-IR	Homeostasis model assessment-insulin resistance
ITT	Insulin tolerance test
IRS-1	Insulin receptor substrate-1
LPL	Lipoprotein lipase
OGTT	Oral glucose tolerance test
SREBP-1c	Sterol regulatory element-binding proteins-1c
ThyQ	Thymoquinone

Introduction

In recent times, obesity has gained unprecedented global importance owing to its central role in inducing hypertension, type-2 diabetes, cardiovascular diseases (CVDs) and certain cancers (Leggio et al. 2017). According to World Health Organization (WHO), 650 million adults, 340 million

Keerthi Ramineedu, Karunakaran Reddy Sankaran have equally contributed to this work.

Extended author information available on the last page of the article

Published online: 18 December 2023

DOI: 10.26599/FSHW.2023.9250012

Contents lists available at SciOpen

Food Science and Human Wellness

journal homepage: https://www.sciopen.com/journal/2097-0765

Astragalin and rutin restore gut microbiota dysbiosis, alleviate obesity and insulin resistance in high-fat diet-fed C57BL/6J mice

Muni Swamy Ganjayi [a], Karunakaran Reddy Sankaran [a], Balaji Meriga [a*], Ruchika Bhatia [b], Shikha Sharma [b], Kanthi Kiran Kondepudi [b]

[a] Department of Biochemistry, Sri Venkateswara University, Tirupati-517502, A.P., India.

[b] Food and Nutrition Biotechnology Division, National Agri-Food Biotechnology Institute, S.A.S. Nagar, Punjab-140306, India.

ABSTRACT: In the present study we investigated the impact of the Combination of Astragalin and Rutin (CAR) on restoring gut-microbial dysbiosis and obesity and obesity related disorders. Randomized male C57BL/6J mice were experimentally divided into five groups and fed either a normal diet or a high-fat diet (HFD) for 16 weeks. Compared to vehicle treated group (HFD group), CAR could substantially improve selected gut microbiota abundance (*Akkermansia, Lactobacillus, Bifidobacteria, muciniphila, Roseburia*), reversed the Firmicutes/Bacteroidetes proportions, and inhibited the growth of *Escherichia coli*, *Salmonella*, and *Klebsiella* in obese mice. In addition, CAR-treated mice showed significantly ($P < 0.05$) increased total short-chain fatty acid production, reduced body weight gain, organs' weights, serum lipid profile (except HDL) and insulin resistance. The mRNA expressions of CCAAT/enhancer binding protein-α (C/EBP-α), sterol regulatory element-binding protein-1c (SREBP-1c), peroxisome proliferator-activated receptor-γ (PPAR-γ), acetyl-CoA carboxylase (ACC), adipocyte protein 2 (aP2), and fatty acid synthase (FAS) were downregulated ($P < 0.05$) and the protein expression of PPAR-γ was downregulated while AMPK was phosphorylated in CAR-treated HFD-fed mice compared to the HFD control group. Interestingly, CAR-treated HFD-fed mice showed significantly improved tissue architecture in the liver and fatty tissues. In conclusion, the findings suggest that CAR/*Moringa oleifera* may be beneficial in the treatment of insulin resistance and obesity disorders.

Keywords: astragalin, gut microbiota, *Moringa oleifera*, obesity, rutin.

1. Introduction

The obesity epidemic and associated disorders including non-alcoholic fatty liver disease, type-2 diabetes and cardiovascular diseases (CVDs) are major public health challenges. Poor diet, sedentary lifestyles, increased urbanization and psychosocial stress are factors contributing to the high rates of obesity [1,2]. However, these factors are often difficult to overcome and therefore obesity continues to be a major health concern. Therefore, exploring effective therapeutics to treat obesity and associated disorders has immense potential [3,4]. Weight management drugs currently approved by Food and Drug Administration

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Received 1 May 2022
Received in revised from 9 July 2022
Accepted 7 October 2022

SRI VENKATESWARA UNIVERSITY:: TIRUPATI
INTERNAL QUALITY ASSURANCE CELL
Feedback on Teacher's Performance from the Final Semester Students for the year 2023-2024

Name of the Faculty : DR M. BALAJI
Designation : Professor
Department : Bio-Chemistry
College : S V U College of Sciences

Number of Respondents : 11

S No	ASPECT	SCORE
1	Knowledge base of the Teacher (as perceived by you)	3.97
2	Communication skills (in terms of articulations and comprehensibility)	3.97
3	Sincerity / Commitment of the teacher	3.97
4	Interest generated by the teacher	3.97
5	Ability to integrate course material with environment / other issues, to provide a broader perspective	3.93
6	Ability to integrate content with other courses	3.97
7	Accessibility of the teacher in and out of the class (includes availability of the teacher to motivate further study and discussion outside class)	3.97
8	Ability to design Quizzes / Tests / Assignments / Examinations and Projects to evaluate students understanding of the course	3.97
9	Provision of sufficient time for feedback	3.97
10	Overall rating	3.97
Aggregate score of the teacher (over the first 9 aspects)		3.97
Rating		**Very Good**

Note: 3.01 – 4.0 Very Good, 2.01 – 3.0 Good, 1.51 – 2.00 Satisfactory , <= 1.5 Unsatisfactory

Director, IQAC

INDIAN COUNCIL OF MEDICAL RESEARCH

ANSARI NAGAR, POST BOX NO. 4911
NEW DELHI-110029

Dated: 17.11.2022

No. Adhoc/210/2022-SBHSR

Subject: Payment of 1st year grant-in-aid for the Ad-hoc research scheme Project entitled "A **study on life style based risk assessment to develop obesity disorders among adolescent school children of selected Govt. schools (fed on midday meal scheme) and Private schools (Non-midday meal) of Tirupati region"** under Dr. Balaji Meriga, Department of Biochemistry, Sri Venkateswara University, Tirupati-517502, Andhra Pradesh.

MEMORANDUM:

The Director General, ICMR sanctions the payment of Rs. 14,57,520/- (Rupees Fourteen lakh Fifty Seven Thousand Five Hundred Twenty Only) as the installment of the grant incurring expenditure in connection with the above mentioned research scheme/project. The amount of Rs. 14,57,520/- may be debited, in the provision of Rs. 14,57,520/- made for the above mentioned research scheme project for the current financial year 2022-23.

A formal bill for Rs. 14,57,520/- is sent herewith for payment by bank transfer to The Registrar, **Sri Venkateswara University, Tirupati-517502** payable at **Tirupati- (A.P)**

RFC No.(P-5)SBHSR/Ad-hoc/8/2022-23, dated: 16/11/2022

Administrative Officer
For Director General

Accounts Section-V, ICMR

1. The Registrar, **Sri Venkateswara University, Tirupati-517502, Andhra Pradesh.** Bank transfer for the amount of Rs. 14,57,520/- 1st year will be sent to you in due course. The grant has been sanctioned on the condition laid down in our letter referred to above.
2. IRIS Cell:-2021-10539.
3. Dr Balaji Meriga, Department of Biochemistry, Sri Venkateswara University, Tirupati-517502, Andhra Pradesh.
4. Finance section **RFC No.(P-5)SBHSR/Ad-hoc/8/2022-23, dated: 16/11/2022**

E-32946
TPN No. / 38639

DST/INT/South Africa/P-01/2021
Government of India
Ministry of Science and Technology
Department of Science & Technology
(International Bilateral Cooperation Division)

Technology Bhavan, New Mehraulli Road
New Delhi-110016
Date: 23/11/2021

ORDER

Subject: Implementation of Indo-South Africa Joint project entitled: "**Investigation of cellular and molecular mechanisms involved in conversion of white adipose tissue to brown adipose tissue, as a therapeutic target to alleviate obesity, using selected marine algae**" coordinated by Indian PI: **Dr. Balaji meriga,** Sri Venkateswara University, Tirupati-**517502** in collaboration with South African PI: **Prof. Md. Shahidul Islam**, University of KwaZulu-Natal (Westville Campus), Durban 4000, South Africa.

Sanction of the President is hereby accorded for incurring an expenditure not exceeding **Rs.40,56,564/- (Rupees Forty Lakh Fifty Six Thousand Five Hundred Sixty Four** only) for implementation of the Indo- South Africa joint project entitled "**Investigation of cellular and molecular mechanisms involved in conversion of white adipose tissue to brown adipose tissue, as a therapeutic target to alleviate obesity, using selected marine algae**" coordinated by Indian PI "**Dr. Balaji meriga,** Sri Venkateswara University, Tirupati-**517502** in collaboration with **Prof. Md. Shahidul Islam**, University of KwaZulu-Natal (Westville Campus), Durban 4000, South Africa for a total duration of 3 years from the date of issue of the sanction order.

2. As per the terms and conditions, agreed by both side, under the project the sending side will bear the cost related to the International air travel, medical insurance and visa charges whereas the receiving side shall bear the cost of accommodation, hospitality and local travels of the visiting scientist. The break-up of approved expenditure is as indicated below:

Headings	1st year (Initial Release)	1st year release (later 6 months)	2nd year	3rd year	Total
Visits by Indian Scientist to South Africa	Nil	Rs.3,80,300/- 1 short visit 1 long visit	Rs.3,80,300/- 1 short visit 1 long visit	Rs.3,80,300/ -1 short visit 1 long visit	Rs.**11,40,900/-** **6 visits**
Manpower :SRF-1 position) @Rs.35,000 + HRA (8%)	Rs.4,53,600/-		Rs.4,53,600/-	Rs.4,53,600/-	Rs.**13,60,800/-**

CAR

Date 14/12/13

No. 137

INDIAN SOCIETY OF AGRICULTURAL BIOCHEMISTS

(Registered Under Act XXI of 1860)
Department of Agricultural Biochemistry
C.S. Azad University of Agriculture & Technology, Kanpur-208 002

Received with thanks from Dr./Shri BALAJI MERIGA, DEPT. OF BIOCHEMISTRY, SRI VENKATESWARA UNIVERSITY, TIRUPATI a sum of Rs./US$ THREE THOUSAND ONLY on account of life membership / membership fee of the Society for the year 2013

Rs./US$ 3000/2

Hony. Gen. Secretary / Treasurer

SRI VENKATESWARA UNIVERSITY:TIRUPATI

S.V.U. College of Sciences

Teacher of Excellence Award

This Certificate is presented to

Dr. M. Balaji

For Extraordinary Service and dedication to your Teaching Profession

Date 26/02/2023

Principal

भारतीय विज्ञान कांग्रेस संस्था

14, डॉ० बिरेश गुहा स्ट्रीट, कोलकाता - 700 017, भारत

THE INDIAN SCIENCE CONGRESS ASSOCIATION

14, Dr. Biresh Guha Street, Kolkata - 700 017, INDIA

ई मेल E-mail : Sec : New Biol.(includ Biochem., Biophys. & Mol. Biol. & Biotech.)

आजीवन सदस्य LIFE MEMBER'S Membership No. : L31352

नाम / NAME : Dr. Balaji Meriga

पता / ADDRESS : Assistant Professor

वर्तमान संबंधन / PRESENT AFFI : Department of Biochemistry

हस्ताक्षर / SIGNA : College of Sciences

जारी करने का दि : S. V. University

Tirupati 517502

ANDHRA PRADESH

28 NOV 2016

प्रो० गंगाधर / Prof. Gangadhar
महासचिव / General Secretary
सदस्यता कार्य / Membership Affairs

SOCIETY OF BIOLOGICAL CHEMISTS (INDIA)

Phone: 080-23601412; E-mail: bcindia@...

Life Membership No. 1900

Dr. BALAJI M
DEPT. OF BIOCHEMISTRY
SRI VENKATESWARA UNIVERSITY
TIRUPATI 517 502

Please quote the above Number in all correspondence with the society. Intimate change of address if any.

ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
Regional Agricultural Research Station, Tirupati-517 502, Andhra Pradesh
RKVY-RAFTAAR ABI SCHEME
Ministry of Agriculture and Farmers Welfare Supported and Funded Project
ANGRAU-Agri Innovations and Entrepreneurship Development Foundation
"ANGRAU Agri-Business Incubator"

"ANGRAU-ABI, AGRI VISION 1.0 – 2024"
Nurturing The Future Harvest

CERTIFICATE
OF PARTICIPATION

This is to certify that

Dr. M. Balaji

has successfully participated in the Agri-Stakeholders Meetup, "AGRI VISION 1.0 - 2024" on 22.03.2024 organized by ANGRAU Agri-Business Incubator, Regional Agricultural Research Station, Tirupati of Acharya N.G. Ranga Agricultural University, Andhra Pradesh.

Associate Director of Research
RARS, TIRUPATI

Principal Investigator & Chief Executive Officer
ANGRAU AGRI-BUSINESS INCUBATOR

Scanned by Scanner

Project on

"Phytochemical Screening, Antioxidant and Invitro Enzyme Inhibitory Activity of a Marine Alga, *Sargassum linearifolium*"

Submitted to

SRI VENKATESWARA UNIVERSITY

In partial fulfillment for the award of degree in

MASTER OF SCIENCE IN BIOCHEMISTRY

By

A. Sumanth Karan
(Regd. No: 20423062002)

Under the esteemed guidance of

Prof. M. Balaji

DEPARTMENT OF BIOCHEMISTRY
SRI VENKATESHWARA UNIVERSITY
TIRUPATI–517502, INDIA

July-2024

Project on

"PHYTOCHEMICAL SCREENING, ANTIOXIDANT AND INVITRO ENZYME INHIBITORY ACTIVITY OF A MARINE ALGA, ULVA LACTUCA"

Submitted to

SRI VENKATESWARA UNIVERSITY

In partial fulfillment for the award of degree in

MASTER OF SCIENCE IN BIOCHEMISTRY

By

M. Maruthi Rami Reddy
(Regd. No: 20423062018)

Under the esteemed guidance of

Prof. M. Balaji

DEPARTMENT OF BIOCHEMISTRY
SRI VENKATESHWARA UNIVERSITY
TIRUPATI–517502, INDIA

July-2024

SAR

TIRUPATI DISTRICT POLICE

POLICE COMMEMORATION DAY - 2023

CERTIFICATE

Of

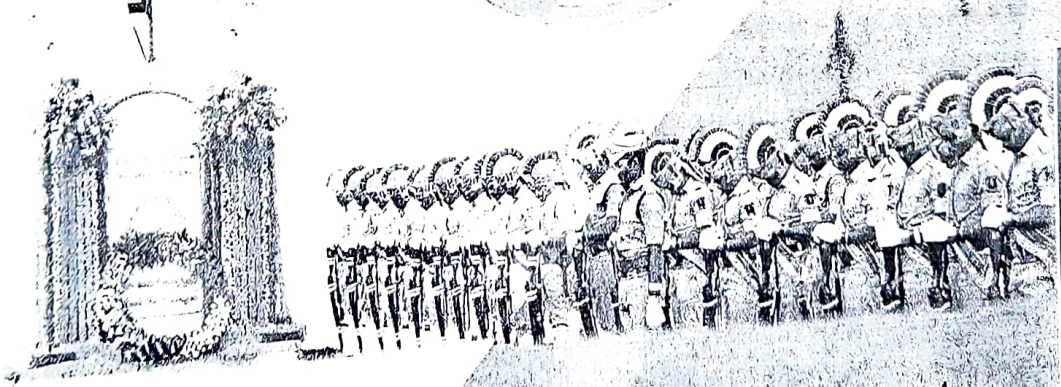
APPRECIATION

This is to place on record the generosity

Sri/Smt. M. Balaji .....

Participated in the blood donation camp held at Rahul Convention hall Tiruchanur Tirupati on the occation of Police Commemoration Day, 21st October, 2023.

Wishing you lots of success and happiness in your career. All the Best.



Sri P. PARAMESWAR REDDY, I.P.S.,
Superintendent of Police
Tirupati Dist.

28.10.2023

DATE

सत्यमेव जयते
Government of India

MALAVIYA MISSION
TEACHER
TRAINING PROGRAMME

ज्ञान-विज्ञान विमुक्तये
University Grants Commission

CERTIFICATE OF PARTICIPATION

NEP 2020 ORIENTATION & SENSITIZATION PROGRAMME

This is to certify that Dr. M. Balaji, Associate Professor, Dept. of Bio-Chemistry, Sri Venkateswara University, Tirupati. has completed the NEP 2020 Orientation & Sensitization Programme under Malaviya Mission Teacher Training Programme (MM-TTP) of University Grants Commission (UGC) Organized by UGC – MMTTC, Sri Venkateswara University, Tirupati from 21-11-2023 to 29-11-2023.

Director/Coordinator (MM-TTC)

National Conference & Millet Products Expo-2023
On
Millets: The Super Food for Sustainable Health and Wellness

Certificate

This is to certify that Dr. M. Balaji Associate Professor Biochemistry has participated in the National Conference & Millet Products Expo-2023 on '**Millets: The Super Food for Sustainable Health and Wellness**' jointly organised by Food Technology & Food Science Nutrition and Dietetics, Department of Home Science, Sri Venkateswara University, Tirupati and Council for Promotion, Research & Trade in Traditional Foods (CPRTTF), New Delhi on 21, September, 2023.

CONVENOR

INTERNATIONAL YEAR OF MILLETS 2023

PRESIDENT

National Seminar on

ADVANCES IN BIOCHEMISTRY

Organized by

Department of Biochemistry, SVU College of Sciences

Sri Venkateswara University, Tirupati (A.P)

Certificate

This is to certify that Dr./Mr./Ms./Mrs Dr. M. BALAJI

has participated in the National Seminar of **"Advances in Biochemistry"** *held on 28th July 2023 at Department of Biochemistry, Sri Venkateswara University, Tirupati.*

~~*He / She*~~ *also chaired a session / delivered a special lecture.*

O. V. S. Reddy

Prof. O. V. S. Reddy

Organizing Secretary, Advances in Biochemistry

Department of Biochemistry

Sri Venkateswara University, Tirupati.

SRI VENKATESWARA UNIVERSITY: TIRUPATI

No.E.II(5)/SVUCHRS/2019 Date: 04.06.2019

PROCEEDINGS OF THE VICE-CHANCELLOR

Sub: SV University – Teaching Establishment - SVU Colleges Hostel for Research Scholars - Appointment of Warden - Orders - Issued.

Read: 1. Proceedings of the Vice-Chancellor No.E.II(5)/ R S Hostel-/2012, dated 19.08.2012.
2. Proceedings of the Vice-Chancellor No.E.II(1)/ CVR/2019, Date 23.02.2019.
3. Vice-Chancellor's Orders dated 03.06.2019.

* * *

ORDER:

Dr. M.Balaji, Assistant Professor, Dept. of Bio-Chemistry, SVU College of Sciences, Tirupati, is appointed as Warden for **SVU Colleges Hostel for Research Scholars**, Tirupati, with immediate effect until further orders, in place of Prof. C.Venkata Rao, Warden, SVU Colleges Hostel for Research Scholars, Tirupati, who was appointed as Director, Dr. A.P.J.Kalam, IIIT, Ongole, on Deputation.

He is allowed to draw an allowance of ₹350/- p.m. for discharging the duties as Warden, by meeting the expenditure from "SVU Development Fund A/c", and he is required to send the compliance report of the taking over charge.

(BY ORDER)

Sd./- P.SREEDHARA REDDY
IN-CHARGE REGISTRAR

To

Dr. M. Balaji,
Assistant Professor,
Dept. of Bio-Chemistry,
SVU College of Sciences, Tirupati

Through :
The Chief Warden
SVU Colleges Hostel for
Research Scholars,
Tirupati.

Copy to Chief Warden, SVU Colleges Hostels for Research Scholars, Tirupati.
Copy to the Head, Department of Bio-Chemistry, SVU College of Sciences, Tirupati.
Copy to the Finance Officer, SVUniversity, Tirupati.
Copy to the Deputy Registrar (Finance), SVU Office, Tirupati.
Copy to A-I, A.VI Section (Development Fund A/c), Finance & Accounts Branch, SVU Office, Tirupati.
Copy to the P.S. to Vice-Chancellor, /Registrar/ P.A to Rector, S.V.University, Tirupati.
Copy to File/ Master copy file/ S.R.Entry / Bill.

//t.c.f.b.o.//

ASSISTANT REGISTRAR
Administration (Teaching)

Scanned with OKEN Scanner

3.4.5
Prof. O.V.S. Reddy

JMBFS
Journal of Microbiology, Biotechnology and Food Sciences
International peer-reviewed scientific online journal
Published by Faculty of Biotechnology and Food Sciences

OPTIMIZATION OF CARBOXY METHYL CELLULASE PRODUCTION BY *CLADOSPORIUM* SP. WITH FOOD WASTE IN BAGASSE SOLID STATE FERMENTATION USING RESPONSE SURFACE METHODOLOGY

Rama Mohan Poludasu [1,2], Obulam Vijaya Sarathi Reddy[1], Piyarat Boonsawang [2], Vani Mathakala [3]*

Address(es):
[1] SV University, Department of Biochemitry, Tirupati, India-517502.
[2] Prince of Songkla University, Faculty of Agro-Industry, Biotechnology Program, Center of Excellence in Innovative Biotechnology for Sustainable Utilization of Bioresources, Hat Yai, Songkhla, Thailand, 90110.
[3] Sri Padmavati Mahila Visvavidyalayam (SPMVV), Department of Applied Microbiology, Tirupati, Andhra Pradesh 517502.

*Corresponding author: rammohanroyal@gmail.com

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ABSTRACT

Enzyme production costs should be reduced by using inexpensively available substrates. In this, we determine the effects of various medium components and food processing waste on *Cladosporium* sp. production of CMCase in SSF. Five factors were tested with a three-level Box-Wilson factorial, central composite design (CCD) to determine how they impacted *Cladosporium* sp. NCIM 901's ability to produce CMCase. For the model, the R^2 (coefficient of determination) value was 0.9349. Based on the process findings, the optimal medium for higher enzyme synthesis had wheat bran (4 g/L), $cacl_2$ (2 g/L), urea (7.5 g/L) and rice bran (8.76 g/L), with the medium's original pH at 5.5. The model's accuracy is confirmed by the experimental result of CMCase, which is 23.42 U/gds and equivalent to the expected yield of 22.31 U/gds. The accuracy of the current experimental design has been verified by experimental validation. The enzyme's properties indicated that its greatest activity occurred at pH 5.5 and that its ideal temperature was about 50 °C. The enzyme is more active toward CMC and less active toward filter paper. $CaCl_2$ and $MgCl_2$ increased the enzyme's activity. Enzymatic hydrolysis of waste-derived polysaccharides into simple sugars is necessary for the industrial manufacture of bioethanol. The efficacy of the produced *Cladosporium* sp. cellulase (CMCase) enzyme to saccharify pearl millet grass results shows that H_2SO_4 treated substrate gave more fermentable sugars compared to the untreated substrate. Results suggest that the indigenous produced-CMCase can be efficiently used for lignocellulosic biomass saccharification (55.40%) compared to the untreated sample (37.10%) in 48 h, which will eventually reduce the cost utilized for purchasing commercial enzymes.

Keywords: *Cladosporium* sp. NCIM 901, Sugarcane bagasse, Wheat and Rice bran, Solid State Fermentation, Central Composite Design, Carboxymethyl cellulase, Characterization, Pearl millet grass saccharification

INTRODUCTION

The abundant microorganisms in nature, especially fungi, play a vital role in agriculture by decomposing organic matter and managing waste. Researchers focus on newly discovered fungal species for their potential in producing essential cellulase enzymes crucial in industrial processes. Extensive research has focused on cellulases in biomass and waste conversion **(Naher *et al.*, 2021)**.

The production of cellulases from less expensive substrates is an effective way to reduce costs. Cellulases, involved in the hydrolysis of cellulose, generally exist in three different kinds. Endoglucanases (EG) attack the carbohydrate chain inside and selectively hydrolyse substituted soluble celluloses like carboxymethyl cellulose (CMC), yet, they are little efficient towards strongly structured crystalline cellulose, for example, Avicel or cotton fibers. Cellobiohydrolases (CBH) can break down crystalline cellulose and produce cellobiose, nevertheless, they have no impact on substituted celluloses. Short cello-oligosaccharides and cellobioses are generated by the enzyme and are hydrolyzed by β-glucosidases to glucose **(Jayasekara and Ratnayake, 2019)**.

For the generation of enzymes, solid-state fermentation (SSF) is an alternative to the more traditional submerged culturing method **(Lopez-Gomez and Venus, 2021)**. Higher output per bioreactor volume, reduced budget and area requirements, simpler apparatus and easy access to downstream processing are some positive aspects of SSF **(Srivastava *et al.*, 2020)**. The development of microbes is restricted by different factors. For microbial development and complex cellulolytic enzyme synthesis during SSF, working parameters including pH, temperature and moisture content are essential **(Farinas, 2018)**. The optimization of crucial factors that influence microbial development and product formation is also essential for an efficient scale-up plan. Optimization of several parameters is sometimes a difficult and time-consuming operation. Response surface methodology (RSM) can be used to assess the importance of a range of variables, mainly when there are complex relationships between the individual components **(Inger *et al.*, 2019)**. RSM based on design of experiments is a set of statistical and mathematical tool for designing experiments and optimizing the effect process variables. The BBD offers optimal results with few experimental runs when compared with other response surface methodology techniques **(Maran *et al.*, 2013)**. Many studies employed RSM design for the cellulase enzyme production **(Shajahan *et al.* 2017; Ahmad *et al.*, 2020)**.

Agro-industrial byproducts can be used in a variety of ways, including wheat straw, cassava waste, sugar beet pulp, maize cobs, wheat bran and apple pomace by using SSF for the stimulation of both cellulolytic and hemicellulolytic enzymes **(Sadh *et al.*, 2018)**. Wheat bran is a compositionally intricate material, comprising cellulose (40–50% of dry matter), hemicellulose (25–35% of dry matter), and lignin (15–20% of dry matter). It represents a valuable source for the production of platform molecules and bioethanol **(Celiktas *et al.*, 2014)**. An important benefit of utilizing wheat bran is that it inherently contains sufficient nutrients, obviating the need for additional carbon and nitrogen sources **(Katileviciute *et al.*, 2019)**. Rice bran constituents vary due to the various processing techniques and machinery utilized, but it typically makes up 5–5% (by weight) of regular rice. Oil normally makes up 14–24% of rice bran, whereas protein is 16–18%, carbohydrate is 33–35% (about 20% crude fiber), water is 7–14% and ash is 8–12%. Additionally, it is abundant in protein, vitamins B and E and other minerals **(Satter *et al.*, 2014)**. Rice bran, wheat bran, and wheat straw were used for cellulase and xylanase production **(Kumar *et al.*, 2016; Devi *et al.*, 2022)**.

The key issue for commercial use is the endoglucanase used in different biotechnological applications, also the high price of manufacture and little titers of this enzyme. As a result, studies on how to enhance the enzyme productivity and the capability of microbial strains to utilise cheap substrate have been conducted. In the current study, an effort was made to improve the medium conditions to increase the enzyme production. The utilization of bagasse, rice bran and wheat bran as the fermentation substrate during SSF while using *Cladosporium* sp. NCIM 901 for CMCase has not received much investigation. Wheat and rice bran are byproducts from the processing of wheat and rice. They have the potential to be utilized as substrates for industrial fermentation since they are commonly obtainable.

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JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Comprehensive review on Next Generation Sequencing methodology and its applications

Deepthi V*, Ramya G.N.V.S, Nandini P and Reddy O.V.S.
Department of Biochemistry, Sri Venkateswara University, Tirupati – 517 502, India

Abstract: The main output of the next generation sequencing is determination of sequence data of DNA or RNA in a vast amount. This sequencing is represented as a series of bases of nucleotides-Adenine, Thymine, Cytosine, Guanine for DNA and Adenine, Uracil, Guanine, Cytosine for RNA. This provides the genetic code of sample which is being sequenced. The first-generation sequencing such as Sanger sequencing analysis which is a time-consuming method when compared with second generation sequencing known as NGS. It may take time from few hours to some days but NGS complete the data sequence of DNA or RNA with in a single day (1). NGS also known as High-Throughput Sequencing (HTS), Massively Parallel Sequencing (MPS), Second generation sequencing etc. This review reflects the importance of NGS methodology and its applications in a simple manner. NGS, a revolutionary advancement over the first-generation Sanger sequencing, enables rapid and comprehensive sequencing of DNA and RNA. NGS deciphers the genetic code of samples with unprecedented speed and efficiency. This review underscores the significance of NGS technology and explores its wide-ranging applications, highlighting its transformative impact on genomic research and diagnostics.

Keywords: NGS methodology, Applications, Advantages and Disadvantages.

Introduction

In the early 21st century the ground breaking technology was proposed which plays a significant role in DNA sequencing known as Next Generation Sequencing (NGS).The introduction of first DNA sequencing method took longer time (25 years) after the discovery of DNA structure by Watson and Crick in the year of 1953 (2, 3). There is a difference between NGS method and Sanger sequencing method. In case of NGS: provides massively parallel analysis, high-throughput from multiple samples at reduced cost (4). Whereas Sanger sequencing method is used to sequence both tiny as well as larger size genomes from bacteria to humans (5).

There are many applications of NGS in the development of Biotechnology, Bioinformatics and molecular biology. Also used in clinical laboratories including DNA testing, typing of Human Leucocyte Antigen (HLA), for the analysis of microbes and gene expression. For the testing of identity by using of short tandem repeats (STRs). At current the most clinically available earliest development is NGS of circulating tumor DNA (ctDNA). Advanced blood group typing like - TypeA1 versus Type A2 (6). This review mainly focuses on methodology of next generation sequencing and its applications and briefly reflects about advantages, and disadvantages. The impact of NGS extends to clinical settings, where it is increasingly used for diagnostic purposes, personalized medicine, and cancer genomics. The ability to rapidly and accurately identify genetic mutations associated with diseases has opened new avenues for treatment and management, highlighting the critical role of NGS in modern healthcare. Despite its remarkable advancements, NGS faces challenges such as data management complexities, the need for high computational power and interpretation of vast datasets. Ongoing improvements in sequencing technologies, bioinformatics tools and data analysis methods are essential to fully harness the potential of NGS. It has emerged as a groundbreaking technology that has revolutionized the field of genomics by providing rapid, accurate, and comprehensive sequencing capabilities. Unlike traditional Sanger sequencing, which sequences DNA one fragment at a time, NGS can sequence millions of fragments simultaneously. This parallel processing enables researchers to achieve a high throughput at significantly lower costs and shorter turnaround. NGS has profoundly impacted biological research and clinical diagnostics, providing deep insights into genetic and molecular mechanisms. As technologies continue to evolve, NGS is expected to become even more integral to personalized medicine, enabling more precise and effective healthcare solutions.

SAR Administrative position

Sri Venkateswara University

Prof. Ch. Appa Rao
I/c Vice-Chancellor

NAAC 'A' Grade

E-mail : vcsvutpt@gmail.com
vice-chancellor@svuniversity.edu.in
Website : www.svuniversity.edu.in
Phone : (O) 0877-2249727
Cell : +91 9441468789

Dated: 16.08.2024

To

The Special Secretary to the Government
in the Environment, Forests
Member Secretary
Science & Technology Department
Government of Andhra Pradesh

Sub:- Nomination of State Level Appraisal Committee Members – Reg.

****

In response to your letter under reference cited, I am to recommend the following faculty of Sri Venkateswara University, Tirupati as State Level Expert Appraisal Committee Members for making recommendations to State Level Environmental Impact Assessment Authority.

S.No.	Name of the faculty	Department	Mobile Number
1.	Prof. V. Padmavathi	Chemistry	9440079363
2.	Prof. M. Sri Murali	Civil Engineering	9848264604
3.	Prof. B. Sarath Babu	Chemical Engineering	9849568083
4.	Prof. T. Damodaram	Environmental Science	9290548816
5.	Prof. O. Vijaya Saradhi Reddy	Biochemistry	9440046293

Thanking You,

Yours sincerely

(Ch. APPA RAO)

SRI VENKATESWARA UNIVERSITY:: TIRUPATI

SAP Administrative position.

No. 13917-UGC-III(S) IBSC-DBT 2018 Dated: 24-08-2024

PROCEEDINGS OF THE IN-CHARGE VICE-CHANCELLOR

Sub: S.V. University – Development Branch – Constitution of Institutional Bio-safety Committees (IBSC s) – Orders – Issued.

Read: 1. Letter dated: 08-07-2024 from Prof. M. Hema, Member Secretary, IBSC - SVU, Dept., of Virology, S.V.U. College of Sciences, Tirupati.
2. Vice-Chancellor's order dated: 23-08-2024.

* * *

ORDER:

The Hon'ble Vice-Chancellor is pleased to constitute a Institutional Bio-safety Committee (IBSC) with the following members to monitor the institutional research activities and project proposals related to recombinant DNA technology (related to genetically modified organisms (GMOs) and infectious diseases) and it is mandatory to submit the IBSC certificate to the national funding agencies to get funding for the project proposals related to GMOs and infectious diseases, as per the guidelines issued by the DBT, Govt. of India from time to time.

1. Prof. O. Vijaya Sarathi Reddy,
Dept., of Biochemistry,
S.V.U. College of Sciences,
TIRUPATI : Chairman

2. Prof. K. V. Santha,
Dept., of Bio-Technology,
S.V.U. College of Sciences,
TIRUPATI : Member Secretary

3. Prof. H. Narendra,
Head,
Dept., of Surgical Oncology (SVIMS),
Tirupati. : Biosafety Officer

4. Prof. M. Hema,
Dept., of Virology,
S.V.U. College of Sciences,
TIRUPATI : Internal Member

5. Prof. M. Balan,
Dept., of Bio-Chemistry,
S.V.U. College of Sciences,
TIRUPATI : Internal Member

6. Dr. M. Charitha Devi,
Dept., of Virology,
S.V.U. College of Sciences,
TIRUPATI : External Member

7. Dr. Y. Amaravathi,
Dept., of Molecular Biology & Bio Technology,
S.V. Agricultural College,
Acharya NG Ranga University,
Tirupati : External Member

8. Prof. B. Kishori,
Dept., of Bio-Technology,
Sri Padmavati Mahila University,
Tirupati : External Member

SRI VENKATESWARA UNIVERSITY:: TIRUPATI

WORLD ENVIRONMENT DAY-2024

Jointly Organized by

DEPARTMENT OF ENVIRONMENTAL SCIENCES, S. V. UNIVERSITY, TIRUPATI

&

A.P. POLLUTION CONTROL BOARD, REGIONAL OFFICE, TIRUPATI

CERTIFICATE

This is to Certify that Prof/Dr/Sri/Kum. **Dr. O.V.S REDDY. PROFESSOR, DEPARTMENT OF BIOCHEMISTRY, SVU COLLEGE OF SCIENCES, S.V. UNIVERSITY, TIRUPATI** has delivered a lecture on **"Natural Resources Conservation"** on the eve of World Environment Day-2024 organized by the Department of Environmental Sciences, Sri Venkateswara University, Tirupati and A.P. Pollution Control Board, Regional Office, Tirupati on 5th June 2024.

Co-ordinator

Dr. T. DAMODHARAM
M.Sc, B.Ed., M.Phil., Ph.D
Professor & Head
Dept. of Environmental Science
Sri Venkateswara University
TIRUPATI-517502, A.P, India.

Prof. T. Damodharam
Head
Dept. of Environmental Sciences

SRI VENKATESWARA UNIVERSITY:TIRUPATI

S.V.U. College of Sciences

Teacher of Excellence Award

This Certificate is presented to

Prof. O.V.S. Reddy

For Extraordinary Service and dedication to your Teaching Profession

Date

Principal

SRI VENKATESWARA UNIVERSITY :: TIRUPATI

No.C-III (1)/608/Dean/F.O.PS/2023 Date: 22-11-2023

PROCEEDINGS OF THE VICE-CHANCELLOR

Sub:- S.V.University – Academic Branch – Deans of Faculties – Nomination of Dean, Faculty of Pharmaceutical Sciences– Orders – Issued.

Read:- Vice-Chancellor's orders dated: 21-11-2023.

@ @ @ @ @

ORDER:-

Consequent on completion of the tenure of ***Prof. S.D. Srinivasa Murthy,*** as Dean, Faculty of Pharmaceutical Sciences and in pursuance of the Statutes (4) of Chapter – VII of the Laws of the University "Faculties", dealing with nomination of "Dean of Faculty", ***Prof. O. Vijaya Sarathi Reddy,*** Department of Bio-Chemistry, S.V.U. College of Sciences, Tirupati, is appointed as ***Dean, Faculty of Pharmaceutical Sciences,*** with immediate effect, for a period of three years or till the date of his retirement, whichever is earlier.

The Dean, Faculty of Pharmaceutical Sciences appointed; is requested to accept the offer and communicate the contact details i.e., Residential Address, Phone Numbers and email ID, to the undersigned for further correspondence.

(BY ORDER)

Sd/- Prof. O.MAHAMMAD HUSSAIN
REGISTRAR

To

Prof. O. Vijaya Sarathi Reddy,
Department of Bio-Chemistry
S.V.U. College of Sciences
Tirupati

Through the Principal, S.V.U. College of Sciences, Tirupati.

Copy to the Prof. S.D. Srinivasa Murthy, Dept., of Bio-Chemistry, SVU College of Sciences, Tirupati, for information and with a request to handover the charge to Prof. O. Vijaya Sarathi Reddy, Dept., of Bio-Chemistry, SVU College of Sciences, Tirupati, immediately.
Copy to the Principal, S.V.U. College of Pharmaceutical Science, Tirupati, for information.
Copy to the Head, Dept., of Bio-Chemistry, S.V.U. College of Sciences, Tirupati, for information.
Copy to all Officers, S.V.University, Tirupati, for information.
Copy to the Supdt., C-I, C-II/B-VI, B-VII, B-XI/E-II Sections, S.V.U, Office, Tirupati, for information.
Copy to the Director I/c, Computer Centre, S.V. University, Tirupati, with a request to place it in University web-site.
Copy to the PS to Vice-Chancellor / PA to Rector/Registrar/Dean, CDC, S.V.U, for information.
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SRI VENKATESWARA UNIVERSITY:: TIRUPATI

WORLD EARTH DAY-2024

Jointly Organized by

DEPARTMENT OF ENVIRONMENTAL SCIENCES, S. V. UNIVERSITY, TIRUPATI

&

A.P. POLLUTION CONTROL BOARD, REGIONAL OFFICE, TIRUPATI

CERTIFICATE

This is to Certify that Prof/Dr/Sri/Kum. **Dr. O.V.S REDDY, PROFESSOR, DEPARTMENT OF BIOCHEMISTRY, SVU COLLEGE OF SCIENCES, S.V. UNIVERSITY, TIRUPATI** has delivered a lecture on "**Soil Pollution**" on the eve of World Earth Day-2024 organized by the Department of Environmental Sciences, Sri Venkateswara University, Tirupati and A.P. Pollution Control Board, Regional Office, Tirupati on 22nd April, 2024

Co-ordinator

Dr. T. DAMODHARAM
M.Sc., M.Phil., Ph.D.
Professor & Head
Dept. of Environmental Sciences
Sri Venkateswara University
TIRUPATI-517502, A.P. India

Prof. T. Damodharam
Head
Dept. of Environmental Sciences

SRI VENKATESWARA UNIVERSITY : TIRUPATI

No.E.II(7)/PRINCIPAL-SVUCPS/2024 Date: 1/ 10.2024

PROCEEDINGS OF THE IN-CHARGE VICE-CHANCELLOR
(PRESENT : PROF. CH. APPA RAO)

Sub: S.V. University - Teaching Establishment - Appointment of Principal, SVU College of Pharmaceutical Sciences - Orders - Issued.

Read: 1. Proc. of the Vice-Chancellor No.E.II-(7)/Principal-SVUPC-Sch/2019, dated 31.10.2019
2. In-Charge Vice-Chancellor's Orders dated 31.08.2024

.....

ORDER:

Prof. O. Vijaya Sarathi Reddy, Department of Bio-Chemistry, S.V.U. College of Sciences, Tirupati, Dean, Faculty of Pharmaceutical Sciences, is appointed as ***In-Charge Principal of S.V.U. College of Pharmaceutical Sciences***, Tirupati with immediate effect till a permanent Principal is appointed.

He shall take over charge of the In-Charge Principalship from Prof. Ch. Appa Rao and send a report of taking charge in the format prescribed for the purpose i.e. Certificate of Transfer of charge.

Prof. Ch. Appa Rao shall handover charge of In-Charge Principalship to Prof. O. Vijaya Sarathi Reddy immediately.

Whenever, the In-Charge Principal goes on leave or on other duty, the Principal, S.V.U. College of Sciences will act as Principal In-Charge.

(BY ORDER)

REGISTRAR

To

Prof. O. Vijaya Sarathi Reddy,
Department of Biochemistry,
SVU College of Sciences,
Tirupati.

Prof. Ch. Appa Rao,
Department of Biochemistry,
SVU College of Sciences,
Tirupati.

Copy to the Principal, S.V.U. College of Sciences, Tirupati with a request to make an entry in the Service Registers of teachers.
Copy to the Principal, SVU College of Arts / Commerce, Management & Comp. Science / Engineering, Tirupati.
Copy to all the Heads of Institutions of S.V.University, for information.
Copy to the Head, Dept. of Bio-Chemistry, SVU College of Sciences, Tirupati.
Copy to the Finance Officer, S.V. University, Tirupati.

SAR Administrative

SRI VENKATESWARA UNIVERSITY : : TIRUPATI

(visit us: WWW.SVUniversity.ac.in)

Telephone No: 91-877-2289429
Fax: 91-877-2289549

No.C-II(c)/ BOS in Pharmacy (Combined)/2022

Date : 20-10-2022

From

THE REGISTRAR
S.V.UNIVERSITY
TIRUPATI

To

Prof.O.Vijayasaradhi Reddy
Department of Bio-chemistry
SVU College of Sciences,
Tirupati

Sir,

Sub: S.V.University – Academic Branch – Re-constitution of Board of Studies in Pharmacy (Combined) – Appointment of Chairman – Regarding.

Ref: Orders of the Vice-Chancellor dated: 14-10-2022.

******

I am by direction to inform you that the Vice-Chancellor is pleased to appoint you as Chairman of the Board of Studies in Pharmacy (Combined) of the University, subject to the provisions as contained in the amended Chapter VIII: "BOARD OF STUDIES" of the Laws of the University. You will hold the Office for re-constitution of three years term of the board w.e.f. **14-10-2022** to **13-10-2025** or till the date of your retirement whichever is earlier.

In this connection, I am also to inform you that as per the Ordinance 4 of Chapter VIII of the Laws of the University. "A Member appointed in his capacity as a teacher in any of the University or Affiliated College, shall ceases to be a Member of the Board of Studies concerned from the date when he ceases to be a teacher in any such college or holder of any such Office or ceases to be a student.

A copy of the list of members of the Board of Studies is herewith enclosed for your kind information.

Please send a panel of Experts (not less than 10 members) to appoint as External Members of the above Board of Studies.

Kindly communicate your acceptance together with your official and residential addresses mobile no and mail ID at an early date for further correspondence.

Yours Sincerely,
Sd/-O.Mohammad Hussain
REGISTRAR

Copy to the Dean, Faculty of Sciences, S.V.U. College of Sciences, Tirupati for information.
Copy to the Principal, SVU College of Pharmaceutical Sciences, S.V.University, Tirupati, for information.
Copy to the Head, Department of Bio-chemistry, SVU College of Sciences, Tirupati, for information.
Copy to the Assistant Registrar(Administration-T), S.V.University, Tirupati for information.
Copy to the Controller of Examinations, S.V.University, Tirupati, for information.

SRI VENKATESWARA UNIVERSITY: TIRUPATI

No. D7 (3)/ Co-ord./MSc.Immuno/SSC/2022-2023. Date 10-08 -2022

PROCEEDINGS OF THE VICE-CHANCELLOR

Sub: SV University – Special cell – M.Sc. Immunotechnology, Self-Supporting Course, Department of Bio-Chemistry, SVU College of Sciences, Tirupati – Extention of Co-Ordinator – Orders - Issued.

Read 1. This office proceedings of even no dated :18-09-2021.
2. Letter No .Nil,dated:23-07-2022, received from the Head, Department of Bio- Chemistry, SVU College of Sciences, Tirupati, along with the DDC resolution dated:23-07-2022, through proper channel.
3. Vice-Chancellor's Orders dated: 03-08-2022.

* * *

ORDER:

Prof. O.V.S.Reddy, Department of Bio-Chemistry, S V U College of Sciences, Tirupati, is **Contuinued** as **Co-Ordinator for M.Sc. Immunotechnology,** Self-Supporting Course, Department of Bio-Chemistry, SVU College of Sciences, Tirupati for a period of **one more year (Second year), ie., from 15-11-2022 to 14-11-2023** without any honorarium and without prejudice to his normal duties in the Department of Bio-Chemistry, S V U College of Sciences, Tirupati.

//BY ORDER//

Sd/-O.MAHAMMAD HUSSAIN
REGISTRAR

To
Prof. O.V.S Reddy,
Co-Ordinator for
M.Sc. Immunotechnology,(SSC),
Department of Bio-Chemistry,
S V U College of Sciences,
Tirupati,

Copy to the **Principal,** SVU College of Sciences, Tirupati, for information and necessary action.
Copy to the **Head,** Dept. of Bio-Chemistry, SVU College of Sciences, Tirupati for information
Copy to the **Joint Registrar,** Finance & Accounts Branch, S V U Office for information
Copy to PS/PA to the **Vice-Chancellor/ Rector/Registrar**, SVU Office for information
Copy to **File.**

// t.c.f.b.o.//

SRI VENKATESWARA UNIVERSITY : : TIRUPATI

No.C-II(c)/BOS/Bio-chemistry(Combined) /2023 Date : 22-07-2023

From

THE REGISTRAR
S.V.UNIVERSITY
TIRUPATI

To

Prof.O.Vijaya Saradhi Reddy
Department of Bio-chemistry
SVU College of Sciences,
Tirupati

Sir,

Sub: S.V.University – Academic Branch - Re-constitution of Board of Studies in Bio-chemistry (PG) – Appointment of Chairman – Regarding.

Ref: Orders of the Vice-Chancellor dated 07-07-2023.

******

I am, by direction, to inform you that the Vice-Chancellor is pleased to appoint you as Chairman of the Board of Studies in Bio-chemistry (Combined) of the University, subject to the provisions contained in the amended Chapter VIII: "BOARD OF STUDIES" of the Laws of the University. You wll hold the office for the above Board w.e.f. **20-07-2023** upto **19-07-2026.**

In this connection, I am also to inform you that as per the Ordinance 4 of Chapter VIII of the Laws of the University. "A Member appointed in his capacity as a teacher in any of the University or Affiliated College, shall ceases to be a Member of the Board of Studies concerned from the date when he ceases to be a teacher in any such college or holder of any such Office or ceases to be a student.

Please send a panel of Experts atleast to a minimum of 10 members to appoint two External Members of the Board of Studies.

Kindly communicate your acceptance together with your official and residential addresses mobile no and mail ID at an early date for further correspondence.

Yours faithfully,
Sd/-O.MOHAMMAD HUSSAIN
REGISTRAR

Copy to the Dean, Faculty of Sciences, S.V.U. College of Sciences, Tirupati for information.
Copy to the Principal, SVU College of Sciences, S.V.University, Tirupati, for information.
Copy to Head, Department of Bo-chemistry, SVU College of Sciences, Trupati for information.
Copy to the Assistant Registrar(Administration-T), S.V. University,Tirupati for information.
Copy to the Controller of Examinations, S.V.University, Tirupati, for information.
Copy to the Superintendent, E-II & B-VII, C-I Sections, S.V.University, Tirupati, for information.
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ACS Omega. 2023 May 5;8(19):16630-16646. doi: 10.1021/acsomega.2c07361
eCollection 2023 May 16.

Appraisal of Pancreatic Lipase Inhibitory Potential of *Ziziphus oenoplia (L.)Mill.* Leaves by *In Vitro* and *In Silico* Approaches

Srinivasa R Vulichi [1 2], Ashish Runthala [3], Siva K Rachamreddy [1], Radhika S P Yaramanedi [1], Partha Sarathi Sahoo [3], Prasad V L S Burra [3], Nameet Kaur [4], Sudheer Akkiraju [5], Somasekhar Reddy Kanala [5], Appa Rao Chippada [1 6], Sistla Durga Srinivasa Murthy [6]

Affiliations
PMID: 37214709 PMCID: PMC10193397 DOI: 10.1021/acsomega.2c07361

Abstract

Pancreatic lipase is one of the crucial lipolytic enzymes of the gut that actively facilitates the digestion and absorption of the dietary triglycerides and cholesteryl esters. Although it has been deemed as one of the most reliable targets for the treatment of obesity and/or dyslipidemia, to date, orlistat is the only known FDA-approved, effective, oral pancreatic lipase inhibitor available for clinical use apart from the centrally acting antiobesity agents. However, it is known to be associated with adverse gastrointestinal and renal complications. In this study, we attempted to assess the antioxidant and porcine pancreatic lipase inhibitory potentials of *Ziziphus oenoplia (L.)Mill.* leaves through a systematic combination of *in vitro* and *in silico* approaches. Among the four different extracts including petroleum ether extract, ethyl acetate extract, ethanolic extract, and aqueous extract obtained through successive solvent extraction, the ethyl acetate extract has outperformed the other extracts and orderly displayed competent peroxide scavenging (IC_{50} value: 267.30 μg/mL) and porcine pancreatic lipase inhibitory (IC_{50} value: 444.44 μg/mL) potentials compared to the selected reference compounds: ascorbic acid (IC_{50} value: 251.50 μg/mL) and orlistat (IC_{50} value: 502.51 μg/mL) in the selected in vitro assay models. In addition, based on the molecular docking simulations of the six essential phytoconstituents of the leaves of *Ziziphus oenoplia (L.)Mill.* and their respective chemical analogues against the crystal structure of pancreatic lipase-colipase complex (PDB ID: 1LPB), four best-ranked molecules (PubChem CIDs: 15515703, 132582306, 11260294, and 44440845) have been proposed. Further, among these, the interaction potentials of the two top-ranked molecules (PubChem CIDs: 132582306 and 15515703) were analyzed through molecular dynamics (MD) simulations at a trajectory of 100 ns. Finally, absorption, distribution, metabolism, excretion, and toxicity (ADMET) parameters were theoretically predicted for all of the molecules using Swiss ADME and ADMET lab2.0. In conclusion, *Ziziphus oenoplia (L.)Mill.* leaves could become a prominent source for various potent bioactive compounds that may serve as prospective leads for the development of clinically cognizable pancreatic lipase inhibitors, provided their pharmacokinetic and in particular toxicity properties are thoroughly optimized.

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Figures

High temperature induced alterations in plant photosynthetic electron transport processes in the thylakoid membranes of maize leaves under *in vitro* conditions

Divya,B.J. and Murthy,S.D.S.

Department of Biochemistry,S.V.University,Tirupati-517502,Andhra Pradesh .India.

Abstract

In this article an attempt has been made to analyze the effect of high temperature on primary events photosynthesis under *in vitro* conditions.In addition, it particularly alters photosystem II by causing inhibition in electron transport activity.In contrast it enhances the PS I activity due to the opening of new site before plastocyanin.It also induces lipid peroxidation in thylakoid membranes during temperature stress.

Keywords: Electron transport; High temperature; Maize plants ; Photosynthesis.

Introduction

Heat stress is often defined as where temperatures are hot enough for sufficient time that they cause irreversible damage to plant physiological functions and development. Due to this several plant physiological processes are getting affected by temperature and one of such processes is photosynthesis (Bauer,1979; Berry and Bjorkmann, 1980;Hussain *et al.*,2016;Posch *et al.*,2019;Bansal *et al.*,2021). In PS II, the main target for high temperature stress is oxygen evolving complex. As a result, there has been loss of Mn ions and extrinsic polypeptides of water oxidation complex (Nash *et al.*, 1985; Enami *et al.*, 1994;Tan *et al.*,2020). It is suggested that the membrane permeability increases during heat treatment, which results in a decrease in the proton gradient formation across the thylakoid membrane and a suppression of the linear electron flow. The inhibition in PS II catalyzed electron transport activity could be due to the migration of phosphorylated LHC II

ISSN : 0950-0707

Defense strategies under heavy metal stress in Plants

Divya,B.J.[1], Krishna,C[2]. and Murthy,S.D.S.*
Department of Biochemistry, S.V.University,Tirupati-517502,A.P.,India.
Corresponding author email: sdsmurthy@rediffmail.com

Abstract

Now a days environment is getting polluted due to accumulation of toxic contaminants like As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn etc. in the natural ecosystem due to anthropogenic activities like advancements in agriculture, industrialization and urbanization process. It has become a serious problem worldwide because heavy metals are noxious, persistent and non-biodegradable which adversely affect crop yields, soil biomass and soil fertility. Although some of these metals are essential micronutrients responsible for many regular processes in plants, their excess, however, can have detrimental effects and can directly influence the plant growth, metabolism, physiology and senescence. This study discusses the toxic effects caused by various metals and also overview the plants defense strategies to combat the heavy metal stress.

Keywords: Defense mechanism, Heavy metals stress, Oxidative stress, Responses of plan

ISSN : 0950-0707

Introduction

Heavy metal (HM) stress is one of the major abiotic stress which leads to alterations in living beings including plants. The term HM includes only the elements with specific gravity above 5 g cm^{-3} but frequently biologists use this term for a vast range of metals and metalloids which are toxic to plants such as Lead (Pb), Copper (Cu), Iron (Fe), Manganese (Mn), Nickel (Ni), Zinc (Zn), Cobalt (Co), Cadmium (Cd), Chromium (Cr), and Arsenic (As) etc. All heavy metals are non-biodegradable, that is, they cannot be purged out naturally from the environment via any possible natural means, although some of them are reported to be immobile, that is, they cannot move from the place where they are accumulated, while there are others that are termed as mobile, that is, they can be taken up by plants root system via diffusion, endocytosis or through metal transporters. Metals like (Arsenic, Mercury, Chromium, Cadmium, Lead etc.) are non-essential and potentially highly toxic even at lower concentrations. The rate of accumulation and plant's tolerance to heavy metals vary from species to species, with some becoming toxic at a faster rate. Some of the HMs, such as (Nickel, Copper, Zinc, Cobalt, Iron, Manganese and Molybdenum) at lower concentrations act as essential micronutrients that are critically involved in the functional activities of large number of proteins involved in sustaining growth and development of plants.

Defense strategy of plants against heavy metals stress

Heavy metal stress exerts multiple effects on several physiological processes like photosynthesis, water balance, and nutrient capture (Sharma and Dubey, 2005). However, some plant species can still survive, grow and reproduce in environment polluted with heavy metals (HMs), indicating that they developed various inherent and extrinsic defense mechanism for tolerance or detoxification whenever confronted with the stressful condition caused by the high concentrations of HMs. As a first step towards dealing with metal

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JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
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MERCURY INDUCED ALTERATIONS IN PHOTOSYSTEM-II PHOTOCHEMISTRY IN MAIZE PLANTS

[1]Srinivasulu P, [2]Divya B.J. and [3]Murthy S.D.S.

[1]Research Scholar, [2]Academic Consultant, [3]Professor

Department of Biochemistry, S.V.University, Tirupati, India.

Abstract:

Mercury is a toxic heavy metal and it inhibited PS-II catalysed electron transport activity in a dose dependent manner. 50% loss was noticed with the treatment of 15μM $HgCl_2$. Spectral measurements clearly indicated that there is an enhancement in F_o value due to changes in LHC-II complex of PS-II in maize leaves. There is a positive correlation between the loss of PS-II and Chl a fluorescence which clearly demonstrates that the inhibitory site lies near PS-II reaction centre of maize thylakoids.

Key words: Electron transport; Fluorescence; Mercury;Maize plants; Photosystem II.

INTRODUCTION:

Heavy metals like Zn, Cd, Ni, Cu, Hg, Co and Pb can inhibit photosynthetic electron transport at multiple sites (Van Assche and Cl ijsters, 1980; Cl ijsters and Van Assche, 1986; Mohanty *et al.*, 1989). Photosynthetic organisms showed reduction in PS II supported electron transport activities when they were grown *in vivo* in the presence of supra optimal level of heavy metals like Cd (Baszynski *et al.*, 1980), Zn (DeFilippis *et al.*,1981b). Majority of the observations on the effect of heavy metal ions on partial photochemical reactions are made in isolated systems *in vitro*. The PS II supported electron transport activity is more susceptible to heavy metals like Zn, Ni (Tripathy *et al*, 1981), Co (Tripathy *et al.*, 1983), Cu, Cd and Zn, Cd (Bazzaz and Govindjee, 1974a) Cu (Cedeno- Maldonado *et al.*, 1972; Shioi *et al.*, 1978a; Shioi *et al.*, 1978b; Samuel son and Oquist, 1980; Renganathan and Bose, 1989; Mohanty *et al.*, 1959al Co, Ni, and Zn (Mohanty *et al.*, I 989b) Pb (Bazzaz and Gov i nd j ee, 1974b) and Hg^{2+}(Honeycutt and Krogmann, 1972; Samson and Popovic, 1990). In addition to this it was also shown that this heavy metal ion induced inhibition is dependent on the illuminating intensity (Zn, Cu: Cedeno- Maldonado *et al.*, 1972). At light limiting conditions, the extent of inhibition was found to be less than that at light saturating conditions. Sites of heavy metal action in PS II catalyzed electron transport. Restoration of Hill activity by semicarbazide in the heavy metal ion treated plant chloroplasts (Zn: Van Assche and Clijsters, 1980; Van Assche and Clijsters, 1986) and by $MnCl_2$ (Cd: Baszynski *et al.*, 1980) indicates that the water splitting site is the site of action of heavy metals. In Cd treated maize chloroplasts restoration of Hill activity by DPC suggests that OEC is the site of action (Cd: Bazzaz and Govindjee, 1974b). In this investigation the effects of mercury on PS-II photochemistry as been compared with spectral alterations in maize plants.

MATERIALS AND METHODS:

Healthy seeds of Maize (*Zea mays. L*) were obtained from Regional Agricultural research station, Tirupati. The seedlings were randomly placed in plastic trays and grown in a growth chamber providing with fluorescence light (Phillips, India) with a light intensity of 30- 35 μ moles m^{-2} s^{-1} at 25 ± 1^0C. Fully expanded 8^{th} day leaf segments (4-5 cm long) were cut from apical region and used for treatment. Isolation of thylakoid membranes was done according to the procedure described by Sabat *et al.* (1986). PS II catalyzed electron transport assay (H_2O → *p*-BQ) activity was measured as O_2 evolution in the thylakoid membranes. The 2 ml reaction mixture contains reaction buffers [50 mM HEPES-NaOH (pH 7.5),100 mM sucrose, 2mM $MgCl_2$ and 5 mM KCl], 0.5 mM freshly prepared p-BQ and thylakoid membranes equivalent to 40 μg of Chl. Fluorescence emission and excitation spectras were recorded by using Jasco FP777 Spectrofluorimeter. PAM kinetic fluorimeter is used for measurements.Lipid peroxidation has been measured according to the method of Carmak and Horst (1991).

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A STUDY ON ANTIOXIDANT DEFENSE MECHANISMS ADAPTED BY MAIZE PLANTS UNDER HEAVY METAL STRESS

[1]Rajya Lakshmi, C., [2]Divya, B.J. and [3*]Murthy, S.D.S.
[1] Lecturer, [2] Academic Consultant, [3*] Professor

Department of Biochemistry, S.V. University, Tirupati-517502, A.P. India.

ABSTRACT

In this article efforts were made to study oxidant mediated damage and possible protection by antioxidant enzymes in maize plants under heavy metal stress. LPO measurements clearly demonstrated that both cadmium or zinc are able to induce LPO due to the production of toxic oxy radicals like superoxide as well as peroxy radicals which cause damage to thylakoid membrane. The induction of SOD or catalase activities indicate the protection made by the maize plants. Thus the plants are protected in environment from unfavourable conditions.

KEYWORDS: Antioxidant enzymes; Catalase; Heavy metals; SOD; Maize plants.

INTRODUCTION

Toxic metals mainly occur in soil, because the parent material of soil contained the metals. Metal ions are deposited on the surface of the earth due to human interaction with the environment. Metal smelters, foundries, thermal power plants are the major sources of heavy metals which are toxic in air, water and soil. Fungicides and pesticides are also sources of heavy metals in the soil. Inhibition of photoelectron transport activity in heavy metal stressed chloroplasts or algae can be explained in terms of replacement of Mn from OEC and Cu from PCy. Van Assche and Clijsters (1986) suggested that Mn is replaced by Zn in Mn deficient condition.

Excess concentrations of heavy metals such as Cd, Hg, Ni and Pb become extremely toxic and plant growth may be severely restricted by heavy metals and Nagajyothi *et al.,*(2010). Some plant species possess unique ability to adapt rapidly and evolve tolerance to toxic or lethal levels of heavy metals. A variety of tolerance mechanisms observed in biological systems are given below. There are enzymes like oxidases and reductases, which convert metal ions from more toxic into less toxic forms. In addition, some alkylating enzymes and dealkylating lyases, are helpful in detoxification of inorganic and organic mercury compounds (Ludger *et al.*,2013). Possibly blocking the heavy metal cellular uptake by altering the uptake pathway. By spending ATP, the heavy metal reached in the intracellular cytoplasm could be pumped again into the external environment. There is the possibility of altering the thiol containing enzymes, those are sensitive to heavy metals in order to obtain resistance.

MATERIALS AND METHODS

Healthy seeds of maize (*Zea mays .L*) were obtained from Regional Agricultural research station, Tirupati, India. The Protein content was determined according to the method of Lowry *et al.* (1951). Thylakoid membranes have been isolated by following the procedure of Renganathan and Bose (1989). Lipid peroxidation has been measured according to the method of Carmak and Horst (1991). The leaf material was homogenized with 10 ml of 0.1 M potassium phosphate buffer (pH 7.0), in a prechilled mortar and pestle. The homogenate was centrifuged at 10000 x g for 30 min, and the supernatant was used as the source of the enzymes. SOD activity was assayed by measuring its ability to inhibit the photochemical reduction nitro blue tetrazolium (NBT) using the method of Van Rossun *et al.,* (1997). The activity of CAT was estimated by the method of Havir and Mc Hale (1987). CAT activity was calculated using the molar extinction coefficient 36 x 10^3 mM^{-1} m^{-1} and expressed as n moles of H_2O_2 destroyed mg^{-1} protein min^{-1} (Zhang *et al.,* 2016). Six day old seedlings of maize were treated with different concentrations of Cd (50-200 µM) or Zn (100-400 µM) for 72 h. On 9th day primary leaves were collected from control and treated plants and proceeded for experimental work.

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INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

DIFFERENTIAL EFFECT OF HIGH TEMPERATURE ON THE PHOTOSYNTHETIC ELECTRON TRANSPORT OF MAIZE PLANTS

[1]Ranjani, R., [2]Divya, B.J. and [3]Murthy, S.D.S*

[1]Professor, [2]Academic Consultant, [3]Professor.

[1]Department of Virology and [2,3]Department of Biochemistry

Sri Venkateswara University, Tirupati-517502, A.P.

ABSTRACT:

In this study an attempt has been made to establish the differential action of high temperature on photosynthetic electron transport mediated by either PS-II or PS- I or both in Maize thylakoids after giving high temperature treatment to primary leaves. The increase in the temperature from 25^{0}C-45^{0}C cause inhibition in PS-II catalysed electron transport. The possible reason for the loss of PS-II catalysed electron transport could be depletion of manganeese from water oxidation complex. In contrary high temperature induced enhancement in PS-I catalysed electron transport due to opening of new site to donate electrons before plastocyanin by reduced DCPIP. Thus high temperature exerts differential effect on PS-II as well as PS-I in Maize plants.

KEY WORDS: Chlorophyll, Electron transport, Photo system, Maize plants.

INTRODUCTION:

In PS II, the main target for high temperature stress is oxygen evolving complex. As a result, there has been loss of Mn ions and extrinsic polypeptides of water oxidation complex (Nash *et al.,* 1985; Enami *et al.,* 1994). It is suggested that the membrane permeability increases during heat treatment, which results in a decrease in the proton gradient formation across the thylakoid membrane and a suppression of the linear electron flow. The changes in the membrane viscosity could be due to the variation of grana and stroma thylakoids ratio. It was observed that the quantity of grana thylakoids in green leaves is enhanced when exposed to damaging temperatures (Gounaris *et al,* 1983). In the past, PS II was considered a key weak link (Santarius 1975; Berry and Bjorkman, 1980; Enami *et* al., 1994) but damage to PS II only occurs at high temperatures, above 35^{0}C (Yamane *et al.,* 1998). Heat stress is often defined as where temperatures are hot enough for sufficient time that they cause irreversible damage to plant physiological functions and development. Due to this several plant physiological processes are getting affected by temperature and one of such processes is photosynthesis (Bauer,1979; Berry and Bjorkmann, 1980). No inhibition in PS I function and intersystem electron transport was detected (Havaux, 1996). HT stress causes conformational change in the Cyt $b_6$fcomplex causing appearance of new electron donor sites (Thomas *et al.,* 1986; Mohanty *et al.,* 1987). In this investigation, an attempt has been made to analyse the effect of high temperature on photochemical activities of maize plants.

MATERIALS AND METHODS:

Healthy seeds of Maize (*Zea mays),* were obtained from Acharya N.G. Ranga Agricultural University, Hyderabad. The seedlings were raised up to 8 days in light. 4-5 long and expanded leaf segments of primary leaves were used for experimental work. Maize primary leaves were taken and given high temperature treatment in growth chamber ranging from 25-50^{0}C for 20 min to perform photochemical assays. After giving the high temperature treatment (35/40^{0}C), the seedlings were placed at growth temperature for 24h and electron transport studies were measured. Thylakoid membranes were isolated according to Swamy *et al.,* (1995) with some modifications. Electron transport rates were measured using Clark type oxygen electrode (Hansatech, UK). These measurements were done at 4^{0}C. The 2 ml reaction mixture contained 50 mM Hepes-NaOH (pH 7.5), 100 mM sucrose, 2 mM $MgCl_2$ and 5 mM KCl and thylakoid membranes equivalent to 40 µg of Chl. The assay mixture was kept continuously stirred during measurements (Sabat *et al.,* 1985). Whole chain electron transport assay (H_2O to MV) was measured as molecular oxygen consumption by using MV as an electron acceptor. PS II assay (H_2O to pBQ) was studied in terms of oxygen evolution in thylakoid membranes. PS I assay (DCPIPH_2 to MV) was studied in terms of oxygen consumption (Mohanty *et al.,* 1987). The thylakoid membranes equivalent to 40 µg Chl were used in all electron transport assays. Intersystem electron transport assay (DQH_2 to MV) was studied in terms of oxygen consumption. Intersystem electron transport assay (DQH_2 to MV) was studied in terms of oxygen consumption (Izawa, 1977).

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TECHNIQUES IN RESEARCH ARTICLE WRITING

[1]Divya,B.J. and *Murthy,S.D.S.
[1]Academic Consultant and *Professor
[1]Department of Biochemistry,S.V.University,Tirupati-517502,Andhra Pradesh. India.

ABSTRACT

The tendency of writing article and paper for both printed and online journals and books increases rapidly. The present paper discusses about the techniques of writing good research article. The author has traced the procedures and rule of making abstract of an article. The steps needed to make a good article have been analyzed. Research methodology based on analysis of review of literature and secondary sources have been adopted. The signification of the use of keywords in an abstract is traded under the study. The paper finds out that there are various methods of citing sources and each method has its own procedures for incorporating data in the references. The paper concludes that every good article must be free from plagiarism and if any portion of an intellectual thought is copied then that must be mentioned by sources of references.

KEYWORDS: Online Journals and Books, Research Methodology, Literature, and Secondary Sources

INTRODUCTION

The Information and Communication Technology with its day by day changing mode of production of documents have ushered in a new era in the educational system. This leads to the development of research in the country and consequently, the volume of literature also increases enormously. The tendency of writing article and paper for both printed and online journals and books increases rapidly. It has become a more common scenario in the field of Education. There is a multitude of different types of articles, including news stories, features, editorial, profiles, instructional (how-to) articles, and so on. While each has specific qualities that are unique to its type, all articles share some common characteristics. From forming and researching the author's idea of writing and editing his/her work, writing articles can give him a chance to share compelling and important information with readers. So the research scholars and academicians should think about the type of article that will best suit the points that they want to convey.

The scholar must do an in-depth, balanced review of the primary research literature relevant to the study chosen prior to designing and carrying out the experiments. This review helps the scholars to learn what is known about the topic that is being investigated and may avoid unnecessarily repeating work done by others. The primary and secondary sources are the heart of any research article. The scholars and academicians very much depend on journals, books (monographs, classic), research report, govt. publication, abstracts, and indexes and so on before writing any research article for a journal. Experience shows that many scholars copy big volume of a particular content at the time of writing a research paper.

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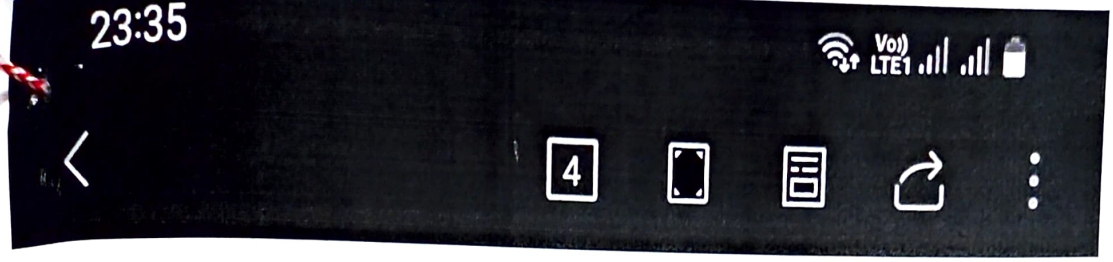
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Sri Venkateswara University, Tirupati, Andhra Pradesh, India

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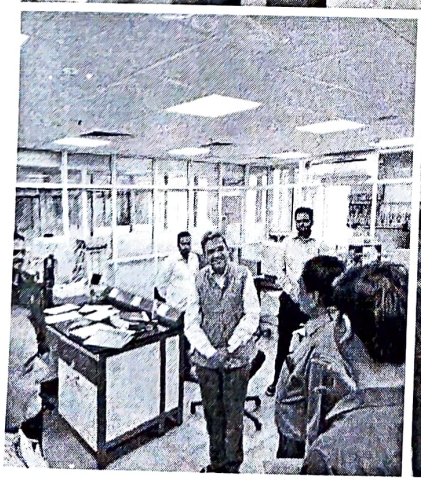
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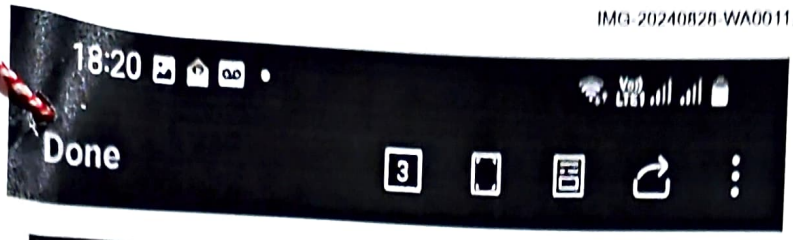


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Tentative Time	Detail	
05:00 – 05.30	Inaugural	
05.30 – 07.30	Award Conferring Procedures	
05.30 – 06.00 Principles/Deans	DR. S.D. SRINIVASA MURTHY DR. BOMMARAJU SRINIVASA RAO DR. ANKUR SRIVASTAVA	DR. HARI SUNDAR G DR. P.HIMA BINDU DR. KOTRA BALAYOGI
06.00 – 06.30 Professors	DR. TIRUMALA RAMASHRI DR. A. DINAKARA RAO DR. SUNIL BHAT DR. BALAJI MERIGA DR. A. PADMAJA DR. UMESHA K DR. ADITYA GOEL DR. SALIKINEEDY KISHORE Dr. RAKESH JAGDISH RAMTEKE DR. PRANAM DHAR	DR. ARJUN G KOPPAD DR. SUCHARITHA.K.V DR. B. DEVA PRASAD RAJU DR. VIDYA NITIN PATIL DR. SANJAT KUMAR SAHU DR. L. V. PADMARANI RAO DR. BISWAJIT RATH DR. K. JAYACHANDRA REDDY DR. MINAKSHI SHARMA
06.30 – 07.00 Associate Professors	DR. VENKATASWAMY MALLEPOGU DR. BISWARANJAN MANDAL DR. SARAD PAWAR NAIK BUKKE DR. GAURAV BHATTACHARYA DR. N. NAGARAJU DR. UJWAL DHANRAJ PATIL DR. R S UMAKANTH	DR. MD. ISRAR EQUBAL DR. MOHAMMAD ASIF EQUBAL DR. SARITA NANDA DR. C. PHANI RAMESH DR. NIDHI SINGH CHOUDHARY DR. HARDEV RAM DR. JAYA DIPTI LAL
07.00 – 07.30 Assistant Professors	DR. M. SOUNDARARAJAN DR. L.RADHIKA RANI DR. S. PRABAKARAN DR. PARTHA PAUL DR. C. GIRISH DR. THARUN KUMAR REDDY BOLLU DR. CHENNUPATI VIDYASAGAR DR. CHHAVI SHARMA DR. E.G.TIRU VENKATA KUMAR DR. MANISH KUMAR RAI DR. SHANKAR LAL MEENA	DR. M. SREEDHARA MURTHY DR. SANGHARATNA GODBOLEY DR. SANJAYA KUMAR PANDA DR. MURUGAN SHANTHAKUMAR DR. TAPAN KUMAR SAHOO DR. VIDYA PADMAKUMAR DR. SLOKASHREE PADHI DR. DIVYA B J MS. B. SWAPNA MS. SWEKSHA BHADAURIA MR. SWAPNIL SHIVRAM KUMARE
07.30 – 08.00	Announcements, Feed Back & Formal Closing of the Celebrations	

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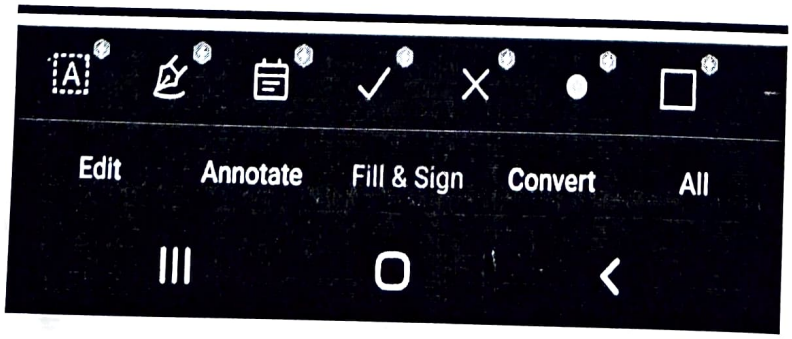
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INFLUENCE OF INDUSTRIAL WASTEWATER ON MORPHOLOGICAL AND CHLOROPHYLL CONTENT OF GROUNDNUT (*ARACHIS HYPOGAEA* L.)

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(Received 27 September, 2023; Accepted 14 November, 2023)

ABSTRACT

The objectives of the present study are to see the influence of industrial wastewater on morphological and chlorophyll content of groundnut (*Arachis hypogaea* L.). Pot culture experiments were conducted on groundnut plants under natural conditions by day and night light in the Department. Seeds were grown in pots for a period of 30 days where the soil was treated with various wastewater concentrations (25, 50, 75 and 100%) collected nearby industrial area and a control was carried out. The heavy metals comprise in experimental crops were determined and observed in experimental days i.e., 10, 20 and 30th day. The metals such as Cr, Cu, Mn, Fe, Ni, Pb, Cd and Zn were estimated in plants by AAS. The germination percentage of seed, seedling growth and chlorophyll content showed a gradual decline with increase in wastewater concentrations. The results have been observed at 25% concentration, there was growth rate in root length, an increase in shoot length and total chlorophyll content up to 20th day. At 30th day, decrease was observed in all the parameters. However, at higher concentrations of the effluent, toxic effects were observed from 20th day onwards.

KEY WORDS : Wastewater, heavy metals, Germination, Cholorophyll, A*rachis hypogaea* L.,

INTRODUCTION

Water and soil pollution has become a global problem due to population growth and industrialization. Wastewater is polluted water which is discharged by human usage and it is unfavorable for any particular purpose like drinking, commercial, agriculture and industrial use.

High concentration of BOD, COD, TDS, AND, Cr etc. in tannery and textile industrial effluents adversely affects soil and water bodies as well as plant growth (P.K. Chhonkar *et, al.,* 2000). Especially the waste water released from the industrial zones is constantly adding toxic substances to the groundwater aquifer. Humans in many parts of the world depend heavily on groundwater for their needs (Babiker *et al.,* 2004; Nair *et al.,* 2006). There are numerous chemical species present in water with concentrations vary from a few mg/l to a few g/l. They are referred as micro-pollutants, which even in small quantities are dangerous to man's health (Ngah WSW *et al.* 2011 and Holzer L *et al.* 2010). The biomass industrial effluents have been showed an adverse affects on morphological parameters and chlorophyll content of green gram (*Phaseolus aureus*). Unsanitary activities and use of waste water for irrigation create serious pollution and adverse effects on soil and crops. Because of the harmful effects of public, hospital, and industrial wastewater on soil, air, water, as well as agricultural product, wastewater treatments and the proper sludge disposal are needed for environmental protection (Dushyanth *et al.,* 2019). Untreated discharge of industrial effluents are responsible for serious water (Otokunefor and Obiukwu, 2005) and soil pollution (Konwar and Jha, 2010), which is considered as one of the major factors responsible for low productivity of crops. Similar findings were revealed on the effect of various industrial effluents

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on different crops (Cabral *et al.*, 2010).

The toxic levels of mineral elements like NH4+, NO_3-, PO_4^{3-}, and SO_4^{2-}, and Mg, Ca, K, Na, Cu, Zn, Fe, M, and Ni in the wastewater resulted in a significant decline in the K, P, Si, and Zn content of plant leaves.

MATERIALS AND METHODS

Wastewater sample was collected in the month of June, 2023 (peak hours) from outlets of industrial area situated at Gajulamanyam Industrial Estate, neat by Tirupati air port, Tiruapti district, Andhra Pradesh. Wastewater sample was collected in well cleaned polythene containers; each bottle was washed with fresh water before collection of the sample. Finally bottle was tightly closed. After filtering, pH, electrical conductivity (EC) of the sample was immediately measured in the laboratory and afterwards the samples were stored at 4°C for physico-chemical analysis (APHA, 2005).

Soil sample was collected near Gajulamandyam industrial zone and used for pot culture studies. The seeds of groundnut were obtained from N.G. Ranga Agriculture College, Tirupati and treated with 0.2 N mercuric chloride for 2 min and washed with running tap water to remove contamination of seed coat, prior to germination studies (Singh *et al.*, 2006). The pot studies were carried out with groundnut as a test crop using various concentrations of industrial wastewater 25%, 50%, 75% and 100% and distilled water was served as control. Each treatment including control was carried out in triplicate using 15 seeds per pot. The number of seeds germinated in each treatment was recorded at 10th, 20th and 30th days of the experiment and the germination percentage was calculated. Growth of the root and shoot length were measured with the help of meter scale and chlorophyll content estimated following the method of Arnon (1949) using UV- UIS spectrophotometer 117 model.

RESULT AND DISCUSSION

This study deals the influence of industrial wastewater on The wastewater sample was colourless, alkaline in nature and contained in high levels of heavy metals like Zn, Pb, Cd, Cr and Fe. It contains considerable amount of Ni, Mn and Co. The higher EC alter the chelating properties of receiving water systems, which create conditions for free metal availability to flora and fauna (Nanda *et al.*, 1999 and Jung Eek Son, 2015). The percentage of seed germination on exposure of different concentrations and duration was presented in graph 1. The maximum seed germination percentage was recorded at 25% and minimum was at 100% of wastewater concentrations, as compared to control. At 25% of wastewater concentration, increase in root and shoot length is high at 30th day as compared to control graph 1 and 2, whereas at 100% of wastewater concentration decrease in length of root and shoot was recorded at 10th, 20thh and 30th days. Inhibition of seed germination may be due to high

Table 1. Physico-Chemical Characteristics of Industrial Wastewater

S. No.	Parameter	Unit	Observed Values	Standards for portable and irrigation waters ISI (1983)
1	Color	–	Colorless	—
2	Odor	–	Odorless	—
3	Temperature	°C	28.0	—
4	pH	–	8.5 ± 0.34	6.5-8.5
5	EC	µmhos/cm	10.5 ± 0.12	2.25
6	TSS	mg/L	647.33± 3.25	—
7	TDS	mg/L	611 ± 11.79	—
9	BOD	mg/L	48.6 ± 2.3	—
10	COD	mg/L	128.66 ± 0.25	—
11	Ni	mg/L	0.041 ± 0.004	0.05
12	Cu	mg/L	0.014 ± 0.002	0.05
13	Mn	mg/L	0.036 ± 0.002	0.1
14	Cd	mg/L	0.028 ± 0.002	0.01
15	Cr	mg/L	0.071 ± 0.003	0.05
16	Fe	mg/L	0.04 ± 0.001	0.3
17	Zn	mg/L	5.73 ± 0.120	5.0
18	Pb	mg/L	0.104 ± 0.002	0.10

amounts of dissolved solids in wastewater, which enrich the salinity and conductivity of the absorbed solute by seed before germination (Gautam *et al.,* 1992; Singh *et al.,* 2006) and Murkumar and Chavan (1987) have reported that the higher concentration of effluent decrease enzyme dehydrogenase activity that is considered as one of the biochemical change which may have disrupt germination and seedling growth. Salt stress affects the seed germination and seedling establishment through osmotic stress, ion toxicity, and oxidative stress (Cuneyt Ucarli, 2020). Chlorophyll content was estimated at various time intervals of exposure and concentrations of wastewater have been represented in Tables 3, 3.1 and 3.2. In the wastewater concentration at 25%, chlorophyll a, b and total chlorophyll contents were increased up to the 20th day and decreased at 30th day in groundnut. Wastewater concentration at 100% overall decrease in chlorophyll content was

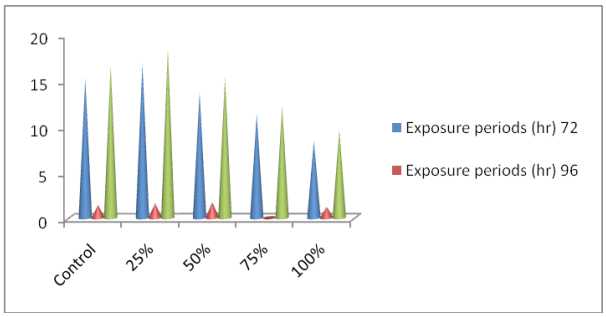


Fig. 1. Germination percentage of groundnut in control and industrial effluent at different time intervals

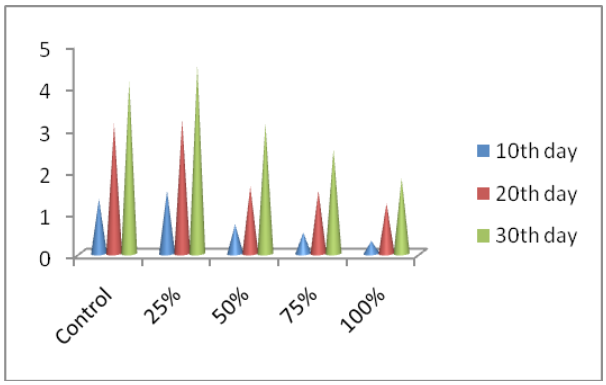


Fig. 2. Influence of industrial wastewater on root length of *Arachis hypogaea* L. (cm seedling^{-1})

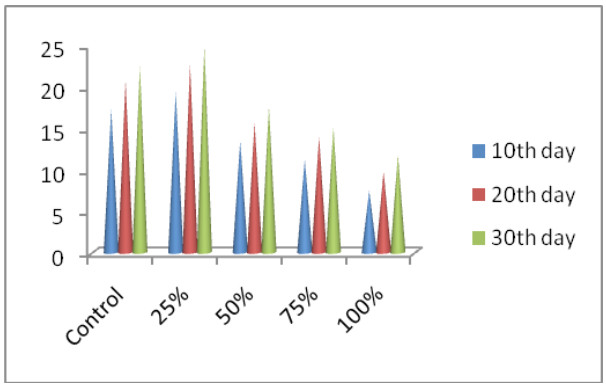


Fig. 3. Influence of industrial wastewater on shoot length of *Arachis hypogaea* L. (cm seedling^{-1})

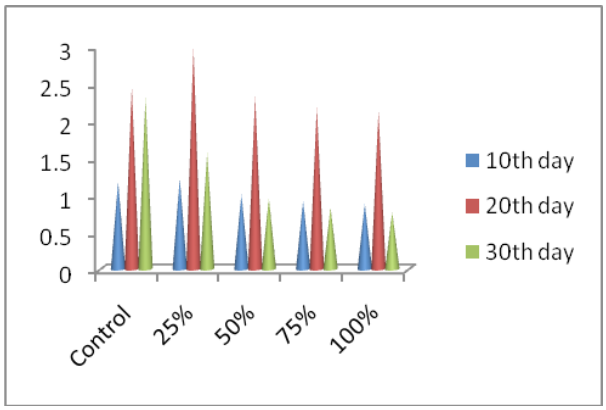


Fig 4. Influence of industrial wastewater on chlorophyll a content of *Arachis hypogaea* L. (mg/g.fr.wt)

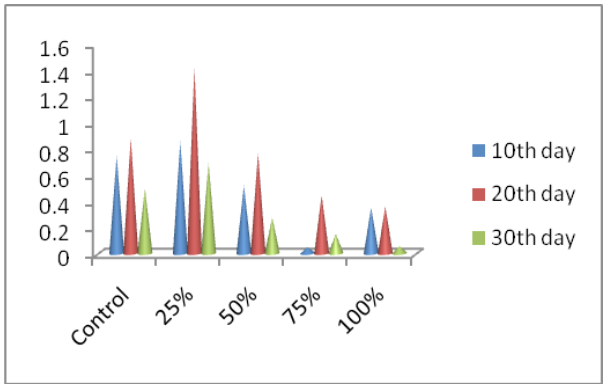


Fig. 5. Influence of industrial wastewater on chlorophyll b content of *Arachis hypogaea* L. (mg/g.fr.wt)

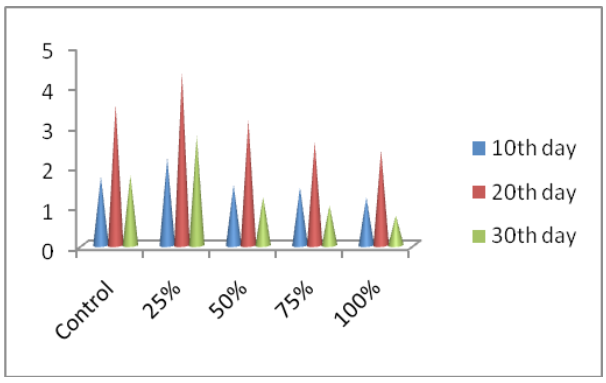


Fig. 6. Influence of industrial wastewater on total chlorophyll content of *Arachis hypogaea* L. (mg/g.fr.wt)

recorded during all the experimental days as compared to control. Changes in total chlorophyll concentration indicate that the chlorophyll synthesizing capacity of the crop has diminished affecting the overall photosynthetic process. Similar findings and observations were reported in earlier investigations (Krupa *et al.,* 1993; Gouia *et al.,* 2003; Shokoofeh Hajihashemi *et al.,* 2020). According to the findings of Klimentina Demerivska – Kepova *et. al.* (2006), Cd has reduced plant length, biomass and leaf pigments and inhibiting the fixation of carbon and decreasing chlorophyll content and photosynthetic activity (Gallego *et al.,* 2012).

Seed germination percentage was reduced at higher concentration of wastewater may be due to the high levels of solids present in the wastewater, which causes changes in the osmotic relationship of the seed and water. Hence the amount of water absorption decreases, resulting in retardation of seed germination due to increasing salinity. Increased salt stress reduces the seed's ability to absorb water (osmotic stress) and causes an ion imbalance in the seed (ionic stress), ultimately inhibiting seed germination and crop production. Therefore, salt water intrusion in growing standard crops can be risk to crop failure (Elizabeth de la Reguera, *et al.,* 2020). Saxena *et al.* (1986) has mentioned that higher concentration of solid in the wastewaters result in a low amount of oxygen in dissolved form, which reduces the energy supply through anaerobic respiration and resulting in limitation of seedling growth and development.

CONCLUSION

This investigation was conducted on the influence of wastewater in morphology and chlorophyll content of groundnut, at higher concentrations of wastewater has clearly showed deleterious effects. Plants growing in such type of polluted waters may accumulate chemical substance at high levels in such plants, if consumed may have similar effects on live-stock and human beings. Hence it may be suggested that nutrients available in 25% in wastewater discharged by industries and it may be used as a suitable liquid fertilizer. It reduces the amount of water required for irrigation and helps conserve water and provides nutrients to the field and plants. Proper precautions should be taken before discharge industrial wastewater to avoid water and land pollution.

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An in-depth analysis of the role of women in environmental protection within the Anupalle village, Ramachandrapuram Mandal, Sri Balaji District, Andhra Pradesh, India.

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Abstract: **The term "natural environment" encompasses both living and non-living elements that exist independently of human intervention. It is commonly used to describe the Earth as a whole or specific regions within it. This encompasses all forms of life, weather patterns, climate, and natural resources that have an impact on human survival and economic activities. In countries like India, women play a crucial role in managing and conserving resources within their households. They devote significant amounts of time to tasks such as collecting and storing water, ensuring access to fuel, food, and fodder, as well as overseeing the management of various types of land, including forests, wetlands, and agricultural areas. The paper explores the significant role that women play in safeguarding the natural environment through an examination of the behaviours and routines of the women in Anupalle village dedicated to environmental conservation.**

Keywords: Women, India, Anupalle village, Environmental Protection, Sustainability, etc.

I. INTRODUCTION

The concept of "environment," derived from the word "to surround," encompasses the dynamic interactions among water, air, and land, as well as their interconnections with each other, humans, other organisms, and property. Women play a crucial role in the stewardship of natural resources, including land, water, forests, and energy. Particularly in underdeveloped regions, women are primary users of resources like land, forests, and water, as they are tasked with gathering food, fuel, and fodder [1]. They hold a wealth of knowledge encompassing both traditional wisdom and modern insights regarding the natural world that envelops them.

Schultz et al. [2] highlight the women, environment, and development (WED) discourse, which critically examines development policies by underscoring the relationships between modernization/industrialization, technology, and environmental harm.

Historically, women have been marginalized and viewed as the subordinate gender. However, globally, women often bear the responsibility of managing and conserving resources for their households. Women are increasingly making significant contributions across various fields, such as researching water resources worldwide and safeguarding forest reserves.

Historically, women were frequently marginalized or dismissed, but there is now a growing acknowledgment of the profound influence they wield over the environment. Furthermore, there is a mounting awareness of how the environment impacts the health and overall well-being of women. This shift in viewpoint is exemplified by significant occurrences like the 1992 UN Earth Summit, the Chipko movement in India, and the Green Belt Movement in Kenya. These movements underscored the crucial role of women's voices and perspectives in advancing sustainable development across various echelons, from top decision-making entities to grassroots communities. Over the past few decades, environmental movements have surged alongside the burgeoning movements advocating for women's rights. The contemporary fusion of nature conservation with women's rights and empowerment has emerged as a response to the historical encroachment on their rights [3,4].

In the regions of Asia and the Pacific Islands, a significant number of women are involved in the agricultural sector. This sector includes a wide range of activities such as working on their own farms, labouring in small enterprises that process fruits, vegetables, and fish, engaging in paid and unpaid work on others' land, and collecting forest products. However, despite their active participation, only a small percentage of these women, approximately 10-20%, have been able to obtain land tenure. This is primarily due to economic and legal obstacles. One such obstacle is the gender disparity in accessing loans, which leads to women receiving fewer and less favourable loans compared to men when it comes to acquiring land [5].

The active participation of women in environmental matters has led to a profound understanding of it. Consequently, women play various roles such as agriculturalists, water resource managers, and traditional scientists, among others. Due to their primary responsibility for domestic and household management, women have a greater interaction with both natural and man-made environments compared to men. This makes them more susceptible to the adverse effects of deteriorated living conditions, inadequate infrastructure, and substandard homes in their communities. Globally, women bear the primary responsibility for farming and domestic food production. Despite an increasing trend of women taking on additional agricultural tasks and expanding their involvement, the gender-based division of labour in terms of reproductive work remains unchanged (6-9).

Gaining a comprehensive understanding of the different approach's women have taken to actively participate in the preservation and governance of the environment is of utmost importance. The aim of this manuscript is to examine the role of women in environmental management, with a particular focus on a small village, in order to incorporate their contributions into environmental initiatives.

The study revealed that women in Anupalle village actively participated in various environmental initiatives, such as waste management, tree plantation drives, and conservation of natural resources. Their involvement was not only limited to household activities but extended to community-wide efforts, showcasing their dedication towards environmental protection.

The findings of this case study emphasize the importance of recognizing and supporting the pivotal role of women in environmental protection. It is crucial to provide them with equal opportunities, resources, and platforms to actively engage in sustainable practices and decision-making processes. By doing so, we can harness the immense potential of women in creating a greener and more sustainable future for all.

II. STUDY AREA

Anupalle, situated in the Ramachandrapuram Mandal within the Sri Balaji District of Andhra Pradesh State, India, falls under the Rayalaseema region. Positioned 12 KM away from Chandragiri town and 32 KM to the West of the District headquarters Sri Balaji, the village's local language is Telugu. As per the 2011 census, Anupalle Village has a total population of 3173 with around 833 houses, and the female population stands at 48.9%. The literacy rate in the village is 52.3%, with the female literacy rate at 21.5%. The primary occupations in Anupalle include cattle maintenance, agriculture including both seasonal crops and vegetables, and silkworm cocoon cultivation, with some residents also engaged in jobs and businesses in and around Tirupati. This study utilizes two distinct sets of data. The first set comprises secondary source materials gathered from previous studies on women's involvement in environmental conservation and management. These sources include books, journal articles, and online publications. The second set of data was collected directly from primary sources by distributing questionnaires to women living in the rural setting of Anupalle Village.

III. REVIEW

3.1. Women in Agriculture

Women have made significant contributions to agricultural production on a global scale, as reported by the Food and Agriculture Organization, which stated that they were responsible for producing over half of all food grown in 1996. In specific regions like sub-Saharan Africa and the Caribbean, women are responsible for producing an impressive 80% of basic foodstuffs. Jayasheela [10] highlights the diverse roles that women play in Indian agriculture, which include production and distribution, planting and cultivation, weeding, hoeing, harvesting, and storage.Research conducted by Adebayo et al [11] revealed that in Asia, women contribute between fifty and ninety percent of the labor force for rice cultivation, while in Adamawa State, Nigeria, 60% of women are engaged in farming activities.

Women in the village of Anupalle play a crucial role in the agricultural industry, contributing significantly to the cultivation of rice, groundnuts, and sugarcane. They are also actively engaged in the farming of livestock crops for their cows, buffalos, goats, and other animals, showcasing a strong connection between women and the environment, particularly the land.

As individuals affected by soil degradation, women have taken part in various initiatives focused on soil conservation. A prime illustration of their dedication can be seen in the Agroforest project located in Yatenga, Burkina Faso. Furthermore, Igbo women have embraced traditional male agricultural duties, alongside their existing responsibilities within the female domain [12,13].

3.2. *Water Resource Management*

Etta (14) conducted a study in Mariko Lower-income settlement in Lagos, uncovering the crucial role women play in managing communal water resources and meeting household water needs. Women are primarily tasked with overseeing communal taps or water points, often taking measures to protect these sources from damage caused by children.

Within households, women and girls bear the responsibility of fetching water for various domestic purposes like cooking and cleaning. On the other hand, men typically dominate the water trade. Unfortunately, these water sources are vulnerable to pollution, particularly from untreated sewage, leading to significant health hazards [14,15].

In rural settings, women are solely in charge of sourcing water for their households. However, the methods used to collect water, especially from riverbanks, contribute to water contamination [16].

3.3. Solid waste disposal

In the particular field of research, the speed at which solid waste is being accumulated exceeds the rate of population growth. The disposal of solid waste typically takes place in assigned dumping grounds or undeveloped regions. Women, due to their proximity to the environment, actively participate in environmental stewardship by taking on tasks such as cleaning and maintaining cleanliness, especially when it comes to garbage disposal. Recognizing the health risks associated with waste, women take on the responsibility of ensuring its regular removal at the community level.

IV. RESULTS

The following section provides an overview of the results obtained from the questionnaire survey conducted to assess the level of women's participation in environmental management in Anupalle Village. Table 1 presents the demographic characteristics, specifically age and marital status, of the women who participated in the survey. It is important to note that only a small percentage, namely 14.8%, of the surveyed women are below the age of 18. The majority, accounting for 69.7%, fall within the middle age group (18-55 years), while only 15.5% are above the age of 55. This age distribution suggests that a significant number of women are still in their prime years and possess the necessary energy and enthusiasm to actively contribute to environmental management activities.

Table 1. Age and marital status of survey women

S.No	Age Group	Number	Percentage
1	Below 18 years	15	14.8
2	Middle age (18-55) Years	35	69.7
3	Above 55 years (51-75)	10	15.5

In Table 2, it is evident that a significant majority of female participants, specifically 64.8%, are involved in agricultural activities within the study area. Among these activities, organic farming stands out as the most used method for soil conservation by women. Additionally, planting trees is recognized as an effective approach to safeguarding the environment and mitigating hazards like windstorms and erosion. The survey results further support the active engagement of women in tree planting, as almost 73.1% of women in the study area have planted trees or flowers within the past five years. Notably, women frequently plant fruit trees such as mango, sapota, papaya, and various other fruit plants. This practice serves a dual purpose of environmental protection and providing fruits for household consumption.

Table 2 Women involvement in Environmental Management

Involvement in Farming	Percentage(%)
Yes	64.8
No	35.2
Planting trees (Farming/Around the house)	Percentage (%)
Yes	73.1
No	26.9
Conserving methods	Percentage (%)
Organic farming	55.3
planting	44.7
Major activities in Environmental Cleaning	Percentage (%)
Weeding	28
Sweeping	60
Drainage	12

The participants highlighted several obstacles encountered by women in environmental management in the study area. Primarily, a lack of environmental awareness among the public was noted. Additionally, there was a deficiency in waste disposal infrastructure, and lastly, inadequacies were observed in drainage systems.

V. RECOMMENDATIONS

To attain sustainable development, it is advised to encourage the active participation of women in environmental management, taking into account the challenges they are currently encountering.

2. To instigate a shift in the mindset of the public and provide them with necessary knowledge, it is essential to make environmental education compulsory for a large portion of women.

3. This measure will help tackle the problem of individuals thoughtlessly littering paper scraps, fruit peels, plastic bottles, and polythene bags on the streets for entertainment purposes.

4. It is crucial to make women's education a top priority and guarantee girls' access to schooling as a necessary policy measure. Educated women are poised to have a substantial impact on closing the divide between environmental concerns and progress. Recognizing and backing the empowerment of women in sustainable human development, along with their pivotal role in environmental preservation, is of utmost importance.

VI. CONCLUSION

To summarize, married and unmarried women alike have been actively participating in efforts to protect the environment. Nevertheless, a significant number of women involved in these initiatives are married. The high representation of married women in this area suggests that they are more likely to take on the responsibility of preserving and keeping the environment clean, given their roles as homemakers. As a result, this research has explored the various ways in which women have been actively involved in safeguarding the environment and overseeing the use of natural resources, with the goal of promoting the sustainable utilization of environmental resources.

The recommendations put forth in the report emphasize the importance of empowering women, recognizing their pivotal roles as resource managers, environmental advocates, and community activists. It is crucial to ensure that women have equal opportunities to engage in environmental initiatives at various levels, from local to international. Achieving gender parity in decision-making bodies is essential for women to effectively contribute to environmental protection efforts. Consulting and supporting women in their environmental conservation endeavours is paramount, as is increasing their involvement in shaping environmental policies, programs, and funding allocations.

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Impact of Soil Pollutants on Groundnut (Arachis hypogaea L.) Seedlings

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ABSTRACT:

The present work is aimed to study the impact of soil pollutants on groundnut (*Arachis hypogea* L.) seedlings. Soil pollution by heavy metals and their toxicity is a problem of increasing significance for ecological, evolutionary and environmental reasons. Heavy metals even in lower concentrations may inhibit the physiological metabolism of plant. *Arachis hypogea* L. was grown in pots for a period of 30 days where the soils were treated with different effluent concentrations (25, 50, 75 and 100%) collected near an industrial area and a control was carried out. The distribution of heavy metals in the soils and corresponding accumulations in the experimental crop was investigated on different experimental days 10, 20 and 30th day. The metals Fe, Cu, Ni, Cr, Zn, Mn, Pb, and Cd in plants and soil samples were analyzed by AAS technique. In *Arachis hypogea* plants Fe was high in 100% effluent at 10, 20, 30th days. It has been observed that at 25% effluent concentration, there is growth in the root length, an increase in shoot length, germination percentage, Chlorophyll a, b and total chlorophyll content in *Arachis hypogea* L. chlorophyll content have increased up to the 20th day and then decreased at 30th day.

Keywords: Wastewater, heavy metals, Germination, Chlorophyll, A*rachis hypogea* L.,

INTRODUCTION

The problem of environmental pollution due to necessary industrial growth is, in practical terms, the problem of disposal of industrial water, whether solid, liquid or gaseous. Contaminated water, along with other substances, impacts, not only in industrial areas but also in agricultural fields, soil, as well as river beds, creating secondary sources of pollution (Barman, S.C., et al., 2000; Kisku, G.C., 2000). Untreated or poorly treated wastewater can have harmful effects on soil, plants, and the environment, and be dangerous to humans. The heavy metal contaminated wastewater finds its way into the environment, threatening human health and the ecosystem. The heavy metals are non-biodegradable (El-Sherif, I. Y., 2013) and could be carcinogenic (Borba, C. E., et al., 2006; Garcia-Nino, W. R. and Pedraza-Chaverrí, J, 2014; Zou, Y. et al 2016; Taseidifar, M., et al., 2017; Tjandraatmadja, G. et al., 2018;), its presence in water by improper amounts could result in critical health issues to living organisms.

Wastewater produced by the petrochemical industry has been found to be contaminated with various types of toxic pollutants such as heavy metals (Dimoglo, A. et al., 2004; Kumar, N.et al., 2013; Abbasia, M. et al., 2018) and using it for crop irrigation led to lower plant biomass and yield (Sharma, R.K.and Agrawal, 2005; Banon, S. et al., 2011; Lyu, S. et al., 2016). Heavy metal pollution interferes with the absorption of K, Mg, S, P, Ca, Fe, Mn, Zn and Cu and affects their translocation from roots to tops depleting the elements required for plant growth (Benavides, M.P. et al., 2005; Shanker, A.K. et al., 2005; Sharma, P. and Dubey, R.S. 2005; Lefevre, I. et al., 2014) . The central atom of chlorophyll, magnesium, can be replaced by heavy metals like cadmium, copper, zinc, lead, and mercury, which blocks the light-harvesting capability of chlorophylls and impairs photosynthesis in stressed plants (Kupper, H. et al.,1996).

MATERIALS AND METHODS

Study Site:

Wastewater sample was collected in the month of June, 2023 (peak hours) from outlets of industrial area situated at Gajulamanyam Industrial Estate, neat by Tirupati air port, Tiruapti district, Andhra Pradesh. Wastewater sample was collected in well cleaned polythene containers; each bottle was washed with fresh water before collection of the sample. Finally bottle was tightly closed. After filtering, pH, electrical conductivity (EC) of the sample was immediately measured in the laboratory and afterwards the samples were stored at 4^{o}C for physico-chemical analysis (APHA, 2005).

Collection of Groundnut Seeds:

Soil sample was collected near industrial area and used for pot culture. The seeds of *Arachis hypogaea* L. were obtained from Acharya N.G. Ranga Agriculture College, Tirupati and treated with 0.2 N mercuric chloride for 2 minute and washed with running water to remove contamination of seed coat, prior to germination studies. This experiment was carried out with groundnut using various wastewater concentrations (25, 50, 75, 100%) and distilled water which served as control. Each treatment including control was performed in triplicate and in every pot 15 seeds were used. The number of seeds germinated in each treatment was recorded on 10, 20 and 30 days of the experiment and the germination percentage was recorded.

Soil Analysis:

Soil samples were dried at 70°C in the laboratory oven. To 1 gm sample, 8 ml conc. HCl and 2 3 ml conc.HNO were added and kept for overnight at 35°C. Digestion was done according to the method of McGrath and Cunliffe, 1985. After dilution and filtration the digested solution was analyzed for determination of Cr, Cu, Mn, Fe, Co, Ni, Cd, Pb and Zn by AAS.

Effluent Analysis: An wastewater sample was collected during April, 2023 from outlets of industrial are situated at Gajulamanyam Industrial Estate, Renigunta, Tirupati district, Andhra Pradesh. Effluent sample was collected in well cleaned polythene bottle.

Before collection each bottle was washed with fresh water. Finally bottle was tightly closed. After filtering the pH, Electrical conductivity (EC) of the sample was immediately measured in the laboratory and afterwards the samples were stored at 4^0 C for physicochemical analysis, methodology of (Element. In: Lancaster JR) was followed.

Plant Analysis:

The plant leaves were carefully washed with deionized water and oven-dried at 70°C in the laboratory. Powdered plant samples (whole plant, 1 gm) were digested with 5ml diacid mixture, nitric acid (HNO_3) : perchloric acid (HCLO) in the ratio of 3:2 at 110°C for 8 hours. Then distilled water was added to the digested samplees to make up the volume to 50 ml and then filtered by Whatman-42 filter paper. The samples were ready for elemental analysis (Instituto Agronomico de S. Paulo, 1978) by AAS.

Plant Growth and Estimation of Chlorophyll:

Growth of the root and shoot length were measured with the help of meter scale and chlorophyll content estimated (Arnon, D.I. 1949) following the method of Arnon using UV-UIS spectrophotometer 117 model.

RESULTS AND DISCUSSIONS

Results:

Physico-chemical Characters and Metals in wastewater:

The physicochemical properties of the wastewater were analysed and presented in table 1. Wastewater is white in colour and odorless. pH is 8.2, EC (Electrical Conductivity) 11.3µmos/cm these values are compared to ISI (Indian Standard Institution) standards recommended for discharge of wastewater on land for not suitable to irrigation purpose. Total suspended solids, Total dissolved solids values are 716 ± 12.66, 694.24 ± 3.17. BOD (Biological Oxygen Demand) value is 58.9 ± 0.15; COD (Chemical Oxygen Demand) value is 140.51 ± 0.29. Chromium is 0.061 ± 0.003, copper 0.016± 0.002, manganese 0.037± 0.002, Iron 0.050± 0.001, nickel 0.047 ±0.0.005, cadmium 0.026 ± 0.002, lead 0.10±0.002, zinc 6.72±0.120. The rest of the metals like chromium, cadmium, lead zinc are present in high concentration in wastewater when compared to ISI standards and are not suitable for irrigation use.

Tab.1 Physico- Chemical Characteristics of Industrial Wastewater

S. No	Parameter	Unit	Observed Values	Standards for portable and irrigation waters ISI (1983)
1	Color	--	Colorless	--
2	Odor	--	Odorless	--
3	Temperature	^{o}C	28.0	--
4	pH	--	8.2 ± 0.34	6.5-8.5
5	EC	µmhos/cm	11.3 ± 0.12	2.25
6	TSS	mg/L	716 ± 12.66	--
7	TDS	mg/L	694.24 ± 3.17	--
9	BOD	mg/L	58.9 ± 0.15	--
10	COD	mg/L	140.51 ± 0.29	--
11	Ni	mg/L	0.047 ±0.0.005	0.05
12	Cu	mg/L	0.016± 0.002	0.05
13	Mn	mg/L	0.037± 0.002	0.1
14	Cd	mg/L	0.026 ± 0.002	0.01
15	Cr	mg/L	0.061 ± 0.003	0.05
16	Fe	mg/L	0.050± 0.001	0.3
17	Zn	mg/L	6.72±0.120	5.0
18	Pb	mg/L	0.10±0.002	0.10

Fig. 1 Germination percentage of *Arachis gypogeae* L in control and industrial wastewater at different time intervals

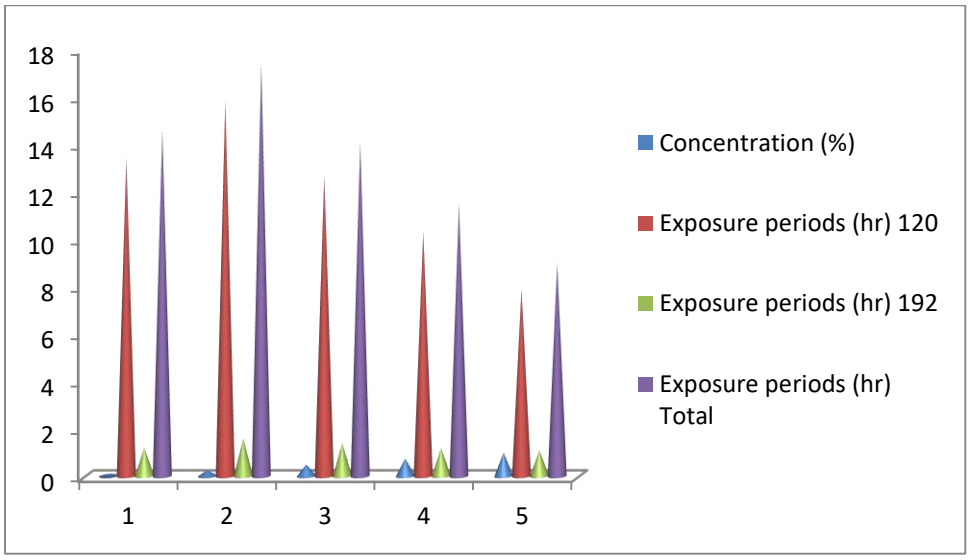


Fig.1

Values are arithmetic mean of three replicates

Fig. 2 Impact of soil pollutants on root length of *Arachis hypogaea* L. (cm)

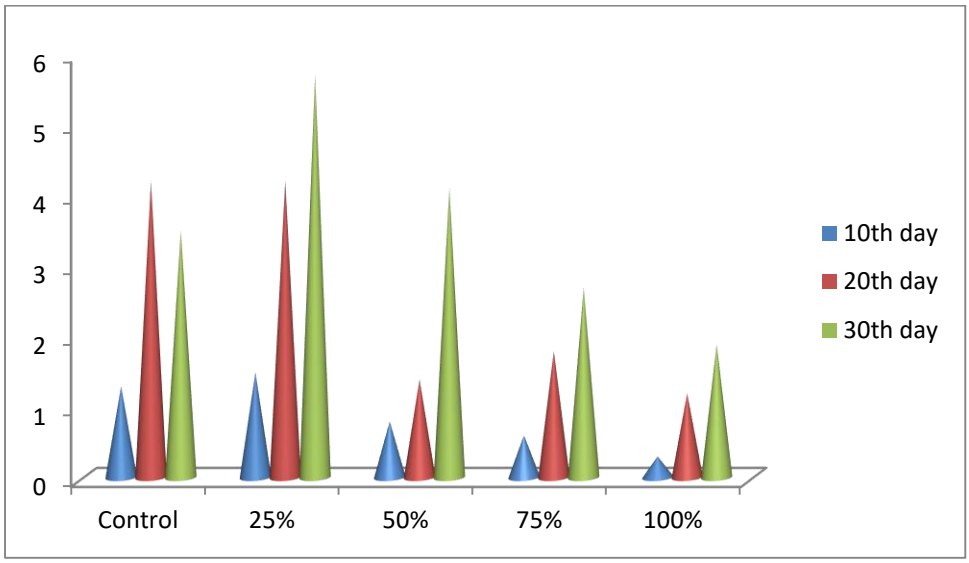


Fig.2

Values are arithmetic mean of three replicates

Fig. 3 Impact of soil pollutants on shoot length of *Arachis hypogaea* L. . (cm seedling)

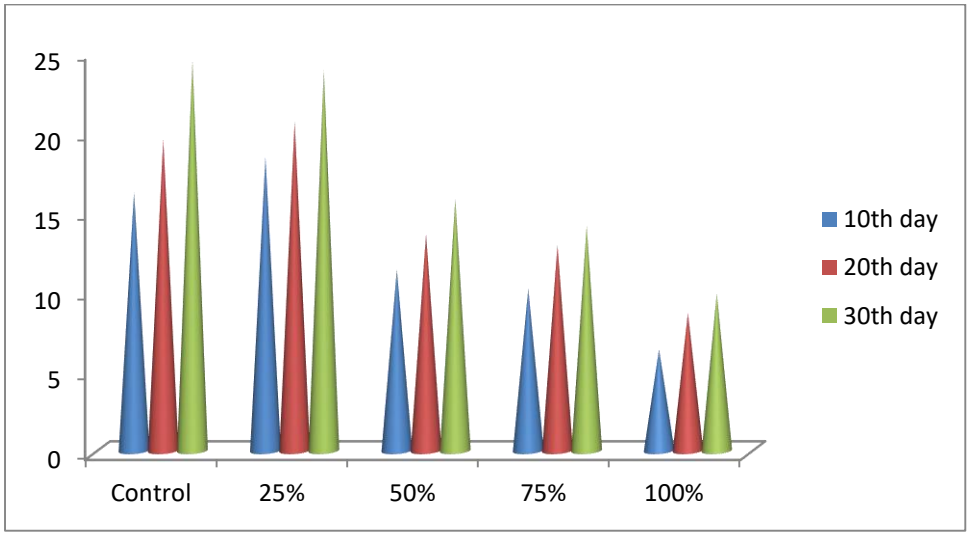


Fig. 3

Values are arithmetic mean of three replicates

Fig. 4 Impact of soil pollutants on chlorophyll a content of *Arachis hypogaea* L. (mg/g.fr.wt)

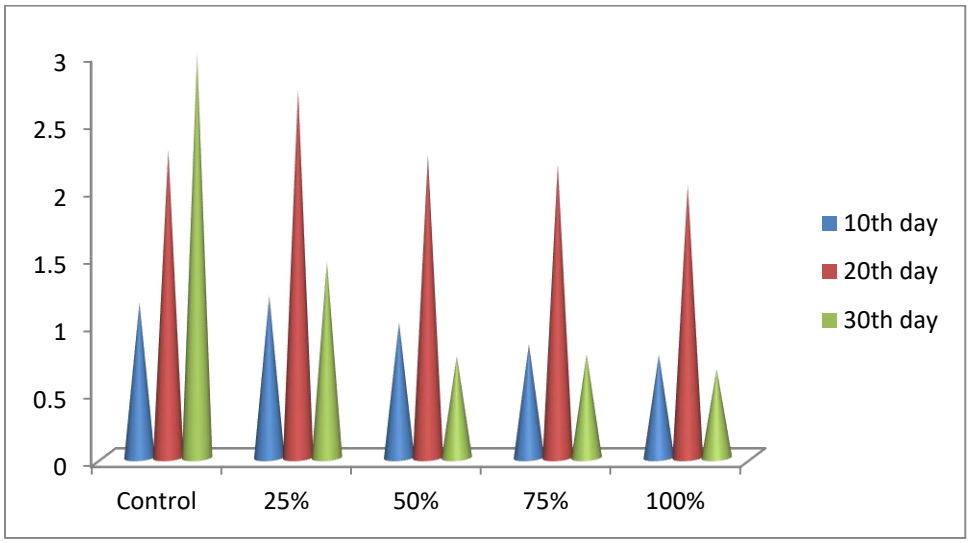


Fig. 4

Values are arithmetic mean of three replicates

Fig. 5 Impact of soil pollutants on chlorophyll a content of *Arachis hypogaea* L. (mg/g.fr.wt)

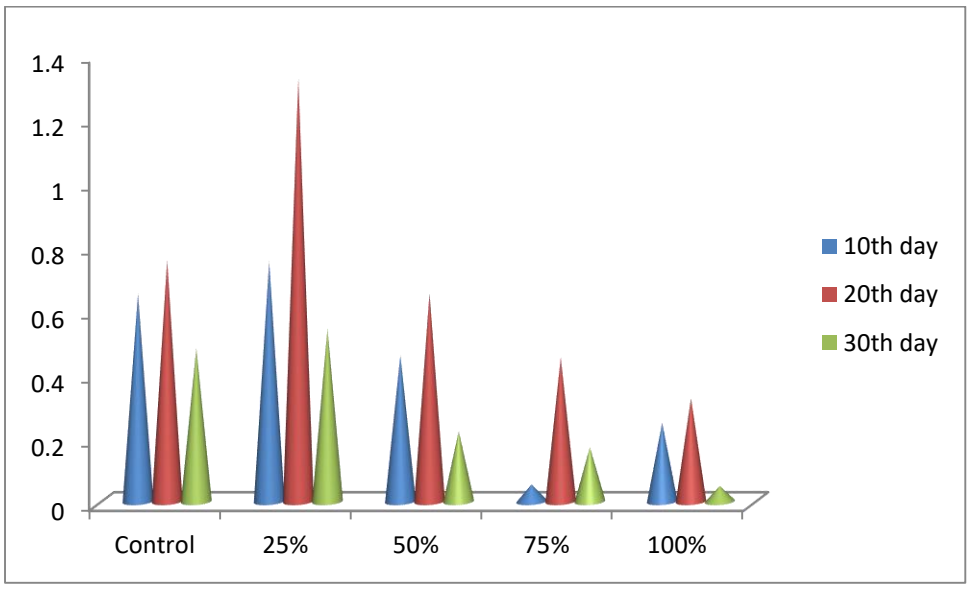


Fig. 5

Values are arithmetic mean of three replicates

Fig. 6 Impact of soil pollutants on total chlorophyll content of *Arachis hypogaea* L. (mg/g.fr.wt)

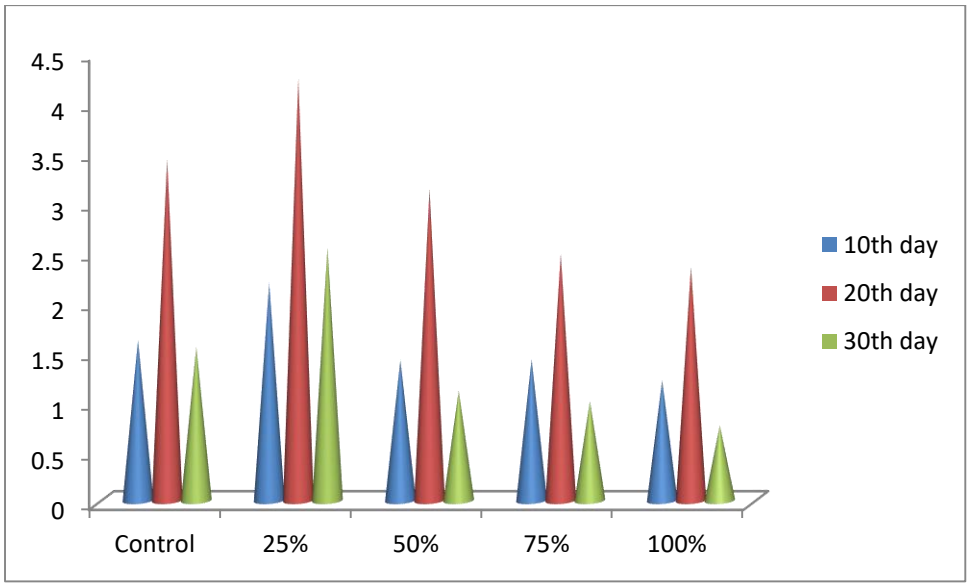


Fig. 6

Values are arithmetic mean of three replicates

Fig. 7 Concentrations of heavy metal in soil at different concentrations and time intervals (mg/g).

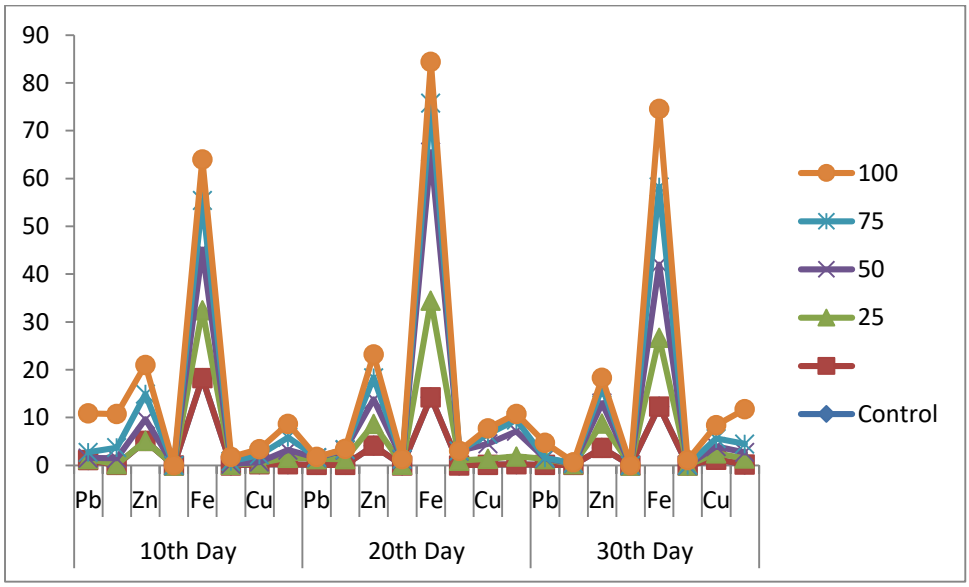


Fig. 7

Values are arithmetic mean of three replicates

Fig. 8 Concentrations of heavy metal in groundnut at different concentrations and time intervals (mg/g).

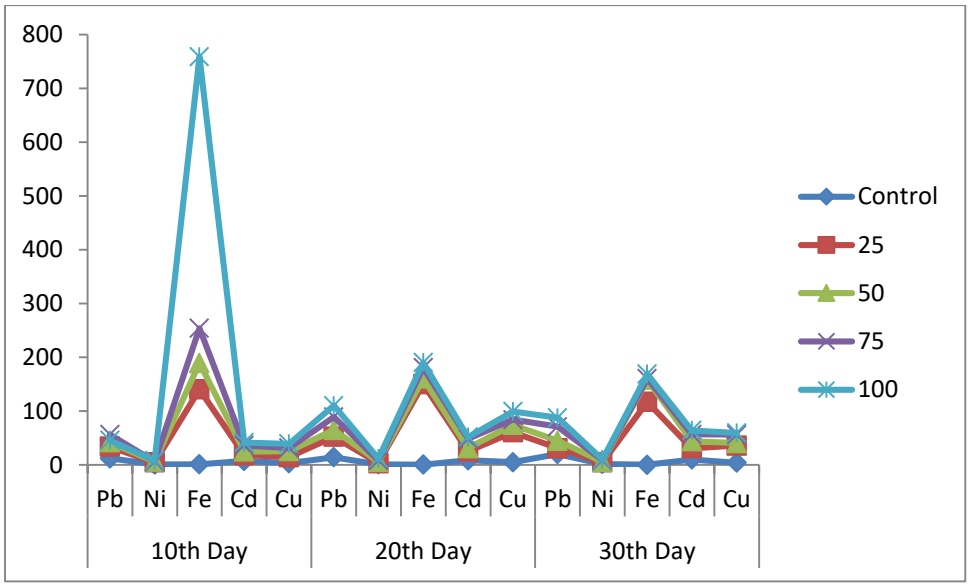


Fig. 8

Values are arithmetic mean of three replicates

Effects of Heavy Metals on Growth and Chlorophyll content:

The germination percentage of groundnut seeds on exposure at various concentrations and duration was (120 and 192 hrs) was shown in Fig.1. The highest seed germination was at 25% concentration and lowest at 100% of effluent were recorded, as compared to control. The root and shoot length were increased at 30th day as compared to control (Fig. 2 and 3) Where as at 100% of effluent concentration length of root and shoot was decreased at 10th day, 20th day and 30th day. The chlorophyll content was evaluated and recorded after exposure to different concentrations of effluent. At 25% concentration, chlorophyll a, b and total chlorophyll content showed an increase up to 20 days and a decrease in chlorophyll contents was observed in groundnut at 30 days. An overall decrease in chlorophyll content was recorded at all the experimental days compared to the control at 100% effluent concentration.

Metals concentration in Soils:

The metal concentrations in experimental plant soils fig.1. Pb, Ni, and Zn (mg/g) were high in 100% treatment at 10th day, on 20th day Mn, Cr, Cu, Ni, Fe, Pb and Cd (mg/g) were high in 50% treatment. Mn, Cu, Cr and Zn were high in 50% effluent on 25th day. Fe, Ni, Pb, Cd, Cu, Mn and Zn (mg/g) in 100% treatment on 30th day.

Metals concentration in plants:

The heavy metals in experimental fig.2. Fe was high in 10th day at 100 % treatment (759.32 mg/g) , in 20th day Ni, Cu, Fe and Pb (11.872, 99.601, 899.81, 110.36 mg/g) were high in 100% wastewater. Pb and Cd were (25.473, 64.357 mg/g) high in 100% effluent at 30th day.

Discussion:

Pot culture studies of groundnut were carried out with different wastewater concentrations. Heavy metals at high concentrations have severe toxic properties in crop plants and, therefore, their uptake and utilization are highly regulated by plant cells (Basharat Ali and Rafaqat A. Gill, 2022). High levels of EC can burn the plant or cause it to kill the plant. Blaylock, M.J. and JW Huang (200) has mentioned that high EC alters the chelating properties of receiving water systems and creates possible conditions for free metal availability to flora and fauna. Reduction of seed germination percentage may be caused by the high levels of dissolved solids in wastewater which enrich the salinity and conductivity of the absorbed solute by seed before germination (Gautam et al., 1992; Singh et al., 2006) and Murkumar and Chavan (1987) have reported that the higher concentration of effluent decrease enzyme dehydrogenase activity that is considered as one of the biochemical change which may have disrupt germination and seedling growth. Salt stress affects the seed germination and seedling establishment through osmotic stress, ion toxicity, and oxidative stress (Cuneyt Ucarli, 2020). Cultivation of crops in soil and water contaminated with heavy elements greatly reduces the yield and quality of their crops (Samiksha Singh *et al.*,2016). Inhibition of root length may be due to high levels of Cu. Zobel *et al.,* (2007) noted that inhibition of root growth was accompanied by an increase in root diameter, suggesting that the plant cytoskeleton may also be a target for heavy metal toxicity. According to the findings of Peto *et al.* (2011) High amounts of Cu inhibit plant root elongation and alter morphology by inducing changes in auxin levels that oppose nitric oxide function. A combination of copper and Cd have a negative effect on germination, seedling length and number of lateral roots in *Solanum melongena* (Nanda, P., *et al.*, 1999). The presence of Zn at high concentrations inhibits plant growth and development by interfering with some important metabolic processes (Alia *et al.*,1995). Salt D.E., *et al., (*1998) has reported that heavy metal induced reduction in total chlorophyll in pigeon pea due to Cd and Ni stress. Dong et al., (2005) mentioned that cadmium stress severely effects the photosynthetic rate and intracellular CO2 concentration in tomato seedlings. Maleva *et al.* (2012) have reported that heavy metals such as Mn, Cu, Cd, Zn and Ni drastically decreased the levels of chlorophyll contents accompanied by a decrease in the photochemical efficiency of photosystem II (PSII) in *Elodeadensa* and in *Thalassia hemprichii (*Li *et al.*,2012). Cadmium in one of the most dangerous heavy metals due to its high mobility, affecting plants even to low concentrations (Barcelo, J. and C.H. Poschenrieder, 1992). Excess levels of cadmium absorbed by plants reduced the concentration of ATP and chlorophyll content and decreased oxygen production. Pb is also one of the heavy metals that control plant growth and showed severe damage in growth and photosynthetic activity of many plants.

Pb is found in plants from many sources, including soil, but reports of the metal in plants were vary (Motto, H.L., *et al.,* 1974 and Muthusamy, A. and N. Jayabalan, 2001). High concentration of Lead causes to retardation in plant growth, negative effects on photosynthesis, blackening of roots and disturb mineral nutrition and water balance, changes hormonal status and affects membrane structure and permeability (Farouk S Nas and Muhammad Al., 2018). Arun K. Shanker *et al.,* (2005) reported that Cr also causes deleterious effects on plant physiological processes such as photosynthesis, water relations and mineral nutrition.

Conclusion

This work was carried out on the impact of soil pollutants on groundnut seedlings. Heavy metals at higher concentrations showed deleterious impacts in experimental plants. Plants growing in such type of contaminated soils and waters; crop yielding reduces and finally it effects live-stock and on human beings. Hence it may be suggested that 25% of wastewater contains nutrients and can be used as a suitable liquid fertilizer for irrigation use. Higher concentrations of heavy metals significantly reduced the plant growth and crop yield. The data presented here are also useful for detecting pollution load in soils due to accumulation of heavy metals from untreated wastewater which is discharged into drains without proper treatment.

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The Pot Culture Experiment Investigated The Influence Of Lead On The Germination And Seedling Growth Of Arachis Hypogaea.

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Abstract- The effect of Lead contamination on the germination and seedling growth of arachis hypogaea was evaluated through a pot culture experiment on Arachis hypogaea. L. (Groundnut) under ordinary laboratory conditions with and without Lead treatment. Lead treatment at 3, 4 and 5 mg/L influenced seed germination when compared to the control. Lead concentrations of 2,3,4, and 5 mg/L influenced root and soot length as compared to the control. The greater dose of 5 mg/L had a significant ($p<0.05$) effect on the seedling and physiological changes. With increasing Lead concentrations, there was a significant decrease in seed germination, seedling development, root, and soot length.
Index Terms – Lead Nitrate, Pot culture, seedling, germination, etc.,

I. INTRODUCTION

The presence of heavy metals poses a significant concern due to their toxic nature, which has adverse implications for ecological, evolutionary, and environmental aspects [1]. Lead, symbolized as "Pb" on the periodic table, is an elemental substance that originates from the Latin term "plumbum." With an atomic number of 82, it falls under the category of heavy metals. The toxicity of lead is significantly detrimental to both humans and other living organisms. Exposure to this element can result in a wide array of health complications, particularly impacting the nervous system. It is important to note that even minimal levels of lead exposure can be detrimental, especially for children, as their developing brains and bodies are more vulnerable to its adverse effects. Various sources contribute to lead exposure, including lead-based paint, lead pipes found in outdated plumbing systems, lead-acid batteries, and the previous utilization of lead gasoline. Additionally, industrial processes, soil contamination, and specific consumer products may also play a role in the exposure to lead.

Lead toxicity often results in the hindrance of seed germination and the stunted growth of plants[2,3,4,5,6,7]. Lead pollution is the result of the introduction of lead, a hazardous heavy metal, into the environment. This contamination can have significant and far-reaching implications for both human health and the environment. The accumulation of lead pollution in soil can occur through various means, such as the presence of lead in old gasoline, industrial runoff, and the deterioration of paint. Additionally, the combustion of lead gasoline, although largely phased out in many areas, and industrial emissions can release lead into the atmosphere. The adverse health effects of lead pollution have been extensively documented and can be particularly severe, especially in children. Exposure to lead can result in neurological and developmental issues, as well as other health complications in both children and adults.

The global concern over the influx of heavy metals into water bodies from various sources, including industrial, agricultural, and domestic activities, is due to their well-documented negative impacts on both human health and ecosystems [8]. The effects of lead on the shoot, root lengths, and seedling dry biomass of Lythrum salicaria were found to be highly significant [9]. The concentration of lead in soil and wheat tissues, as well as along roads, was found to decrease with increasing distance from the roads [10]. Lead-induced changes in germination behavior, growth and inhibition of δ-aminolevulinic acid dehydratase activity in Raphanus sativus L [11]. Effects of lead on seed germination and seedling growth of wheat (triticum Aestivum) [12]. The release of harmful exhaust gases and toxic pollutants, such as unburnt and partially burnt hydrocarbons and lead compounds, from dense traffic contributes to the pollution of urban environments. The objective of the current study was to examine the impact of lead on the process of seed germination and subsequent seedling growth of Arachis hypogaea.

II. METHODOLOGY

Seeds of Arachis hypogaea L. were procured in a random manner from Dr. A. G. Ranga Agricultural University in Tirupati, Andhra Pradesh, India. To eliminate any impurities from the seed coat, a treatment of 0.1N Lead Nitrate was administered for a duration of two minutes, followed by five washes with running tap water. The study was conducted on Arachis hypogaea L. using varying concentrations of Lead Nitrate (1, 2, 3, 4, and 5 mg/L), with distilled water serving as the control. Twenty-five seeds were placed in petri dishes, and a daily addition of 10 ml of Lead Nitrate solution was made. Each day, twenty-five seeds were planted in petri dishes on Whatman paper No.42, along with 5 ml of the heavy metal Lead Nitrate solution. The research was carried out in a laboratory setting, both during the day and at night, to evaluate the root, shoot length, and seedling growth of Arachis hypogaea L. through a pot culture experiment. After an incubation period of 5 days, the number of seed germinations was recorded and expressed as a percentage of germination. Following 21 days of seedling growth, the length of the roots and branches was measured using a meter scale.

III. RESULTS

The data on groundnut seed germination, seedling, root, and shoot lengths are presented in Table 1. The application of Lead Nitrate solution at varying concentrations (1,2,3, 4 and 5 mg/L) resulted in a reduction of these parameters as compared to the control. Notably, the Lead treatment at concentrations of 3 mg/L, 4 mg/L, and 5 mg/L had a significant impact on seed germination. Additionally, an increase in Lead Nitrate content by 5 mg/L had a substantial effect on the growth of groundnut seedlings in comparison to the control. However, an increase in the concentration of Lead Nitrate up to 3 mg/L had detrimental effects on root growth and shoot length.

Treatment Lead Nitrate (Pb) mg/ L	**Seed germination (%)**	**Root Length (cm)**	**Shoot Length (cm)**	**Seedling Length (cm)**
Control	90 ± 0.276	6.5 ± 1.006	10 ± 1.062	11 ± 0.186
1mg/ L	86 ± 0.514	4.4 ± 0.112	7.9 ± 0.375	10.7 ± 0.698
2 mg/ L	66 ± 0. 286	2.6 ± 0.128	7.4 ± 0.129	10 ± 0.682
3mg/ L	48 ± 0.012	2.4 ± 0.126	7.1 ± 0.216	5.6 ± 0.445
4 mg/ L	34 ± 0.008	2.0 ± 0.268	5.9 ± 0.238	5.4 ± 0.182
5 mg/ L	22 ±0.216	1.7 ± 0.146	5.1 ± 0.234	5.0 ± 0.292

Values are arithmetic mean ± S. E. of three replicates.

Table 1. Effect of different concentration of Lead Nitrate on seed germination, root, shoot and seedling length of Arachis hypogeae *L*.

Number followed by the identical letter within the corresponding column exhibit no substantial variation at a significance level of $P< 0.005$.

IV. DISCUSSION

Arachis hypogaea L, a member of the Fabaceae family, is a valuable cash crop and rotation crop. The byproducts of groundnut, including shell, haulms, and hay, serve as excellent sources of fodder. Groundnut cake, a nutritious feed for cattle, can also be utilized as manure following oil extraction. Its high dietary fiber content renders it an ideal food for digestion. Trees and plants can directly or indirectly absorb metals through water and soil contamination. Lead, which is detrimental to human health, as well as bacteria, plants, and animals, exhibits a gradual decrease in concentration during the process of seed germination and seedling growth in Arachis hypogaea L. The treatment of Lead significantly inhibits seed germination in comparison to the control group. However, the shoot length and root growth of Arachis hypogaea L show an increase with rising concentrations of Lead when compared to the control group. Ultimately, it has been determined that Lead Nitrate poses a significant hazard to the growth of seedlings in Arachis hypogaea L.

V. CONCLUSION

The necessity for additional investigation into Lead contamination in plants via soil is underscored by the findings of this study on the impact of Lead Nitrate on Arachis hypogaea L. This research holds considerable significance in elucidating the effects of Lead pollution on plants through soil, as it facilitates the exploration of plant physiology by utilizing diverse metal concentrations. Furthermore, it is imperative to conduct further research to comprehensively analyze metal determination in the environment and various plant regions.

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The Impact Of Mercury On The Germination And Seedling Growth Of Arachis Hypogaea In A Pot Culture Experiment

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Abstract- Mercury is the only common metal which is liquid at ordinary temperatures and occurs in several forms, all of which can produce toxic effects in high enough doses. In the laboratory, a pot culture experiment was performed on Arachis hypogaea. L. (Groundnut) with and without mercury chloride treatment. Mercury treatment at 6, 8 and 10 mg/L influenced seed germination when compared to the control. Mercury concentrations of 4, 6, 8, and 10 mg/L influenced root and soot length as compared to the control. The greater dose of 10 mg/L had a significant (p 0.05) effect on the seedling and physiological changes. With increasing Hg concentrations, there was a significant decrease in seed germination, seedling development, root, and soot length.

Index Terms - Mercury, Pot culture, seedling, germination, etc.,

I. INTRODUCTION

Mercury (Hg) is a perilous heavy metal that, when found in aquatic ecosystems, has the potential to disturb the ecological equilibrium. It is noteworthy that mercury is the sole common metal that remains in a liquid state under normal temperatures and exists in various forms, all of which possess the ability to induce toxic effects when administered in sufficiently high quantities. The existence of heavy metals in the atmosphere, soil, and water, even in minute concentrations, can give rise to severe complications for all living organisms. It is important to note that heavy metals, when present in concentrations surpassing a certain threshold within a narrow range, transform into toxic substances [1].

Mercury (Hg) is a hazardous heavy metal element that poses a significant threat to both organisms and the environment when it contaminates aquatic environments. The accumulation of Hg in aquatic habitats is attributed to both natural and anthropogenic sources. Natural sources include geologic parent material, rock outcroppings, wind-blown dusts, volcanic eruptions, marine aerosols, and forest fires, while anthropogenic sources include mining, coal combustion, and hazardous industrial solid/liquid waste disposal. The release of Hg into ecosystems worldwide is a result of modern industrialization and urbanization. [2-4].

While it is widely acknowledged that the toxicity of mercury in plants is linked to its availability in the surrounding environment, limited research has been conducted on the effects of mercury under controlled conditions with restricted concentrations. Plants employ two primary strategies, namely accumulation and exclusion, to respond to high levels of heavy metals [5]. Heavy metals pose a significant environmental concern, and their increasing presence has become a pressing issue from ecological, evolutionary, and environmental perspectives [6]. The pollution caused by mercury has emerged as a critical global problem due to its detrimental impact on the environment [7]. In the 1950s and early 1960s, mercury was utilized in the separation of lithium isotopes to produce nuclear weapons [8].

The increasing influx of heavy metals into the human body as a result of industrial, agricultural, and domestic activities is a matter of global concern due to their well-documented negative effects on both human health and ecosystems [9]. Heavy metal contamination has been observed in various locations worldwide, impacting the biosphere [10-12]. The accumulation of trace metals, particularly heavy metals, in the soil has the potential to hinder the soil's functionality, cause toxicity to plants, and contaminate the food chain [15]. The presence of heavy metals can lead to a significant ecological crisis, as they are non-degradable and tend to accumulate in plant parts, resulting in a detrimental biological impact that is magnified through trophic levels. For instance, mercury has been found to reduce the levels of potassium, manganese, and magnesium in roots, while accumulating iron in root tips [16]. It is worth noting that the effects of metals are typically studied under sterile and simplified laboratory conditions, which may differ to varying degrees from real-world field conditions [17]. Plant-based bioassays offer a cost-effective and appealing approach to assess the impacts and hazards associated with various contaminants or environmental factors [18]. Moreover, they can provide valuable guidance for biomonitoring and bioremediation efforts [19, 20]. These procedures rely on the unique ability of plants to accumulate specific substances [21]. Recently, there has been a growing interest in utilizing duckweed for biomonitoring and bioremediation purposes. Duckweeds belong to the Lemnaceae family and are a type of free-floating aquatic plant. They can be found in diverse freshwater habitats, including ponds, lakes, ditches, and rice paddies [22]. Additionally, several studies have investigated the effects of mercury on seed germination [23, 24].

II. METHODOLOGY

Seeds of Arachis hypogaea L. were obtained in a random manner from Dr. A. G. Ranga Agricultural University in Tirupati, Andhra Pradesh, India. To remove any contaminants from the seed coat, the seeds were subjected to a treatment of 0.1N Mercuric chloride for a duration of two minutes, followed by five washes with running tap water. This experiment was carried out on Arachis hypogaea L. using different concentrations of Mercuric chloride (2, 4, 6, 8, and 10 mg/L), with distilled water serving as the control. Twenty-five seeds were placed in petri dishes, and daily 10 ml of $Hgcl_2$ solution was added. Each day, twenty-five seeds were planted in petri dishes on Whatman paper No.42, along with 5 ml of the heavy metal $Hgcl_2$ solution. The investigation was conducted in a laboratory setting, both during the day and at night, to assess the root, shoot length, and seedling growth of Arachis hypogaea L. through a pot culture experiment. After a period of 5 days of incubation, the number of seed germinations was recorded and expressed as a percentage of germination. Following 21 days of seedling growth, the length of the roots and branches was measured using a meter scale.

III. RESULTS

Table 1 presents the data on the seed germination, seedling, root, and shoot lengths of groundnut. The application of mercuric chloride solution (2, 4, 6, 8, and 10 mg/L) resulted in a reduction in the parameters of groundnut as compared to the control. Notably, the mercury treatment at concentrations of 6 mg/L, 8 mg/L, and 10 mg/L exhibited a significant impact on seed germination. Furthermore, a 10 mg/L increase in mercury chloride content had a substantial effect on the growth of groundnut seedlings in comparison to the control. However, an increase in the concentration of mercuric chloride up to 6 mg/L had detrimental effects on root growth and shoot length.

Treatment Mercury chloride (Hg) mg/ L	**Seed germination (%)**	**Root Length (cm)**	**Shoot Length (cm)**	**Seedling Length (cm)**
Control	92 ± 0.282	6.3 ± 1.042	10 ± 1.084	12 ± 0.186
2mg/ L	84 ± 0.523	4.6 ± 0.114	8.0 ± 0.357	11.8 ± 0.707
4 mg/ L	63 ± 0. 298	2.8 ± 0.136	7.5 ± 0.132	11 ± 0.707
6mg/ L	46 ± 0.075	2.5 ± 0.135	7.3 ± 0.217	5.9 ± 0.434
8 mg/ L	32 ± 0.074	2.0 ± 0.286	6.0 ± 0.244	5.5 ± 0.189
10 mg/ L	24 ±0.220	1.8 ± 0.162	5.0 ± 0.242	5.1 ± 0.296

Values are arithmetic mean ± S. E. of three replicates.

Table 1. Effect of different concentration of $Hgcl_2$ on seed germination, root, shoot and seedling length of Arachis hypogeae *L*.

Number Followed by the same letter in the same column are not significantly different at P< 0.005.

IV. DISCUSSION

Arachis hypogaea L, a member of the Fabaceae family, is a valuable cash crop and rotation crop. The byproducts of groundnut, including shell, haulms, and hay, are excellent sources of fodder. Ground nut cake is a nutritious feed for cattle and can also be used as manure after oil extraction. Its high dietary fiber content makes it an ideal food for digestion. Trees and plants can absorb metals directly or indirectly through water and soil contamination. Mercury is harmful to human health, as well as bacteria, plants, and animals. The concentration of mercury in seed germination and seedling of Arachis hypogaea L. gradually decreased. Mercury treatment significantly reduced seed germination when compared to the control. However, shoot length and root growth of Arachis hypogaea L increased with increasing mercury concentrations when compared to the control. Finally, it was discovered that mercury chloride posed a significant hazard to the seedling growth of Arachis hypogaea L.

V. CONCLUSION

The findings of this study regarding the impact of mercuric chloride on Arachis hypogaea L highlight the necessity for further investigation into mercury contamination in plants via soil. This research holds significant importance in elucidating the effects of mercuric pollution on plants through soil, as it enables the exploration of plant physiology through the utilization of diverse metal concentrations. Moreover, additional research is imperative to comprehensively analyze metal determination in the environment and various plant regions.

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WOMEN ROLE IN ENVIRONMENTAL PROTECTION: A CASE STUDY IN GANGUDUPALLI VILLAGE, CHANDRAGIRI MANDAL, SRI BALAJI DISTRICT, ANDHRA PRADESH, INDIA.

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Abstract: The natural environment refers to all living and non-living components that exist without human interference. This word is frequently used to describe the Earth or specific areas of it. It includes all living organisms, weather patterns, climate, and natural resources that influence human survival and economic endeavours. In developing countries like India, women bear the primary responsibility for managing and conserving resources within their families. They dedicate significant amounts of time to tasks such as gathering and storing water, ensuring access to fuel, food, and fodder, as well as overseeing the management of various types of land, including forests, marshes, and agricultural areas. This paper discusses about how a women play a key role in protecting the natural environment by studying the practices and daily activities of Gangudupalli village women towards environmental protection.

Index Terms: **Women, India, Gangudupalli village, Environmental Protection, Sustainability, etc.**

I. INTRODUCTION

The term "environment," which means "to surround,". The word "environment" refers to the interaction of water, air, and land, as well as their interactions with one another, humans, other living things, and property. According to Schultz et al., [1] the women, environment and development (WED) -debate is based on a critical perspective of development policies, emphasizing the connection between modernization/industrialization, technology, and environmental degradation. Women, on the other hand, have long been considered the lower sex. On a worldwide scale, women are often in charge of managing and saving resources for their families. Women are breaking new ground in a range of sectors, including the investigation of the world's water resources and the conservation of forest resources.

Women play a vital role in the management of natural resources, including land, water, forests, and energy. Women in underdeveloped regions of the world are regarded as the primary consumers of natural resources such as land, forests, and water, as they are accountable for collecting food, fuel, and fodder [2]. They possess both traditional and modern knowledge about the natural environment surrounding them. In the past, women were often overlooked or disregarded, but there is now a growing recognition of the significant impact they have on the environment. Additionally, there is an increasing understanding of how the environment affects the health and well-being of women. This shift in perspective is evident in events such as the 1992 UN Earth Summit, the Chipko movement in India, and the Green Belt Movement in Kenya. These initiatives highlighted the importance of women's voices and perspectives in promoting sustainable development at all levels, from the highest decision-making bodies to local communities. In recent decades, environmental movements have increased as the movements for women's rights have also increased. Today's union of nature preservation with women's rights and liberation has stemmed from invasion of their rights in the past [3,4].

In the Asian and Pacific Island regions, the majority of women involved in the economy are engaged in the agriculture sector, which encompasses various activities such as work in own-account farms, labor in small enterprises for processing fruits, vegetables and fish, paid and unpaid work on other people's land, and collecting forest products. However, only a small percentage of these women, ranging from 10-20%, have been able to secure tenure to the land they work on due to economic and legal barriers. One such barrier is the gender disparity in access to loans, which results in women receiving fewer and less favorable loans to acquire land compared to men [5].

Women's direct involvement with the environment has resulted in a deep grasp of it. As a result, Women act as agriculturalists, water resource managers, traditional scientists, etc among others. Women interact with the natural and man-made environments more extensively than males, owing to their major duty for domestic and home administration. As a result, individuals are more vulnerable to the negative consequences of degraded home, neighbourhood, and city environments, and they incur a greater cost associated with living in substandard homes and communities with inadequate residential and health infrastructure. Women are predominantly responsible for farm work and domestic food production across the globe [6,7,8,9]. Although there is a growing trend of women taking on more agricultural tasks and expanding their involvement, the gender-based division of labour remains unchanged in terms of reproductive work.

It is imperative to comprehend the diverse methods through which women have actively engaged in the preservation and administration of the environment, with the intention of incorporating them into environmental management initiatives. The purpose of this manuscript is to evaluate the participation of women in environmental management, specifically focusing on a small village.

II. STUDY AREA

Gangudupalli is a Village in Chandragiri Mandal in Chittoor District of Andhra Pradesh State, India. It belongs to Rayalaseema region. It is located 6 KM from Chandragiri town and 21 KM towards West from District headquarters Sri Balaji. According to 2011 census, Gangudupalli Village Local Language is Telugu. Gangudupalli Village Total population is 1080 and number of houses are approximately 250. Female Population is 53.3%. Village literacy rate is 61.6% and the Female Literacy rate is 33.0%. Their major occupation is Agriculture, Cattle maintenance, Silkworm cocoon cultivation. Apart from that, few of them doing Jobs and businesses at various sectors located in and around Tirupati.

In this paper, we employ two different categories of data. The initial category consists of secondary source materials, acquired from prior research on women's participation in environmental preservation and control. These materials encompass books, journal publications, and articles obtained from online sources. The second category of data was procured from primary sources, specifically through the distribution of questionnaires to the women residing in the rural area of Gangudupalli Village.

III. REVIEW

3.1. Water Resource Management

Etta [10] conducted a survey in Mariko Lower-income settlement in Lagos, which revealed that women hold a pivotal role in managing communal water resources and fulfilling household water requirements. Women are primarily responsible for regulating and supervising communal taps or water points, and they often secure these sources to prevent damage by children. At the household level, women and girls are burdened with the task of fetching water for various domestic activities such as cooking and washing. Conversely, men tend to dominate the water trade. Unfortunately, these sources are susceptible to pollution, especially from untreated sewage, which poses significant health risks [11,10]. In rural areas, women are solely responsible for procuring water for their domestic needs. However, the methods and practices employed in obtaining water, particularly from riverbanks, contribute to water pollution [12].

3.2. Women in Agriculture

Women's contributions to agricultural production have been significant worldwide, with the Food and Agriculture Organization reporting that they are responsible for producing more than half of all food grown in 1996. In certain regions, such as sub-Saharan Africa and the Caribbean, women produce an astonishing 80% of basic foodstuffs. Adebayo et al [13] found that in Asia, women provide between fifty and ninety percent of the labour force for rice cultivation, while in Adamawa State, Nigeria, 60% of women are involved in farming. Jayasheela [14] outlines the various roles that women play in Indian agriculture, including production and distribution, planting and cultivation, weeding, hoeing, harvesting, and storage.

Women in Gangudupalli Village play a significant role in the agricultural sector by contributing to the production of rice, groundnuts, and sugarcane. Additionally, they are actively involved in cultivating livestock crops for their cows, buffalos, goats, and other animals. This highlights the close interaction between women and the environment, particularly the land. As victims of soil degradation, women have actively participated in initiatives aimed at conserving soil. A notable example of their involvement is the Agro-forestia project in Yatenga, Burkina Faso. Moreover, Igbo women have taken on traditional male agricultural responsibilities, in addition to their existing roles within the female sphere [15, 16].

3.3. Solid waste disposal

In the specified research domain, the rate of solid waste accumulation surpasses the pace of population expansion. The disposal of solid wastes commonly occurs at designated dumping sites or undeveloped areas. Women, owing to their proximity to the environment, actively engage in environmental stewardship by undertaking responsibilities such as cleaning and upholding cleanliness, particularly in relation to garbage disposal. Acknowledging the health hazards linked to waste, women assume the responsibility of ensuring its consistent removal at the communal level.

IV. RESULTS

The present section presents the outcomes of the questionnaire survey carried out to examine the extent of women's involvement in environmental management within the specified study area, namely Gangudupalli Village. The demographic characteristics, specifically age and marital status, of the women are presented in Table 1. It is worth mentioning that a mere 17.6% of the women surveyed are below the age of 22 years. The majority, accounting for 66.4%, belong to the middle age group (23-50 years), while only 16.0% are aged above 50 years. This distribution of age indicates that a significant proportion of the women are still in their prime years and possess the necessary Vigor to actively engage in environmental management activities.

Table 1. Age and marital status of survey women

S.No	Age Group	Number	Percentage
1	Below 22 years	18	17.6
2	Middle age (23-50) Years	65	66.4
3	Above 50 years (51-75)	17	16

Table 2 displays that a significant majority of female participants, specifically 66.4%, are involved in agricultural activities in the study area. Organic farming is the most used method of soil conservation by women. Planting trees is recognized as an effective approach to safeguarding the environment and mitigating hazards such as windstorms and erosion. The survey results indicate that almost 76.2% of women in the study area have planted trees or flowers within the past five years, further supporting the notion that women actively engage in tree planting. Fruit trees, such as mango, sapota, papaya, and various fruit plants, are frequently planted by women, serving the dual purpose of environmental protection and providing fruits for household consumption.

Table 2 Women involvement in Environmental Management

Involvement in Farming	Percentage(%)
Yes No	66.4 33.6
Planting trees (Farming/Around the house)	Percentage (%)
Yes No	76.2 23.8
Conserving methods	Percentage (%)

Organic farming planting	55.7 44.3
Major activities in Environmental Cleaning	Percentage (%)
Weeding Sweeping Drainage	22 63 15

The challenges faced by women in environmental management within the study region were identified by the participants as follows: firstly, there is a lack of environmental consciousness among the general population; secondly, there is a shortage of waste disposal facilities; and finally, there is an insufficiency in drainage systems.

V. RECOMMENDATIONS

To achieve sustainable development, it is recommended that active involvement of women in environmental management be promoted, while considering the obstacles they currently face. To bring about a transformation in the mindset of the populace and equip them with relevant knowledge, it is crucial that environmental education becomes mandatory for the majority of women. This will address the issue of individuals carelessly discarding paper scraps, fruit peels, plastic cans, and polythene bags on the streets for mere amusement.

Additionally, prioritizing women's education and ensuring access to education for girls should be considered a policy imperative. Educated women will play a significant role in bridging the gap between the environment and development. It is important to duly acknowledge and support the empowerment of women in sustainable human development, as well as their role in safeguarding the environment.

VI. CONCLUSION

In conclusion, it is evident that both married and single women have actively engaged in the preservation of the environment. However, a noteworthy proportion of women involved in this endeavour are married. This substantial presence of married women within the study area implies that they are more inclined to assume responsibility for the conservation and cleanliness of the environment due to their roles as homemakers. Consequently, this study has examined the diverse ways in which women have actively contributed to the protection of the environment and the management of natural resources, aiming to ensure the sustainable utilization of environmental resources.

Based on the findings, recommendations are proposed, particularly those that can facilitate the empowerment of women. The crucial role of women as managers of resources, advocates for the environment, and activists within their communities must be acknowledged when devising strategies for environmental protection. It is imperative to provide women with the opportunity to participate in environmental matters at the local, regional, national, and international levels. For women to have a substantial influence on decision-making processes, their representation should be equal to that of men. As resource managers, women should be consulted and supported in their ongoing efforts to safeguard the environment. Specifically, a greater inclusion of women in decision-making processes concerning environmental policies, programs, and funding is essential.

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LANDFORMS AND LAND SYSTEMS OF CHITTOOR DISTRICT, ANDHRA PRADESH, INDIA

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Abstract
Landforms and Land systems are the collective form of Geomorphology, which contributes more to the ground water and agricultural resources of an area. Ground water and Agricultural resources are basic for the economic prosperity of a country. The various land systems and landforms include Mountains, Plateaus, Plains, Rocky mounds, Escarpments, Domal hills, etc. As the human settlements and activities are generally restricted in regions where mountains dominate, the population in such regions is comparatively sparse. Agriculture is not well developed because of the scarcity of level land, the problem of soil erosion and restricts the ground water flow in the area. Chittoor District, in which the present study is one, is one of the drought prone areas of the State of Andhra Pradesh due to its peculiar location in the leeward side of the Western Ghats. So, in the present paper an attempt has been made to identify various landforms and landsystems and examine how they contribute to ground water resources and allied agricultural activities.

Key Words: *Landforms, Land systems, Undulating terrain, Fluvial plains, Escarpments, Palaeo-channels, Landslides, Lineaments, Geological formations.*

Introduction

Geomorphology is the science of different Landforms. Since each landform has its own characteristic attributes that reveal the conditions that lead to its formation, reconstruction of the physical process that operated or operating in the area can be interpreted based on the identification of landforms in that area. As such geomorphology assumes importance, since it involves interpretation of the origin and dynamics of various Earth's surface features and thus provides essential inputs for evaluation of resources like groundwater, soils and materials; Civil engineering (i.e. for locating suitable sites for the construction of roads, canals, buildings, bridges and dams etc.) and other branches of knowledge which requires understanding of the Earth's surface. It also explains the occurrence of landslides, which is one of the natural hazards of this area. So, the identification and mapping of landforms and land systems is an important facet of geomorphology. They are treated as '**Land Resources'** of the study area. So the aim of the present study is to deciper the various land systems and landforms of Chittoor District keeping in view its role in the formation of soils, ground water flow and agricultural activities.

Study Area

Chittoor District derives its name from Chittoor, its head-quarters town from 1st April 1911. It was located 12° 37' to 14° 8'N and 78° 3' to 79° 55'E. It is bordered by Anantapur, Cuddapah and Nellore districts in the north and by Tamil Nadu State in the south and east and by Karnataka State towards the west. It is situated in the south-eastern fringe of Andhra Pradesh. It is the smallest district in area compared to all the districts of Rayalaseema, covering an area of 15,152 sq.km with a population of in 2001 census, Chittoor had a population of 37,45,875 of which males were 1,889,690 and remaining 1,856,185 were females. Survey of India (SOI) Toposheets bearing the numbers 57K, 57L and 57O on 1:50,000, 1:25,000 scale (1975) formed the base for mapping the region and the satellite imageries of IRS-IC (LISS-IV) (2006) and CARTOSAT for the study of temporal changes that occurred. That was centuries ago. All that has changed. The resources of land and water have become minimum and prosperity has yielded place to poverty. For the last hundred years, the economic history of Rayalaseema, in which the present study is one, has been the very history of droughts and famines mainly due to failure of monsoon and hence today "Rayalaseema is referred to as the "Famine Zone of South India", "the blakest spot on the famine map of India" and the Mezzogiorno" of Andhra Pradesh.

Review of Literature

Many attempts have been made by Geologists, Hydrogeologists, Geographers and other scientists to map various land resources, as they are extremely significant in the formation of soils, soil erosion, ground water occurrence and ground water flow etc. Such a study is also useful to note the areas of landslides, which is one of the natural hazards of this area. In this context, Jayaraju and Bhaskara Reddy (1989) worked much on the identification of Landforms of Chittoor district, basing upon LANDSATS on scale 1:250,000. The "Indian Photo interpretation Institute" at Dehradun and the 'National Remote Sensing Centre" at Hyderabad have been instituted by the Government of India to publish Aerial Photographs and LANDSATS, which are of great use in assessing land resources and landuse. Raghavaswamy and Vaidyanadhan (1981), worked on the Landforms of Visakhapatnam District. Sambasiva Rao and Nageswara Rao (1983), worked more on the Landforms of Godavari and Krishna rivers respectively. Vohara (2008) has published a paper on "Land and water management problem in India" basing upon the availability of landforms and landsystems.

Methodology

Remote Sensing and Geographical Information System (GIS) techniques were adopted to study the Landsystems, Landforms, Landuse, Lineaments and Relief etc. The studies were undertaken critically on Air Photos on scale 1:60,000, Landsats 1:1 million, 1:250,000 and False Color Composits (Fcc's) 1:1 million and 1:250,000. The Survey of India (SOI) Topographical numbers 57K, 57L and 57O on 1:50,000, 1:25,000 scale were used as the base maps.

Geological Formation

The nature and structure of geological formations have many indirect influences on agricultural lands. Geological formations provide the basic materials and structures for the parent materials of the soils. Through the relief, the geological formations have a strong impact on climate and hydrology. Hence, these geological formations were studied in greater depth, which is also a land resource. The rock types met within the district are of diverse types ranging in age from Archaean to recent. Most of the area in Chittoor district is covered by precambrian granites, which are highly magmatised. Cuddapahs and Upper Gondwanas occur as outliers at one or two places. The geological sequence of the district is given below.

Geology Map of Chittoor Distirct

Age	Formation
Quaternary	
Subrecent –alluvium	Gravels, course to fine sands, silts and clays 3 to 5mts. thick.
Recent –Talus	Pebbles and other debris in valley fill areas.
Pleistocene-Laterite	Very hard and compact rocks of fine quartz graining in ferruginous material
Upper Gondwanas	Conglomerates of quartizite pebbles embedded in ferruginous matrix.
Lower Cuddapahs – Nagari	Quartzites with intercalating shales.
Archaeans – Dharwars and other Crystallines	Dolerite Dykes, granites and gneisses with (Porphyritic) feldspar, quartz, mica and hornblende.

RELIEF AND LAND SYSTEMS

The influence of relief on agriculture is multifaceted. Relief is the expression of the interact ion of several different phenomena and processes within the earth Is crust and on its surface. Its forms and dimensions are primarily related to geological formations and to the climate, which have either directly or indirectly acted upon these formation through the process 3f weathering and the concomitant soil formation, So, relief is therefore typically connected with many of the other land resources. Its influence on climate (which was mentioned previously), hydrology and formation of soils (including its negative aspect of soil degradation) are largely dependent upon the nature of the relief. In the present course of investigation the interactions of relief can be observed clearly in *the* formation of soils, climate, hydrology, landforms, drainage and even in the distribution of population, etc. *The* study area lies in a morphologically transitional zone between the interior plateau and the coastal plain. In addition, the north-aouth running Eastern Ghat ranges run in the middle of the district forming its backbone and *the* water divide for many streams, The district slopes down from west to east from an average elevation of about 750 mts,, on the west to about 50

mts on the eastern margin. The district may conveniently be divided into 3 natural divisions as given below.

(a) The Western Hilly Region he Karnataka plateau)

Which comprises isolated hills and hillocks covering the areas of Punganur, Madanapalli and Thamballapalli.

(b) The Central Upland Region

Which comprises three ranges, i.e., (1) Mahendragiri hills covering the areas of Kuppam, Palamaner, Chittoor, Chinnagottigallu and Vayalapadu, (2) The southern portions of Palakonda and Velikonda ranges partly covering the areas of Vayalapadu, Srikalahasti and Chandragir Fort and (3) Nagari hill s covering parts of the areas of Puttur, Nagari and Satyavedu.

(c) **The Plain Region**

Which consists of the valley plains of Bahuda, Pincha, Swarnamukhi, Paler, Arani and Nagari rivers and the coastal plain which lies to the east of Palakondas and Nagari hils.

The relief and land systems of the study area have been delineated based on studies from topographic sheets and false colour composites (F.C.C'S) of LANDSATS. The land systems are delineated based on the assumption that similar grey tones under similar topographic expression reflect similar surface and subsurface moisture conditions, vegetation and organic content of the soils. Tentatively light tones were considered to reflect red soils, colluviurn and sands medium tones to reflect sandy soils to sandy loams on rolling plains and dark tones to reflect sandy, silty , clays on level plains, namely, flood plains, ancient channels, etc. These tones may help in deleneating areas of relative importance in locating groundwater. Field trips have been carried out to various parts of the district to counter check the various systems identified from the study of topographic and related fields. The various land systems identified are:

(1) Hilly terrain

The western part of the district is bordered by a group of hills which belong to Eastern Ghats trending NE-NNE and SE direction, These hills are composed of mainly granites, quartzites and charnockites, The general elevation in these hills range from 1,314 mts. (Horsely Hills) to 1,131 mts. (Tirumala hills) above MSL., with steep slopes exceeding 20 per cent. Field studies in these regions also throw light on differential weathering particularly in the regions where sections of folds are clearly exposed. The general alignment of the disturbed hills in the western and central parts presents that this region in the geological history could have been a major domal structure and this contention has been proved owing to the presence of general 'Radial pattern of drainage' in the district.

(2) Undulating terrain

The central undulating terrain constitutes the hilly slopes, pediments, piedmont plains, valley fills, pediplains and colluvial fans. The slope in this terrain varies from 5 to 25 per cent. The irregularity in the distribution of material in extent and thickness is due to irregular

bed profiles, slope and different geomorphic agents to work. The presence of piedmont plains and colluvial fans with convex facing slopes is an indication of the fact that the rate of accumulation is exceeding the rate of transportation.

(3) Rolling Plains

The slope in these plains is low and varies from 2 to 5 per cent or less than 2 per cent and constitutes of creep built plains, wash plains aid mixed soil plains. The rolling nature of the plains is attributed due to differential rate of weathering, erosion and deposition of materials by gravity stream and wind action. The rolling plains occupy the major part of the district constituting red sandy soils, sandy loans and black soil plainer and reflect low to medium grey tones on the LANDSATS. A few isolated hills/insul bergs stand out prominently in the plains along without crops and give hindrance to agricultural operations.

(4) Fluvial plains

The major rivers during their course of development of river valleys have deposited fine textured alluvial soils on either side of the banks especially on the eastern part and hence this region is 'somewhat plain' in nature, with less than 2 per cent slope, These soils are very fertile and are usually used for cultivation of Rice, Sugarcane, etc., which reflect in dark grey tones on LANDSATS of band 7. As the western and central parts of the district composed of a number of hills and hillocks with exposed outcrops, the panoramic view gives the idea that it is more slopy and undulating. As the rainfall is frackish and erosion of the top soil is more, agriculture in this region is more discouraging and uneconomic. The etymological study of some of the place names in the western part of the district may supports this contention, For example, Rallabuduguru (a place with stones), Bodabandla (etymology Bodibandla, which means 'a barren hill), Ghattu (a hillock), Peddatippa Samudram (Pedda means big, Tippa means rock ‘samudram’ denotes here the 'uncultivable) . In the same way, as the eastern part which is somewhat plain and low lying in nature, some place names like 'pallam' (low lying area) 'Thungundram' (slope of a hill) may supports this view.

3. LANDFORMS (GEOMORPHOLOGY)

The various landforms identified based on grey tonal variation, crustal trends, nature of vegetation, soil texture and drainage characteristics, etc., are classified into broad divisions based on major geomorphic processes involved in their formation. They are

I. Destructional Landforms

Landforms which are grouped to this category owe their origin predominantly by sheet movements of weathered material by erosion and deposition. Exogenetic process, namely, degradation, weathering, mass-wasting and erosion have collectively played important roles in the destruction of these landforms. Field checks to various parts of the district denote that predominantly mechanical weathering process dominates over chemical weathering process due to semiarid nature of climate. Differential weathering in different

parts of the hilly terrain particularly in Horsely Hills in the west and Nagari Hills in the east throw light that structural disturbances might have played significant role in partial destruction of granitic terrain in this part of the district.

(a) Remnants of planation surfaces

Relatively flat topped with gentle slopes with barren surfaces and isolated hills which reflect light to medium grey tons are recognized at an altitude of about 750 m., in the district are presumed to be some of the remenants of planation surfaces. However**,** these surfaces are not associated with lateritic cappings in the eastern part of the study area. Planation surface is an amnibus term and includes Davisian's peneplain, or peneplane concept (Fairbridge, 1968).

Subrahmanyam (1982) while studying the morphology and evolution of Dharmapuri district has identified a series of etchplains at different altitudes where stripping and dissecting are important processes which are involved in the development of these plains. However, such plains are hardly recognized in the study area. A series of profiles taken in E-W direction throw light that there could have been 4 denudational levels, namely, 150-300 m., 300-600 m., 600-900 m., and above 900 m., above MSL, of the 4 denudational levels, it is presumed that levels lying in between 150-300, 300-600 and 600-900 m.**,** clearly depict that these could have been planated surfaces.

Pediments

These are cut rock surfaces with thin to thick veneer of debris. According to Mabbut (1966) they are rarely composed of sub-alluvial semiments over the existing pediments possibly due to lateral deposition of sediments by fluvial action. The pediments are distinctly noticed in and around Tirumala hills and Kuppam hills, The main process involved in the moulding of pediments are back weathering, rain wash, sheet wash and sheet flow. The low angle of pediment and meagre relative relief of residual remnants are presumed to be due to uniform lithology. In a few pockets granites and charnockites are left as residual boulder remenants indicating that the pediments here owe t h e i r origin more too lithological control and differential erosion.

Pediplain

A pediplain is defined as a sum of all pediments, together with residual nubbins (monadnocks) on any flood plains of major rivers (King, 1962). 'Pediplanation is generally accepted as the process responsible for landscape evolution as an alternative to the concept of process of peneplanation. A pediplain is also considered as a plain resulting from coalescence of a number of pediments over a sizeable area developed by the process operating in a semiarid cycle of denudation (Bajada). In the study area, the pediplain is well marked on the northern and western part of the district. They are in continuation of the pedlplain described by Vaidyanathan (1975). These plains in Chittoor District are covered by red sandy soils with a few residual hills and reflect very light in grey tone in the LANDSAT band 7,

Escarpments

An escarpment or scarp is defined as steep rock faces of great length. Two general types are recognized, namely, structural and erosional escarpments. Structural escarpment is a direct product of fault displacement, In the present study area the Tirumala hills, Nagari hills, parts of Kupparn hills and other minor hill ranges show distinct steep escarpments, which run to a distance of about 2 to 5 km. The Tirumala escarpment might have been formed by the structural activity during the development of Tirupati valley upto Nagari nose.

Residual Hills

The multi cyclic residual mountains, namely, exfoliation domes, tors, boulders, domal hills are well distributed on the plains of piedmont colluvial plains, pediments and pediplains. Typical tors and boulders of granitic gneisses are numerous in and around the study area, which causes hindrance to agricultural operations.

Constructional Landforms

The term denudation should in strict sense relate to destructional farms, but has been widely used to constructional forms related to gravitational process could be included under the heading constructive denudational forms to conform to the IGU Classification (Denmek, 1972).

Creep built plains

These are the deposits composed of unassorted material with angular gravel, pebbles and cobbles in a matrix of coarse sand and grit. These creep built plains are partly derived from the bordering hilly terrain and the piedmont colluvial plains by gravity, sheet wash and sheetflow. The thickness of sediments in these plains also varies from 2 to 7 meters and the slope ranges from 2 to *5* per cent. The creep built plains are very widely deposited on the eastern and central parts of the district.

Wash plains

These are stretches of plains next to creep built plains and pediments near to residual hills, with less than 2 per cent slope. These are composed of mixed soils, namely, red sandy and silt soils, which might have formed partly due to overflowing of water over these plains during peak flood periods along major river courses. On the eastern part of the district, soma patches of black soil plains which have been derived from insitu biotite gneisses may also be noticed.

Valley fills

These are the deposits derived from the bordering hilly terrain by gravity, sheet wash and sheet flow. The valley fill deposits consist of fine to coarse textured sandy soils and sandy loams with a few pebbles and cobbles derived from the surrounding hills.

Colluvial fans

A fan is an accumulation of debris brought down by a stream descending through a steep ravine and debounching in the plain beneath, where the debris materials spread out in

the shape of a fan (Denny, 1967). A number of fans are noticeable on either side of Tirupati valley, where plantations of cashew nut and red sanders could be seen. The material is a well weathered colluviurn with stone layers separating successive contributory lobes. In each lobe, the basal horizon is usually constituted by a less weathered stone layer and the upper structure by a very well weathered colluvium.

Flwial plains

The river Swarnamukhi, Arani, and Ponnai have developed canspicuous flood plains which are likely to be inundated during peak flood periods. The plains relatively show law relief, A flood plain is usually built by later deposits with an overlay of vertical accration of flood deposits (Leopold, 1957). The river built plains are utilized for cultivation of rice, sugarcane and banana, Old channels of river Arani could be traced on LANDSAT and due to the change of river courses fluvial terrances could also be traced.

Aeolian deposits

Patches of aeolian sands are recognised in between Madanapalli and Thamballapalli on the piedmont colluvial plains. The extensions of these deposits are very limited.

LINEAMENTS

An analysis of lineaments of the district denotes that NE-SW and NNE-SSW trending lineaments predominate and lie more or less parallel to the structural trends of the hilly terrain. The district possesses hard rock terrain and therefore due importance has to be given to study the lineaments traced from LANDSAT for excavation of groundwater resources. The prominent hills, namely, Mahendragiri, Palakonda, Velikonda, Chandragiri hills, Tirumala hills and Nagari hills are subjected to have low to moderate lineaments, The dominant trend on these parts of the hills is NE-SH and NNE-SSW. Similar lineaments are also traced on plain and upland regions. A careful analysis in the study of name of structural trend, topographic variations and drainage denote that some of the rivers are structurally controlled. For example, the river Poini in Chittoor town which flows to south-east found to be genetically controlled by a fault, lying parallel to the river course. From the study of lineaments, it may be concluded that 14 lineaments lie in between 0°-So to 26'-30° NE in direction having a cumulative length of 314.42 kms., 32 lineaments lie in between 31°-3S0 to 56'-6S0 NE in direction, with a total cumulative length of 823.04 km., and 4 lineaments in between 61°-65' to 71°-7S0 NE in direction with cumulative length of 102-40 km. The total number of lineaments in north-west direction is 22. Out of them, 12 lineaments lie in between 0°-5O and 26O-35O NW in direction with cumulative length of 222.93 km., 10 lineaments lie in between 3b0-40° to 56°-600 NW in direction with a cumulative length of 302.08 km., and only one lineament lies in between 80°-85 NW in direction with a length of 10.24 km. Further studies with the help of air photos and geophysical studies may throw light on the Neotectonics of the district.

Conclusion

The various landsystems, hilly terrain, undulating terrain, leveled plains and fluvial plains and landforms identified with the help of LANDSATS (F.C.Cs) aerial photographs,

geological maps and survey of India toposheet comprise the fluvial landforms(Rapids, waterfalls, pediments, pediplains, terraced plains, riverbuilt plains, flood plains and palaeo channels). The Aeolian lanforms(Tors and mounds, residual hills, taluscones/Talus and Debris slides) structural landforms (Escanpments and landslides) and fluvial-colluviallandforms(Washplainsandcreepbuiltplains).Mostofthe plains in the study area are "creep-built plains', "wash plains", "pediment plains" and "fluvial plains', which hardly supports the agricultural development of the area.

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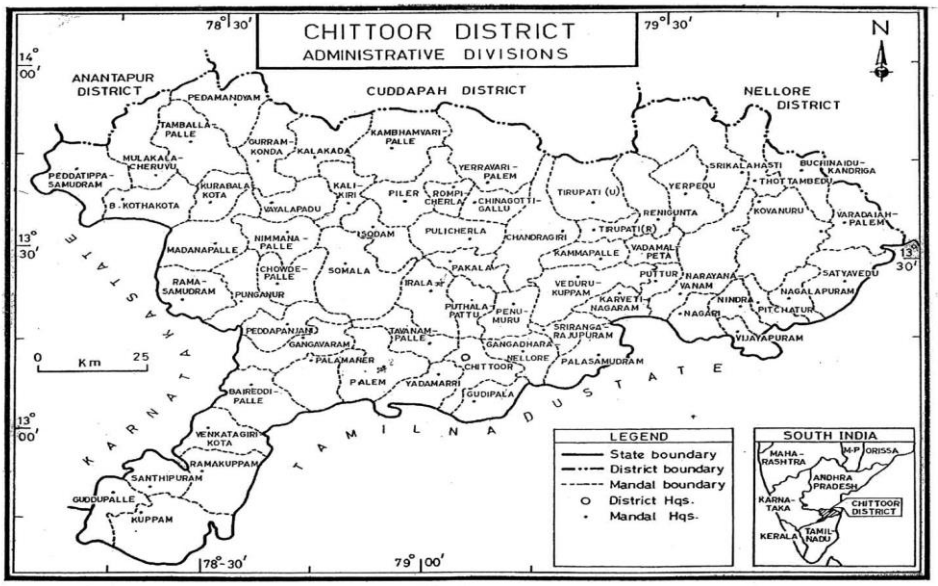
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Study Area Map



A comprehensive approach using remote sensing and geographic information systems (GIS) is proposed for the purpose of optimizing water resources in the Tirupati Revenue Division, located in the Chittoor District of Andhra Pradesh.

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Abstract: This research highlights the imperative need for the implementation of strategic water resource management strategies in order to address the increasing water scarcity resulting from population increase, industrialization, and urban development in the specific geographical region under investigation. The proposal suggests the implementation of small-scale projects along the Swarnamuki river belt with the objective of improving water resources for agricultural development in areas with high concentrations of water bodies in the eastern region, as well as addressing anticipated storage deficiencies. By using satellite data and the METRIC approach, this study computes the evapotranspiration (ET) for the Tirupati region, therefore uncovering significant water requirements for crops such as sugarcane. The research provides support for the use of drip and sprinkler systems as new irrigation technologies, emphasizing their potential to effectively reduce water usage. Furthermore, it proposes the use of drip irrigation techniques for sugarcane cultivation and the adoption of the System of Rice Intensification (SRI) for paddy farming as effective measures to mitigate water wastage, emphasizing the need of flexible agricultural approaches. In general, the research offers significant insights into irrigation methods that may effectively reduce water wastage and improve agricultural output, so making a vital contribution to the sustainable management of water resources.

1. Introduction:

Water supplies are being put under strain as a result of population growth, industrialization, and urbanization. Water scarcity is caused by factors such as large fluctuations in annual and inter-annual rainfall, ineffective infiltration, low hydraulic conductivity and storitivity, and high evaporative demand. The development and management of watersheds involve optimal use of water, land, and biomass resources in order to satisfy fundamental necessities in a manner that is environmentally sound. In order to accomplish this goal, runoff and soil loss must be reduced, and infiltration must be increased. Saving water can be accomplished by lowering surface runoff, increasing infiltration rates, and constructing buildings that are suited to their environments. Thematic data can be generated and analyzed with the use of remote sensing and GIS. However, remote sensing provides frequent synoptic coverage of the ground surface, which can be easily researched and represented in GIS. This is a significant advantage. For the purpose of runoff computation, it may include information on land utilization, land cover, and terrain topography (elevation, slope, and drainage network). Therefore, geospatial techniques may be used to select water harvesting sites in order to maximize the availability of surface and ground water for irrigation, domestic usage, and other purposes (Krishnan & Sankararajan, 2021).

The most severely impacted industry across the board is agriculture due to the global water crisis. Seventy percent of the world's freshwater is used for agriculture. Water is essential to the production of food. Since the production of biomass requires a significant amount of water, we could argue that agriculture is both the source of and a victim of water scarcity. The rising demands brought on by population growth come at

a high cost to the environment. The supply of water and the demand for it, in addition to agricultural practices, could be impacted by climate change and the generation of bioenergy. Agriculture, both rain-fed and irrigated, is impacted by climate change because of the way it alters hydrological regimes and the availability of freshwater (López-Mata et al., 2019). There has been an increase in temperature, as well as increased rainfall variability, semi-arid regions have seen a decrease in precipitation, while temperate regions have seen an increase in rainfall. This has a particularly negative impact on agriculture in tropical and subtropical regions. River runoff and aquifer recharge both have an effect on the amount of water that is available and enhance the demand that humans place on water resources.

Water is scarce in India since the country has 16% of the world's population but just 4% of its pure water supply. Irrigation accounts for the majority of water consumption. Agriculture consumes up to 80 percent of the world's fresh water resources. Irrigation uses up roughly 80 percent of India's available water resources. Given its size of 3.3 million square kilometers and annual rainfall of 1170 millimeters, it is estimated that India has water resources equal to 4,000 cubic kilometers. Over half of this water is lost through processes such as evaporation, percolation, and underground flow to the oceans, which leaves 1953 billion cubic meters (BCM) of water that can be accessed. According to Phansalker and Verma (2005), the amount of water that is available varies, bringing the total down to 1086 BCM. It is anticipated that by the year 2025, the Annual Water Resource will have decreased to 1496 cubic meters, from 2214 cubic meters in 1996. According to (Gulati et al., 2009) findings, just 25 percent of the water resource that is available has been developed

2. Materials and Methodology

Crop evapotranspiration refers to the combined process of evaporation from the soil surface and transpiration from plants. It is a ETc, or reference evapotranspiration, is a fundamental parameter used in the assessment of crop water needs and the development of effective irrigation management strategies. In this study, the estimation of crop evapotranspiration (ETc) was conducted using a combination of satellite-derived reference evapotranspiration (ETo) and the crop coefficient (Kcb) technique. Following the pre-processing of satellite pictures, the estimation of ETc was conducted over the whole of the research region. The FAO-56 technique is often used for calculating evapotranspiration (ETo) and is frequently accessed via the Google Earth Engine Flux (EEFlux) webpage on a daily basis. The estimation of the basal crop coefficient (Kcb) is conducted via the use of the normalized difference vegetation index (NDVI) in relation to Kcb. The procedure for this estimation is elucidated as follows.

2.1 Data Used

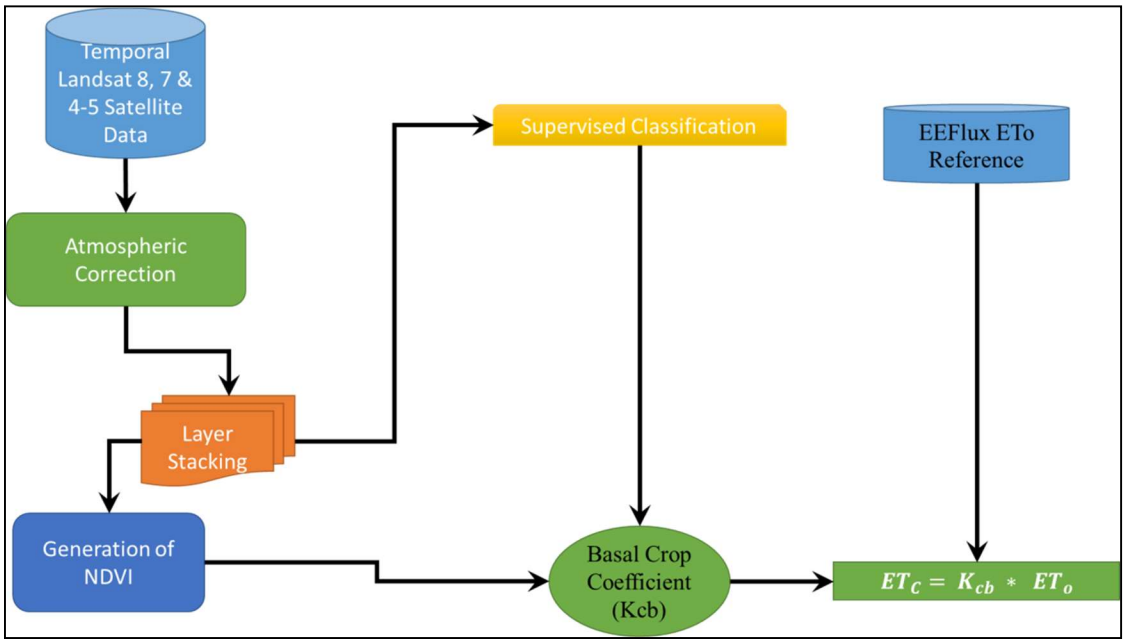
In order to accomplish the purpose of the current study, the researchers used several satellite products, supplementary data, and software tools.

Remote sensing data refers to the collection of information about an object or phenomenon from a distance, often using sensors or instruments.

The satellite dataset used in this work is shown in Table 1. Specifically, Landsat 8, 7, and 4-5 data were employed throughout the pre-monsoon and post-monsoon periods of the years 1997, 2008, and 2016.

S. No	Data Type	Date of Acquisition	Resolution	Source
1	Landsat - 8	April 2016 December 2016	30 m	https://earthexplorer.usgs.gov/
2	Landsat - 7	April 2008 December 2008	30 m	
3	Landsat 4-5	March 1997 December 1997	30 m	
4	METRIC (ET reference)	April 2016 December 2016	30 m	http://eeflux-level1.appspot.com/

Table 1 : Details of satellite data products used in this Study



Methodology flowchart

2.2 Ground Measurements

GPS coordinates were collected from study area for the sample sites for accurate identification of particular locations and for further analysis. Ground measurement site map is shown in figure 1.

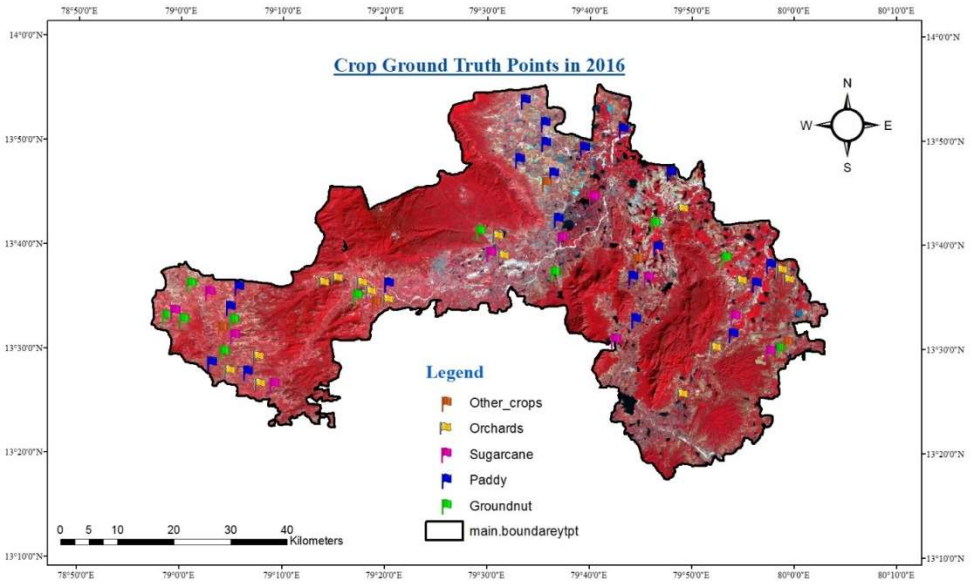


Fig 1: Ground truth measurement site map

2.3 Basal Crop Coefficient

The approaches for determining crop coefficients play a vital role in the estimation of crop evapotranspiration (ETc) and the formulation of irrigation scheduling strategies. The use of generalized coefficients often necessitates the implementation of local adjustments, hence generating inherent uncertainty. Vegetation indices (VIs) obtained using remote sensing techniques, such as the normalized difference vegetation index (NDVI), provide immediate and valuable information on crop variability. There is a scarcity of research available that indicates the potential of vegetation indices (VIs) in accurately estimating the basal crop coefficient (Kcb). The primary objective of this work is to use NDVI measurements in order to estimate Kcb values, with the ultimate goal of enhancing irrigation water management.

$$K_{cb} = K_{cb\max} \frac{(NDVI - NDVI_{min})}{(NDVI_{max} - NDVI_{min})} \quad (1)$$

Where $K_{cb\max}$ is Basal crop coefficient and $K_{cb\max}$ is Basal crop coefficient at effective full ground cover i.e., 1.3 (Hunsaker, 1994)

2.4 Potential/ Reference Evapotranspiration

The use of the METRIC technique, in conjunction with Landsat data and the Google Earth Engine Evaporation Flux (EEFlux), offers a straightforward and precise means of estimating soil water storage

capacity at a spatial resolution of 30m. Notably, this approach does not need the use of soil or vegetation maps. The process of evapotranspiration (ET) is of utmost importance in the hydrological cycle, and it is significantly influenced by sun radiation. The Potential Evapotranspiration (PET), also known as grass reference Evapotranspiration (ETo), plays a crucial role as an agrometeorological parameter, contributing to water balance models and regional evaluations of water demand for rainfed agriculture. The PET product has a precision level ranging from 80% to 90%.

2.5 Crop Evapotranspiration

Crop evapotranspiration (ETc) is defined as the combined process of evaporation and transpiration from a healthy crop, cultivated in expansive agricultural areas with enough water and fertilizer supply (Ding et al., 2013). The estimation of crop evapotranspiration (ETc) plays a crucial role in the calculation of the soil water balance and the development of effective irrigation scheduling strategies. The behavior of ETc is influenced by weather patterns and the state of the crops. Mathematically, the expression for ETc may be formulated as

3. Results and Discussion

3.1 Water Harvesting Sites

Dams block water or subsurface streams. They retain, gather, and store water for equal distribution (Zhang et al., 2023). Worldwide, dams have provided agricultural and urban water for millennia (Chelshi, 2023). The appropriateness of a built dam type in a possible dam site is always questioned. Dam type appropriateness decisions may include trade-offs between various intangibles.

Many methods are used to identify water collecting locations. The most prevalent method, AHP, combined with remote sensing and GIS, provides a worldwide site selection notion (Jayswal et al., 2023). Water harvesting and recharge locations rely on terrain, climate, precipitation, soil porosity, stream order, catchment area, and slope. These characteristics are acquired from various sources, incorporated into the GIS environment using multi-criterion decision making, and the location is chosen. The table below lists water harvesting site selection criteria.

Structure	**Slope %**	**Porosity and permeability**	**Runoff potential**	**Stream order**	**Catchment area (*10^4 m^2)**
Farm ponds	0–5	Low	Medium/high	1	1–2
Check dams	<15	Low	Medium/high	1-4	>25
Subsurface dyke	0-3	High	Medium/low	>4*	>5
Gully plug	15-20	Low	High	1	-
Percolation pond	<10	High	Low	1-4	25-40

Table 2: Selection criterion used for water harvesting sites

3.2 Slope Role

Line slope specifies its steepness and direction. It calculated slope steepness. One of the most essential elements in choosing locations for water collecting structures like check dams is topography steepness and surface runoff potential.

The slope indicates topography, which helps choose water gathering sites. The slope % is defined according to Integrated Mission for Sustainable Development (IMSD, 1995) and Food and Agriculture Organization (FAO, 1977) recommendations for choosing water collecting location. Present area slope classifications are displayed in the figure. CartoDEM (30m resolution) is used to generate % slope map in ArcGIS surface tools.

The slope map provides significant data on the zone's steepness, allowing us to estimate spillover. The region's slope may be divided into seven slant classes: (a) ‘nearly level’ (0–1%), (b) ‘very gentle’ (1–3%), (c) ‘gentle’ (3–5%), (d) ‘moderate strong’ (5–10%), (e) ‘strong’ (10–15%), (f) ‘moderate steep’ (15–30%), and (g) ‘very steep’ (> Slope grades 'nearly level' and 'sensitive' are increasingly suitable for water collection.

3.3 Runoff Generation

Runoff potential depends on DEM slope. According to slope-based criteria for surface runoff production, slope categories will be graded from least to most suited, with steeper slope categories generating more runoff. Runoff potential is classified as ‘moderate’ (200-300 mm), ‘poor’ (100-200 mm), and ‘very poor’ (<100mm).

Proposed aircraft for water resource management research. With above prospects and previous chapter studies of drainage morphometry, land resources, and land use land cover analysis and GIS integration, acceptable and necessary proposals are presented to the research region. Slop is the main source of runoff, thus the Tirupati Revenue Division receives water and soil conservation site suitability maps from slop and existing water resources location study.

Building modest irrigation projects

Apart from its tributaries, the Swarnamuki River runs 80 kilometers in Tirupati Revenue Division. Detailed examination after even shows no irrigation project except Kalyani tributary river. This river has greater discharge than others when it rains more. This project using natural briars is low-cost and beneficial for agriculture and drinking water.

3.4 Building medium and minor check dams

With serious stream network analysis and runoff calculations, a location map was proposed for the constriction of check dams like rock bonds, concrete dams, and earth bounds, especially in the west due to water scarcity. More check dams in that region will help recharge ground water and meet agricultural water needs Farm pound digging and contour ditching from the vast area of research, it is difficult to identify potential locations, but GIS was used to extract barren and fallow land locations suitable for these types of

construction to recharge ground water and expand the agricultural mask. This structure is simple and affordable. This style is also suggested for agricultural land and will assist farmers. Fig.5.5 shows where to build farm pound and contour ditches.

3.5 Other water-saving methods Except from above, this area has additional water saving methods like fallows.

3.5.1. Reusing wastewater Tirupati Revenue Division's largest city produces more urban waste water. Industrial and associated uses of urban waste water may boost indirect agricultural development using waste water cleansing plants. As fresh water can be converted to agriculture, more irrigated land is feasible. However, adopting and managing it is more expensive, so the government may lead water conservation.

3.5.2. Modernized irrigation

Modern drip, sprinkler, and subsurface irrigation minimize water evaporation compared to surface irrigation. It also waters plants straight at their roots. Thus, water waste will decrease and production will increase. According to FAO, converting traditional irrigation methods to modern irrigation will increase the irrigated area by three times. A small attempt was made to irrigate the area with 100% modern irrigation methods using existing water.

The calculation of Evapotranspiration values was conducted during the pre-monsoon and post-monsoon seasons of 2016. This was done in order to provide accurate ground truth data on crop conditions for that specific year, enabling the categorization of crops for the same time period. The subsequent years, namely 1997 and 2008, were analyzed by referring to the District Hand Book and assuming ET values similar to those of 2016.

3.6 Pre-Monsoon Water Requirement

The reference data for evapotranspiration (ET) has been multiplied by the basal crop coefficient (Kcb). The following ranges of evapotranspiration (ET) were observed for the key crops during the Pre-monsoon season of 2016.

S.No	Crop	Range (mm/day)
1.	Groundnut	3.5 to 4.01
2.	Paddy	5.7 to 6.12
3.	Sugarcane	4.16 to 4.438
4.	Orchards	2.271 to 3.246

5.	Other Crops	1.545 to 2.116

Table 3: ET ranges in 2016 pre-monsoon

The Paddy crop exhibits a wider range of ET values during the pre-monsoon period in 2016, with Sugarcane and Groundnut following suit. The range of evapotranspiration (ET) values for orchard crops is quite low due to the prevalence of younger plantings, which constituted around 20% of orchard crops between 2008 and 2016, as reported in the handbook. Younger plants typically need less water during their first growth phases.

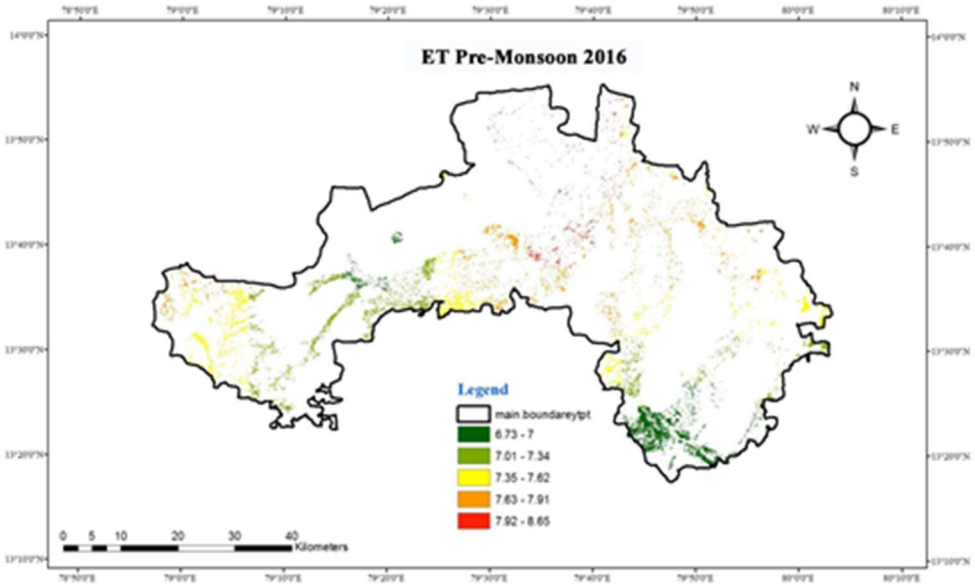


Fig 2. Evaporation in 2016 pre monsoon

The mean values of evapotranspiration (ET) for different crops are as follows: 3.76 mm/day for Groundnut, 5.91 mm/day for Paddy, 1569.14 mm/day for Sugarcane, and 2.76 mm/day for Orchards. The water consumption of the aforementioned crops per hectare, taking into consideration their respective growth periods, is as follows:

S. No	Crop	Growing Period	Average ET (mm/day)	Water requirement (mm/growing period)	Water requirement (cubic meter/ ha)
1.	Groundnut	140	3.76	525.70	5257.00
2.	Paddy	140	5.91	827.40	8274.00
3.	Sugarcane	365	4.30	1569.14	15691.35

4.	Orchards	365	2.76	1006.67	10066.70
5.	Other Crops	90	1.83	164.70	1647.00

Table 4 :Pre-monsoon average ET and water requirement per ha

Sugarcane, a significant agricultural commodity in the nation, necessitates a substantial amount of water over its whole growth cycle, which spans from 12 to 18 months. The specific duration of this cycle is contingent upon the agro-climatic areas, which range from sub-tropical to tropical. According to the Food and Agriculture Organization (FAO), the yearly water demand for this particular crop is within the range of 1500-2500 mm. The estimated yearly water demand for sugarcane in our research region is 1569.14 mm during a period of 12 months.

S. No	Crop	Water requirement (cubic meter/ ha)	Area (Ha) Pre monsoon			Total Water Consumption (Million Cubic meter/Total Cropped Area)		
			1997	2008	2016	1997	2008	2016
1.	Groundnut	5257	21348	419	3326	112.23	2.20	17.48
2.	Paddy	8274	22774	2252	3132	188.43	18.63	25.91
3.	Sugarcane	15691	8653	4475	4992	135.78	70.22	78.33
4.	Orchards	10066.7	7563	8463	10402	76.13	85.19	104.71
5.	Other Crops	1647.	7201	796	1090	11.86	1.31	1.80

Table 5: Pre-Monsoon Water requirement and Consumption for different crops

3.7 Post-Monsoon Water Requirement

The ET reference data has been multiplied by the basal crop coefficient (Kcb). The following information presents the range of evapotranspiration (ET) values for the key crops during the post-monsoon season of 2016.

S.No	Crop	Range (mm/day)
1.	Groundnut	3.42 to 3.76
2.	Paddy	5.538 to 5.914
3.	Sugarcane	3.84 to 4.564
4.	Orchards	2.193 to 3.346
5.	Other Crops	1.21 to 1.896

Table 6: ET ranges post-monsoon

The range of evapotranspiration (ET) values for the aforementioned crops varies from 1.21 to 5.91 mm/day, with the maximum ET being reported by the paddy*:*

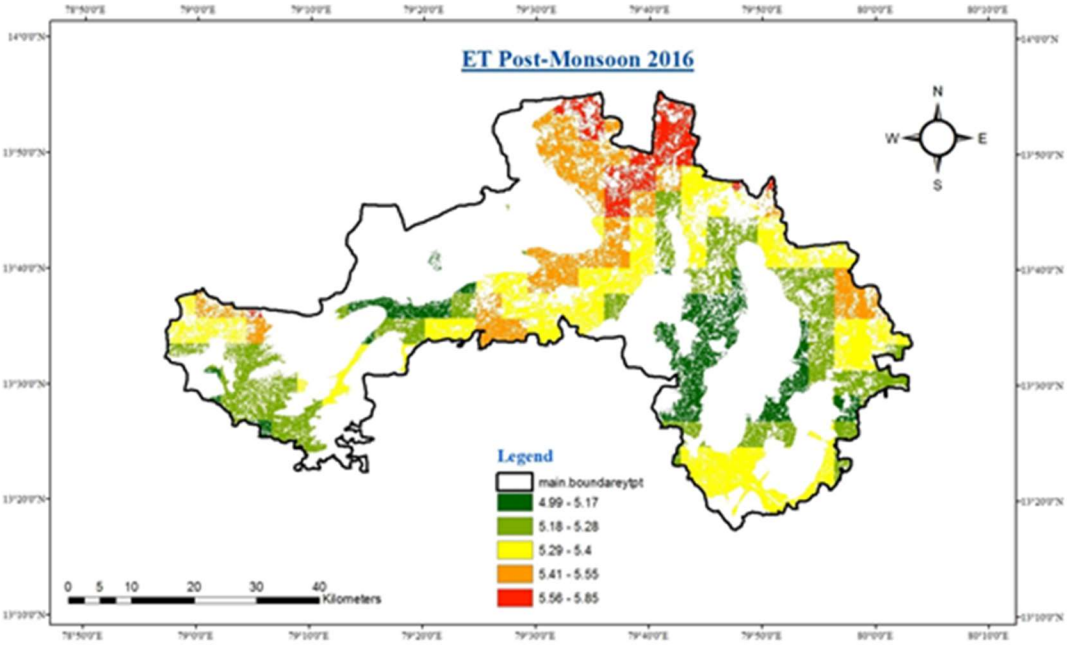


Fig 3. Evapotranspiration in 2016 post monsoon

S.No	Crop	Crop Period	Water Requirement Avg. Value (mm/day)	Water requirement (mm/crop period)	Water requirement (cubic meter/ ha)
1.	Groundnut	140	3.59	502.60	5026.00
2.	Paddy	140	5.73	801.64	8016.40
3.	Sugarcane	365	4.20	1533.73	15337.30
4.	Orchards	365	2.77	1010.87	10108.68
5.	Other Crops	90	1.55	139.77	1397.70

Table 7: Post-monsoon average ET and water requirement per ha

The groundnut crop exhibits an average evapotranspiration of 3.59 in its third position during the post-monsoon season, with a water need of 5026 cubic meters per hectare. The rice crop has the greatest average evapotranspiration (ET) value, whereas sugarcane surpasses it in terms of water

need, with a daily rate of 15331.3 mm/day. This is due to the longer growth time of sugarcane compared to paddy.

S.No	Crop	Water requirement (cubic meter/ ha)	Area (Ha) Pre monsoon			Total Water Consumption (Million Cubic meter / Total Cropped Area)		
			1997	2008	2016	1997	2008	2016
1.	Groundnut	5026.00	26384	20594	20594	132.61	103.51	103.51
2.	Paddy	8016.40	38414	44440	34440	307.94	356.25	276.08
3.	Sugarcane	15337.30	8653	4992	5732	132.71	76.56	87.91
4.	Orchards	10108.68	7563	8463	10402	76.45	85.55	105.15
5.	Other Crops	1397.70	37599	32765	22382	52.55	45.80	31.28

Table 8: Post-Monsoon Water requirement and Consumption for different crops

The water consumption for high water need crops, such as paddy, saw a drop in 2016 as compared to the levels seen in 1997. This occurrence may be attributed to a decline in the overall cultivated land area. Nevertheless, under the provided cropping plan, rice cultivation continued to occupy the top position. The total area under cultivation is mostly allocated to crops other than paddy. However, if the current tendency persists, there is a possibility of further reduction in the cultivated area for paddy, perhaps leading to its replacement by other crops such as orchards, which have shown an increasing trend in cultivated area over the years. Hence, the adoption of System of Rice Intensification (SRI) may be considered for paddy farming, while the implementation of drip irrigation can be recommended for sugarcane production, with the aim of mitigating excessive water consumption in both agricultural practices.

3.8 Other important factors in growth performance of agriculture sector

3.8.1 Fertilizers Consumption

Soil productivity increases with proper fertilizer and manure application. From 2007 to 2016, Tirupati Revenue Division consumed more fertilizers, as seen in Fig. 5.10. Urea, NPK, DAP, and others are used 76, 25, 95, and 200 percent more. Chemical fertilizers have helped farmers grow crops since the 1930s. Chemical fertilizers can cause stream pollution, crop burn, air pollution, soil acidification, and mineral loss. Farmers in these regions should limit fertilizer use and switch to organic farming to naturally increase soil fertility.

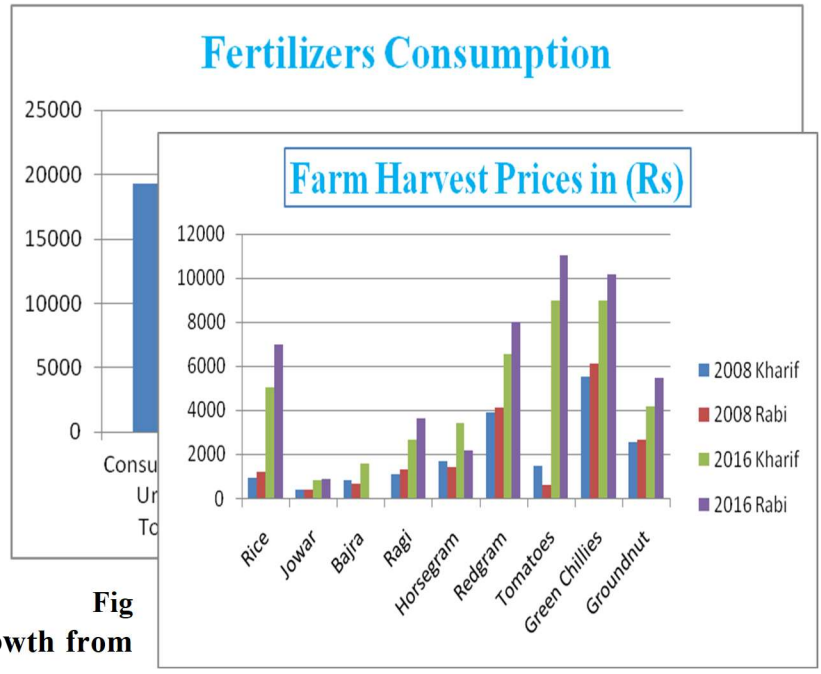


Fig 4. Fertilizers consumption growth from 2007-2016

3.8.2 Farm Harvest Prices

Agricultural harvest prices include product and input prices at various marketing phases. In India, the government's agricultural price strategy tries to ensure growers receive fair prices to stimulate investment and productivity. Annual minimum support prices for main agricultural goods are set after considering Commission on Agricultural Costs and Prices recommendations. In real life, harvesting prices are rising double and triple but minimum support rates are not, so farmers are converting to laborers and losing agricultural land. Fig 5.11 displays agricultural crop harvest prices. Massive increases lead to agricultural deficits. The government will disclose the minimum support price as rates rise.

Fig. 5 Farm harvest prices growth from 2008-2016

3.8.3Agricultural Credit

Each economic sector relies on credit. Farmers need credit for investment and working capital. Poor investment credit hinders HYV seed expansion and optimal input use. Like other sectors, agriculture needs easy, appropriate, and timely credit. Even though India has several Rural Financial Institutions (RFIs), the formal banking industry neglects a substantial percentage of the rural population. However, formal Indian banks have rigid credit flows and security-based lending. Additionally, "Long gestation period, lack of educated technical staff to discover potential activity, inadequate eligibility, and security issues contribute to limited loan flow to agriculture. For agriculture financing to move quickly, it must be fixed.

3.8.4 Irrigation system

The Revenue Division's agriculture and allied operations require irrigation, thus the study area's needs must be met. Modern drip, splenkar, and tube well irrigation increases, as seen in Fig.5.12. It is good, but only 10–15% of the remaining land uses traditional methods, which require more water. The irrigation system in this income division has to be changed.

Fig. 6 Irrigation system growth from 1997-2008-2016

3.8.5 Agricultural literacy

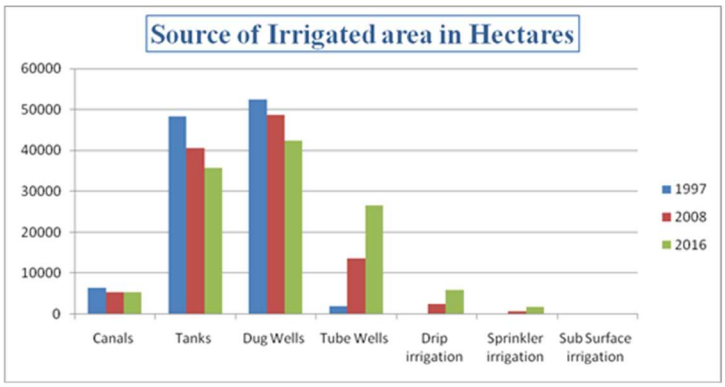
Agricultural literacy involves critical thinking and value judgments regarding agriculture's economic, environmental, and social and political impacts. An agriculturally literate person can assess “trade-offs” to people and society from agricultural activities. Decisions and values shape agricultural content. The ability to discuss and make decisions about societal choices shows agricultural understanding.

However, the Revenue division does not have clear statistics on this, and most of the area is rural, and I have seen little agricultural literacy. Thus, farmers must be educated through street performances, night schools, and other techniques to use technology immediately.

3.8.6 HYV, SRI and Mechanization

Modern methods and technology including high-yielding variety (HYV) seeds, tractors, irrigation infrastructure, herbicides, and fertilizers transformed Indian agriculture into an industrial system during the Green Revolution. Mostly found by M.S. Swaminathan. The Green revolution, started by Norman Borlaug, used agricultural research and technology to boost output. Implementation of high yields variety is not complete in study area.

The System of Rice Intensification SRI maximizes farmers' land, labor, and capital returns by lowering their seed, water, and labor needs. This boosts their incomes and helps the environment. SRI plants are resilient to water stress, storm damage, pests, and diseases, which is needed as climate change threatens. This skill may grow in importance. According to the divisional agriculture officer interview, the revenue division has practiced fewer than 20 to 30 hectors of SRI during the past five years. Thus, ground-level technological deployment is crucial for water and agricultural sustainability.



The income division is improving as mechanization continues, but the percentage is low. According to the district statistical handbook, the improvement from 10 years is only 15 to 20% in all types of mechanization. The research region did not properly implement technological mechanization including harvesting machinery and cultivator’s machinery save for land ploughs and electrical pump sets.

3.8.7 Agricultural research staff and centers

The study region had 1–2 agricultural staff per mandal and little technical staff, who were mostly involved in administrative tasks. Most of the study area lacks time to solve basic difficulties. The Southern Zone headquarters, Regional Agricultural Research Station (RARS), Tirupati, is one of two research stations in the study area. The station is 7 kilometers from Tirupati on the Tirupati–Chittoor route. The station was founded in 1979 to research groundnut and groundnut-based agricultural systems, soil and water management, pulses, biofuels, watershed management, and fodders. By 2011, RARS, Tirupati had established Agricultural Polytechnic College in addition to research. Institute of Frontier Technologies was founded in RARS, Tirupati with modern infrastructure and lab facilities to explore biotechnology, bioinformatics, nanotechnology, bio control, soil and water analysis, and quality analysis. The university and Tirupati's best labs are at this institute. Another research station is Krishi Vigyan Kendra, Vanasthali, in Renigunta mandal near Karakambadi. Has district-level Farm Science Centers created by the Indian Council of Agricultural Research (ICAR), New Delhi to speed up technology transfer to farmers. These centers transfer cutting-edge agricultural technologies to end users to boost production and productivity. It collaborates with other agencies. Farmers are interacting with both research sites and answering their agricultural questions. Research is also being implemented locally.

4. Conclusion

In conclusion, the research emphasizes how urgently the study region requires strategic water resource management, in particular as a reaction to the concentrated distribution of current water bodies in the eastern side and the expected gap in water storage projects. The plan that has been presented places an emphasis on the building of modest projects along the Swarnamuki river area. The goal of the strategy is to strengthen water resources in order to facilitate increased agricultural production.

In addition, a technique that is based on remote sensing is used in the research to estimate the amount of evapotranspiration (ET) that occurs in the Tirupati Region. The use of the METRIC method makes it easier to calculate ET values for a variety of crops throughout the pre-monsoon and post-monsoon seasons in the year 2016. The results highlight the enormous water needs of crops such as sugarcane, calling for novel irrigation techniques such as micro-irrigation, with drip and sprinkler systems displaying significant water consumption savings. The findings also call for innovative irrigation strategies such as micro-irrigation.

According to the findings of the study, there is a possibility that excessive water consumption may be reduced by applying the System of Rice Intensification (SRI) for paddy farming and by boosting drip irrigation for sugarcane. In addition, the research identifies fluctuations in farmed areas across various types of crops, which indicates the need for adaptable agricultural techniques. In general, the study produces useful insights for the management of water resources in a sustainable manner, and it argues for the use of contemporary irrigation practices in order to improve water usage efficiency and agricultural yields in the area.

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Quantifying Crop Water Consumption and Stress Patterns in Bagpath District, Western Uttar Pradesh: A Comprehensive Analysis Using Multidate Resourcesat Satellite Data

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Abstract

This research utilizes remote sensing techniques and incorporates NDVI-based classification methods to estimate crop evapotranspiration (ETc) in the region of Bagpath, located in Western Uttar Pradesh. The approach employs NDVI profiles to accurately map sugarcane-wheat and rice-wheat cropping systems, achieving an accuracy of 86.86% for Kharif crops and 79.72% for Rabi crops. The potential evapotranspiration exhibits seasonal variations, characterized by significant peaks in Kcb values between the months of September and February for both systems. The research examines the variation in ETc, ranging from 3.09 to 6.87 mm day−1, throughout the period of June 2017 to April 2018, with a specific focus on the water requirements for cultivating sugarcane. The dynamics of water stress, as shown by WS_LSWI data, exhibit a correlation with the various phases of crop development, therefore emphasizing the influence of harvesting operations on the levels of water stress.

1. Introduction

Agriculture has significant importance across all economic sectors due to its susceptibility to water constraint. At present, the agricultural sector is responsible for around 70% of the total worldwide freshwater withdrawals. Water has a pivotal role as an essential element in the process of food production. Given the substantial water transpiration demands associated with biomass production, it would not be inaccurate to assert that agriculture serves as both a catalyst and a casualty of water shortage. The exponential increase in population has resulted in significant environmental consequences due to the escalating demands placed on natural resources. The potential effects of climate change on water supplies and water demand, as well as the influence of bioenergy generation on agriculture, are subjects that now lack certainty. Climate change has the potential to modify hydrological patterns and the accessibility of freshwater resources, hence affecting both rain-fed and irrigated agricultural practices (FAO, 2008; FAO, 2011a). There has been seen an augmentation in precipitation levels within temperate regions, along by a decline in precipitation within semi-arid areas. Additionally, there has been noted a heightened variability in the distribution of rainfall, coupled with an overall rise in temperature. The aforementioned factors have a distinct influence on agriculture in tropical and sub-tropical regions. Changes in runoff in rivers and recharging of aquifers have a significant impact on the availability of water, hence exacerbating the strain on water resources caused by human activities.

India has a significant scarcity of water resources, as it accommodates around 16.0 percent of the global population but possesses just 4.0 percent of the available fresh water suitable for use. The irrigation industry is the largest consumer of water resources. Approximately 80% of the global water resources are allocated for the purpose of irrigation. In India, irrigation accounts for almost 80% of the used water resources. The projected water resources of India amount to 4000 cubic kilometers, based on the country's geographical

size of 3.3 million square kilometers and an average annual rainfall of 1170 mm. Approximately half of the water undergoes various processes such as evaporation, percolation, and subterranean flows towards the seas, resulting in a loss. Consequently, only a total of 1953 Billion Cubic Meters (BCM) of water is accessible. According to Phansalker and Verma (2005), the presence of water is subject to temporal and spatial fluctuations, resulting in a further reduction to 1086 BCM. According to estimates, the Annual Water Resource, which measured 2214 cubic meters in 1996, is projected to decrease to 1496 cubic meters by the year 2025. According to Gulati et al. (2005), the Developed Water Resource (DWR) accounts for about 25% of the total accessible water resource.

Low water availability limits plants. Stomata regulate plant water, oxygen, and carbon dioxide flow. Water stress causes stomata to shut to save water, limiting the oxygen, water, and carbon dioxide exchange route and decreasing photosynthesis (Porporato et al., 2001). Thus, water stress affects leaf development more than root growth because roots can adjust. Reduced photosynthesis due to water scarcity reduces crop growth and development. Soil moisture, canopy temperature/evapotranspiration (ET), leaf water content, and LWP affect crop water stress.

Water stress detection helps farmers reduce output losses. Remote sensing and ground-based methods may identify water stress.

Traditional stress assessment methods include predawn leaf water potential (Dixon, 1914), leaf pigment concentration (Lichtenthaler, 1987), leaf chlorophyll fluorescence (Muller, 1874) and ET (Priestley and Taylor, 1972). Predawn leaf water potential estimation employs pressure chamber. This method has measured tree and shrub water relations for 40 years. Manual operation is sluggish and laborious. Leaf water content approach analyzes plant water status by measuring relative leaf water content. Most plant water is in mesophyll cells. The ratio of fresh, dry, and turgid leaf weights determines relative leaf water content. This approach is time-consuming since the water potential difference between stressed and non-stressed plants is largest in the morning. Leaf pigment concentration approach assumes plant pigment concentration changes with species, phenology, and natural and human stress. Chlorophyll levels are higher in healthy plants and lower in stressed ones. Traditional chemical methods involve destructive sample and time-consuming laboratory studies, whereas chlorophyll meters are simple, portable, and fast. Leaf chlorophyll fluorescence is being employed to study photosynthetic equipment. This approach employs a portable optical equipment and fluorescence meter. Photosynthesis is dependent on light, water, and nutrients, which cause plant stress. Thus, this device is a useful diagnostic of plant stress because Chlorophyll fluorescence changes before tissue degradation is noticed in plants, allowing stress to be diagnosed before physical damage. The downside is that this method does not produce commercial instruments. Plant ET is measured with lysimeters.

All ground-based measurements can quantify plant water stress at ground level or local regional level, but not at large geographical scales like remote sensing. Either ground measurement can ground truth remote sensing applications.

Remote sensing for plant and environmental research became popular in the 1980s.Remote sensing provides accurate, quantitative, and timely crop condition data at a lower cost than field approaches (Shen et al., 2009). Remote sensing detects crop growth, stress, and assists agricultural development decisions (Shen et al., 2009). The spectral characteristics of vegetation are determined by leaf internal structure and elements like water, nitrogen, cellulose, and lignin absorption and scattering. Leaves' cellular structure and water content are identified in near and mid-infrared, while their colors are recognized in visible band.

Chlorophyll and water content are key plant stress indicators. Stressed flora has less chlorophyll, which affects leaf pigment light absorption. Therefore, it directly impacts plant spectral signature by lowering

green band reflection and increasing blue and red band reflection, modifying normal plant spectral signature. Thus, Visible, Near Infrared (NIR), SWIR, and TIR bands may detect water stress. Vegetation water stress index (VWSI) and Land Surface Wetness Index (LSWI) are SWIR and NIR indices (Ghulam et al., 2007), while Crop Water Stress Index (CWSI) and Water Stress Index (WSI) are TIR indices.

Precision agriculture depends on irrigation scheduling to avoid water stress and maximize production under restricted water circumstances, hence satellite monitoring of vegetation water stress is crucial. This research used optical data to diagnose sugarcane water stress in Bagpath, western UP.

2. Study Area

The study area includes Bagpath, located in Western Uttar Pradesh. The Western U.P region makes a significant contribution to the overall food grain output, accounting for 34 percent at the state level and 6 percent at the national level. The prevailing agricultural produce in this area is sugarcane.

The research region is situated within the latitudinal range of 28.8 degrees to 29 degrees and the longitudinal range of 77 degrees to 77.5 degrees. The western region is geographically demarcated by the presence of the Yamuna River, which serves as a natural boundary separating it from the neighboring states of Haryana and Delhi. The research was carried out in the Bagpath district located in western Uttar Pradesh.

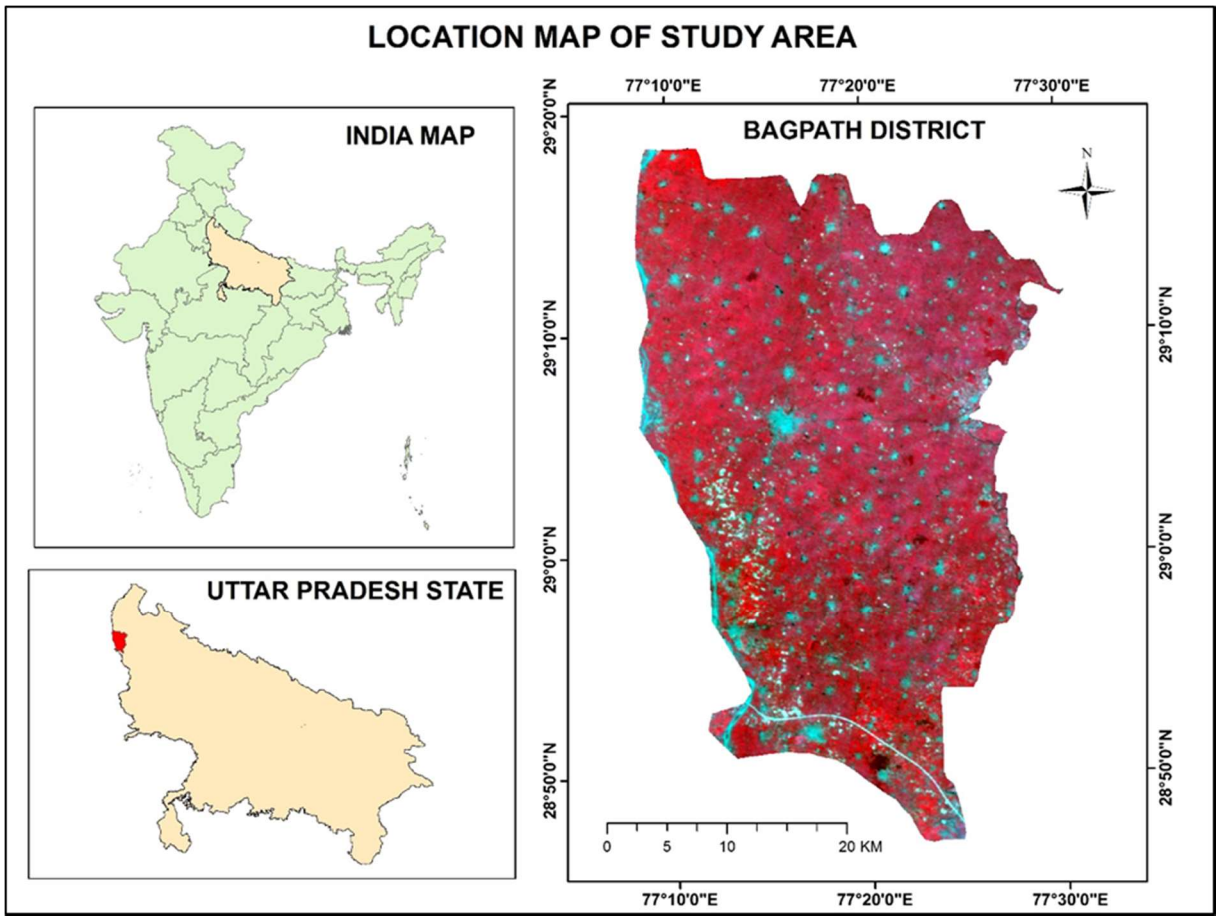


Fig 1. Location Map of the study area

2.1 Soils

Western UP soil is coarse-to-medium alluvium and somewhat alkaline. Their dark gray color indicates considerable organic matter. Loam and silty clay loam cover much of the terrain. 2016 (Nitika et al.)

2.2 Farming Method

Farmers' main business is crop production. This area also farms dairy. Agro-horticulture and agro-forestry are other growing agricultural industries in this area. Sugarcane dominates this region's commercial crop. Due to delayed sugarcane harvesting, wheat field preparation begins in November and lasts until the second week of December. Over 90% of land is irrigated wheat, which receives 4–5 irrigations. 2016 (Nitika et al.)

3. Materials and Methodology

Evapotranspiration of crops ETc provides the foundation for agricultural water needs assessment and irrigation control. This study evaluated ETc using satellite-derived ETo and Kcb. ETc was calculated for the whole research region after satellite image preprocessing. ETo is most often calculated using the FAO-56 technique, which is retrieved daily from MOSDAC. NDVI is used to determine the basal crop coefficient Kcb, as detailed below.

3.1 Data Used

Satellite products, supplementary data, and software were employed to fulfill the study's goal.

3.2 Remote sensing data

Table 3.2 lists the satellite dataset utilized in this investigation.1. AWIFS data was unavailable in February, March, and April 2018, hence Sentinel data was utilized.

S. No	Data Type	Date of Acquisition	Resolution
1	Sentinel-2A	25th April 2018 26th March 2018 14th February2018	10 m (Resampled to 56 m)
2	AWiFS	4thJune 2017 27th September 2017 17th October 2017 20th November 2017 18th December 2017	56 m

		30th January 2018	
3	INSAT-3D (PET_Daily)	8th April 2017 11th May 2017 4th June 2017 27th September 2017 17th October 2017 20th November 2017 18th December 2017 30th January 2018	5 km (Resampled to 56 m)
4	MOD04, 05, 08 Products	For Aerosal Optical Depth, Water Vapour and Ozone	Source Giovanni(Average value data)

Table 3.2 Details of satellite data products used in this Study

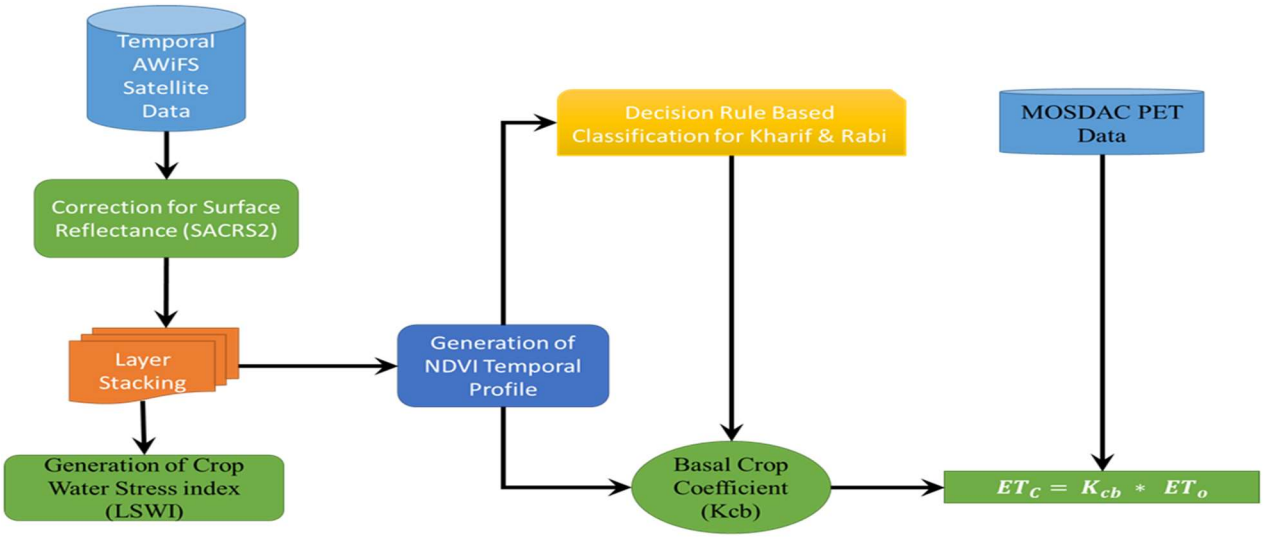


Fig 2. Methodology flowchart

3.3 Basal Crop Efficient

Estimating crop ETc for irrigation scheduling using crop coefficient methods is common. Generalized crop coefficient curves in the literature only estimate ETc for "optimum" crop conditions within a field, which must be modified for local conditions and cultural practices and adjusted for seasonal crop and weather variations. Thus, generalized crop coefficient uncertainties may lead to ETc predictions that are considerably different from real ETc, which might lead to poor irrigation water management. Crop attributes like percent cover and leaf area index may be modeled using vegetation indices (VIs) to quantify real-time crop fluctuations from remotely-sensed VI measurements. VIs can also predict the basal crop coefficient (Kcb) for maize and cotton, according to limited studies. This study estimated Kcb using NDVI measurements.

$$\boldsymbol{K_{cb}} = \boldsymbol{K_{cb\,max}} \frac{(\boldsymbol{NDVI - NDVI_{min}})}{(\boldsymbol{NDVI_{max} - NDVI_{min}})} \qquad (1)$$

Where $\boldsymbol{K_{cb\,max}}$ is Basal crop coefficient and $\boldsymbol{K_{cb\,max}}$ is Basal crop coefficient at effective full ground cover i.e., (Hunsaker, 1994)

3.4 Evapotranspiration potential

INSAT 3D is a geostationary meteorological satellite launched in 2013 as an exclusive INSAT spacecraft. This radiometer has four bands: wide VIS (0.52-0.75), SWIR (1.55-1.70), MIR (3.8-4.0), WV (6.5-7.0), and thermal TIR1(10.2-11.2), TIR2 (11.5-12.5) with 19 sounder channels. VIS and SWIR have 1 km x 1 km spatial resolution, whereas MIR, WV, and two thermal IR bands have 4 km x 4 km. INSAT Meteorological Data Processing System (IMDPS) automates ‘full-globe’ and ‘sector’ data products in all bands at half-hour intervals at 4 km spatial resolution. Daily purchases are limited to 48.

Evapotranspiration (ET) drives the hydrological cycle. ET is unique in its position as a link between the energy and water cycles. Solar radiation, wind speed, air temperature, and vapour pressure deficit affect ETo. Solar radiation is the most sensitive, affecting ETo variability by 60-70%. PET, also known as grass reference ETo, is the quantity of water transferred per unit time to atmosphere from a water-non-limiting surface covered with evenly and actively growing short grass like Alfalfa. ETo is the atmospheric evaporative demand for a given climate. Water stress results from moisture deficiency. Reference Evapo-transpiration is a hydrological and agricultural variable. It is a crucial input in soil water balance models together with precipitation. Many of these models use daily or hourly evapotranspiration data to predict plant water needs. The regional water demand would vary by agroclimatic conditions and agricultural season. Space rainfall and ETo may enable rainfed agriculture monitor water shortfall and excess throughout growing season. PET product accuracy is 80-90% (INSAT-3D Manual, 2015).

3.5 Crop Evaporation Transmission

Crop ETc is the evapotranspiration of a disease-free crop produced in wide fields with plenty of water and fertilizer (Doorenbos and Pruitt, 1977). Calculating soil water balance and irrigation schedule requires ETc estimation. Weather and crop conditions determine ETc. ETc is mathematically represented as $\boldsymbol{ET_C = K_C * ET_O}$ (2)

Kc is the crop coefficient, which varies by crop and growth stage, and ETo is the reference crop evapotranspiration.

3.6 Land Surface Wetness Index

LSWI assesses stress using NIR and SWIR. This measure is sensitive to soil background and total vegetation liquid. LSWI was estimated using this equation:

LSWI=NIR-SWIR/NIR+SWIR (3)

Water stress scalar (Ws) was calculated using estimated LSWI (Xiao et al., 2005).

$$W_S = \frac{1-LSWI}{1+LSWI_{max}} \quad (4)$$

Where LSWI is pixel value and LSWImax is maximum pixel LSWI value for growth season.

4. Results and Discussion

4.1 Crop discrimination

Each crop has a distinct spectral signature, therefore remotely sensed data can distinguish crops. Typical crop spectral reflectance displays pigment absorption in visible area (0.62-0.68 m) and significant near infrared reflection owing to leaf cellular structure. Red absorption and near-infrared reflectance indicate crop health (Navalgund et al., 1991b).

A rule-based classification analysis identified and distinguished rice, sugarcane, and wheat crops from other land use/land cover groupings. Rule-based feature selection using basic mathematical logics is successful. For crop discrimination, AWiFS temporal NDVI was utilized to create rules based on NDVI values of

various seasons, such as September. The transformation NDVI*127.5+127.5 linearized NDVI values between 0-255 (Ray S S et al., 2000).

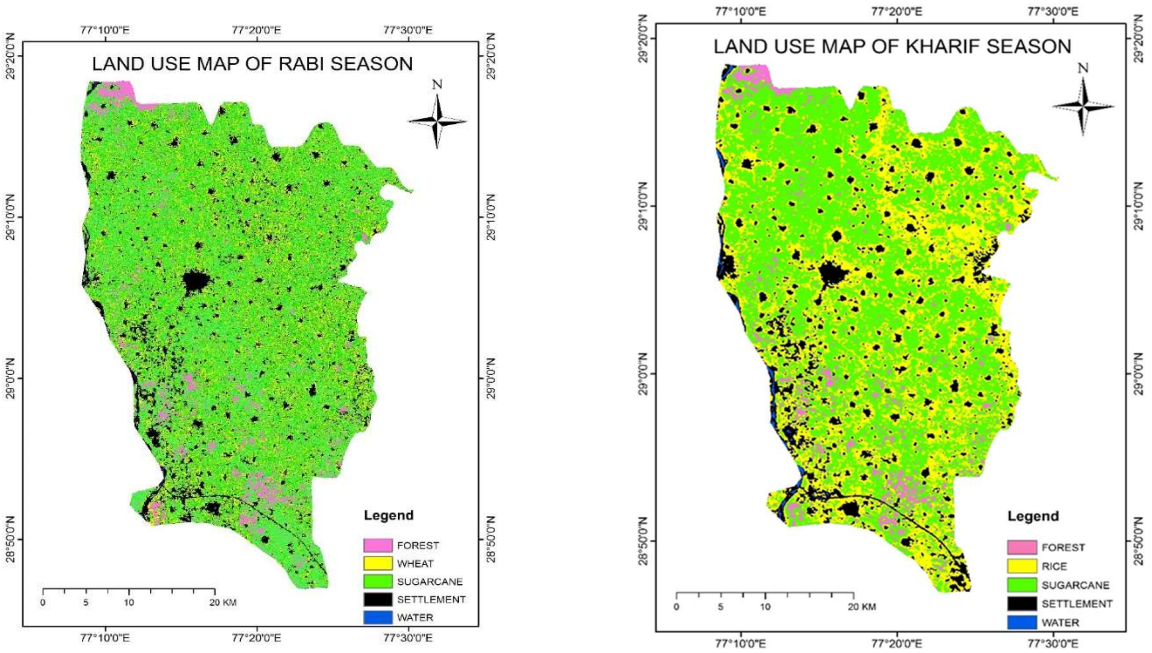
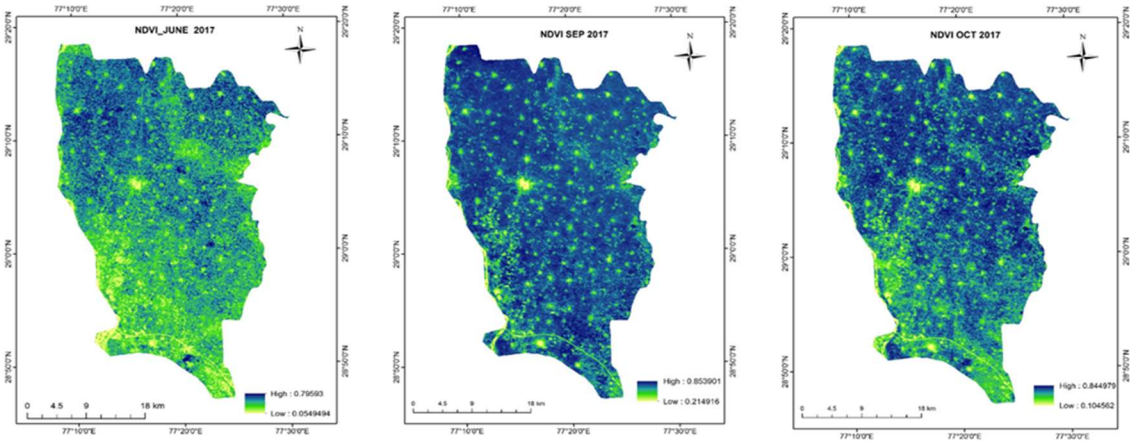


Fig 3. Shows the crop inventory map of Kharif Season & Rabi Season

4.2 NDVI Variation Throughout the Crop Season

A time-series of NDVI was created from all 9 AWiFS dates throughout crop growing seasons. Figure 4 show the 2017–2018 Kharif and Rabi NDVI temporal and geographical variance in the research region. NDVI peaks in November, whereas Rabi season (November–April) peaks in February. The greatest NDVI score indicates crop peak growth in Kharif and Rabi seasons. Kharif season had a higher average NDVI than Rabi season, perhaps owing to factors that accelerated crop growth: Higher rainfall (south-west monsoon), increased photosynthesis due to longer sunny hours, and wider crop area in Kharif season.



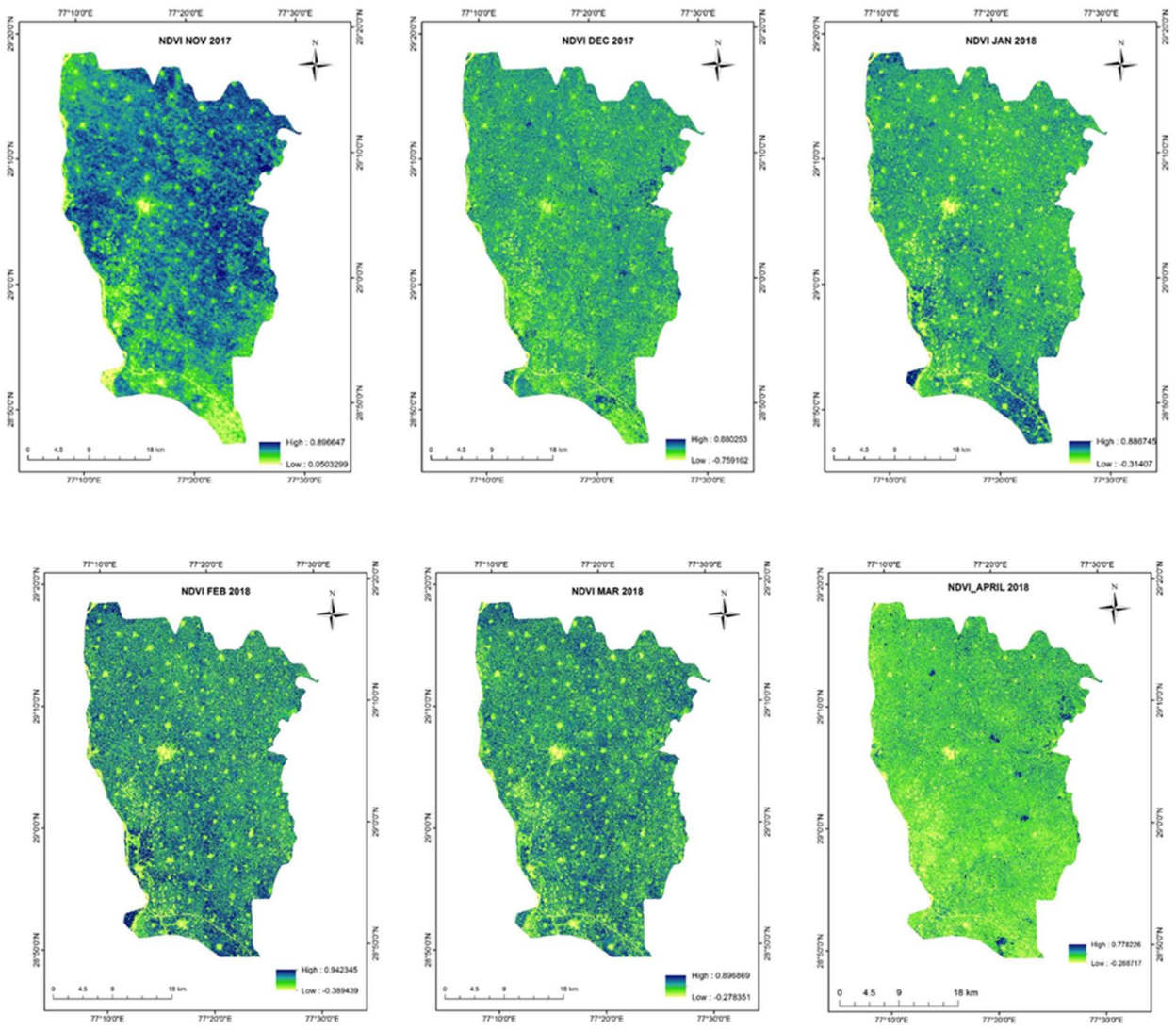


Fig 4. Spatial distribution of NDVI for June 2017 to April 2018

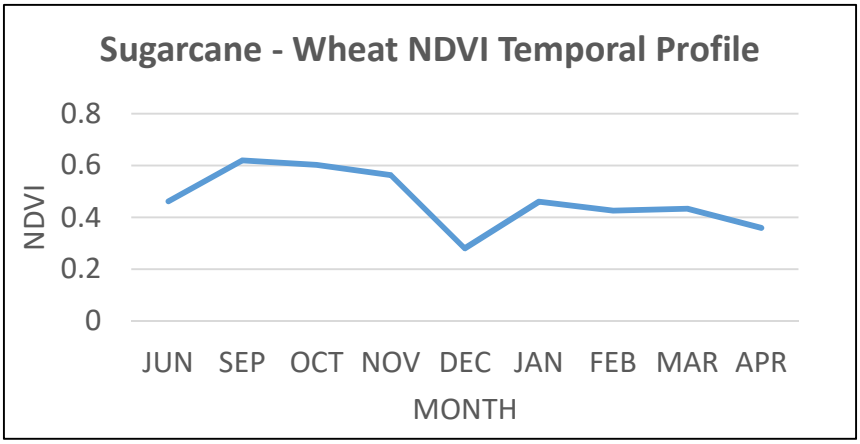


Fig 5. Temporal variation in NDVI for sugarcane–wheat cropping system

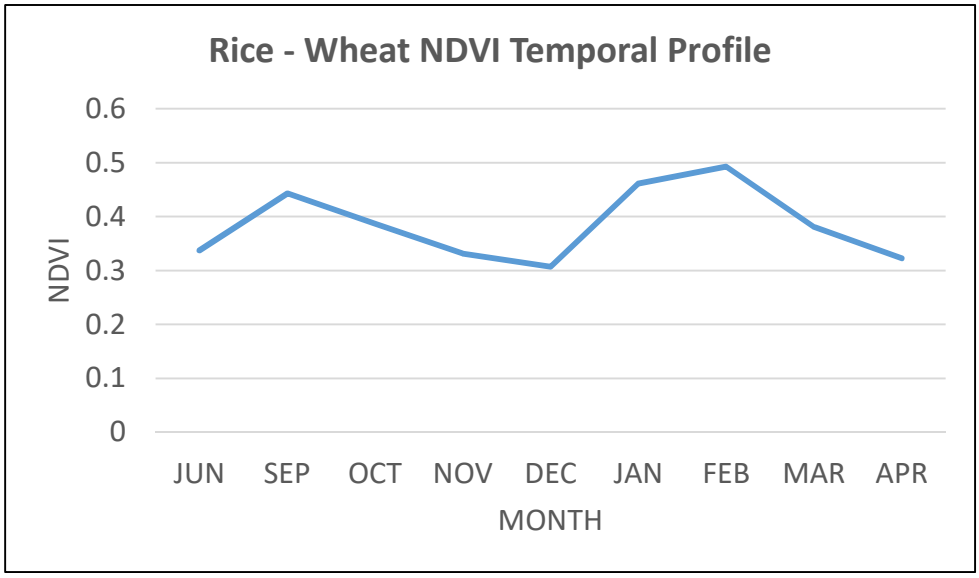


Fig 6. Temporal variation in NDVI for rice–wheat cropping system

The Normalized Difference Vegetation Index (NDVI) exhibited variability in relation to different crops and their phonological progression throughout the course of the growing season. The temporal fluctuations in NDVI for the sugarcane-wheat cropping system and the rice-wheat cropping system are shown in Figure 5 and 6, correspondingly. Figure 5.23 clearly demonstrates a decrease in NDVI values during December 2017. This decline corresponds to the development of wheat throughout the winter season after the harvest of sugarcane, as well as the early vegetative stage of sugarcane. The majority of the sugarcane crop was gathered in the month of December under the sugarcane-wheat agricultural system. Furthermore, a well-defined Normalized Difference Vegetation Index (NDVI) curve was found for the rice-wheat cropping system (refer to Figure 6). This curve clearly illustrates the trend of NDVI values while the rice and wheat crops undergo continuous phonological growth. These fundamental factors have effectively distinguished between the two systems. The observed NDVI patterns in this study exhibit similarities to the NDVI patterns reported by Kumari et al. (2013) in the context of sugarcane-wheat and rice-wheat cropping systems.

4.3 Basal Crop Coefficient

NDVI was used to derive the basal crop coefficient. The spatial representation of maps is below. Kcb and ETc fluctuated with crop and phenological development throughout the season, affecting crop water requirements. Fig.7 shows the temporal change of Kcb in Rice-Wheat and Sugarcane-Wheat cropping systems. Fig.7 show a fall in November and December 2017 owing to rice harvesting from Kharif season and a rise in Rabi season wheat transplanting. Rabi season adopts same profile. When temporal profile peaks, crop plant growth is maximum, hence water requirements are higher. The rice-wheat cropping system peaked in September and February with Kcb values of 1.2 and 1.23. In sugarcane-wheat cropping

system, Kcb temporal profile peaks in September and February with values of 1.24 and 1.03, although wheat peak value is low, perhaps because to mixed pixel combination with immature sugarcane plantings.

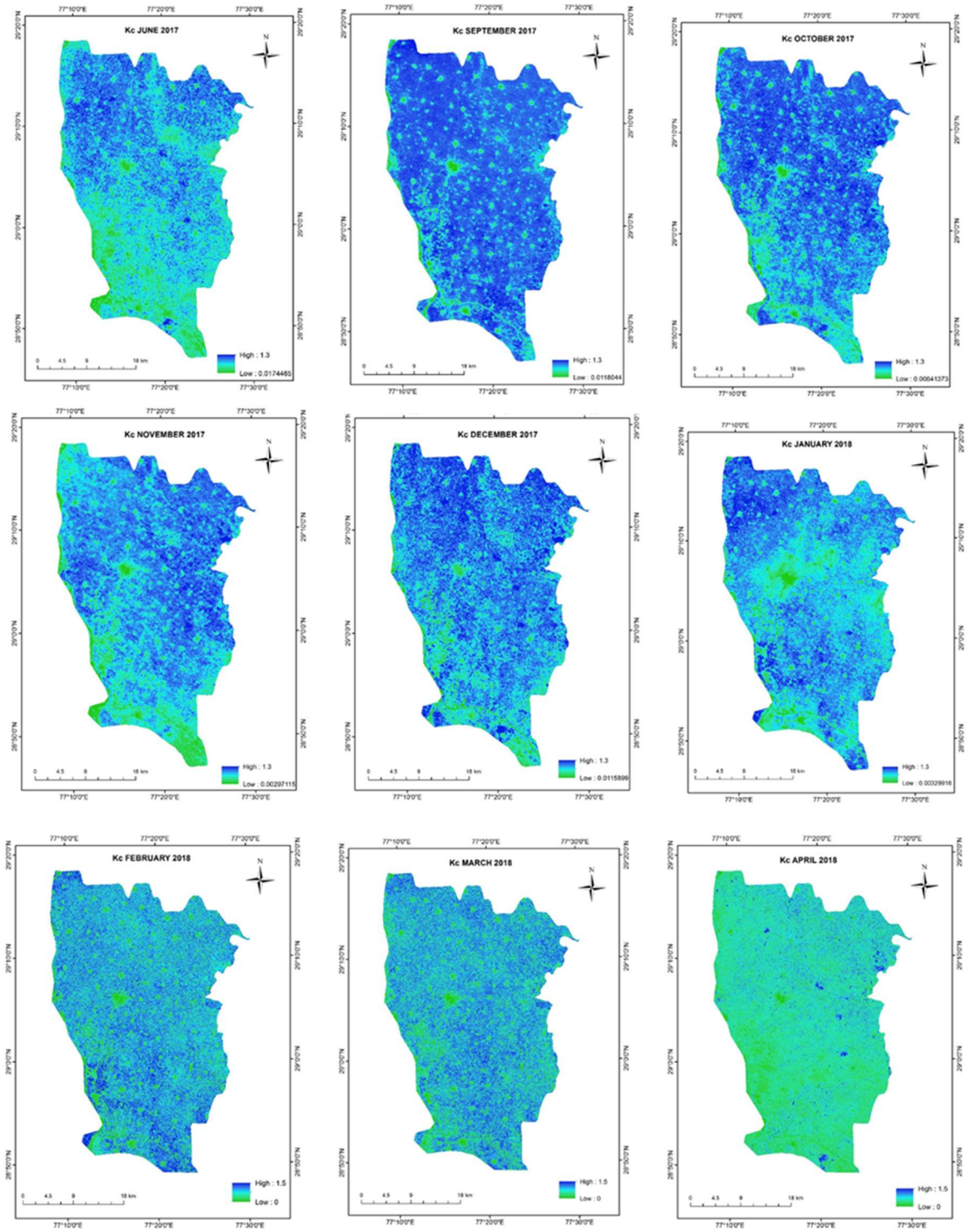


Fig 7. Spatial distribution of Kcb for June 2017 to April 2018

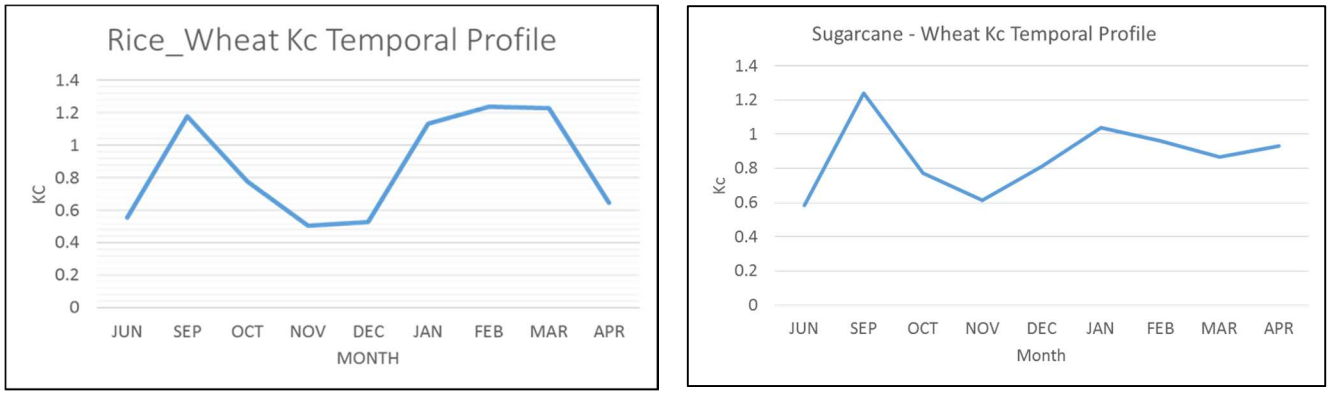
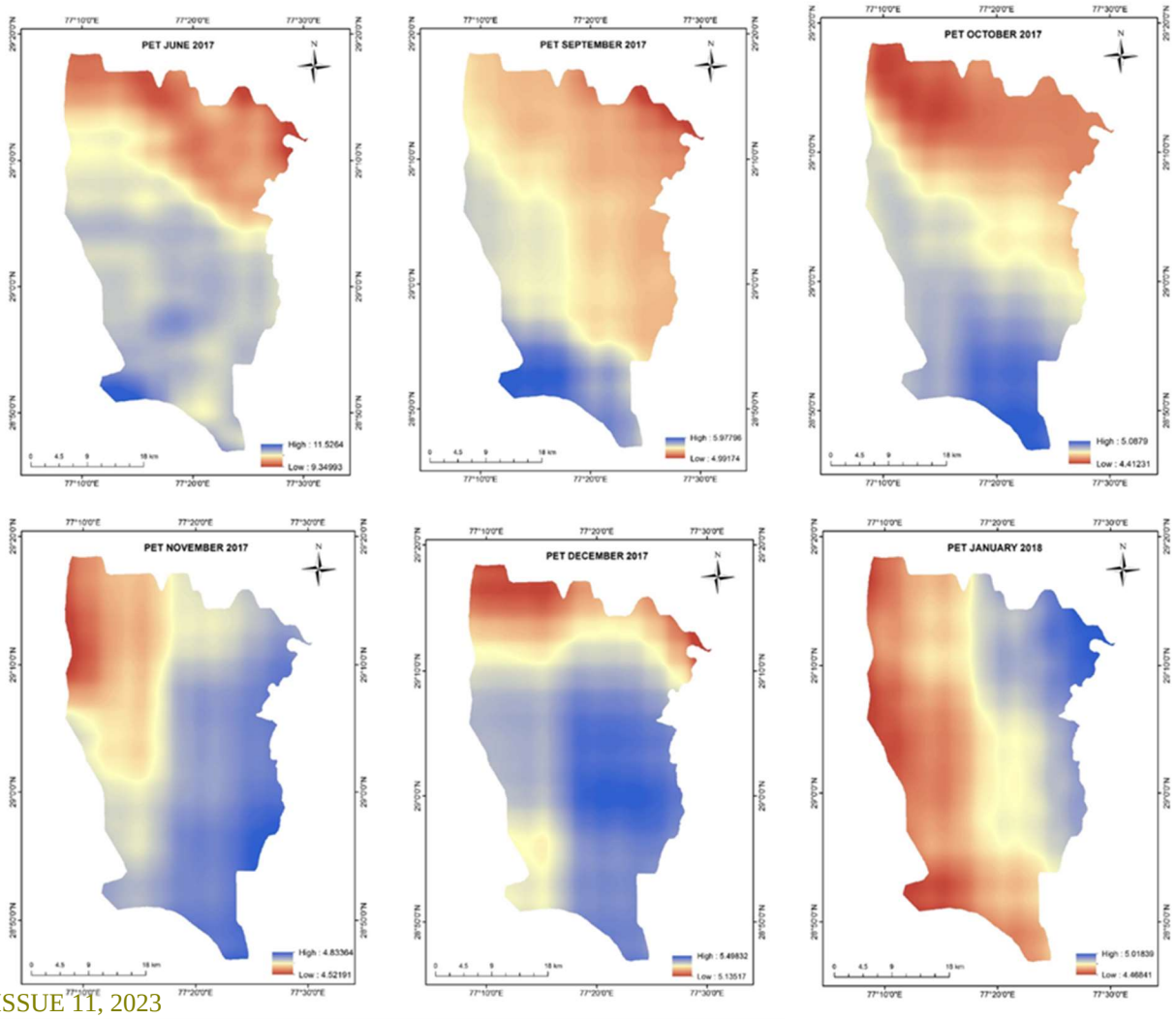


Fig 8 Temporal variation in Kcb for rice–wheat & sugarcane–wheat cropping system

4.4 Potential Evapotranpiration

The daily PET data downloaded from MOSDAC with a resolution of 5 km is resampled to 56 m resolution of AWiFS data. This is a daily average data product and the units of the PET data is in mm/day. The accuracy of the PET product is about 80-90% (INSAT-3D Manual, 2015). The temporal variation of daily PET as shown in figure 9. In Kharif and Rabi season the average value of PET in ranges between 4.41 to 5.91 mm/day and 3.30 to 5.42 mm/day



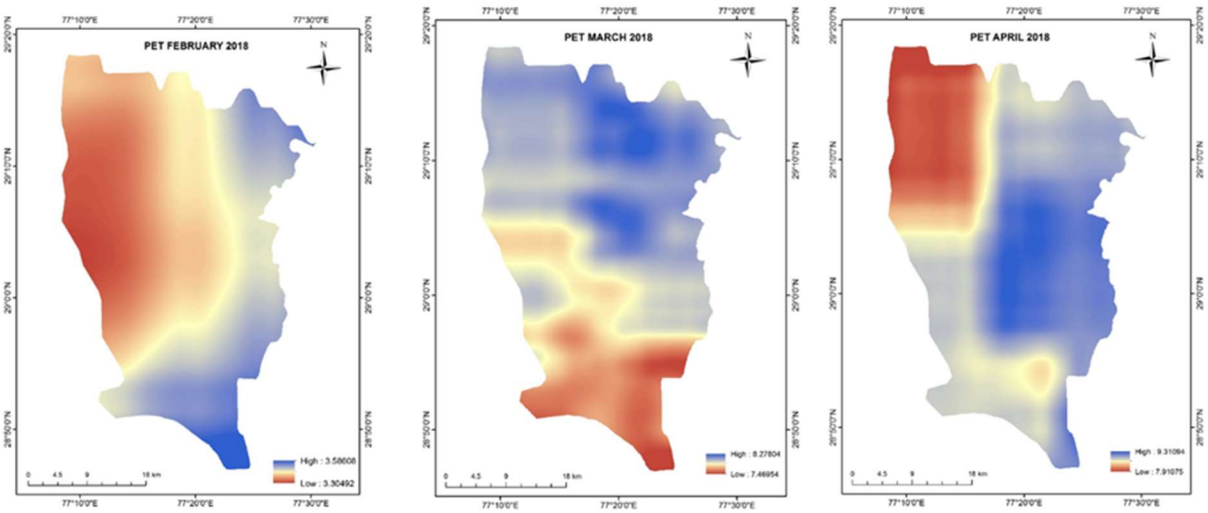


Fig. 9 Spatial distribution of PET (mm/day) for June 2017 to April 2018

4.5 Crop Evapotranspiration

The daily data from the PET (Potential Evapotranspiration) has been multiplied by the base crop coefficient (Kcb). The analysis of actual evapotranspiration (ET) based on the baseline crop coefficient and potential evapotranspiration (PET) reveals a marginal increase in ET during the month of November, followed by a fall in February. This may be attributed to the growth of sugarcane in November, with a significant portion being harvested by December. Lower readings are being recorded in February owing to the early vegetative development of wheat. The monthly photos exhibit a discernible pattern in the geographical distribution of monthly evapotranspiration. The evapotranspiration (ETc) exhibited a range of 3.09 to 6.87 mm day−1 throughout the period from June 2017 to April 2018. It is noteworthy that the mean ET value for sugarcane cultivation was determined to be 4.29 mm day−1. Sugarcane, a significant agricultural commodity in the nation, necessitates a substantial amount of water over its whole growth cycle, which typically spans 12 to 18 months. The specific duration may vary based on the agro-climatic areas, which range from sub-tropical to tropical. The crop's yearly water need in sub-tropical states like as Uttar Pradesh, Punjab, Haryana, and Bihar has been estimated to be 2000 mm (Shukla, S.K, 2017). The Food and Agriculture Organization (FAO) suggests that the range for this requirement falls between 1500-2500 mm. The estimated annual water demand for sugarcane in our research region is 2316.6 mm over a period of 18 months, and 1544.4 mm over a period of 12 months. The graphic shown below illustrates the spatial distribution of evapotranspiration (ET) and its temporal change.

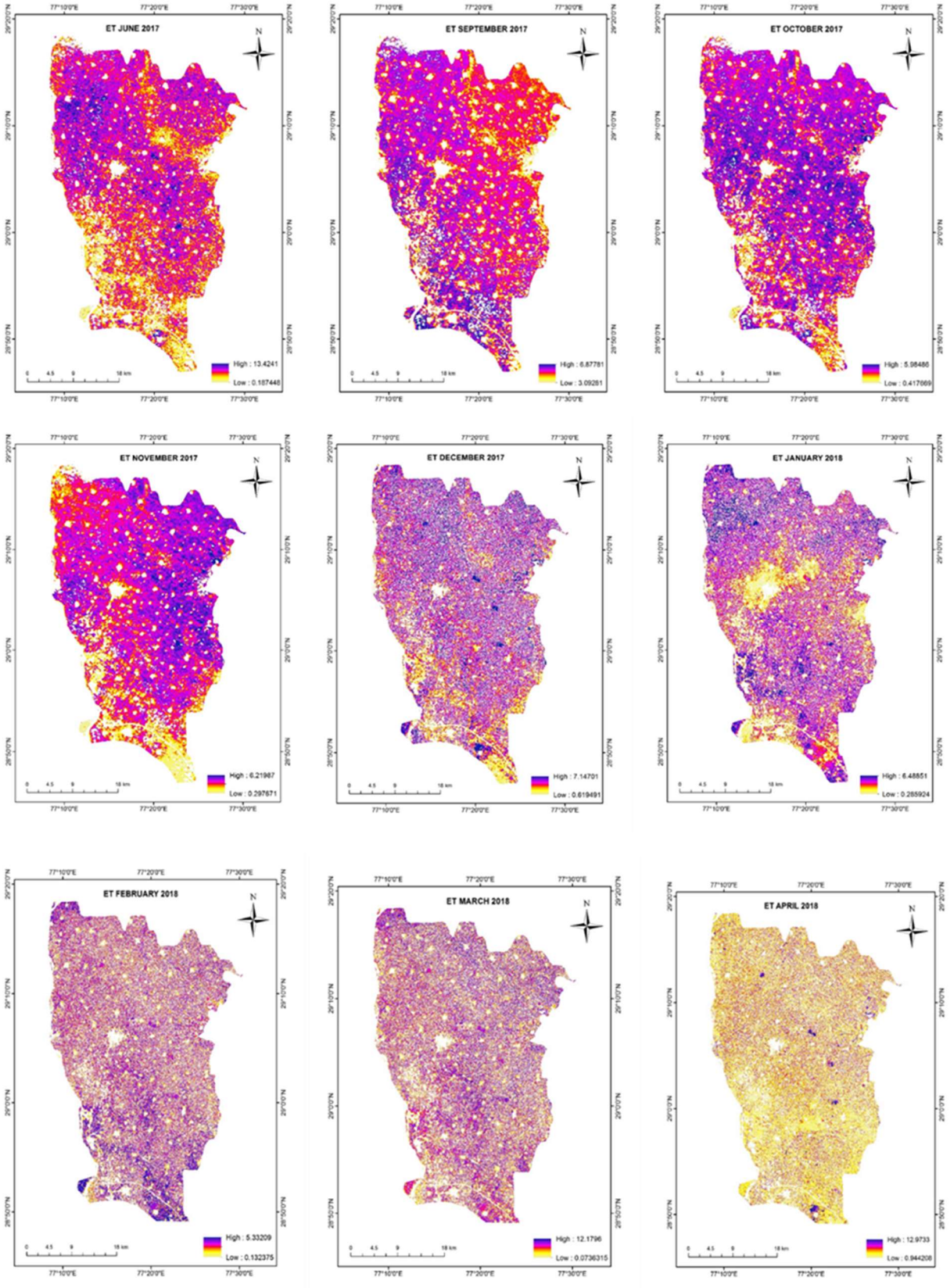


Fig. 10 Spatial distribution of Daily ET (mm/day) for June 2017 to April 2018

4.6 Land Surface Wetness Index (Lswi)

Land surface wetness index is a linear combination of NIR and SWIR bands. LSWI value ranges between -1 to +1 (Xiao et al., 2005).

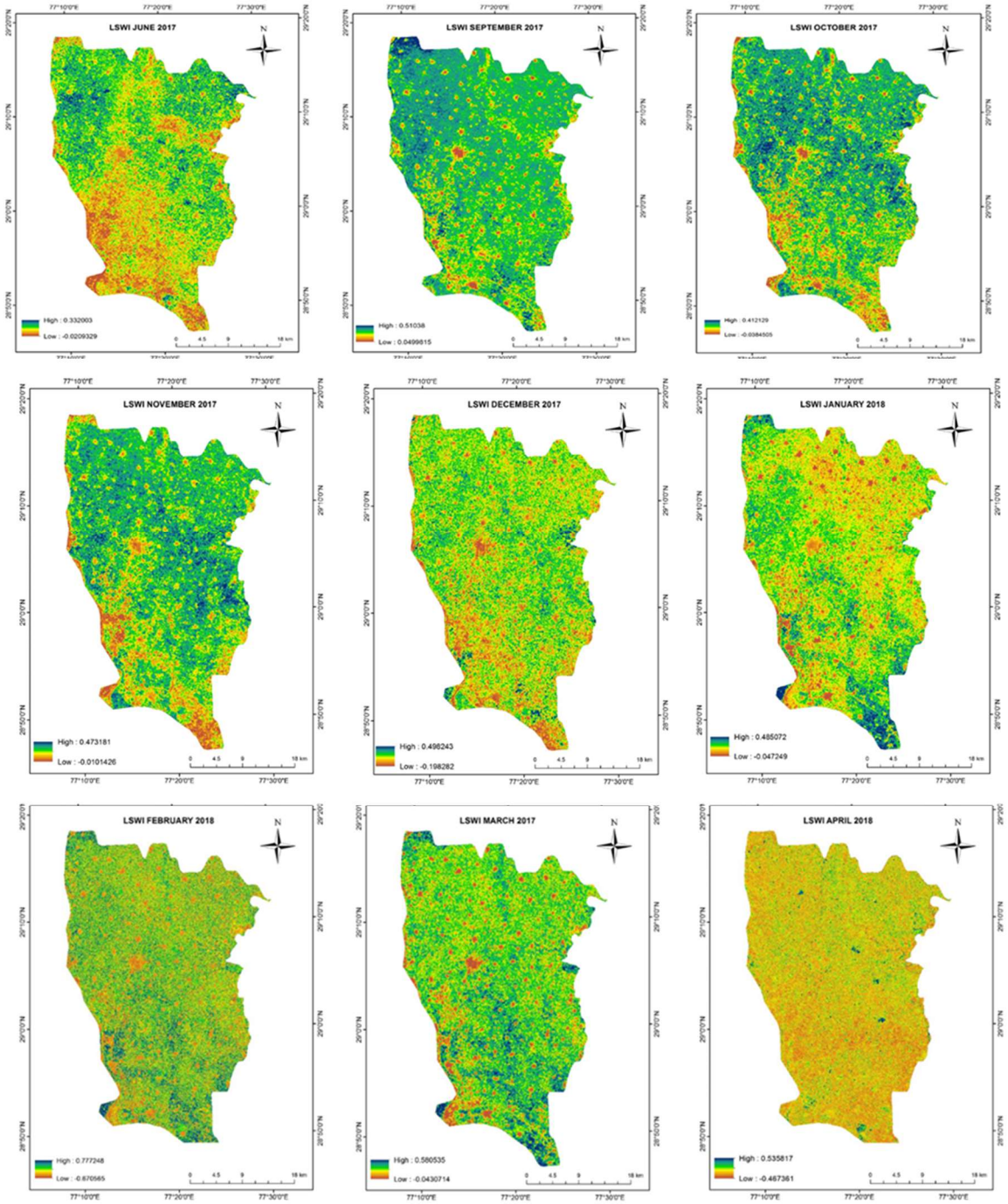


Fig. 11 Spatial distribution of LSWI for November 2017 to April 2018

4.7 Water Scalar Land Surface Wetness Index (Ws_Lswi)

The index is characterized by a numerical scale ranging from 0 to 1, with 0 denoting the absence of stress and 1 representing the presence of severe stress. The time distribution of water scalar may be noticed in Figure 5.71. Based on the findings from the period spanning June 2017 to January 2018, the observed trend may be attributed to the successive cultivation of kharif crops followed by rabi crops, leading to increased strain on the agricultural system. Subsequently, from February to April, the recorded values indicate a decline, which can be attributed to the commencement of crop harvesting during this period. In the month of June, a stress level of 0.56 was detected. However, in the subsequent months of September and October, the stress level exhibited a declining trend due to the increased vegetative development of sugarcane and rice crops. In November, there was a modest rise in the stress level, and by December, the value reached 0.50. This increase in stress may be attributed to the harvesting activities of rice and the presence of older sugarcane farms. The water scaler values show a decline subsequent to December, indicating a decrease in water stress. This trend aligns with the development of wheat crops occurring in January, February, and March. However, in April, a greater level of stress is noticed, as indicated by a value of 0.69, which may be attributed to the harvesting of wheat during this period.

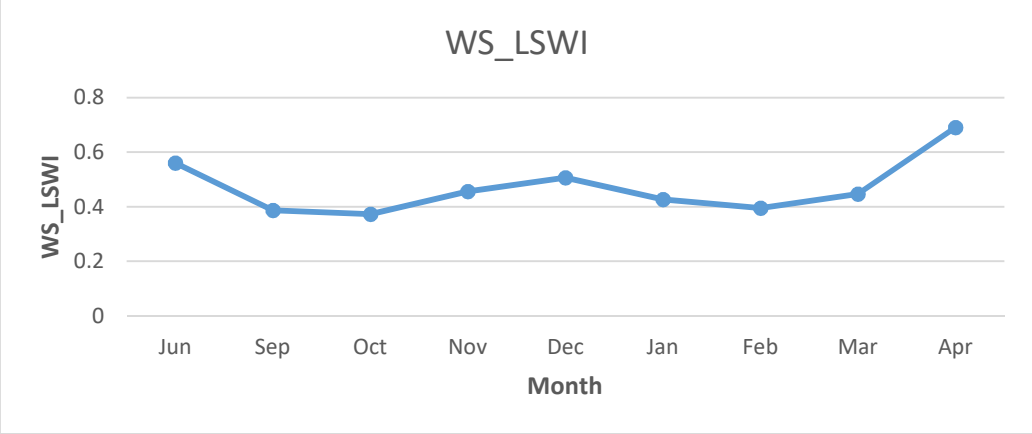


Fig. 12 Temporal variation in WS_LSWI

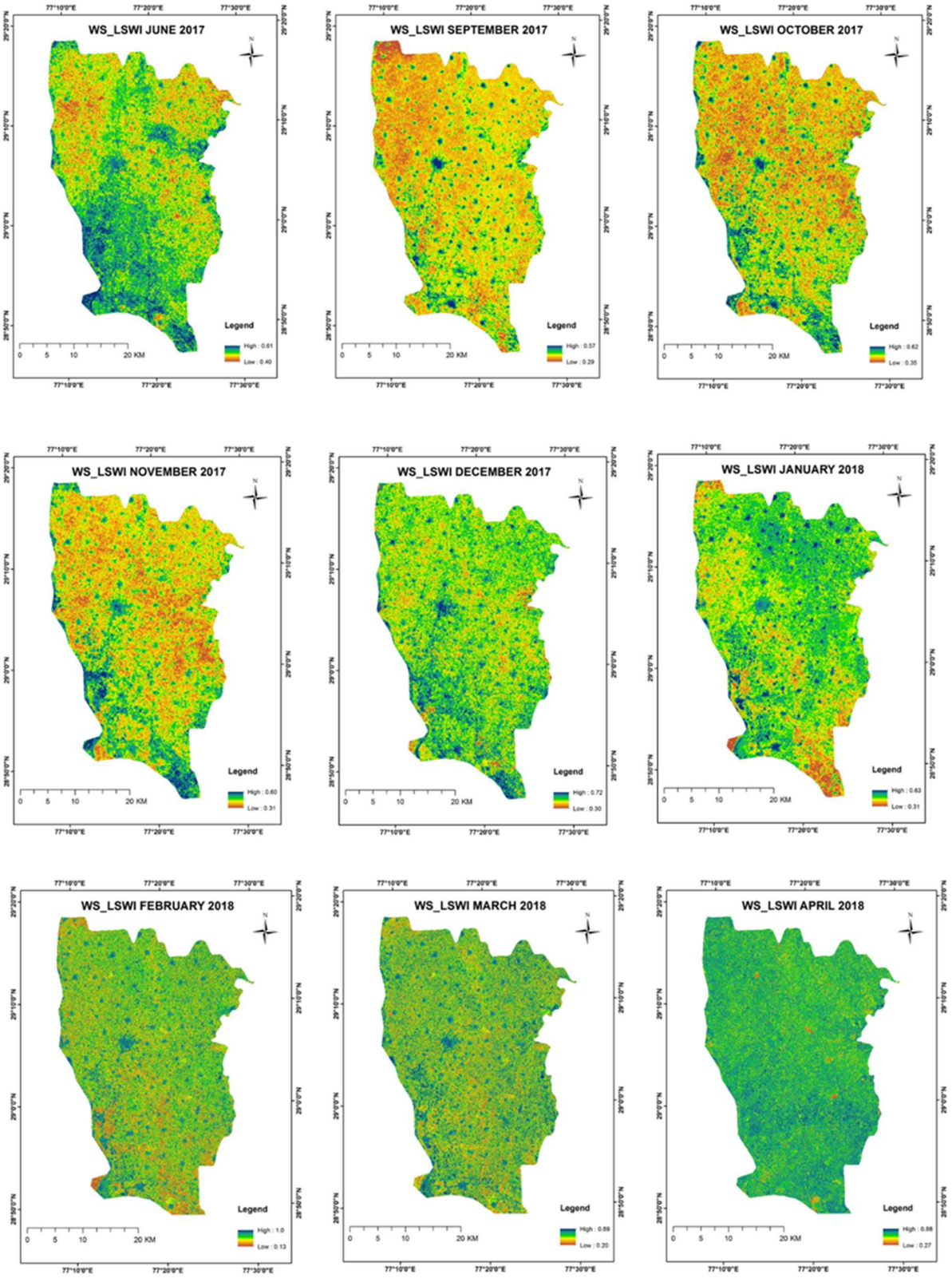


Fig. 13 Spatial distribution of WS_LSWI for June 2017 to April 2018

CONCLUSIONS

The current work used a remote sensing-based technique to estimate crop evapotranspiration (ETc) from Bagpath, located in Western Uttar Pradesh. A rule-based classification using the Normalized Difference Vegetation Index (NDVI) was conducted to classify Kharif and Rabi Seasons. This included establishing thresholds for various classes within the research region. The resulting classification achieved an overall accuracy of 86.86% for Kharif crops and 79.72% for Rabi crops. The kappa coefficients for Kharif and Rabi crops were determined to be 0.81 and 0.712, respectively. The assessment of the NDVI profile effectively covers the growth season of the sugarcane-wheat and rice-wheat cropping system, allowing precise crop mapping within the designated research region. During the Kharif and Rabi seasons, the mean potential evapotranspiration (PET) varies from 4.41 to 5.91 mm/day and 3.30 to 5.42 mm/day, respectively. In the rice-wheat cropping system, a notable surge was seen between the months of September and February, with corresponding Kcb values of 1.2 and 1.23, respectively. The temporal profile of Kcb in the sugarcane-wheat cropping system exhibits peaks in the months of September and February, with corresponding values of 1.24 and 1.03, respectively. However, it is seen that the peak value of wheat is relatively lower, which might perhaps be attributed to the presence of mixed pixels resulting from the mixture of young sugarcane plants. The evapotranspiration (ETc) exhibited a range of 3.09 to 6.87 mm day−1 throughout the period spanning from June 2017 to April 2018. It is worth noting that the average ET value for sugarcane cultivation was determined to be 4.29 mm day−1. The estimated yearly water demand for sugarcane in our research region is 2316.6 mm over a period of 18 months and 1544.4 mm over a period of 12 months. The WS_LSWI data was collected between June 2017 and January 2018. In the month of June, a stress level of 0.56 was recorded. However, in the subsequent months of September and October, the stress level exhibited a downward trend due to the significant rise in vegetative development of sugarcane and rice crops. In November, there was a modest increase in stress levels, which may be attributed to certain factors. Finally, by December, the stress level reached a value of 0.50, likely due to the harvesting activities of rice and the presence of older sugarcane farms. The water scaler readings show a decline subsequent to the month of December, indicating a decrease in water stress. This decline coincides with the growing period of the wheat crop, which occurs mostly in the months of January, February, and March. However, in April, a greater level of water stress is detected, with a recorded value of 0.69. This increase in stress may be attributed to the harvesting of the wheat crop during this period.

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Enhancing Urban Resilience: An Innovative Software Model for the Design and Administration of Gully Control Structures in Storm Water Systems

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Abstract

Gully control structures are primarily used for the sake of soil and water conservation, as well as the development of plants. These structures are comprised of dams of many designs that are built with the intention of stabilizing the slope, storing water, and mitigating the speed of runoff. Software models refer to abstract representations or descriptions of software systems, which are used to facilitate understanding, analysis, and design of these systems. Various design options for permanent gully control structures are now available on the market. However, the focus of our work is on evaluating these options. An endeavor was initiated to build software that offers a simplified manner for the design of check dams. Permanent gully management structures are engineered interventions designed to mitigate the erosive effects of gullies in a long-lasting manner. The model was built with the Visual Studio 2013 software. The validation of GCS_Designer was observed in the check dam, resulting in an error of 2.7523%. The highest value for the lowest compressive stress was determined, with an associated error of 0.0681%. The minimum length requirement for the check dam. A total of 25 criteria are taken into consideration. The validation of GCS_Designer for check dam involves assessing the percentage of compliance with the 10 parameters. The error and remaining values indicate a zero % error. The aforementioned figures are subject to an overestimation of 80%. The positive value is seen, whereas the remaining numbers indicate an underestimation. The drop spillway has a length of 28.6 units. The percentage of values that are overestimated is greater than the percentage of values that are underestimated, with 71.4% of values falling into the latter category. In a similar vein, a mistake has been identified. The event took place at a drop inlet spillway, involving a total of eight parameters. It is worth noting that 87.5% of the values examined did not exhibit any errors. the present study, we aim to investigate the impact of social media on adolescent mental health. The design of chute spillways resulted in overestimation and underestimation of values, with 87.5% and 12.5% respectively. Please provide individual estimates for each item. Design considerations may be undertaken for the construction of a check dam, drop spillway, drop inlet spillway, and chute. The GCS_Designer program was used with great effectiveness to design a spillway that is adequate for the local circumstances.

1. Introduction

The issue of soil erosion in India exhibits significant variation in terms of extent, intensity, and characteristics throughout various regions of the nation. These variations are influenced by factors such as climate, terrain, soil composition, land use, and the prevailing agricultural economy. According to the research conducted by Dhruva and Ram in 1983, it was shown that soil erosion occurs at a rate of about 5334 metric tons per year, equivalent to 16.35 metric tons per hectare, alone as a result of agricultural and related activities.

The rivers of the nation transport around 2052 metric tons, equivalent to 6.26 tons per hectare. Approximately 29% of the total eroded soil, amounting to roughly 1572 million metric tons, is transported annually by rivers to the sea. Additionally, around 480 million metric tons of soil are deposited in different reservoirs, leading to a loss of storage capacity ranging from 1 to 2%. India has a total geographical area of 329 million hectares (Mha), with around 167 Mha (51% of the total) being impacted by significant water and wind erosion, as estimated by Das in 1985. Approximately 127 million hectares (Mha) of land are affected by significant soil erosion, while an additional 40 Mha have been degraded due to various factors such as gully formation, ravines, shift cropping, water logging, salinity, alkalinity, changing river courses, and desertification. According to Maji (2007), in India, about 120.72 million hectares of land, out of a total geographical area of 329 million hectares, are impacted by different types of land degradation. Among these, water-induced soil erosion above 10 megagrams per hectare per year accounts for 82.57 million hectares.

1.1 Control Measures for Gullies

Structures are primarily used for the purposes of soil and water conservation, as well as the development of plants. These structures are comprised of dams of different designs that are built with the intention of stabilizing the slope and decreasing the speed of runoff. Temporary and permanent structures may be used in situations where runoff is not severe and may be effectively managed via the presence of well-stabilized vegetation. The user's text is too short to be rewritten in an academic manner. Within gullies, the growth of vegetation is crucial until it becomes firmly entrenched. Temporary constructions are constructed using readily accessible materials found in the surrounding area, such as brush, poles, woven wire, loose gravel, and boards. In cases when runoff is substantial and the implementation of vegetation-based control measures is not viable, the use of permanent gully control structures becomes necessary. Several types of gully control structures include the check dam, drop spillway, drop inlet spillway, and chute spillway.

1.1.1 Check Dam

A check dam is a small-scale structure constructed across a watercourse to control the flow of water and prevent erosion. It is typically A check dam is a diminutive and transitory barrier positioned inside a ditch or watercourse with the intention of impeding erosion by diminishing the speed of fluid motion. The installation of a dam inside a ditch or channel disrupts the natural movement of water, resulting in a decrease in its velocity. While it is true that sedimentation may occur behind a dam, it is important to note that check dams are not primarily designed to catch sediment. Instead, they are often built using loosely distributed erosion stone or rip rap, or by using stone-filled gabions. The drop spillway, also known as a stepped spillway, is a hydraulic structure often used in dam engineering to safely release excess water from a reservoir.

The drop structure under consideration is classified as a weir structure, with a maximum allowable drop of 3 meters. The water passes through a hydraulic structure known as a weir, where it subsequently cascades over an apron, resulting in the dissipation of the water's energy. These structures are strategically positioned at regular intervals along a waterway, with the purpose of stabilizing it by altering its configuration from a consistently steep slope to a sequence of gradually sloping sections. Additionally, they serve as discharge points for tile and surface water located at the upstream terminations of drainage ditches. In the majority of soil conditions, it is feasible to construct drop spillways using commonly available masonry materials such as stone or brick, as well as concrete and concrete blocks, with or without reinforcing. The use of temporary storage to achieve a significant decrease in discharge along the structure is not appropriate.

1.1.3 Drop Inlet Spillway

The drop inlet spillway is a hydraulic structure often used in civil engineering projects to manage the flow of water. It is designed to efficiently divert excess water. A drop inlet or shaft spillway is characterized by the ingress of water by a horizontally oriented riser or inlet, often in the form of a circular or rectangular box. Subsequently, the water proceeds through a circular conduit, which may be either horizontal or nearly horizontal, towards an outlet protection system. The drop inlet spillway is a suitable solution for situations when it is necessary to regulate the flow of the downstream channel by creating a temporary storage area upstream of the structure. The structure comprises of a dam constructed from earthen materials and a spillway designed in the form of a pipe. The dam facilitates the temporary retention of runoff from the contributing watershed, while the spillway allows for the controlled release of the designed flow downstream. The adaptation occurs when the descent exceeds a magnitude of 3.0 meters. The drop inlet structure is comprised of three main components: the inlet, conduit, and outlet. When the form of the intake resembles a funnel, it is sometimes referred to as a Morning Glory or Glory Hole spillway.

1.1.4. The chute spillway

chute spillway is a hydraulic structure often used in dam engineering to safely discharge excess water from a reservoir. A chute spillway, also known as an open channel or trough spillway, is a hydraulic structure designed to transport the discharge of water from the upper portion of a channel or reservoir to the downstream channel level. This is achieved by using an open channel that is positioned next to a dam, abutment, or saddle. Chute structures are often used for the purpose of gully head management, proving to be effective for drops ranging from 5 to 6 meters in height. The chute spillway offers more advantages compared to the drop spillway in situations when there is a need to discharge a significant amount of runoff from a particular location. The flow in a chute spillway occurs at velocities that are classified as super-critical.

1.2 Design Planning

The design of structures necessitates thorough research into the numerous components that impact the characteristics of runoff approaching the structure. These investigations should include unique site circumstances, downstream flow characteristics, and any other special needs. There is a lack of universally applicable answers for the many challenges experienced in the field.

The design should include a comprehensive review of all the pertinent aspects that exert influence on the task. The data necessary for the design of these structures is as follows.

1. The topographic map of the contributing watershed and the adjacent downstream region is being referred to.

2. Soil data refers to information pertaining to the composition, properties, and characteristics of the soil within a certain area or region.

3. Rainfall data and characteristics include the quantitative measurements and qualitative attributes associated with precipitation, including its frequency, intensity, duration, and spatial distribution.

4. The existing land use pattern denotes the current arrangement and use of land within a specific geographic area, including various activities such as agriculture, residential, commercial, industrial, and natural areas.

1.3 Study Scope

The primary objective of a watershed development program is to mitigate the adverse effects of water and soil by enhancing the process of infiltration into the soil. This is achieved via the implementation of measures to regulate and mitigate excessive runoff, effectively manage and harness runoff, and minimize soil erosion in order to safeguard the integrity of the land. The successful design of buildings that are both economically efficient and safe requires a comprehensive understanding of the subject matter, proficiency in engineering principles, and much practical experience in the area. It is important to consider the local design factors, which include the soil texture, rainfall patterns, and agricultural practices of the indigenous population. A significant number of individuals engaged in watershed management lack enough proficiency in design, while existing textbooks on soil and water conservation fail to provide comprehensive design guidance tailored to specific regional contexts. Hence, it is important to develop a complete software solution for the purpose of managing soil and water conservation structures. There are other software models that exist for the creation of permanent gully control systems. However, the focus of our work was to produce software that is characterized by its simplicity.

The method for the design of check dams and permanent gully control systems. The model was constructed with Visual Studio 2013. The model was developed with the purpose of serving as a dam designer for field workers, while also functioning as an instructional tool for students to analyze the impact of modifying input parameters on the design output.

Taking into consideration the aforementioned concerns, the current investigation was conducted with the accompanying aims. The objective is to **1. create software that may be used for the purpose of designing gully control structures. 2. A Comparative Analysis of Various Parameters between Software-generated Output and Manually-generated Output. 3. The statistical analysis is used to compute the error for various parameters of structures.**

2. MATERIAL AND METHODS

Process for Gully Control Structure Design The gully control structure design process has three phases: hydrologic design, which calculates runoff rates and volumes. intended to manage, hydraulic design examines dimensions' needs. structure to withstand high runoff via drop and chute structures and structural design provide components strength and stability. Structural components. It analyses structure-affecting forces.

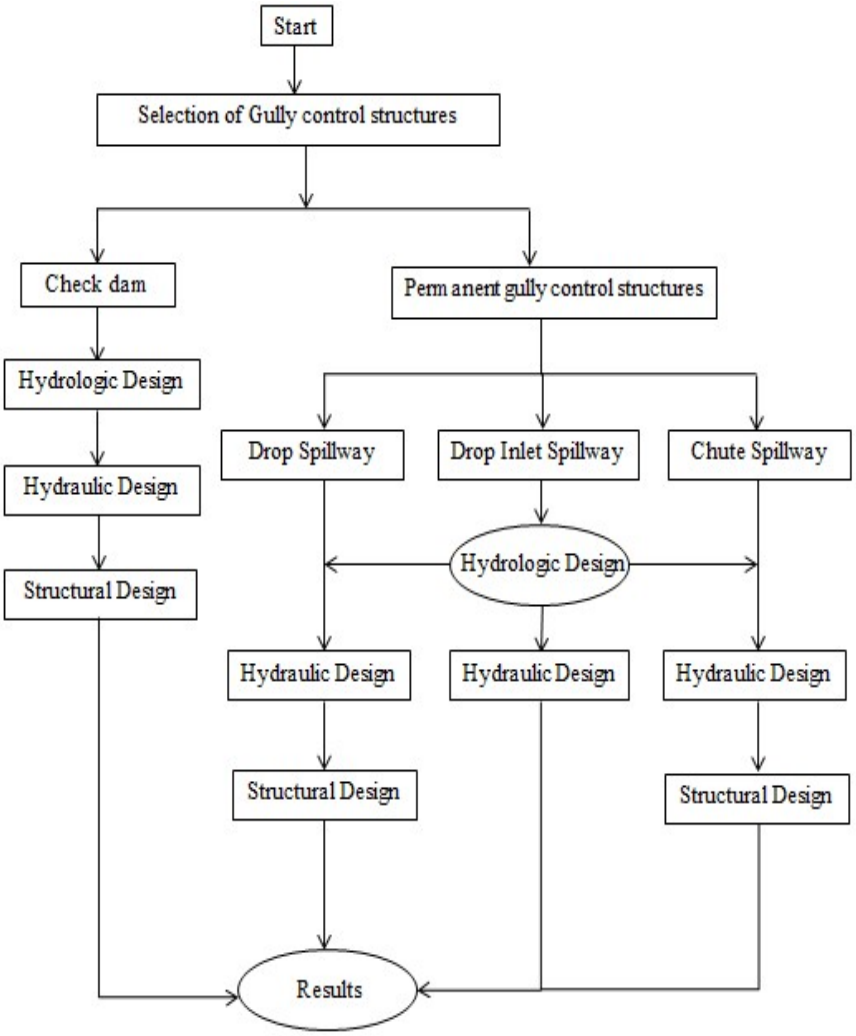


Fig.2.1 Flow chart for software design of gully control structures

2.2 DESIGN PROCEDURE OF CHECK DAM

2.2.1 Hydrologic Design

Structure can be designed for the maximum possible peak runoff rate which may occur within a reasonable frequency of interval (25/30/50 Years).The peak rate of runoff for a catchment is generally estimated for check dam by Dicken's Method.(WALAMTARI)

Computation of maximum flood discharge $\boldsymbol{Q = CA^{3/4}}$, cusecs

Where, **Q** = Maximum flood discharge (Cusecs)

C = Dickens constant (Appendix-I)

A = Catchment Area (square miles)

2.2.2 Hydraulic Design

The step by step procedure of check dam hydraulic design for software development by using the visual basic as described below.(Dhan Foundation, Chittoor)

I. CREST LEVEL OF THE CHECK DAM ($\mathbf{l_C}$)

The apex of the weir body wall where water is at full reservoir level is its crest.

II. HEIGHT OF THE CHECK DAM($\mathbf{H_b}$)

It is the elevation difference between the highest point and lowest point of water flow in the watershed.

III. LENGTH OF CHECK DAM, $\boldsymbol{L = 4.75\sqrt{Q}}$, m

IV. DISCHARGE PER METER RUN, $\boldsymbol{q = \frac{Q}{L}}$, Cumecs

V. APRON LEVEL, $\mathbf{l_A = [\, l_c - H_b]}$, m

VI. TOP LEVEL OF DOWNSTREAM(D/S) SOLID APRON, $\mathbf{l_{DA} = l_A}$, m

VII. DOWNSTREAM TAIL WATER LEVEL (T W L)

Tail water depth, $\mathbf{d_t = [\frac{Q}{1.656L}]^{2/3}}$, m

T W L on D/S, $\mathbf{l_{TW} = l_{DA} + d_t}$, m

VIII. UPSTREAM MAXIMUM FLOOD LEVEL

The depth of water flowing over the crest of the Check Dam is the difference between the Maximum Water Level and Full Reservoir Level.

- Head over crest

$$\mathbf{d_c=[\frac{Q}{1.845L}]^{2/3}}, \text{ m}$$

- Maximum flood level on U/S

$$\mathbf{l_{FU} = l_c + d_c}, \text{ m}$$

Provide 0.3 m thickness of foundation wall below the bottom level of check dam

IX. SCOUR DEPTH CALCULATIONS

- Regime Scour depth **R = 1.346 $[\frac{q^2}{f}]^{1/3}$,** m

  f = Laceys silt factor (Appendix-II)

- D/S bottom level of foundation = **[l_{TW} - 1.5R],** m

  Provide D/S cut-off wall 1.5 m below the body wall of check dam

  - U/S bottom level of foundation = **[(l_{FU}) - R],** m
  - Provide U/S cut-off wall 0.9 m below the foundation bottom level

X. LENGTH OF APRONS , L_A = **$10C_a [(H_b * q)/231]^{0.5}$**, m

XI. LENGTH OF SOLID APRON **(L_{SA})**

L_1= [1.5 + 2*(dc* h)$^{0.5}$], m

Where,**h = [(l_{FU}) - (l_{TW})],** m

L_2= [2*(H_b + d_c)], m

L_3= [4*C_a *(H_b/33)$^{0.5}$], m

L_{SA}= [(L_1+L_2+L_3)/3], m

XII. LENGTH OF TALUS, **L_T = L_A- L_{SA},** m

Provide length of talus at least 2 m

XIII. THICKNESS OF SOLID APRON, **t_{SA} = [0.5 * (d_c + h)$^{0.5}$],** m

Provide solid apron for a thickness of (t_{SA} – 0.1) m with 0.1 m thick wearing coat over it.

2.2.3 Structural Design

The following components are designed to develop software for the structural stability of the structure as given below. (Dhan Foundation, Chittoor)

I. BODY WALL OF THE CHECK DAM

- Top width of the check dam, **Tw = [(3*d_c)/(2*spwc)],** m

  Note: Provide 0.6 m top width if calculated T_W is less than 0.5 m

- Bottom width of the check dam, **Bw = [(H_b + d_c)/(spwc)$^{0.5}$],** m

  Note: Provide B_W as equal to H_b, if calculated B_W is less than H_b

II. THICKNESS OF CUSHION WALL

Solid wall constructed at the downstream end of apron, **t_c = (Tw/2),**m

III. STABILITY CALCULATIONS OF WALL

Stability of the wall can be calculated in two cases namely consider water is up to the crest level and water is discharging at maximum flood level.

Case I: Consider water is up to the crest level

For Calculating stability of wall formulas are considered as shown in the Table3.1

Table: 2.1 Inflow water is up to crest level

Force (1)	Magnitude (t/m) (2)	Lever arm (m) (3)	Moments about A(t) (2)*(3)
W_1	T_W*H_b*spwc	$(T_w/2)$	
W_2	$0.5*(B_w - T_w)*H_b*spwc$	$\{[(B_w - T_w)/3]+T_w\}$	
W_H	$[H_b]^3/6$	-	
Total	$\sum W =$		$\sum M =$

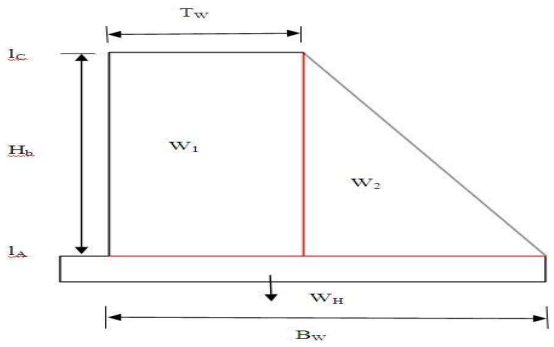


Fig.2.2 Water is up to crest level of the check dam

- Resultant $R_{s1} = \sum M/\sum W$, m

a) Check against tension

The resultant thrust lies in the middle third of the base width {**i.e.** $(B_w/3)$ **to** $[(2*B_w)/3]$m,then the wall is safe against tension at its base.

b) Check against overturning

The resultant thrust is passing within the base then the wall is safe against overturning.

c) Check against compression

- Eccentricity developed $(e) = [(0.5*B_w) - R_{s1}]$, m
- Eccentricity limit $= \{B_w/6\}$, m
- Compressive stress developed

*Maximum compressive stress $=\{(\sum W/B_w)*[1 + \{(6*e)/B_w\}]\}$ t/m^2

*Minimum compressive stress $=\{(\sum W/B_w)*[1 - \{(6*e)/B_w\}]\}$ t/m^2

The stresses developed are within permissible limits then it is safe against compression.

Case II: Water is discharging at maximum flood level

For Calculating Discharge at maximum flood level formulas are considered as shown in the Table 3.2

Table: 2.2 Water is discharging at Maximum flood level (M F L)

Force (1)	Magnitude(t/m) (2)	Lever arm (m) (3)	Moments about A (t) (2)*(3)
W_1	T_W*H_b*spwc	$(T_w/2)$	
W_2	$0.5*(B_w - T_w)*H_b*spwc$	$\{ [(B_w - T_w)/3]+T_w \}$	
W_3	T_w*d_c*spww	$(T_w/2)$	
W_4	$0.5*[(d_t/H_b)*(B_w - T_w)]*d_c*spww$	$\{ [\{(d_t/H_b)* (B_w - T_w)\}/3]+T_w \}$	
W_5	$[(d_t/H_b)*(B_w - T_w)]*(l_c - l_{TW})*spww$	$\{ [(B_w - T_w)/2]+T_w \}$	
W_6	$0.5*[(d_t/H_b)*(B_w - T_w)]*d_t*spww$	$\{ (B_w)- [(d_t/H_b)* (B_w - T_w)] \}$	
W_H	$[H_b]^3/6$	-	
Total	$\sum W =$		$\sum M =$

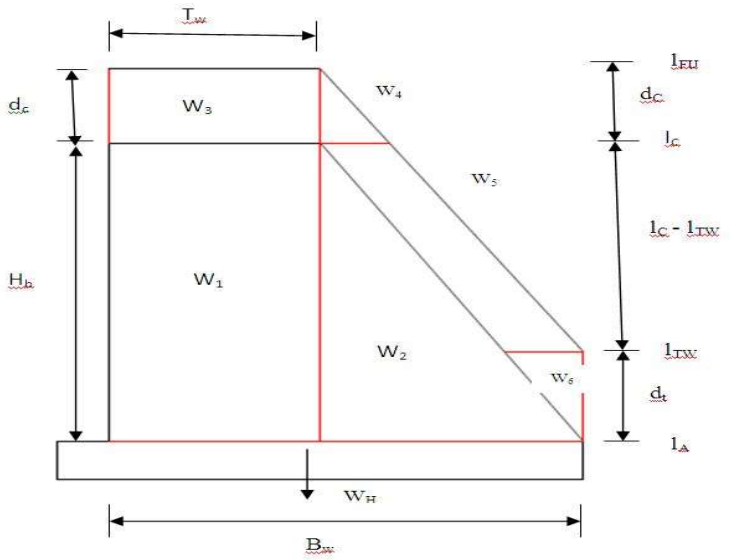


Fig.2.3 Check dam is discharging at maximum flood level

- Resultant $\mathbf{R_{s2}} = \sum \mathbf{M}/\sum \mathbf{W}$, m

a) <u>Check against tension</u>

The resultant thrust lies in the middle third of the base width **{i.e, $(B_w/3)$ to $[(2*B_w)/3]$**m,then the wall is safe against tension at its base.

b) Check against overturning

The resultant thrust is passing within the base then the wall is safe against overturning.

c) Check against compression

- Eccentricity developed **(e) = [(0.5*B_w) – R_{s1}]**, m
- Eccentricity limit = **{B_w/6 },** m
- Compressive stress developed

*Maximum compressive stress=**{ (∑W/B_w)*[1 + {(6*e)/B_w}] }** t/m^2

*Minimum compressive stress=**{ (∑W/B_w)*[1 - {(6*e)/B_w}] }** t/m^2

The stresses developed are within permissible limits then it is safe against compression.

IV. CREEP LENGTH PROVIDED FOR CHECK DAM

- Creep Length required, **C_L = ($C_a$$H_b$),** m
- Creep length provided, **C_{LP} =L_h + L_v** , m

= [2T_W+B_W+L_A+L_T] + [0.3+0.9+t_{SA}+H_b]

If Creep length provided is more than the creep length required hence design is safe against creep otherwise Provide “creep length required”

V. CHECK AGAINST PIPING

- Weighted creep ratio (C_W) = {[∑L_h + 2∑L_v]/(3H_b)}

The calculated C_w is greater than tabulated C_w value (Appendix-III) then the structure is safe against piping.

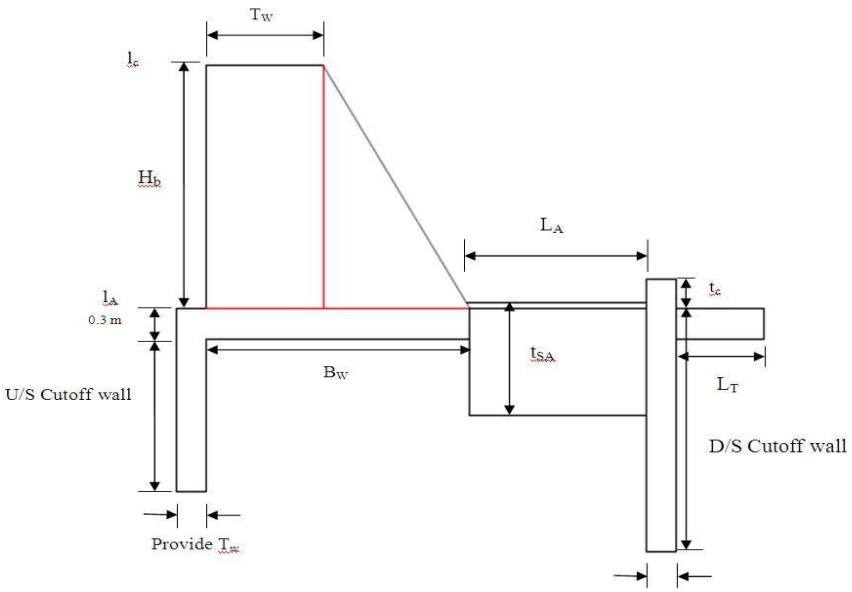


Fig.2.4 Creep path provided for check dam

2.3 DESIGN PROCEDURE OF DROP SPILLWAY

2.3.1 Hydrologic Design

Flood discharge volume calculated by computing the runoff rate for 25/ 30/ 50 years return period. Runoff rate is calculated by Rational method. (Ghanshyam Das, 2012)

Computed discharge value, **Q=CIA/360**

Where, Q= peak runoff rate, cumecs

C= coefficient of runoff (Appendix-IV)

= **(1/A)*(C_1A_1+ C_2A_2+ C_3A_3+……..+ C_nA_n)**

I= Intensity of rainfall, mm/h

2.3.2 Hydraulic Design

The width of gully and depth of gully are known then determining the length of crest, depth of the weir to provide required capacity and maintain free board. (Ghanshyam Das, 2012)

I. LENGTH OF WEIR CREST, **L=Width of gully – 0.5,** m

II. HEIGHT OF WATER AT CREST, **$Q=(2/3)* C_d *(2g)^{1/2}*L*h^{3/2}$,** cumecs

Where C_d = discharge coefficient (0.6)

g = 9.8, m/sec^2

L = length of weir crest, m

h = height of water at crest, m

III. HEIGHT OF THE WEIR, **d = h+0.15**, m

IV. HEIGHT OF WATER DROP FROM THE CREST, **H=depth of gully –d,** m

V. BASIN/APRON LENGTH, $\mathbf{L_B = 0.75(H+d)+H,}$ m

VI. WIDTH OF THE SIDE WALL, **W=H+d+1,** m

VII. HEIGHT OF THE SIDE WALL

a) At the end sill end = at least 1.5d $\geq$H/2, m

b) At the weir end = equal to gully width, m

VIII. LENGTH OF THE WING WALL, $\mathbf{L_W = 2.25h}$, m

IX. DEPTH OF THE TOE WALL, **h +0.1**, m

2.3.3 STRUCTURAL DESIGN

The force analysis of drop spillway can be carried out here. (Ghanshyam Das, 2012)

I. TOTAL UPLIFT PRESSURE, $\mathbf{P_U = H-0.5,}$ m

II. ANALYSIS OF FORCES

Drop spillway structural forces can be calculated, if know the volume of component, material density, lower arm length of the structure as described in the Table 3.2.

Table: 2.3 Analysis of forces of the Drop Structure

Forces on structure	Volume of component per unit length (m^3)	Material density (kg/m^3)	Force per unit length of structure (kg/m) (2)*(3)	Lower arm length (m)	Moment(kg) (4)*(5)	Type of moment
(1)	(2)	(3)	(4)	(5)	(6)	(7)
P_1	(d*H)*1			0.5*H		Over Turning
P_2	$0.5*H^2*1$			(1/3)*H		Over Turning
P_{u1}	$0.5*(L_B+1.5)*1*1$			$(2/3)*(L_B+1.5)$		Over Turning
P_{u2}	$0.5*(L_B+1.5)*1$			$0.5*(L_B+1.5)$		Over Turning
W_1	(H-0.5)*1*1			$((L_B+1.5)-0.5)$		Restoring
W_2	0.5*(H-0.5)*0.5			$L_B+[(2/3)*0.5]$		Restoring
W_3	$0.5*(L_B+1.5)*1$			$0.5*(L_B+1.5)$		Restoring

1- Safety against overturning

Safety against overturning is calculated by following formula

Total restoring moment > Total overturning moment

2- Safety against sliding

For safety against sliding,

$\sum f_h$ should not be greater than $C_f*\sum f_h+C_rA$ i.e. **[$\sum f_h < (C_f*\sum f_v+C_rA)$]**

Where, $\sum f_h = P_1+P_2$ = horizontal forces, m^3

$\sum f_v = W_1+W_2+W_3 - P_{u1} - P_{u2}$ = vertical forces, m^3

$C_f = \tan\emptyset$, ($\emptyset$ = angle of internal friction of soil)

C_r = cohesion resistance of soil (Kg/m^2)

$A = [H*(L_B+1.5)]$=area of plane of sliding , m^2

If it satisfies $\sum f_h < (C_f*\sum f_v+C_rA)$ sliding is safe otherwise redesign

3- Safety against tension

The eccentricity (e) should not be greater than [width (d)/6] then the structure is safe against tension.

$e = Z-[Width(d)/2]$, m

$Z=[\sum moments/(\sum f_v)]$, m

4-Safety against compression

The force should be compressive in nature, so that there is no floatation of the structure. Thus, the resultant force should act downwards,

$$\text{Contact pressure, } P_e = \{(\sum f_v/A)*[1\pm(6e/d)]\}$$

Where the +ve sign will give pressure at the upstream, and the –ve sign will give pressure at the downstream.

5- Safety against piping

The weighted creep ratio (C_W) should be higher than the recommended value then the structure is safe against piping.

$$C_W = \{(\sum L_h+2\sum L_V)/(3H)\}$$

Where, C_W = Weighted creep ratio

$\sum L_h$ = Sum of all horizontal (flat) contact distances, m

$\sum L_V$ = Sum of all vertical r steep contact distances, m

H = Head between the head water and the tail water, m

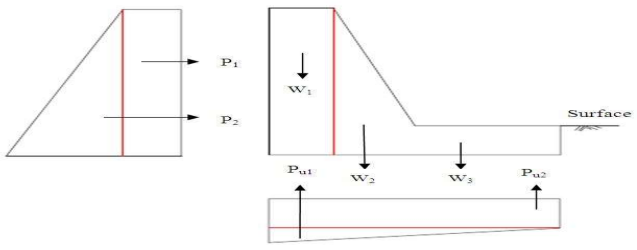


Fig.2.5 Analysis of forces for Drop spillway

2.4 DESIGN PROCEDURE FOR DROP INLET SPILLWAY

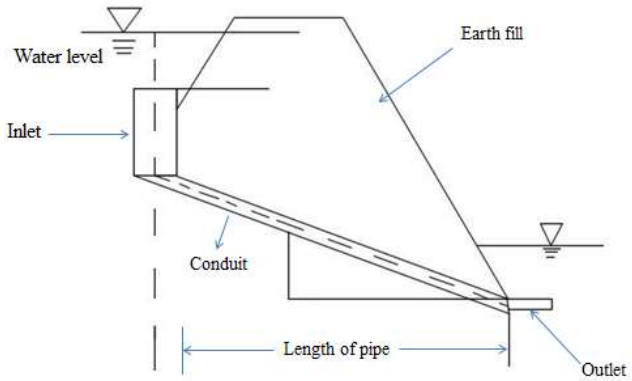


Fig.2.6 Components of Drop inlet spillway

2.4.1 Hydrologic Design of drop inlet spillway

Estimation of flood discharge volume by computing the Runoff rate for 25/ 30/ 50 years return period. Runoff rate is calculated by Rational method.(Ghanshyam Das, 2012)

Computed discharge value, **Q=CIA/360** , cumecs

Where, Q= peak runoff rate, cumecs

C= coefficient of runoff (Appendix-IV)

$= \mathbf{(1/A)*(C_1A_1+ C_2A_2+ C_3A_3+\ldots\ldots\ldots..+ C_nA_n)}$

I= Intensity of rainfall, mm/h

2.4.2 Hydraulic Design for drop inlet spillway

The width of gully and depth of gully are known, the design consists of determining the length of the pipe, velocity of flow, radius of pipe, natural slope. (Ghanshyam Das, 2012)

I. LENGTH OF PIPE,**L**=Base width of the embankment, m

II. VELOCITY OF FLOW IN CULVERT PIPE, $\mathbf{V= (2gH)^{0.5}/(1+K_e+K_cl)^{0.5}}$, m/s

Where, K_e = Coefficient of entrance losses

K_c = Head loss coefficient

g = 9.81, m/s^2

H= water head, m

III. CROSS SECTIONAL AREA OF A PIPE, $\mathbf{A=Q_0/V}$, m^2

Where, Q_0=discharge, cumecs

IV. RADIUS OF A PIPE, $\mathbf{r = (A/\pi)^{0.5}}$, m

V. DIAMETER OF THE PIPE, **d = 2 * r,** m

VI. NATURAL SLOPE, $\mathbf{S_n= (K_cV^2/2g) /(1-(K_cV^2/2g)^2)^{0.5}}$, **%**

VII. PIPE SLOPE=**height of drop/pipe length,%**

2.5 DESIGN PROCEDURE OF CHUTE SPILLWAY

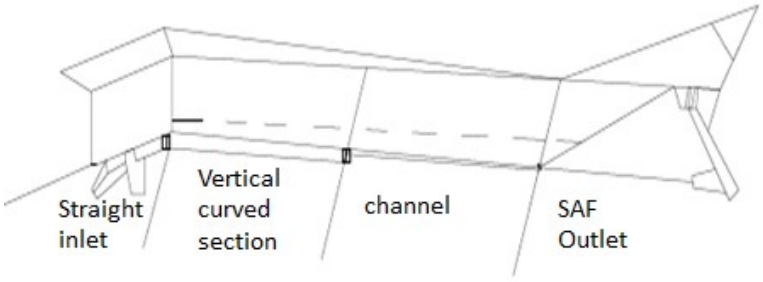


Fig.2.7 Chute spillway

2.5.1 Hydrologic Design of chute spillway

Estimation of flood discharge volume is calculated by computing the runoff rate for 25/ 30/ 50 years return period. Runoff rate is calculated by Rational method. (Ghanshyam Das, 2012)

Computed discharge value,**$Q=CIA/360$**

Where, Q = peak runoff rate, cumecs

C= coefficient of runoff (Appendix-IV)

= **$(1/A)*(C_1A_1+ C_2A_2+ C_3A_3+\ldots\ldots\ldots..+ C_nA_n)$**

I= Intensity of rainfall, mm/h

2.5.2 Hydraulic Design of chute spillway

The design consists of determining the length of weir, head loss, sequent depth, if know the width and depth of gully. (Ghanshyam Das, 2012)

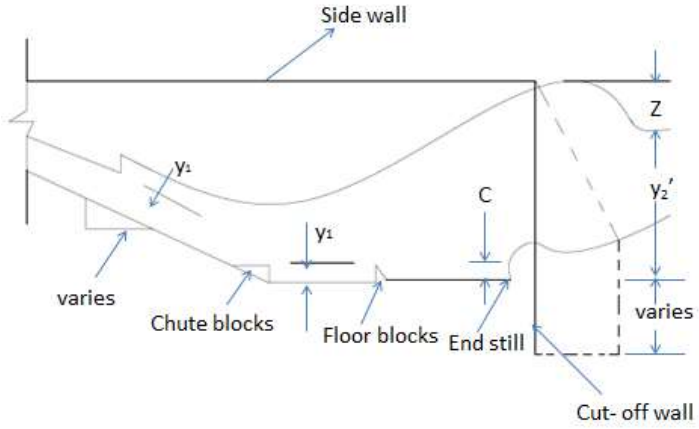


Fig.2.8 Sectional view of chute spillway

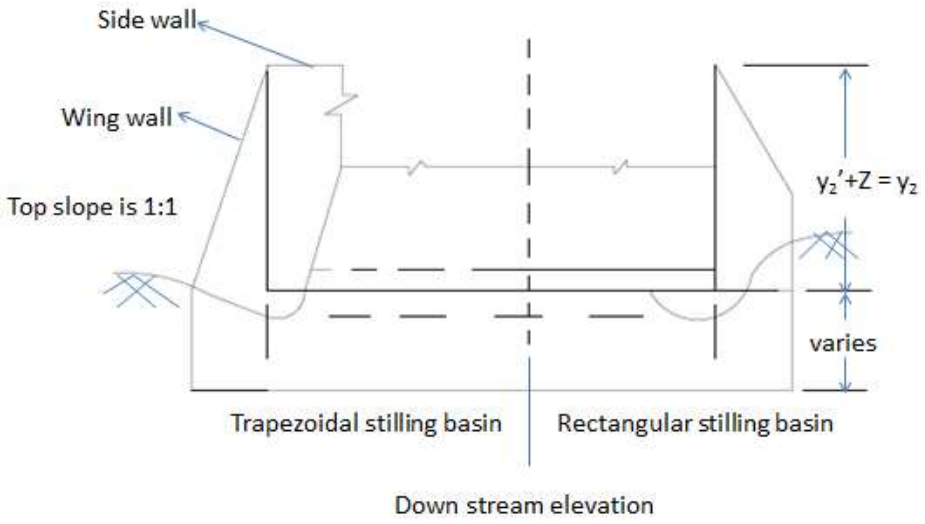


Fig.2.9 SAF stilling basin outlet

I. LENGTH OF STRAIGHT INLET , **$L=Q/1.77*H^{3/}2$,**m

Q=Discharge, cumecs

H=Depth of flow, m

II. HEAD LOSS AT TOE, **h_e=drop in gully head(D)-10% of gully head(D),** m

III. VELOCITY AT STIILING BASIN TOE, **$V=(2gh_e)^{0.5}$,** m/s

Where, g=9.81, m/s^2

IV. INITIAL DEPTH OF THE FLOW, **$y_1=Q/LV$,** m

V. FROUDE NUMBER, **$F_r=V/(g*y_1)^{0.5}$**

VI. SEQUENT DEPTH, **$y_2=y_1*0.5((1+8(F_r)^2)^{0.5}-1)$,** m

VII. FLOOR AND CHUTE BLOCK HEIGHT= **y_1**,m

VIII. SPACING AND WIDTH BETWEEN FLOOR AND CHUTE BLOCKS=**$0.75*y_1$**, m

IX. DISTANCE OF FLOOR BLOCKS FROM THE SIDE WALLS =**$0.375*y_1$**, m

X. TAIL WATER DEPTH OVER THE STILLING BASIN, **$y_2' = 1.4y_1*(F_r)^{0.45}$,** m

XI. STILLING BASIN LENGTH,**$L_B=4.5y_2/(F_r)^{0.38}$,** m

XII. SIDEWALL AND STILLING BASIN HEIGHT = **$(y_2/3)+y_2'$**,m

XIII. TRANSVERSE SILL HEIGHT = **$0.07*y_2$,** m

XIV. SIDE WALL FREE BOARD TO BE PROVIDED ABOVE THE TRAILED WATER DEPTH = **$y_2/3$,** m

XV. WING WALL HEIGHT= **$(y_2/3)+y_2'$**m

2.5.3 STRUCTURAL DESIGN OF THE CHUTE SPILLWAY

I. FORCES ANALYSIS

Forces can be analyze by using head of each section upstream, head of each section downstream, force per horizontal width of the water body as shown in Table 3.4. (Ghanshyam Das, 2012)

Table: 2.4 Force analyses for Chute spillway structure

Pressure diagram section no.	Head of each section up stream (m)	Head of each section downstr eam (m)	Force per horizontal width of the water body (m)	Pressure diagram area (m^2)	Uplift force (Kg)	Cumulative uplift force (Kg)	Weight of each section (Kg)	Cumulative weight of the structure (Kg)	Comments— safe when weight > the uplift force(Safe or Unsafe) (9)>7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	d	P=A-B	x/4	0.5(d+(A-B))*x/4	(5)*W*1000		W_t		
2	A-B	C-D	x/4	0.5*((A-B)+(C-B))*x/4	(5)*W*1000		W_t		
3	C-D	E-F	x/4	0.5*((C-D)+(E-F))*x/4	(5)*W*1000		W_t		
4	E-F	G-H	x/4	0.5*((E-F)+(G-H))*x/4	(5)*W*1000		W_t		
5	G-H	0.01	W_S	0.5*W_S*(G-H)	(5)*W*1000		Wt_s		

$$P=\left\{\frac{D+d}{x+ws}*\left((x+ws)-{}^{x}/_{4}\right)\right\}-\left\{\frac{D}{x}\left(x-{}^{x}/_{4}\right)\right\}$$

$$A=\left\{\frac{D+d}{x+ws}*\left((x+ws)-{}^{x}/_{4}\right)\right\}$$

$$B=\left\{\frac{D}{x}\left(x-{}^{x}/_{4}\right)\right\}$$

$$C=\left\{\frac{A}{(x+ws)-x/4}*\left((x+ws)-2\,{}^{x}/_{4}\right)\right\}$$

$$D=\left\{\frac{B}{(x-x/4)}*\left(x-2\,{}^{x}/_{4}\right)\right\}$$

$$E=\left\{\frac{C}{(x+ws)-2x/4}*\left((x+ws)-3\,{}^{x}/_{4}\right)\right\}$$

$$F=\left\{\frac{D}{(x-2x/4)}*\left(x-3\,{}^{x}/_{4}\right)\right\}$$

$$G=\left\{\frac{E}{(x+w\ )-3x/4}*\left((x+ws)-4\,{}^{x}/_{4}\right)\right\}$$

$$H=\left\{\frac{F}{(x-3x/4)}*\left(x-4\,{}^{x}/_{4}\right)\right\}$$

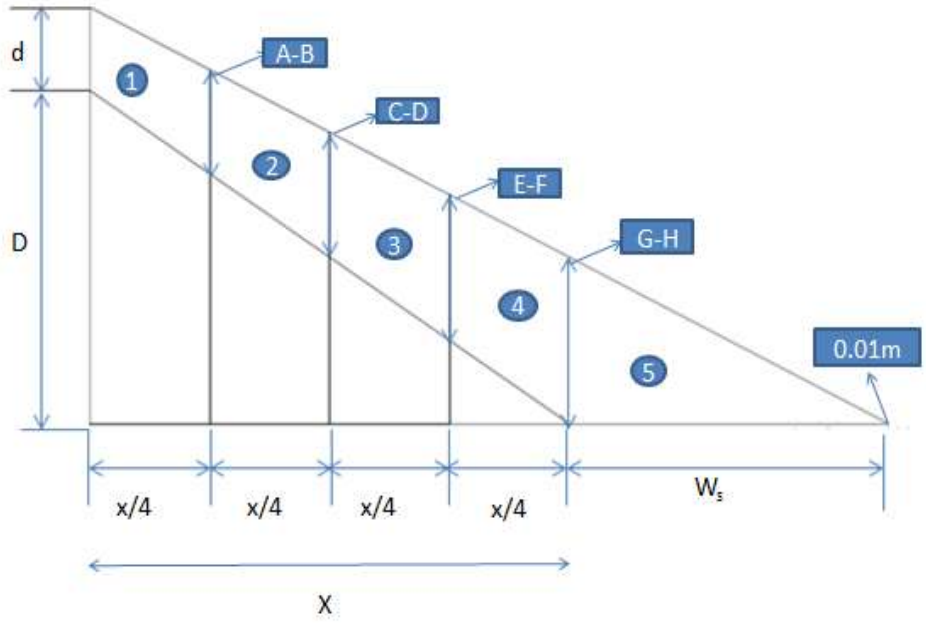


Fig. 2.10 Pressure diagram for chute spillway

II. THE WEIGHT OF THE SECTION OF STRUCTURE

=**Cross-sectional area of a section (L/4*W) *thickness (t)*density,** Kg

III. LENGTH OF THE TOTAL CHANNEL**(L)=(D^2+x^2)$^{0.5}$,** m

IV. LENGTH OF EACH SECTION=**L/4,** m

V. WEIGHT OF THE BASE OF EACH SECTION= **(L/4)*W*t*density,** Kg

VI. WEIGHT OF TWO SIDE WALLS ON EACH SECTION =**2*((L/4)*d*t*density),** Kg

VII. TOTAL WEIGHT OF EACH SECTION

(W_t)=((L/4)*W*t*density)+(2*((L/4)*d*t*density)), Kg

WEIGHT OF THE STILLING BASIN

VIII. WEIGHT OF THE BASE=**W_s*W*t* density,** Kg

IX. SUPPOSE THE HEIGHT OF SIDE WALLS OF THE STILLING BASIN=**0.7,** m

X. WEIGHT OF THE SIDE WALLS=**2*(W_s*0.7*t* density)**, Kg

XI. TOTAL WEIGHT OF THE STILLING BASIN

(Wt_s)=(W_s*W*t* density)+(2*(W_s*0.7*t* density)), Kg

3. RESULTS AND DISCUSSION

Gully control structures, such as check dams, drop spillways, drop inlet spillways, and chute spillways, are developed using hydrologic, hydraulic, and structural stages.

3.1 Check Dam Design Hydrologic design for gully control structures is similar, but check dam design differs. Hydraulic and structural designs vary each structure. Using mathematical formulas from the previous chapter, structures are constructed in Visual Studio 13.3.1 Check Dam Design - Hydrologic design based on numerical formulas - Fig. 3.1 - Hydraulic design procedure - Fig. 3.2 - Structural design - Fig. 3.3 - Check dam discharging at maximum flood level - Fig. 3.4 - Check against

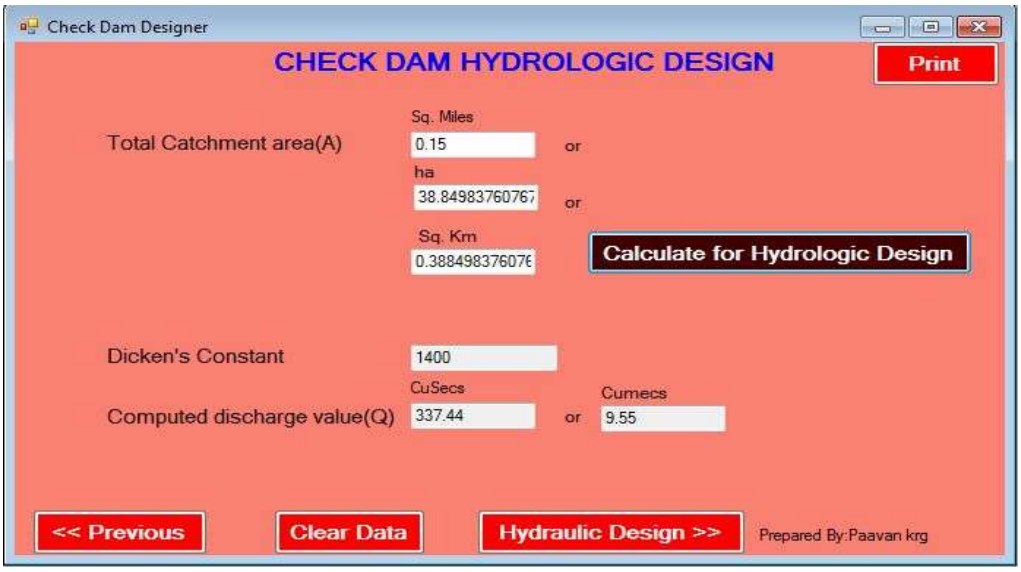
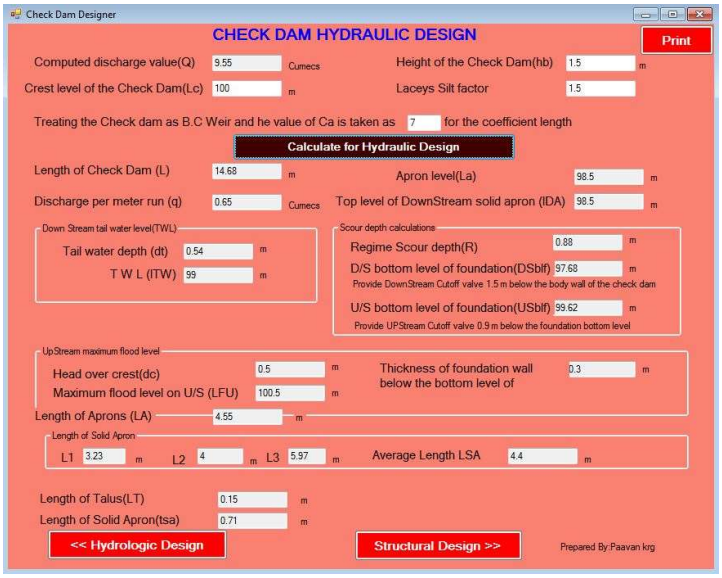


Fig.3.1. Hydrologic design of check dam



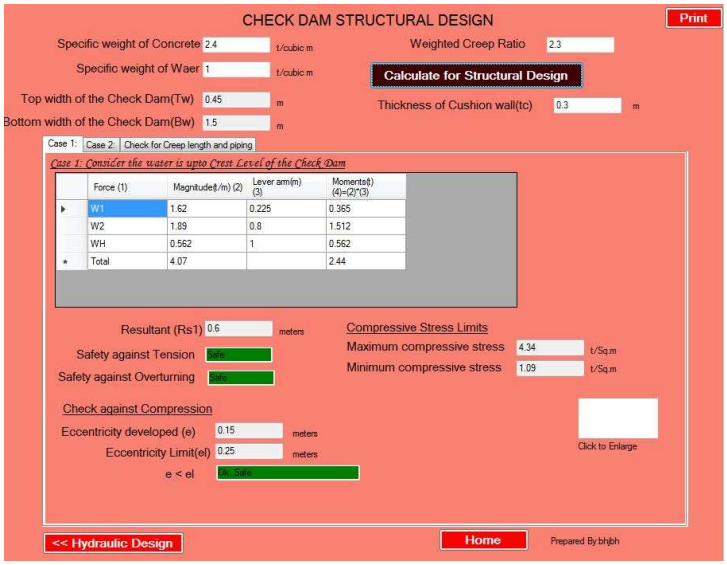


Fig.3.2. Hydraulic design of check dam **Fig.3.3. Water is up to crest level of check dam**



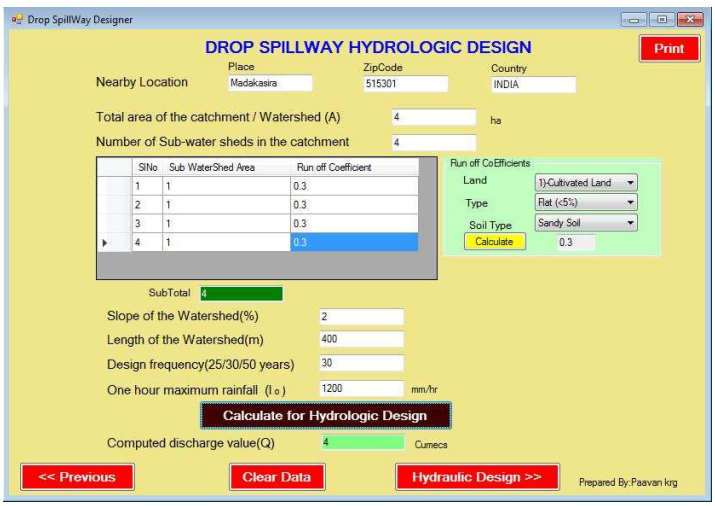


Fig.3.4. Check dam is discharging at maximum flood level

Fig.3.5. Check against creep length and piping

4.2 Drop spillway design

The hydrologic design of a drop spillway is determined by the rational formula, as shown in Figure 3.6. The hydraulic design process for the drop spillway is illustrated in Figure 3.7. Additionally, the structural design of the drop spillway is analyzed by force analysis.



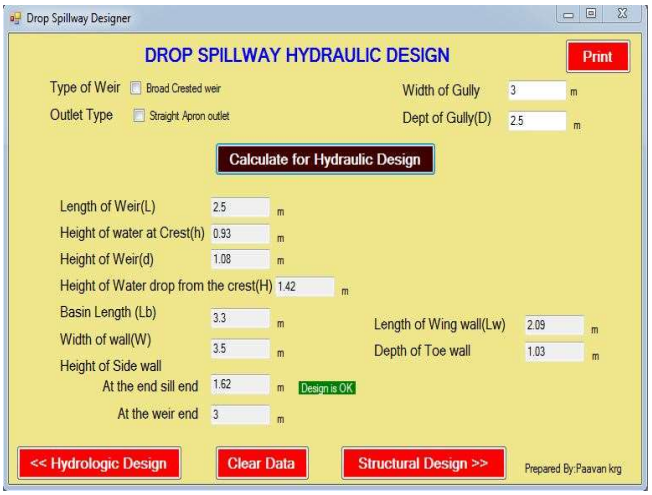
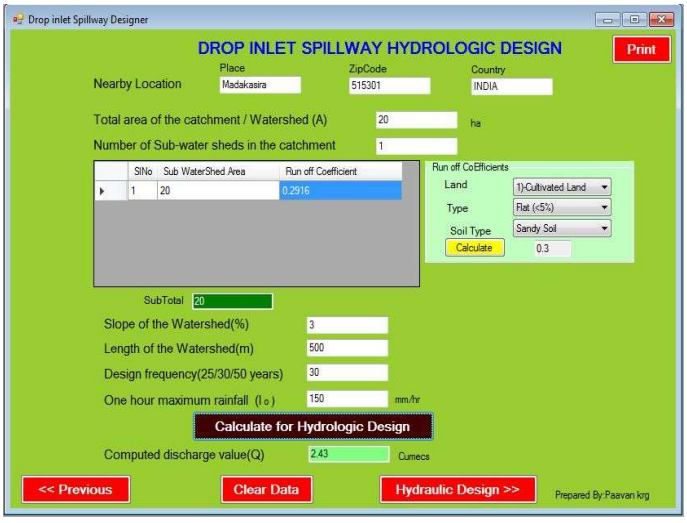


Fig.3.6. Hydrologic design of Drop Spillway **Fig.3.7. Hydraulic design of Drop Spillway**

4.3 Drop Inlet spillway design

The design of the drop intake spillway takes into account the hydrologic design, as shown in Figure 3.8, and the hydraulic design of the pipe spillway, which considers factors such as the percentage of pipe flow, as illustrated in Figure 3.9.



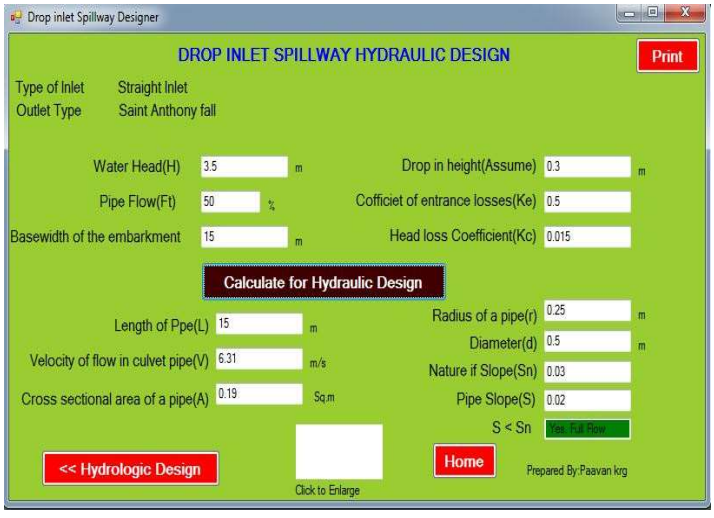


Fig.3.8. Hydrologic design of Drop Inlet Spillway **Fig.3.9. Hydraulic design of Drop Inlet Spillway**

3.4 Chute spillway design

The hydrologic design of a chute spillway is also determined by using the rational method for calculating the maximum flood flow, as seen in Figure 3.9. The dimensions of the chute spillway are determined by the hydraulic design technique, as seen in Figure 3.10. The structural design of the chute spillway involves the performance of strength and stability calculations.

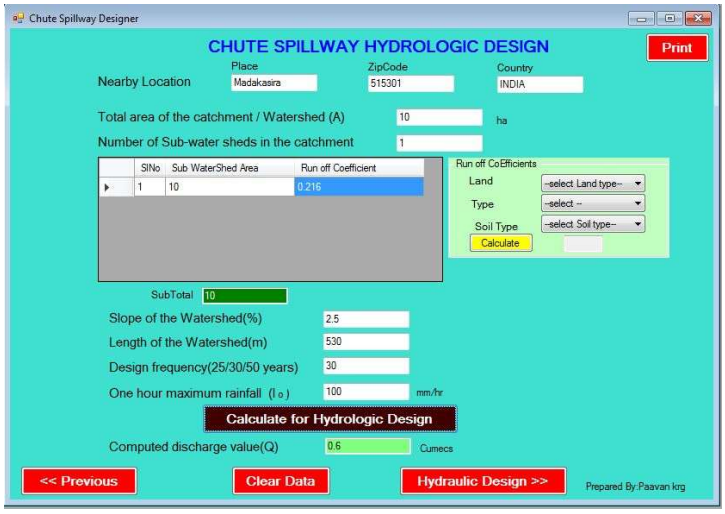


Fig.3.9. Hydrologic design of Chute Spillway

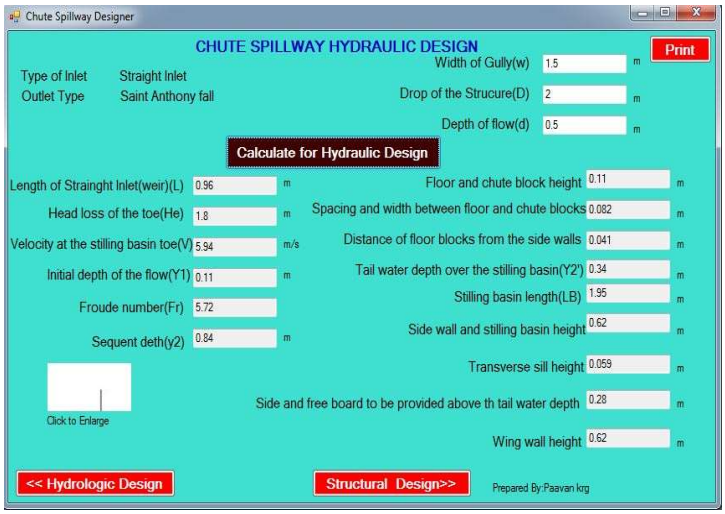


Fig.3.10. Hydraulic design of Chute Spillway

3.5 Validation of GCS_Designer for check dam

Table 3.1 shows the hydrologic, hydraulic, and structural design parameters computed by the program and compared to manual output or human computation for the check dam. GCS_Designer software and hand calculation yielded the same maximum flood discharge of 9.55 m3/s, hence no mistake was discovered.

The manual check dam length was 14.67 m and the GCS_Designer length was 14.68 m, and the truncation error was 0.0681 due to rounding. Except for length of apron 4.54 m and 4.55 m, length of solid apron 4.39 m and 4.40 m, and thickness of solid apron 0.70 m and 0.71 m for manual and GCS_Designer, the remaining hydraulic design parameters have similar values in both outputs and zero percentage error.

In two cases, structural design parameters have split. In circumstance 1 (water up to the check dam crest), manual and GCS_Designer had maximum compressive stress of 4.37 and 4.34 t/m2 and minimum of 1.06 and 1.09 t/m2. Maximum and lowest compressive stresses have -0.6192% and 2.7523% errors.

In case 2 (check dam discharge at maximum flood level), manual and GCS_Designer had maximum compressive stress of 4.93 and 4.90 t/m2 and minimum of 2.25 and 2.31. Maximum and lowest compressive stresses have errors of -0.6122% and 2.5974%.

Manual and GCS_Designer creep lengths were 12.34 m and 12.36, with weighted creep ratios of 4.25 and 4.26. Creep length and weighted creep ratio have 0.1618 and 0.2347 percentage errors. Table 4.1 creep length for structural design was correct.

GCS_Designer validation in check dams yielded 2.7523 % error for minimum compressive stress and 0.0681 % inaccuracy for length. Validating GCS_Designer for check dam involves 25 parameters. 10 parameters have % errors while the rest have zero. The remainder are under estimate (negative) and 80% are above estimate (positive).

Table: 3.1. Validation of GCS_designer for check dam

Design parameter	Manual output	GCS_Designer output	% of Error	Remarks
Hydrologic Design				
Computation of maximum flood discharge (Q),m^3/s	9.55	9.55	0.0000	do
Hydraulic Design				
Length of check dam (l),m	14.67	14.68	0.0681	Truncation
Discharge per meter run (q),m^3/s	0.65	0.65	0.0000	do
Apron level (l_a),m	98.50	98.50	0.0000	do
Top level of downstream solid apron (l_{da}),m	98.50	98.50	0.0000	do
Tail water depth (d_t),m	0.54	0.54	0.0000	do
Head over crest (d_c),m	0.50	0.50	0.0000	do
Scour Depth Calculations				
Regime Scour depth(R), m	0.88	0.88	0.0000	do
Length of aprons (LA),m	4.54	4.55	0.2198	Truncation
Length of solid apron (LSA) ,m	4.39	4.40	0.2273	Truncation
Length of talus(LT),m	0.15	0.15	0.0000	do
Thickness of solid apron($\mathbf{t_{sa}}$),m	0.70	0.71	1.4085	Truncation
Structural Design				
Case-1 (Water is up to crest level of the check dam)				
Resultant (Rs1),m	0.60	0.60	0.0000	do
Maximum Compressive Stress, t/sq.m	4.37	4.34	-0.6912	Truncation

Minimum Compressive Stress, t/sq.m	1.06	1.09	2.7523	Truncation
Eccentricity developed (e), m	0.15	0.15	0.0000	do
Eccentricity limit (el),m	0.25	0.25	0.0000	do
Case-2 (Check dam is discharging at maximum flood level)				
Resultant (Rs2),m	0.66	0.66	0.0000	do
Maximum Compressive Stress, t/sq.m	4.93	4.90	-0.6122	Truncation
Minimum Compressive Stress, t/sq.m	2.25	2.31	2.5974	Truncation
Eccentricity developed (e), m	0.09	0.09	0.0000	do
Eccentricity limit (el),m	0.25	0.25	0.0000	do
Check against creep and piping				
Creep Length required (C_L), m	10.50	10.50	0.0000	do
Creep length provided (CLP), m	12.34	12.36	0.1618	Truncation
Weighted creep ratio (C_W)	4.25	4.26	0.2347	Truncation

3.6 Validation of GCS_designer for drop spillway structure

GCS_Designer software and hand calculation yielded the same maximum flood discharge of 4.00 m3/s, hence no mistake was discovered.The height water at the crest was 0.93 m and 0.96 m (error = -3.2258 %), the weir was 1.08 m and 1.11 m (error = -2.7778 %), the water drop from the crest was 1.42 m and 1.39 m (error = 2.1127 %), the basin apron was 3.30 m and 3.27 m (error = 0.9091%), and the wing wall was 2.09 m and 2.16 m (error = -3.3493%). The weir crest length, side wall width, and side wall height were correct. In structural design of drop spillway, total uplift pressure was 0.92 m in both outputs, therefore no mistake occurred. The findings were in Table 4.2. GCS_Designer validation in drop spillway showed -3.3493 % error for wing wall length and -0.0309 % error for head wall extension at end sill end. Out of 12 parameters analyzed for GCS_Designer drop spillway validation, 7 exhibit % error and the rest show zero. 28.6% of drop spillway values are above estimate and 71.4% are under estimate.

Table: 3.2. Validation of GCS_designer for Drop Spillway Structure

Design parameter	Manual output	GCS_Designer output	% of Error	Remarks
Hydrologic Design				
Computed discharge value (Q),m^3/s	4.00	4.00	0.0000	do
Hydraulic Design				
Length of weir crest (L),m	2.50	2.50	0.0000	do
Height of water at crest (h),m	0.96	0.93	-3.2258	Truncation
Height of the weir (d),m	1.11	1.08	-2.7778	Truncation
Height of water drop from the crest (H),m	1.39	1.42	2.1127	Truncation
Basin apron length (Lb),m	3.27	3.30	0.9091	Truncation
Width of the side wall (W),m	3.50	3.50	0.0000	do
Length of the wing wall(Lw),m	2.16	2.09	-3.3493	Truncation
Depth of the toe wall, m	1.06	1.03	-2.9126	Truncation
At the end sill end, m	1.67	1.62	-0.0309	Truncation
At the weir end, m	3.00	3.00	0.0000	do
Structural Design				
Total Uplift Pressure (P_u),m	0.92	0.92	0.0000	do

3.7 Validation of GCS_designer for Drop Inlet spillway

The discharge value of 2.43 m3/s was determined for both the manual calculation and the output from the GCS_Designer program. The velocity of the flow in the culvert pipe was measured to be 6.31 m/s and 6.30 m/s (with an error of 0.0016%) for the GCS_Designer software output and manual output, respectively. However, no error was observed in the measurements of the pipe's length (15 m), cross-sectional area (0.19 m2), radius (0.25 m), natural slope (0.03%), and pipe slope (0.02%), as indicated in Table3.3. The user's text is incomplete and does not provide any information. The validation of GCS_Designer was seen in the drop inlet spillway, resulting in a velocity of flow in the culvert pipe with an inaccuracy of 0.0016%.

The validation of GCS_Designer for drop inlet spillway involves the consideration of a total of 8 parameters. Among these parameters, one parameter exhibits a percentage of error, while the rest

parameters exhibit zero % error. A mistake has been observed in the drop inlet spillway among a total of 8 parameters, while the remaining 87.5% of values do not exhibit any errors.

Table: 3.3. Validation of GCS_designer for Drop Inlet Spillway

3.8 Validation of GCS_designer for Chute spillway

The discharge value of 0.60 m3/s was determined using the GCS_designer program, and no errors were detected throughout the hydrologic design process. The Froude numbers were determined to be 5.72 and 5.85, with an error of -2.2727%. The sequent depths were measured to be 0.84 m and 0.82 m, with an error of 2.3810%. The spacing and width between the floor and chute blocks were found to be 0.082 m and 0.08 m, with an error of 2.4390%. The distance of the floor blocks from the side walls were measured to be 0.041 m and 0.04 m, with an error of 2.4390%. The tail water depth over the stilling basin was determined to be 0.34 m and 0.33 m, with an error of 2.9412%. The length of the stilling basin was measured to be 1.95 m and 1.85 m, with an error of 3.0769%. The height of the sidewall and stilling basin was found to be 0.62 m and 0.60 m, with an error of 3.2258%. The transverse sill height was measured to be 0.059 m and 0.06 m, with an error of -1.6949%. The side wall free board above the trailed water depth was determined to be 0.28 m and 0.27 m, with an error of 3.5714%. The wing wall height was measured to be 0.62 m and 0.60 m, with an error of 3.2258%. The GCS_Designer software output and manual output yielded these results, with no errors found in the remaining parameters of the hydraulic design of the chute spillway, as presented in Table 3.4.

Design parameter	Manual output	GCS_Designer output	% of Error	Remarks
Hydrologic Design				
Computed discharge value (Q),m3/s	2.43	2.43	0.0000	do
Hydraulic Design				
Length of pipe (L),m	15.00	15.00	0.0000	do
Velocity of flow in culvert pipe (v), m/s	6.30	6.31	0.0016	Truncation
Cross sectional area of a pipe (A), sq.m	0.19	0.19	0.0000	do
Radius of a pip(R),m	0.25	0.25	0.0000	do
Diameter of a pipe(d),m	0.50	0.50	0.0000	do
Natural slope (Sn), %	0.03	0.03	0.0000	do
Pipe slope(S), %	0.02	0.02	0.0000	do

Table: 3.4. Validation of GCS_designer for Chute Spillway

The chute spillway's structural design parameters were length of the total channel 3.61 m and 3.6 m

Design parameter	Manual output	GCS_Designer output	% of Error	Remarks
Hydrologic Design				
Computed discharge value (Q),m^3/s	0.60	0.60	0.0000	do
Hydraulic Design				
Length of the straight inlet(L),m	0.96	0.96	0.0000	do
Head loss at toe (H_e),m	1.80	1.80	0.0000	do
Velocity at stiiling basin toe (V), m/s	5.94	5.94	0.0000	do
Initial depth of the flow (Y1),m	0.11	0.11	0.0000	do
Froude number (Fr)	5.85	5.72	-2.2727	Truncation
Sequent depth (Y2),m	0.82	0.84	2.3810	Truncation
Floor and chute block height, m	0.11	0.11	0.0000	do
Spacing and width between floor and chute blocks, m	0.08	0.082	2.4390	Truncation
Distance of floor blocks from the side walls, m	0.04	0.041	2.4390	Truncation
Tail water depth over the stilling basin(Y2'),m	0.33	0.34	2.9412	Truncation
Stilling basin length(LB),m	1.89	1.95	3.0769	Truncation
Sidewall and Stilling basin height, m	0.60	0.62	3.2258	Truncation
Transverse sill height, m	0.06	0.059	-1.6949	Truncation
Side wall free board to be provided above the trailed water depth, m	0.27	0.28	3.5714	Truncation
Wing wall height, m	0.60	0.62	3.2258	Truncation
Structural Design				
Horizontal length of spillway(x),m	3.00	3.00	0.0000	do
Length of the total channel(L),m	3.60	3.61	0.2770	Truncation
Length of each section, m	0.90	0.90	0.0000	do
Weight of the base of each section, kg	466.70	466.75	0.0107	Truncation
Weight of two side walls on each section, kg	310.20	310.50	0.0966	Truncation
Total weight of each section(W_t), kg	778.35	778.41	0.0077	Truncation
Weight of the stilling basin				
Weight of the base, kg	1035.00	1035.00	0.0000	do
Weight of the side walls, kg	965.00	966.00	0.1035	Truncation
Total weight of the stilling basin(Wts), kg	2000.00	2001.00	0.0500	Truncation

(error = 0.2770%), weight of each section's base 466.75 kg and 466.70 kg (error = 0.0107%), weight of two side walls 310.50 kg and 310.20 kg (error = 0.0966%), total weight of each section 778.41 kg and 778.35 kg (error = 0.0077%), and weight of the stilling basin side walls 966 kg and 965 kg (error = 0.1035%). For GCS_Designer software output and manual output, chute spillway structural design was error-free. Horizontal length was 3.0 m, section length was 0.9 m, and stilling basin base weight

was 1035 kg. GCS_Designer proved valid in chute spillway with 3.5714 % error for side wall free board above tail water depth and 0.0077 % error for total section weight. 16 of the 25 parameters analyzed for GCS_Designer chute spillway validation exhibit percentage of error, while the rest show zero percentage error. 87.5 % and 12.5% values were over estimate and under estimate, respectively.

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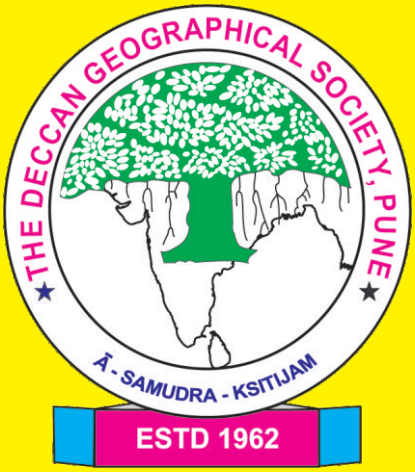
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HUMAN VULNERABILITY AND RISK OF LANDSLIDE HAZARD IN UPPER RAVI RIVER CATCHMENT- A SPATIAL APPROACH

Pooja Sharma, Vishwa B.S. Chandel, Simrit Kahlon, and Som Nath Thakur

Abstract

The paper examines landslide hazard in relation to human vulnerability and risk in River Ravi catchment. The work is built on the understanding that slope failure processes are inherent to mountainous regions, however, vulnerability and risk potential to such a hazard is rooted in human attributes of the landscape. Therefore, an attempt has been made to address the local contexts of landslide vulnerability to highlight human risk using a spatial approach. By taking into account the elements at risk and their exposure levels and vulnerability (physical, social, economic and environment), the research highlights significant variations in risk potential. Chamba town and its surroundings emerge as the most risk prone area on all accounts while remotely located areas on account of low development exhibit relatively low risk. The analysis establishes a positive relation between landslide risk and anthropogenic activities; high degree of risk in populated and developed areas underscores seriousness of problem that requires proactive mitigation strategies.

Introduction

The burgeoning risk of disasters is a testimony to the severity of undesirable events of both natural and human origin. The mounting impact and devastations observed globally is attributed to increasing frequency and magnitude of disasters. However, occurrence alone does not define disaster risk. It is the combined effect of hazards coinciding with vulnerability of exposed elements and lack of societal capacity to cope with adverse situations that yields disturbance and stressors on human population. Disasters in the 21st century has paralyzed the world (Ismail-Zadeh and Cutter, 2015) especially in the Asia-Pacific region where according to number of disaster events, death toll and people affected was maximum in recent years. The contemporary thinking places disaster risk analysis at the center of sustainable development practices. Risk reduction has become the most advocated initiative after the adoption of Sendai Framework for Disaster Risk Reduction (2015-2030).

The framework specifically focuses on understanding risk and strengthening risk governance for building resilience against the impacts of disasters. The recent catastrophic events in India, viz. cyclones in the Indian Ocean, floods in Uttarakhand in 2021, landslides and flash floods in Himachal Pradesh in 2023 have further highlighted the necessity of coordinated efforts to lessen disaster risk and human vulnerability. It has been estimated that risk due to disasters is likely to increase by 40 per cent by 2030 (UNDRR, 2022). In this context, vulnerability and risk assessment, therefore, becomes instrumental in ensuring effective disaster mitigation. Disasters and disaster risk have spatial specificities and locational predisposition. The nature, type, mechanisms, and impacts of disasters are guided by geographical and locational attributes. For mountainous areas, landslide is amongst the devastating processes causing tremendous loss of lives and infrastructure. In India, 48 major landslides recorded in the recent past has killed over 5000 people, affected 4 million and caused loss of US$ 55 million (EM-DAT, 2016). Such events have the propensity to occur in mountainous landscapes where risk factor is amplified by geo-tectonic attributes in association to accelerated human-induced landscape transformations (Sharma & Kumar, 2008; Chandel, Brar, & Chauhan, 2011). The geo-tectonic characteristics certainly make an area susceptible to slope failures, however, it is the human-induced changes that adds to the problem by making such fragile unstable slopes vulnerable (Barnard et al., 2001) risking human population and infrastructure. Therefore, contemporary research must address the local contexts of hazard, human vulnerability, and risk for appropriate solution to multidimensional problem of disasters.

Study Region

Ravi River catchment in Himachal Pradesh extends over four tehsils, viz. Chamba, Bharmour, and Holi of Chamba district and Multhan tehsil of Kangra district. Situated between the Pir-Panjal range in the north, and the Dhauladhar mountains in the south, a high altitudinal range (700-6100 meters above the mean sea level) has produced diverse micro-climates in this catchment. Summers are mildly warm whereas winters are severely cold. The mean annual precipitation is more than 1300 mm; a significant decrease in rainfall takes place to the north-eastern and eastern parts. Winter precipitation is driven by the western disturbances that also cause heavy snowfall in areas above 2000 meters elevation. Ravi is the main river fed by glacial melt and several tributary streams. The geomorphology of the areas is carved by tectonic and fluvioglacial processes. Active faults, joints, and lineaments have dislocated slopes thus making the landscape susceptible to slope failure.

A number of landslides observed along roads indicate human alteration of slopes (Chandel, Brar, & Chauhan, 2011; Sharma, Chandel, & Kahlon, 2018) for infrastructure and developmental activities in recent years (Thakur, Kahlon, & Bhutani, 2016). In such a scenario, it is likely that risk to human life and livelihood may get amplified posing serious challenges in times to come.

Objectives

The paper intended to examine the exposure, spatial vulnerability and risk to landslide hazard in the catchment of Ravi River in Chamba district of Himachal Pradesh. The key objectives were (a) to analyse the elements of risk and their exposure to landslides in the catchment and to analyse the vulnerability and risk potential to landslide hazard in the study area

Database and Methodology

This work offers an insight to human vulnerability and exposure of elements at risk. Primary data involved identification of past landslides through field survey wherein an inventory template was designed to record information on location, type, size, material involved, and key terrain characteristics of landslide sites. The researcher logged 100 sites of slope failures during the fieldwork out of which debris slides, rock slides, slumps, and rock & debris fall were the most common slope failure (75 per cent) type; the subsidence and lateral spread was observed mainly along road edges adjacent to river Ravi. It was noticed that rock fall sites are associated with exposed slopes in proximity to road construction sites. Similarly, earth flow, mud flow, and debris flow were spotted at numerous places. Almost every site of earth flow revealed reactivated landslides. Debris flows were noticed near streams, roads, and in areas where toe erosion by streams is prevalent. In addition to physical factors, anthropogenic activities have significantly triggered slumps in agricultural areas and slides along road construction and widening sites. The inventory on landslide sites and types formed the basis to evaluate risk factor by taking into account exposure, vulnerability, and the amount of elements-at-risk. The level of exposure (association between elements-at-risk and landslide hazard) was computed via spatial overlay of susceptibility (landslide probability under given set of terrain conditions) and vulnerability of elements-at-risk. This paper examined vulnerability in terms of 17 elements of risk. The index value closer to 1 indicate very high potential for damages and vice a versa. The risk assessment involved vulnerability calculation using Spatial Multi-Criterial Evaluation (SMCE) method using AHP model. The reliability of assessment was verified through

consistency index (CI) and consistency ratio (CR); its values for all elements-at-risk did not exceed the threshold value (0.1) which confirms the reliability of weightages assigned by the research. The study focussed on four vulnerability subgroups. Physical vulnerability expresses potential for physical impacts on built-up environment on account of landslide manifestation. Its indicators include settlements, roads (National, State, and Village roads), and helipads. Social vulnerability refers to potential impact on exposed societal groups. Here, we have defined social vulnerability in terms of population density (total, female and child population), essential and non-essential services (euclidean distance to healthcare facility, educational facility, postal facility, nutritional centers, and public distribution shops. Economic vulnerability is evaluated in terms of exposure to cropland, plantation, and forest cover whereas the environmental vulnerability is evaluated in terms of potential impacts on protected forests, reserved forests, and water bodies. The overall vulnerability was computed by aggregating physical, social, economic, and environmental vulnerability using weighted linear combination. Finally, the risk analysis was done through an indicator-based approach using input layers (landslide susceptibility, vulnerability, and amount of exposed elements-at-risk) via spatial overlay wherein risk factor was analysed for all elements-at-risk to produce the overall risk assessment.

Results and Discussion

Exposure of Elements-at-Risk

The 'elements-at-risk' represents people, assets, and things valuable to individuals or community that may get affected or suffers from loss due to hazard manifestation. For geographers, elements-at-risk (people, buildings, and infrastructure etc.) have locational stipulations; their exposure depends on proximity to hazard and degree of susceptibility. Here, we examined exposure of 17 elements of risk (Table-1). The physical element at risk defined in this work relates to settlements that being located in the vicinity of observed landslides have a potential to suffer from damages. Total area under settlements is 5007.53 hectare out of which majority area falls in Chamba (3927.45 hectare or 78.43%) tehsil. About 2313.81 hectare (46.20 per cent) has high to very high exposure (index value ≥ 0.6) to landslides while another 31.70 % has moderate exposure. The degree of exposure exhibits spatial variation; about 50 per cent settlements in Chamba especially around the town have high exposure and another 33 percent are moderately exposed to landslide hazard. Settlements in Bharmour (30%),

Table-1: Exposure of Elements-at-Risk

	Settlement Area		Total Population		Female Population		Child Population		Health Facilities	
Exposure Level	Hectare	%	Persons	%	Persons	%	Persons	%t	Number	%
Very Low (Below 0.2)	247.30	4.94	17649	8.59	8708	8.50	2527	9.11	23	10.18
Low (0.2 - 0.4)	858.76	17.15	72616	35.33	36056	35.20	9076	32.72	60	26.55
Moderate (0.4 - 0.6)	1587.66	31.71	58127	28.28	28890	28.20	8353	30.11	69	30.53
High (0.6 - 0.8)	1682.85	33.61	45051	21.92	22728	22.19	6176	22.26	54	23.89
Very High (0.8-1)	630.96	12.60	12085	5.88	6053	5.91	1609	5.80	20	8.85
Total	5007.53	100	205528	100	102435	100	27741	100	226	100

	Other Essentials*		Educational Institutions		Area under Roads		Helipad		Area under Cropland	
Exposure Level	Number	%	Number	%	Hectare	%	Number	%	Hectare	%
Very Low (Below 0.2)	120	13.06	79	9.43	724.78	8.85	0	0.00	716.08	5.38
Low (0.2 - 0.4)	253	27.53	249	29.71	1734.41	21.19	1	20.00	2162.06	16.25
Moderate (0.4 - 0.6)	273	29.71	242	28.88	2325.57	28.41	2	40.00	3680.16	27.67
High (0.6 - 0.8)	222	24.16	222	26.49	2407.29	29.41	2	40.00	4799.28	36.08

Contd...

Very High (0.8-1)	51	5.55	46	5.49	994.49	12.15	0	0.00	1944.09	14.62	
Total	919	100	838	100	8186.54	100	5	100	13301.67	100	
	Area under Plantations		Area under Forest Land		Area under Protected Forest		Area under Reserved Forest		Area under Water Bodies		
Exposure Level	Hectare	%	Hectare	%	Hectare	%	Hectare	%	Hectare	%	
Very Low (Below 0.2)	6.68	6.79	50705.32	79	8037.76	64.21	2189.38	34.26	112.62	9.38	
Low (0.2 - 0.4)	19.96	20.29	28205.25	249	3221.78	25.74	2304.54	36.06	121.85	10.15	
Moderate (0.4 - 0.6)	34.27	34.84	14237.51	242	961.1	7.68	1315.02	20.58	294.36	24.51	
High (0.6 - 0.8)	31.49	32.01	6018.01	222	263.65	2.11	515.81	8.07	412.03	34.31	
Very High (0.8-1)	5.97	6.07	1001.17	46	33.63	0.27	66.33	1.04	260	21.65	
Total	98.37	100	100167.3	838	12517.92	100	6391.08	100	1200.86	100	

*Other Essential Services includes three types of elements- Postal Services, Nutritional Centres and Public Distributional Services (PDS)

Holi (47.13%) and Multhan (21.5%) tehsils also shows a considerable area under high to very high exposure. The exposure of demographic elements (total population, female population and child population) reveals significant facts. The study area has a total population of 205528 residing in 537 villages (including 226 uninhabited). Population concentration exhibits influence of proximity to urban centre and roads. People of different ages, gender, and other demographic characteristics display distinct exposure levels. Females are amongst the most vulnerable due to social inequalities and lack of learning and economic opportunities. Similarly, exposure is also high for child population due to their dependency, lack of knowledge and ability to cope with disasters on their own. Over half of the total population (56.08%), female (56.30%), and child (58.17%) population is exposed to landslides hazard of moderate to very high level (index value ≥ 0.4). As much as a quarter (27.80 %, 28.10%, and 28.06 %, respectively) of these demographic groups has high-very high (≥ 0.6) exposure. In terms of absolute number, Chamba tehsil has the largest proportion of total population as well as female population and child population exposed to landslide hazard.

The provision of essential and non-essential services is vital to deal with disaster risk. The availability and accessibility to such services not only facilitate effective response but is crucial during disaster emergency. Health services are vital to ensure quick medical support for disaster-affected population. The study area has provision of medical services at 226 locations (Table-1), of which 142 are in Chamba tehsil, 59 in Bharmour, and 24 in Holi tehsil whereas Multhan tehsil has only one dispensary. The majority facilities are dispensary, primary health sub-centre, and primary health centre that provides basic health services only. However, lack of adequate doctors, staff, and medicines was observed during the field work. Moreover, these centers do not have adequate provisions for disaster emergency as in-patient care facility is absent except for a few locations. As per the exposure analysis, more than 63 per cent such services have moderate to very high exposure of landslides and one third fall in high to very high exposure class. Chamba tehsil has maximum number (142) of different medical services available of which 71.83 per cent falls in moderate to very high exposure; this proportion is 42.37 % and 62.50 % for Bharmour and Holi tehsils whereas Multhan tehsil being remotely located and having only one medical institution exhibits moderate exposure to landslides. Poor road connectivity is a challenge for providing emergency services in the area especially during the monsoon season and winters wherein landslides induced road blockades leads to delayed response of medical teams.

The study area is predominantly rural; life in such areas rely heavily on services such as post offices, sub-post offices, post telegraph offices, public distribution system, integrated child development scheme, Anganwadi centres, and nutritional centres. Any discontinuity in the availability of such services has serious impact on rural life. These services have locational bias; interior villages are either devoid of such provisions or services are inadequate, especially in Multhan tehsil. The exposure analysis shows that 29.71 per cent (Table-1) of such essential services has high to very high exposure. Chamba (33.65%) tehsil has the maximum proportion of these services under high to very high exposure followed by Bharmaur (23.30%) tehsil. The distribution of services is more in Chamba and Bharmour compared to other two tehsils where these are almost absent, particularly in Multhan. The exposure of educational institutions to landslide hazard is higher during the monsoons wherein several incidents in the past occurred in the proximity to such institutions. The study area has a total of 838 different educational facilities ranging from elementary schools to higher education institutes. Out of these, nearly a third (31.98%) have high to very high exposure of landslide hazard. The higher educational facilities are few and have low to moderate exposure. However, primary and middle schools have considerable exposure ranging from moderate to high level. As many as 214 (35.08%) such facilities in Chamba, 22 (26.19%) in Holi, and 32 (23.53%) in Bharmour has high to very high exposure. Multhan tehsil being a remote tribal region does not have higher educational institutes and number of schools is limited.

Therefore, its low to moderate exposure level is due to the unavailability of facilities and not because of the higher level of safety measures. Transportation is a crucial element in hilly regions that establishes links between sparsely and remotely located settlements and facilitates key services. Out of the total 537 villages, only 132 villages have access to all-weather roads. The total length of roads in the area is 951.49 km; however, road access is limited to certain villages. Moreover, many settlements have poor road conditions; most are unmetalled and in dilapidated conditions due to landslides, especially during monsoon and winter seasons. It was observed during the fieldwork that roads are highly vulnerable to landslides; frequent blockade restricts the movement of people and halts supply of key services. Nearly 41.55 % area along roads has high to very high exposure. The road network is denser in Chamba tehsil wherein 49.52 % land area along the roads has high exposure to landslides. Similarly, nearly 43.56 % and 24.09 % land along the roads in Holi and Bharmour tehsils have high to very high exposure of slope failure.

In addition to road transportation, there are 5 helipads out of which three are in Chamba and one each in Bharmour and Holi tehsil. Out of these, 2 helipads in Chamba are exposed to a high level and another 2 located in Chamba and Holi show a moderate level of exposure to landslides. A major source of livelihood in the area is agriculture and allied activities. Such activities are done on terraced farms and valley slopes susceptible to landslides during high intensity rainfall. This results in economic loss and stressed livelihood. Total cropland in the study area is 13301.67 hectare; more than 3/4th is in Chamba tehsil alone while other tehsils account for a much smaller area under cropland. Out of the total area of 98.37 hectare under plantation, Holi tehsil leads with 40.2 hectare followed by Chamba (33.25 hectare), and Bharmour (24.92 hectare). In contrast, people in Multhan tehsil so far are dependent on subsistence farming. Overall, a substantial land under agriculture (50.70%) and plantation (38.08%) displays high to very high exposure (Table-2). A significant level of exposure reflects from the fact that 81.45 % cropland in Chamba, more than 75 % in Holi, 66 % in Multhan, and 62 % in Bharmour shows moderate to very high exposure. Landslide inventory and field visits reveals several landslide sites in natural settings as well. In Holi tehsil, 31 hectares of protected forests have very high exposure. Approximately 108 hectares in Bharmour and 136 hectares in Chamba has very high to moderate exposure; the same is also observed for areas under reserved forests.

Vulnerability to Landslides

Vulnerability is a crucial component of disaster risk analysis; it is dynamic and determined by physical, environmental, social, and economic factors. Physical vulnerability has direct impact on population and infrastructure. Here, we have analysed physical vulnerability of key elements-at-risk, i.e., settlements, roads (national, state-highway, and village roads), and helipads on a relative scale of '0' (no damage) to '1' (total damage); their weightage were defined depending on each element's relative importance. The analysis shows only 0.75 % of the total area has very highly vulnerability (index ≥ 0.8) to landslides while another 14 % has moderate to high vulnerability (Table-2). Chamba (64.83 hectare) has the largest proportion under very high vulnerability followed by Holi (5.99 hectare) and Bharmour (3.93 hectare). Since population is concentrated in low altitude zones and along the roads, the physical vulnerability too is confined to such areas. It is higher in the western parts where settlements are more and larger. It has also been observed that vulnerability decreases towards higher altitudes and in the interior areas.

The other tehsils have low vulnerability that is confined to the valley floor and areas adjacent to roads and settlements.

Table-2: Vulnerability Assessment (Area in Hectares)

Physical Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	1373.36	4972.53	711.64	1.61	7059.14	71.02
Low (0.2-0.4)	194.05	1074.3	116	2.37	1386.72	13.95
Moderate (0.4-0.6)	74.75	817.78	92.19	1	985.72	9.92
High (0.6-0.8)	38.06	361.96	32.72	0.26	433	4.36
Very High (Above 0.8)	3.93	64.83	5.99	0	74.75	0.75
Total	1684.15	7291.4	958.54	5.24	9939.33	100
Social Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	26908.71	15221.49	15800.91	0	57931.11	32.97
Low (0.2-0.4)	14018.93	40084.71	17821.11	0	71924.75	40.94
Moderate (0.4-0.6)	3793.1	23521.11	817.55	0	28131.76	16.01
High (0.6-0.8)	1843.14	8464.67	54.95	0	10362.76	5.90
Very High (Above 0.8)	1311.12	6025.7	0.19	0	7337.01	4.18
Total	47875	93317.68	34494.71	0	175687.39	100.00

Contd...

Economic Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	19766.39	31325.82	17864.18	4376.77	73333.16	64.19
Low (0.2-0.4)	4493.72	22588.3	5560.65	1990.08	34632.75	30.32
Moderate (0.4-0.6)	790.9	3879.07	901.45	489.06	6060.48	5.31
High (0.6-0.8)	28.57	125.11	23.84	4.36	181.88	0.16
Very High (Above 0.8)	9.39	21.05	0.66	0	31.1	0.03
Total	25088.97	57939.35	24350.78	6860.27	114239.37	100.00
Environ. Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	1371.81	1949.25	14835.85	33.39	18190.3	89.71
Low (0.2-0.4)	73.55	487.31	743.1	33.63	1337.59	6.60
Moderate (0.4-0.6)	75.54	501.54	34.69	15.41	627.18	3.09
High (0.6-0.8)	11.02	97.33	7.89	1.71	117.95	0.58
Very High (Above 0.8)	0.18	0.91	2.5	0	3.59	0.02
Total	1532.1	3036.34	15624.03	84.14	20276.61	100.00

Contd...

Overall Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	71756.21	15689.08	40635.97	57848.37	185929.63	57.53
Low (0.2-0.4)	17284.34	39694.01	15313.73	3424.01	75716.09	23.43
Moderate (0.4-0.6)	7148.02	29427.98	6745.16	1730.32	45051.48	13.94
High (0.6-0.8)	1452.26	11320.48	1407.11	142.12	14321.97	4.43
Very High (Above 0.8)	175.4	1840.42	139.51	0.94	2156.27	0.67
Total	97816.23	97971.97	64241.48	63145.76	323175.44	100.00

Source: Computed by Authors Note: Area in hectares.

Social vulnerability expresses weakness in societal structure to deal with disasters. Its key markers include socially disadvantageous groups and essential services such as healthcare, educational facilities, postal facilities, nutrition centres, and PDS. These elements-at-risk examined via normalised vulnerability scores shows as much as 26 % area has moderate to very high vulnerability; about 4.18 % has very high vulnerability and another 6 % exhibits high vulnerability (Table-3). Chamba tehsil being the most populous has higher social vulnerability; more than 40 % area shows moderate to very high vulnerability while 15 % area is under high to very high vulnerability. About 14 % area in Bharmour too has moderate-very high vulnerability out of which 6 % is in high vulnerability class. The spatial distribution of social vulnerability shows concentration around certain pockets in the western and central parts of study area while eastern and northern areas have low vulnerability. The high vulnerability zone is apparent around Chamba town and other large settlements such as Sarol, Mehla, Dharwala, and Bharmour. The remaining areas are either uninhabited or have small size settlements with low population. Overall, about 26 % area exhibits high social vulnerability; such zones coincide with high population density in the study area. Economic vulnerability defines the threat of landslide to economic assets. The study area being an agrarian economy relies heavily on agriculture, horticulture, and other allied activities for livelihood and income. About 6 % area shows moderate to very high economic vulnerability.

Table-3: Risk Assessment of Upper Ravi River Catchment

Risk Elements	Risk Level (area in Hectare)					
	Very Low (Below 0.2)	Low (0.2-0.4)	Moderate (0.4-0.6)	High (0.6-0.8)	Very High (Above 0.8)	Total
Settlement Area (ha.)	1294.67 (25.85)	617.02 (12.32)	1237.32 (24.71)	1371.17 (27.38)	487.35 (9.73)	5007.53 (100)
Number of Villages	61 (19.81)	101 (32.79)	94 (30.52)	51 (16.56)	1 (0.32)	308 (100)
Total Population	22045 (10.73)	60696 (29.53)	61659 (30.00)	41195 (20.04)	19933 (9.70)	205528 (100)
Female Population	10790 (10.53)	30058 (29.34)	30813 (30.08)	20812 (20.32)	9962 (9.73)	102435 (100)
Child Population	3057 (11.02)	8642 (31.15)	8629 (31.11)	5549 (20.00)	1864 (6.72)	27741 (100)
Number of Education Facilitates	100 (11.93)	271 (32.34)	251 (29.95)	195 (23.27)	21 (2.51)	838 (100)
Number of Health Services	30 (13.27)	68 (30.09)	62 (27.43)	61 (26.99)	5 (2.21)	226 (100)
Number of Essential Services	155 (16.88)	311 (33.88)	275 (29.96)	177 (19.28)	0 (0)	918 (100)
Road Area (ha)	608.08 (7.43)	1838.57 (22.46)	2708.42 (33.08)	2921.31 (35.68)	110.16 (1.35)	8186.54 (100)
Number of Helipad	0 (0)	1 (20)	2 (40)	2 (40)	0 (0)	5 (100)
Cropland Area (ha.)	793.15 (5.96)	2786.36 (20.95)	4954.68 (37.25)	4723.93 (35.51)	43.55 (0.33)	13301.67 (100)
Area Under Plantation (ha.)	7.55 (7.68)	30.4 (30.9)	31.98 (32.51)	28.38 (28.85)	0.06 (0.06)	98.37 (100)
Forest Area (ha.)	51433.04 (51.35)	31074.12 (31.02)	13598.54 (13.58)	4039.27 (4.03)	22.29 (0.02)	100167.3 (100)
Protected Forest (ha.)	8656.37 (69.15)	3064.38 (24.48)	699.95 (5.59)	97.21 (0.78)	0 (0)	12517.91 (100)
Reserved Forest (Ha.)	2299.99 (35.99)	2585.18 (40.45)	1211.24 (18.95)	294.3 (4.6)	0.37 (0.01)	6391.08 (100)

Note: Values in the parenthesis are in percentp

In terms of spatial distribution, Chamba (146 hectare) tehsil has maximum area under high to very high vulnerability followed by Bharmour (38 hectare) and Holi (25 hectare) whereas less than 5 hectares in Multhan has high vulnerability (table-3). However, in terms of proportion, Multhan (7.19 %) has maximum area under moderate to very high vulnerability. It suggests that landslides have a higher potential to cause economic risk in remotely located areas. The proportion of moderate to high vulnerability in Chamba is 6.95 % while in other tehsils it remains below 4 per cent. The distribution pattern shows higher vulnerability along rivers and roads; it decreases with the altitude due to absence of arable land. A large part of study area is either uninhabited or sparsely populated with low infrastructure development. Such areas are covered with forests, highland pastures, and water bodies. An insignificant area (0.02 per cent) under such features has very high vulnerability. Holi tehsil has largest percentage of very high vulnerability; however, Chamba (97.33 hectare) and Bharmour (11.02 hectare) account for maximum area of high vulnerability. Holi tehsil has less than 10 hectares under high vulnerability; it is below 2 hectares in Multhan.

The two zones of vulnerability are most visible. First is the valley floor along the river Ravi in the western parts of Chamba tehsil and the other comprises of low to moderate vulnerability in the higher altitude areas of Holi and Multhan tehsils. The cumulative index derived by aggregating physical, social, economic, and environmental indicators shows a considerable area (19 %) under moderate to very high vulnerability (Fig.-1). Less than a per cent area falls in very high vulnerability. Out of the total 2156.27 hectare under this class, more than 85 per cent is in Chamba (1840.42 hectare) tehsil followed by Bharmour (175.4 hectare), and Holi (139.51 hectare). High vulnerability area accounts for 14321.97 hectare (4.43 per cent); Chamba is the leading vulnerable tehsil (11320.48 hectare) whereas Bharmour and Holi tehsils have a little over 1400 hectare under high vulnerability. Similarly, 45051 hectare (14 percent) display moderate vulnerability. In this category too Chamba (29427.98 hectare) has the largest proportion followed by Bharmour (7148.02 hectare), Holi (6745.16 hectare), and Multhan (1730.32 hectare). The analysis shows a visible spatial pattern of vulnerability in the catchment; clusters of high to very high vulnerability are confined to the western parts (Fig.1). The most critical sites include areas around Chamba town, Sarol, Mehla, Dharwala, and Bharmour. Moderate vulnerability surrounds these areas of high vulnerability. Chamba tehsil having more infrastructure, urban population, bigger rural settlements, and human activities display higher vulnerability especially at lower elevations and along the valley floor.

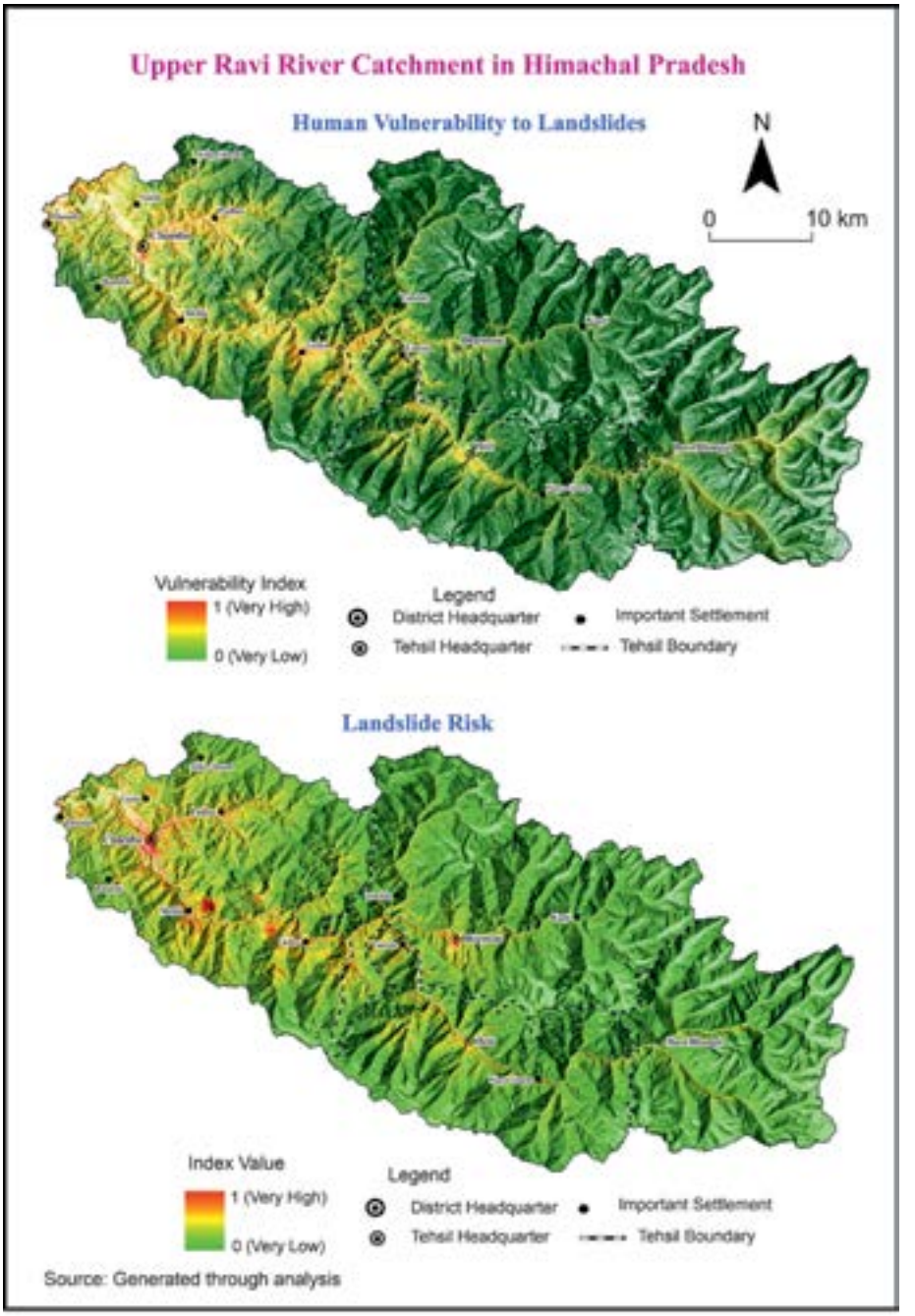

Upper Ravi River Catchment in Himachal Pradesh
Human Vulnerability to Landslides
N
0
10 km
Vulnerability Index
1 (Very High)
0 (Very Low)
Legend
District Headquarter
Important Settlement
Tehsil Headquarter
Tehsil Boundary
Landslide Risk
Index Value
1 (Very High)
0 (Very Low)
Legend
District Headquarter
Important Settlement
Tehsil Headquarter
Tehsil Boundary
Source: Generated through analysis

Fig. 1

Vulnerability pattern reveals higher damage potential in the narrow valley along the highway between Chamba and Bharmaur. Bharmour and Holi tehsils, where road development has taken place recently to boost hydropower projects also show moderate to high vulnerability.

Risk Assessment

Ravi River catchment demonstrate varying spatial patterns of vulnerability. These in conjunction with landslide susceptibility and the amount of elements-at-risk were further examined to analyse risk potential. The gravity of landslide risk reflects from the fact that out of the total 5007.53 hectare under settlements, more than 37 % has high to very high risk (index ≥ 0.6), and another 25 % in moderate risk category. Similarly, 17 % and 31 % villages are at high and moderate risk, respectively. In terms of population characteristics (Table-4), as much as 10 per cent, 20 per cent, and 30 per cent of the total population as well as female population is at very high (index above 0.8), high (0.6-0.8), and moderate (0.4-0.6) risk of landslides, respectively. Such proportions for child population too are of the same magnitude. The contribution of human-induced risk is therefore evident as majority of high-risk settlements are in the relatively developed parts of Chamba tehsil and its surrounding areas. The basic essential services like educational institutes under risk certainly emerge as a matter of concern since more than a quarter (25.78 per cent) are at high to very high risk alongside another 30 per cent at moderate risk (Table-4). The majority of such services are related to primary and middle schools wherein the young population do not have the skills to deal with hazardous situation. The state of affairs is no different for health services and infrastructure. A similar level of risk exists for health-related services. The areas of Holi and Multhan tehsils exhibiting low risks have no health facilities. Hence, low risk in these areas is not due to better facilities but because of its non-availability (Table-4).

Table-4: Overall Risk Assessment

Risk Class (Index Value)	Risk Potential (Area in Hectares)				
	Bharmour	Chamba	Holi	Multhan	Total
Very Low (Below 0.2)	81790.86 (38.08) (83.61)	34794.73 (16.20) (35.51)	47534.84 (22.13) (73.98)	50693.65 (23.60) (80.31)	214814.1 (100) (66.47)

Contd...

Low (0.2-0.4)	11011.63 (17.72) (11.26)	29808.65 (47.98) (30.43)	11434.78 (18.40) (17.80)	9875.02 (15.89) (15.64)	62130.08 (100) (19.23)
Moderate (0.4-0.6)	3742.81 (11.63) (3.83)	21965.36 (68.24) (22.42)	4189.14 (13.01) (6.52)	2292.27 (7.12) (3.63)	32189.58 (100) (9.96)
High (0.6-0.8)	1270.43 (9.17) (1.30)	11242.25 (81.11) (11.47)	1088.26 (7.85) (1.69)	259.3 (1.87) (0.41)	13860.24 (100) (4.29)
Very High (Above 0.8)	6.02 (3.52) (0.01)	162.29 (94.98) (0.17)	2.55 (1.49) (0.004)	0 (0.00) (0.00)	170.86 (100) (0.05)
Total	97821.75 (30.27) (100)	97973.28 (30.32) (100)	64249.57 (19.88) (100)	63120.24 (19.53) (100)	323164.8 (100) (100)

Note: Values in the parenthesis are in percent

The risk is high for road infrastructure as well; 37 % of areas have high-very high risk and another 33 % have moderate risk thus making over 70 % areas along roads at risk of landslides. The worse affected areas include Chamba and Holi tehsils. Such a high risk to road infrastructure also impacts other essential and non-essential services as these provisions are directly linked to road accessibility. As a result, these services get affected and become non-functional in case of roads blocked by landslides. Rural livelihood too is at risk as cropland, plantations, and forest resources display substantial risk. The cropland and area under plantation show 36 % and 29 % area under high to very high risk while another 37 % and 32% have moderate risk, (Table-6). With more than 70 % of the area that provides income and livelihood to people under persistent risk, it is but obvious that the catchment exhibits a high degree of uncertainty in the attainment of income and the well-being of its population. The analysis demonstrates uneven spatial distribution of landslide risk. About 14.30 % area has very high (above 0.8) to moderate (0.4-0.6) risk. A noteworthy variation in the spatial distribution of risk is discernible. Three areas, viz. Multhan (95.96%), Bharmour (94.87%), and Holi (91.78%) display minimal risk; the degree of moderate to high risk in these is limited. On the contrary, Chamba tehsil has about 12 % area under high to very high risk and additional 22.42% area has moderate risk (Table-3 and Fig. 2).

Here, it is important to acknowledge that this high-risk zone has the largest proportion of population. Looking at risk potential in terms of proportion of each tehsil to the total area under a specific risk class, it is evident that risk proportion in Chamba tehsil successively increase towards higher risk classes while the same diminishes in rest of the three tehsils. Out of the total 170.86 hectare under very high-risk class, nearly 94.98% falls in Chamba alone while other three cumulatively account for less than 5 %. The same is true for high and moderate risk classes wherein Chamba alone accounts for 81.11% and 68.24%, respectively whereas remaining tehsils have much smaller proportion in these risk classes. A higher risk in Chamba tehsil is due to greater concentration of population and infrastructure whereas remotely located areas despite a high susceptibility possesses far less risk of damages by landslides. However, as infrastructure development is gradually extending to remote areas, risk to landslides in these tehsils is likely to increase.

Conclusion

This paper intended to examine the likely threats of landslides to physical, social, economic, and environmental elements in the Ravi River catchment. Visualizing risk is crucial to envisage appropriate mitigation measures and capacity building to ensure safe development. Landslides are not life-threatening in all circumstances; however, these certainly impact human activities and crucial resources in mountainous regions. Landslide driven damage to life and property is exorbitantly high in the study area. This study evaluated landslide exposure, vulnerability, and risk via a blend of quantitative or qualitative approaches. Realizing the high degree of physical susceptibility to landslides in the Ravi River catchment, this paper outlined threat potential to human population and infrastructure. The study places Chamba as one of the most perilous tehsils in the catchment in terms of landslide risk to people, settlements, agriculture, infrastructure, essential services and economic activities. On the contrary, Multhan, a poorly developed tehsil displays the least risk on account of it being low development. It is evident that the area has high degree of susceptibility to slope failure, however, risk is the product of development coinciding with landslide potential. The more developed areas possess higher risk to landslides and vice versa. The risk assessment shows high-risk clusters around Chamba town and its surrounding areas mainly Sarol, Mehla, Dharwala, and Bharmaur. The very high to moderate risk exists along the roads and an inverse relation is evident between distance from the roads and degree of risk. A discernible spatial pattern emerges that shows clusters of higher risk in the western parts of the study area. High-risk zones exist at fewer locations that are surrounded by moderate risk.

The overall assessment shows maximum risk in Chamba tehsil followed by Bharmour, Holi, and Multhan tehsils. The higher risk to landslide in Chamba tehsil is attributed to clustered human population and economic activities whereas remotely located areas of Holi and Multhan despite high physical susceptibility show much less human risk and vulnerability to landslide hazard. The latter represents a landscape with limited anthropogenic meddling; low human occupancy, and underdeveloped roads and other infrastructure. Consequently, risk to human assets and resources is low. However, as the infrastructure development would proceed to such areas, landslide hazard may pose serious challenge. The spatial distribution of high-risk zones also establishes a positive association between landslide hazard and anthropogenic activities. The analysis points to the role of human transgressions in this tectonically and climatically sensitive area. It is clear that the large parts of the catchment, either habited or uninhabited, have high susceptibility to slope failure. However, high degree of risk in populated and relatively developed parts underlines the seriousness of existing threat to human life, property, and infrastructure. Landslides may not always be life-threatening but the ongoing process of infrastructure development is likely to escalate the degree of risk. This research contributes towards anticipating threat that the local community might face in the future. It provides a base to devise appropriate mitigation measures and build capacities to deal with the risk that landslides may pose.

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AN ASSESSMENT OF RAINFALL VARIABILITY ON GROUND WATER LEVEL IN TELANGANA USING LINEAR REGRESSION MODEL

Anupama Dubey and Sanjit Kumar

Abstract

Climate change will have a significant impact on freshwater supplies, as evidenced by a number of recent international studies. Groundwater is necessary for life as we know it. Global climate change can affect the availability of groundwater by influencing the amount and quality of water that is recharged, evaporated and transpired, and indirectly by affecting the amount of water pumped and abstracted. In regions where the water tables are relatively close to the surface, alterations to the groundwater system can also impact the surface water system. It is essential to comprehend the potential ramifications of climate change on groundwater systems in order to effectively and strategically manage the water supply. But it is not feasible to forecast the potential impact of climate change on groundwater systems. Forecasting impacts of climate change on groundwater systems is currently very difficult. The problem is exacerbated by the presence of uncertainty around future climate predictions.

Introduction

Climate change is expected to accelerate the hydrological cycle globally, aggravating regional and temporal differences in hydrological resource distribution (Huntington, 2006, Trenberth, 1999). Global warming is anticipated to increase the severity of extreme rainfall events in many places, even if the mean rainfall is decreasing (e.g., Wilby and Wigley, 2002). Climate adaption methods typically require accurate knowledge on the frequency of these catastrophic events. (Kumke, 2001). Many studies have been done on the issue of rainfall trends in India over the century. Others have studied changes in southwest monsoon/annual rainfall in India. According to Dash et al. (2009), Over the previous 50 years, moderate-to-heavy rainfall has decreased. India is seeing more frequent and longer monsoon

breaks with 100 mm per day rainfall in some locations, confirm this (Goswami et al., 2006). Alterations in precipitation, temperature, and evapotranspiration have a direct influence on the replenishment of groundwater. Precipitation and groundwater recharge are positively correlated. The thawing of permafrost will lead to an increase in groundwater recharge (Potter 2002; Kitabata et al. 2006). Modifying the rate of recharging will primarily result in adverse outcomes. Regions characterized by abundant rainfall are projected to experience an upward trend in precipitation, while regions with little rainfall and high rates of evaporation, which are now facing water scarcity, are anticipated to witness a decline (IPCC 2007; Issar & Zohar 2007). Immediate modifications to the existing infrastructure network are necessary in order to adapt to evolving circumstances (Potter 2002; Semadeni-Davies et al. 2007). The primary objective of this study is to investigate the impact of fluctuations in precipitation on local water resources and the accessibility of groundwater, as well as to identify significant risks and determine the most important measures for adaptation. Groundwater systems will also be affected by land use, surface water availability, human water needs, the distribution of native and cultivated plant communities, and climate change and rising carbon dioxide levels that affect native and crop plant water consumption. (Eckhardt & Ulbrich; Scanlon et al., Thomson et al.; Green et al.). Currently, there is a lack of adequate observation, understanding, and measurement of how groundwater resources respond to short-term climate variability, such as changes occurring within a year or decade. Climate change can affect groundwater systems in four ways: alterations in precipitation quantity and distribution, shifts in precipitation type (rain versus snow), and modifications in the rates of evaporation, transpiration, and groundwater extraction. Alterations in rainfall patterns can directly impact the replenishment of groundwater systems, while modifications in multiple other climatic factors can influence the different processes via which groundwater (and soil moisture) is discharged, either individually or in conjunction.

Study Region

Telangana was created on June 2, 2014, becoming the 29th state of India. Hyderabad is the capital of the state of Hyderabad. It is surrounded by four states: Maharashtra to the northwest and north; Andhra Pradesh to the south and east; and Karnataka to the west. From 15°46'N to 19°47'N is the latitude range, and from 77°16'E to 81°43'E is the longitude range. There are 1,12,077 square kilometers (43,273 square miles) in the expansion.

Objective

This paper is an attempt to correlate two variables of climate change, precipitation and ground water.

Database and Methodology

Data was compiled from various government reports, websites, census reports Telangana State Ground Water Boards, the Irrigation Department, CWC, the Ministry of Jal Shakti, and other relevant departments. The association between yearly mean rainfall and groundwater depth in the research area was determined using SPSS software. SPSS software enables us to run a linear regression model using a single dependent variable and a few independent variables. Groundwater depth was used as a dependent variable in this study, while the impact of rainfall was examined as an independent variable.

Result and Discussion

Even after mild rainfall, most of the districts in the research area had a deep groundwater level, according to the findings. The association between groundwater level and climate change is found to be similar in the state, highlighting the impact of climate change on groundwater levels. The irregularity in rainfall affects the depth of groundwater in all three states, as seen by the map of rainfall and groundwater depth. The average annual rainfall in Telangana varies between 650 m to 1200 m, depending on the region. Districts in the north and north-eastern region receive high rainfall, whereas southern districts near receive comparatively less rainfall hence coming under the first category. The coefficient of variation, on the other hand, is relatively high in southern districts and continues to decrease as one moves north-eastern in the state. This variation in rainfall has an impact on groundwater depth across the state, which may be shown on a map. Districts with substantial yearly rainfall fall into the group of districts with very shallow groundwater depths. Districts with minimal annual rainfall, on the other hand, reveal that the depth is extremely high in most part of the district. (Fig. 1)

Status of Ground Water Resources in Selected Sample States

Status of Ground Water resources in Telangana

Based on the data of Telangana district-wise average depth of ground water level data, the minimum water level is 5.43 meters below ground level (m bgl) in

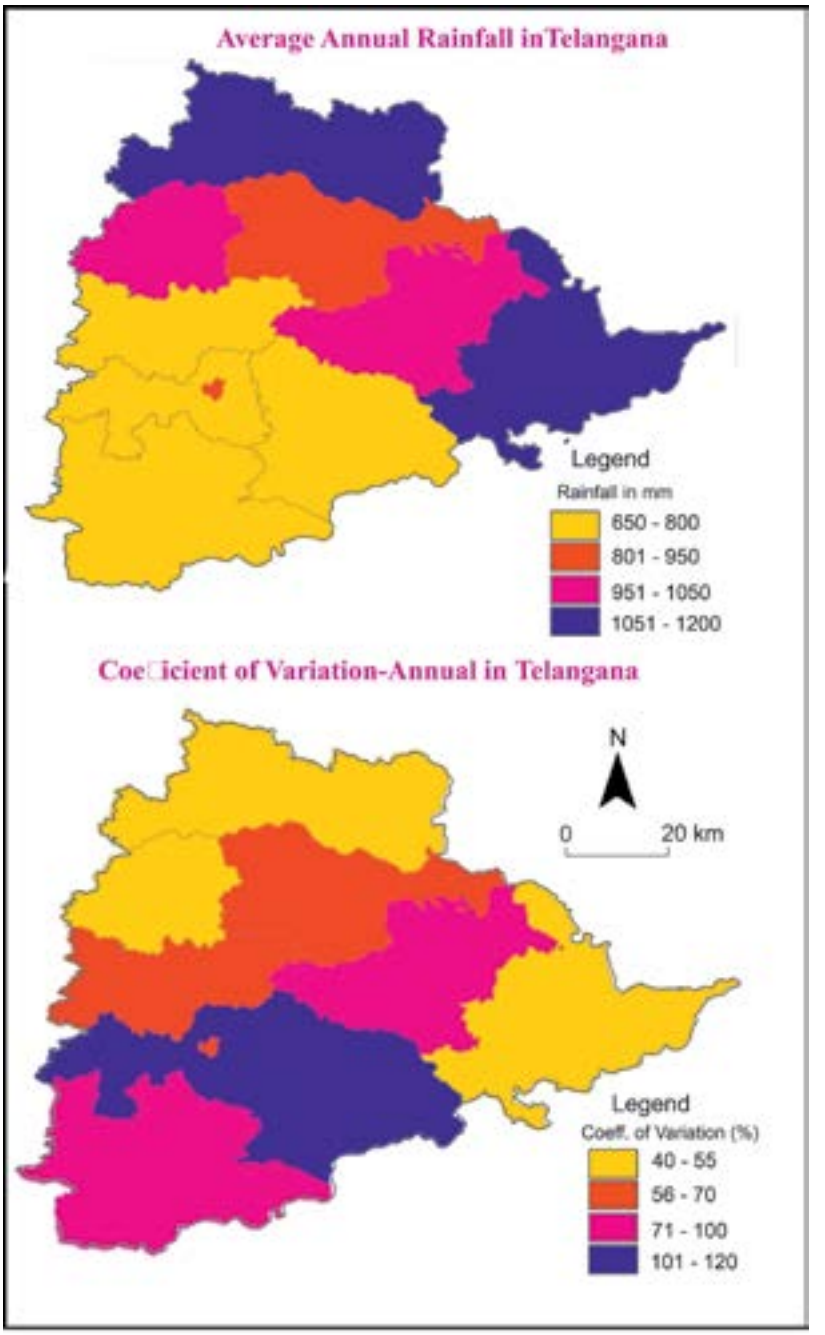

Average Annual Rainfall inTelangana
Legend
Rainfall in mm
650 - 800
801 - 950
951 - 1050
1051 - 1200
Coe icient of Variation-Annual in Telangana
N
0
20 km
Legend
Coeff. of Variation (%)
40 - 55
56 - 70
71 - 100
101 - 120

Fig. 1

Khammam district and the maximum is 20.84 m bgl in Medak district in 2018. Table-1 depicts the water index of ground water levels in Telangana. Ground water levels in the range of 5.43 to 8.51 m bgl in extremely shallow depth cover 33114.64 square kilometers in Telangana, with a percentage of 28.84. This area was covered on the east and north sides of Telangana in 2018, as well as a tiny part on the south side. This range includes the whole Bhadradri (Kothagudem), Komram Bheem, and Manchrial districts, as well as portions of Wanaparthy, Hyderabad, Jagityal, Warangal Rural, Adilabad, Mahabubabad, Khammam, and Peddapally districts. In Telangana, ground water levels in the low depth range of 8.52 to 11.59 m bgl cover 31188.27 sq km, with a percentage of 2.58. In 2018, this area was covered in the northeast and south to northwest parts of Telangana, as well as a tiny amount in the southwest. This range encompasses parts of the Medak and Sanga Reddy districts. Ground water levels in the intermediate depth range of 12 to 14.67 m bgl cover 33605.2 sq km in Telangana, with a proportion of 29.26. In 2018, this area was covered in Telangana from the northwest to the middle to the south and southwest. This range includes the whole Yadadri and Sircilla districts, as well as portions of Nizamabad, Kama Reddy, Jangaon, Medchal, Nalgonda, Nagarkurnool, Rangareddy, and Mahabubnagar (Fig. 2). In Telangana, ground water levels in the range of 14.68 to 17.75 m bgl (high depth) cover 13973.73 sq km, with a percentage of 12.17. This area was covered under Telangana's west side in 2018. This range comprised the entire Vikarabad district, as well as parts of the Kama Reddy, Medak, Sanga Reddy, Rangareddy, Mahabubnagar, and Siddipet districts. Ground water levels in the range of 17.76 to 20.83 m bgl, which is very deep, cover a total area of 2958.159 sq km in Telangana, with a percentage of 28.84. This area was covered under Telangana's west side in 2018. This range includes the whole Bhadradri (Kothagudem), Komram Bheem, and Manchrial districts, as well as portions of the Wanaparthi, Hyderabad, Jagityal, Warangal Rural, Adilabad, Mahabubabad, Khammam, and Peddapally districts.

Correlation and Variation

The SPSS linear regression was used to create (Table-4). Whereas average yearly rainfall serves as the independent variable in this model, groundwater depth serves as the dependent variable. Below is a table that summarizes the model. If the R-value exceeds 0.4, which is comparable to 40%, further inquiry is necessary to establish the correlation between the maximum groundwater depth and the quantity of rainfall received. Hence, the number is 0.664, which is equal to 66.4%,

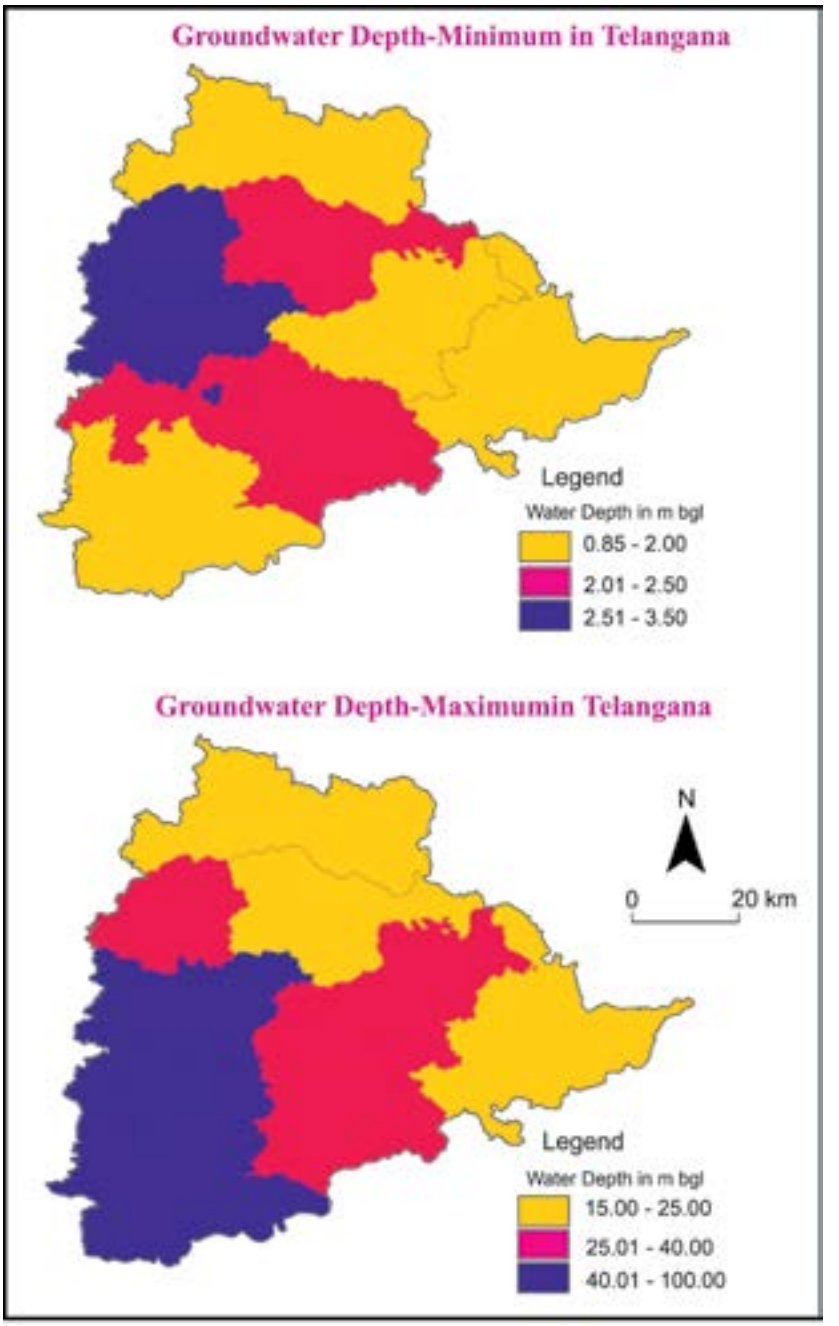

Groundwater Depth-Minimum in Telangana
Legend
Water Depth in m bgl
0.85 - 2.00
2.01 - 2.50
2.51 - 3.50
Groundwater Depth-Maximumin Telangana
N
0
20 km
Legend
Water Depth in m bgl
15.00 - 25.00
25.01 - 40.00
40.01 - 100.00

Fig. 2

indicates that model fits well under for the available data. The R-squared value rises above 0.4, indicating that more than 40% of the variable variance can be explained. The model accurately describes water usage, which is 0.440 or 44.0 percent. The decreasing R-square value indicates discovery frequency. The adjusted R-square number represents the generalizability of the results, which is also known as sample variation. The R-square and Adjusted R-square should have a marginal disparity, with both values being .390 or 39.0%, which is deemed satisfactory. Begin by referring to the model summary table. The P-value and 95% confidence level for this table were established in advance of conducting this research. As a result, statistical significance is defined as a p-value less than 0.05. As a result, the effect is substantial. As a result, the findings are critical. Similarly, the F ratio quantifies the accuracy with which a model predicts a given variable after accounting for the model's flaws. A model that is efficient can be developed with a F ratio of 8.659, which is greater than one. It explains the suitability of the sample for conducting the test. Based on these findings, there is a chance to reject the null hypothesis that there is no significant difference in groundwater depth and rainfall received, because the ANOVA's p-value is less than the tolerated level of significance. Annual rainfall and groundwater depth have a close link. This study established a relationship between the estimates (predictors) of the independent factors and the dependent variable. For each unit change in parameter estimates, the projected value increases or drops by the same amount. Univariate analysis of variance can employ effect size, parameter estimations, and cross-sectional approaches. The R square and adjusted R square values (0.440 and 0.390) remain unchanged from the previous technique, which employed a fixed effects dummy variable (t values, significant levels). The regression value of the dummy variable differs due to its interaction with a discrete dummy coexistence. The data is presented (Table-1, 2 and 3). Demonstrates a strong correlation between the depth of groundwater and the average annual precipitation.

Table-1: Variables Entered-Removed(b)

Model	Variables Entered	Variables Removed	Method
1	Mean Annual Rainfall(a)	.	Enter

(a) All requested variables entered.

(b) Dependent Variable: Groundwater Maximum Depth

Table-2: Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.664(a)	.440	.390	13.30672

(a) Predictors: (Constant), Mean Annual Rainfall

(b) Dependent Variable: Groundwater minimum depth

Table-3: ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1533.208	1	1533.208	8.659	.013(a)
	Residual	1947.758	11	177.069		
	Total	3480.965	12			

(a) Predictors: (Constant), Mean Annual Rainfall

(b) Dependent Variable: Groundwater Maximum Depth

Table-4: Coefficients and Residuals Statistics(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	81.316	18.132		4.485	.001
	R_M	-.055	.019	-.664	-2.943	.013
		Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value		1.1123	1.2111	1.1762	.03333	13
Residual		-.85496	1.41245	.00000	.71144	13
Std. Predicted Value		-1.915	1.049	.000	1.000	13
Std. Residual		-1.151	1.901	.000	.957	13

A Dependent Variable: Groundwater Maximum Depth

Evaluation of Telangana Government Schemes to Increase Water Storage

Mission Kakatiya – Telangana: The aim is to increase the storage capacity of minor irrigation water resources like tanks and ponds.

Methodology Adopted

(1) Desiltation of tanks, repair of bunds, re-sectioning of irrigation channels, restoration of tributary channels, and increasing water level to Full Tank Level (FTL).

(2) Villagers participated in Gramasabhas to discuss the action plan for managing water resources in containers and ponds. Farmers were motivated to incorporate the silt into their plots.

(3) Establishment of district-level Coordination Committees to ensure continuous village participation in irrigation management.

(4) Formation of Coordination Committees at the district level to activate the villagers continuously to participate in irrigation management.

Results

(1) Increase in the capacity of reservoirs and other bodies of water to store water. The availability of water extended to small and medium-sized producers.

(2) By tilling in sediment into the fields, the land's capacity to retain water was enhanced. Additionally, the incorporation of silts into fields increased their nutrient content, which reduced the need for chemical fertilizers and increased the value of crop diversification.

(3) Groundwater level elevation. Progression of livestock and fisheries.

Conclusion

Region-specific, the average annual precipitation in Telangana ranges from 650 to 1200 meters. Northern and northeastern districts experience substantial precipitation, while southern districts in close proximity receive comparatively less precipitation, thus falling within the first category. In contrast, the coefficient of variation exhibits a comparatively high value in the southern districts and progressively declines as one traverses towards the northeastern region of the state. This variation in precipitation affects the depth of groundwater throughout the state, which may be depicted on a map. Districts characterized by significant annual precipitation are

classified as having extremely shallow groundwater depths. Conversely, districts with negligible annual precipitation exhibit exceptionally deep water throughout the majority of the district. Realizing the urgent need of water storage and percolation, government of Telangana has implemented various schemes such as Mission Kakitya and Swar, depicting substantial productive outcomes of the plans. But still there is a long way to cover, for securing water for the upcoming generations.

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AVAILABILITY OF HOUSEHOLD AMENITIES AND ASSETS AMONG SCHEDULE CASTES AND NON-SCHEDULE CASTES IN RURAL HARYANA

K. V. Chamar and S. K. Chamar

Abstract

Availability of household amenities and assets reflects a household's quality of life among various social groups. For the present research work, primary data has been collected from 1365 households comprising 975 from scheduled castes category and 390 from non-scheduled castes from 39 selected villages of 15 blocks covering the five districts of Ambala, Panipat, Rohtak Rewari, and Sirsa that represent the northern, eastern, central, southern, and western parts of the Haryana state respectively. The surveyed households were represented by 37 castes comprising 24 castes from non-scheduled castes and 13 castes from scheduled castes. After that, caste-wise as well as among the scheduled castes and non-scheduled castes availability of household amenities and assets were worked out. Thereafter, caste-wise availability of amenities and assets of all the selected 16 indicators in the households were worked out in percent in proportion to total sample households. Furthermore, the weighted score has been assigned to selected amenities and assets depending upon their relative function and value to derive composite weighted scores. To find out the 'composite weighted scores' of availabilities of amenities and assets among select caste in respect to each of the indicator the 'weighted scores' have been added of all the selected indicators. Finally, to assess the levels in availability of household amenities and assets of each caste among scheduled castes and non-scheduled castes in rural Haryana, 'average composite weighted scores' have been identified by dividing the number of households of each caste among scheduled castes and non-scheduled castes of the total composite weighted scores. The analysis reveals marked variations in availability of amenities and assets among scheduled castes and non-scheduled caste in rural Haryana.

Introduction

Availability of household amenities and assets reflects a household's quality of life among various social groups. It plays an important role in our day to day life.

It also helps in the socio-economic importance of housing, improvement of housing and the condition of the households. "Safe drinking water and sanitation facilities reduce the prevalence of gastrointestinal diseases in any society. The availability of piped water, facility of electricity within the household and better electric appliances and furniture facilitate effective education among children. Likewise, availability of motor vehicles, communication and mass media strengthen the household's connection to the country as a whole. Access to these amenities thus reflects a household's quality of life. In modern era, they also act as symbol of social status among various social groups" (Desai et. al, 2010). Similarly, computer technology has also become an essential part of our daily lives. It can do complex tasks including data processing, storage and retrieval, and calculations fast, effectively and accurately. Many studies have been undertaken on the availability of household amenities or facilities and assets in different forms in India. Tiwari and Nayak, (2013) examined, "the drinking water and sanitation facilities in Uttar Pradesh.

They described the inter-regional disparity in Uttar Pradesh in the availability of drinking water and sanitation facilities. The study reveals that female literacy rate plays a significant role for improving access to sanitation facilities". Kaur and Sharma (2021) examined, "living conditions of POJK displaced persons in Jammu district by considering the various parameters such as demographic profile, family composition, family system, education, occupation, income, drinking water, house design, and housing facilities. The study reveals that the magnitude of loss of POJK displaced persons was very high. Hence, proper compensation, social security and political representation are very important issues and should be taken up seriously". Besides that few studies at micro level have also been conducted by the researchers in India. Some studies explore regional inequalities in the quality of living space in the rural areas of Haryana using tehsil level census data (Bairagai and Chamar, 2019; Chamar and Bairagi, 2019). Others are based on data collected through primary survey at micro level. Using a similar approach some studies have examined differentials in quality of living space among different clans in scheduled castes in different rural areas of Haryana at micro level (see Chamar and Rekha, 2016; Chamar and Chamar, 2018; Rani and Chamar, 2019: Dhanak and Chamar, 2021).

Study Region

Haryana is one of the most prosperous states of India. It is a landlocked state and located to the north-western part of India. It extends from 27º 39′ 0" to 30° 55′ 5" north latitudes and 74° 27′ 8" to 77° 36′ 5" east longitudes. It covers an

area of about 44,212 km2. Yamuna is the important perennial river of the state, which make its eastern boundary. Physiographically, the eastern sector of Haryana is largely plain, more fertile and featureless with better transport facilities, high literacy rate whereas the western sector is traversed by numerous sand dunes. Basically, Haryana is an agricultural state. It plays a vital role in the economy of Haryana and it is the main occupation of the people of the state. Its agriculture and manufacturing industries have experienced continuous growth after the formation of Haryana as an independent state. The economy of Haryana also relies on manufacturing, retailing and information outsourcing. Ambala, Yamunanagar, Sonipat, Gurgaon and Faridabad are the big industrial hubs of Haryana. On the other hand, Kurukshetra and Rohtak are important educational hubs. The location factor that is nearness to the National Capital (New Delhi) has helped the state to achieve the status of a leading industrialized state in India. As per 2011 census, it has 21 districts, 74 tehsils, 114 community development blocks and 6955 (6764 inhabited and 191 un-inhabited) villages. According to census 2011, out of total population of Haryana, about 165.09 lakh persons (65.12 %) live in rural areas comprising 87.74 lakhs males (53.15 %) and 77.35 lakh females ((46.85 %) persons. The total rural scheduled castes population in the study area is 37.20 lakh (22.53 %) persons, comprising 19.73 lakhs males (53.04 %) and 17.47 lakh females (46.96 %) persons, which reside in 7.23 lakh households.

Objectives

The major objective of the study is to analyze the levels in availability of household amenities and assets among scheduled castes and non-scheduled castes in rural Haryana.

Database and Methodology

The present study is based on the primary data collected on the basis of a well-structured schedule and personal interview conducted with the head/member of the household. The primary data has been collected from 1365 households comprising 975 from scheduled castes category and 390 from non-scheduled castes with the help of stratified random sampling from 39 selected villages of 15 blocks covering the five districts of Ambala, Panipat, Rohtak, Rewari, and Sirsa that represent the northern, eastern, central, southern, and western parts of the Haryana state respectively. To identify the levels in availability of household amenities and assets the following 16 indicators such as; Pipe water (X_1), Hand pump (X_2), Tube well (X_3), Toilet Facility (X_4), Electricity Facility (X_5), Chair (X_6), Fan (X_7),

Pressure Cooker (X_8), Refrigerator (X_9), Radio/Transistor (X_{10}), Television (X_{11}), Mobile only (X_{12}), Computer/Laptop (X_{13}), Bicycle (X_{14}), Scooter/Motorcycle (X_{15}), and Car/Jeep (X16) have been considered. After that, caste-wise total households have been bifurcated. The surveyed households were represented by 37 castes comprising 13 castes from scheduled castes and 24 castes from non-scheduled castes including seven from general castes and 17 from other backward castes. Initially, caste-wise availability of amenities and assets in the households were worked out in percent in proportion to total sample households. Furthermore, the weighted score has been assigned to selected amenities and assets depending upon their relative function and value (Table-1) to derive composite weighted scores. To find out the ‘composite weighted scores' of availabilities of amenities and assets among select caste in respect to each of the indicator the 'weighted scores' have been added of all the selected indicators. Finally, to assess the levels in availability of selected amenities and assets of each caste among scheduled castes and non-scheduled castes in rural Haryana, 'average composite weighted scores' have been identified by dividing the number of households of each caste among scheduled castes and non-scheduled castes of the total composite weighted scores.

Table-1: Selected Indicators and Weighted Scores

Selected Indicators	Weighted Score	Selected Indicators	Weighted Score
Pipe Water	1.0	Refrigerator	2.0
Hand Pump	0.5	Radio	0.2
Tube Well	0.5	Television	3.0
Toilet Facility	1.0	Mobile	2.0
Electricity Facility	1.0	Comp./Laptop	8.0
Chair	0.1	Cycle	0.5
Fan	0.2	Scooter/ Motorcycle	20.0
Cooker	0.2	Car/Jeep	100.0

Source: Compiled by Authors.

Results and Discussions

Based on data pertaining to 1365 sample households, the total population of 37 select castes is 6796 persons comprising 3582 males (52.71 %) and 3214 (47.29%) females in the study area (Photo-1 and 2). The data collected for study related to select 13 from scheduled castes and 24 non-scheduled castes.



Photo -1: Fieldwork Survey



Photo -2: Fieldwork Team

Population Characteristics

Based on 975 sample households, the Chamar, the Balmiki and the Dhanak are numerically dominant castes among scheduled castes which accounts for more than 84 percent population in the study area. The Odh and the Majhabi Sikh castes each shared by about four per cent. The other select castes namely the Meghwal, the Bazigar, the Khatik, the Sansi, the Doom, the Ramdasia Sikh, the Bawaria, and the Sapera accounts for nearly eight percent. The overall literacy rate among scheduled castes is about 76 percent, while the male and female literacy rates are 84 percent and 68 percent respectively. The average sex ratio is recorded 908 females per thousand males and the average size of the household is found 5 persons/household. Among the non-scheduled castes, it is noted that the Jat, the Brahman, the Ahir, the Jatt Sikh, and the Punjabi are dominant castes, which accounts for three-fifths of the total population at the time of survey. The literacy rates vary across among social groups. The highest literacy rate is observed among other backward castes (86 %) which are almost identical to that of among general castes but much higher as compared to that among scheduled castes with 76 per cent. The sex ratio is recorded 897 females/1000 males in rural Haryana. The highest sex ratio (909 females/ 1000 males) is recorded among other backward castes followed by scheduled castes (908 females/ 1000 males) and general population (841 females/ 1000 males). The average size of the household in rural Haryana is 5.0 persons, and there is not much of variation in the same across different social groups. It is recorded 4.8 persons per household among general castes, 4.9 persons among other backward castes and 5.0 persons in scheduled castes groups.

Availability of Household Amenities and Assets among Scheduled Castes

Based on sample survey, it is recorded that more than two-third households used pipe water for drinking; about 31 percent households used water from hand pump and nearly 15 percent households used tube well water for drinking. The facility of hand pump for drinking water is not available in any of the household in Odh caste. Pipe water is used by all the households belonging to the Doom and the Bawaria castes; hand pump is used by the Sapera caste and tube well is used by all the households belonging to the Ramdasia caste. About three-fifths households have the facility of toilet in the study area. Except the castes such as the Balmiki, the Dhanak, the Doom and the Sapera, all other castes have toilet facility above the average percentage. The facility of electricity is much better among all the households. About 92 percent of the households have the facility of electricity. Further, it is observed that more than two-third households have the asset of chair.

Fan is available in all the households belonging to the castes like the Khatik, the Sansi, the Ramdasia Sikh and the Sapera. Pressure cooker is used by about 46 percent of the total sample households, while little more than one-fifth households have the asset of refrigerator. The maximum availability of refrigerator is found in the Bawaria caste, followed by the Ramdasia Sikh and the Bazigar castes, while the refrigerator was not available in any of the household belonging to the castes such as the Khatik, the Sansi, the Doom and the Sapera at the time of field survey. Furthermore, it is found that about 12 percent households still fond of radio, but it is not available in any of the household belonging to the castes like the Khatik, the Sansi, the Bawaria and the Sapera. More than three-fifths households have the availability of television, and castes like the Balmiki, the Majhabi Sikh, the Sansi, the Doom and the Sapera have the asset of television below the average (62 %) in rural Haryana. On the other hand, about 73 percent households have mobile. The availability of mobile is found in all the households of the Sapera caste, followed by the Meghwal, the Odh, the Dhanak, the Ramdasia Sikh castes and the least is recorded in the Doom caste.

It may be noted that only three percent households among scheduled castes have the asset of computer and laptop, and only the Bazigar and the Chamar castes have such assets above the average that is 4.8 percent and 4.2 percent respectively. The other castes like the Odh, the Balmiki and the Dhanak have also asset of computer/ laptop. About half of the sample households have used the cycle, but it is not used in any of the household belonging to the Sapera caste. Further, about one-tenth households have scooter/motor cycle in the study area. The maximum number of households having such asset in the caste like the Bawaria, followed by the Doom and the Ramdasia castes. The lowest is recorded among the Majhabi Sikh and it is followed by the castes like Dhanak and Balmiki. Scooter/motor cycle is not found in any of the household belonging to the Sapera caste. Similarly, less than two per cent households have own car. The Odh caste has the highest number of households having own car (8.1 %), followed by the Bazigar, the Meghwal, the Majhabi Sikh and the Chamar castes, while the lowest is recorded among the Balmiki. On the other hand, the household belonging to the castes like the Dhanak, the Khatik, the Sansi, the Doom, the Ramdasia Sikh, the Bawaria and the Sapera have not their own car in the study area.

Availability of Household Amenities and Assets among Non-Scheduled Castes

Among the non-scheduled castes, it is recorded that about two-third households used pipe water for drinking; nearly one-third households used water from hand

pump and more than one-fourth households used tube well water for drinking. Pipe water is only used by all the households belonging to the Maniyar caste. On the other hand, the facility of hand pump is not available in any of the household belonging to the castes such as Rajput, the Kamboj, the Gujjar and the Muslim; and tube well water is not used by the Kumhar, the Sunar, and the Mali castes. Hand pump water is used by all the households of the Darji caste, and tube well water is used by all the households belonging to the Dhobi caste. Further, it is observed that, 86 percent households have the facility of toilet. All the caste belonging to general category and the castes belong to other backward castes such as the Jhinwar, the Kamboj, the Gujjar, the Sunar, the Darji and the Dhobi have the toilet facility above the average in the study area. All the households, except the castes like the Jhinwar, the Khati and the Lohar have the facility of electricity among the non-scheduled castes in rural Haryana.

Further, it is found that 87 percent households have the asset of chair. Except the caste like the Punjabi and the Rajput, all the households have chair among the general castes. Likewise, fan is available in nearly 97 percent of the surveyed households. The Rajput among general castes and the Jhinwar, the Khati, the Joginath, the Saini, the Kumhar and the Kashyap among other backward castes have the asset of fan below the average percentage. Pressure cooker is used by more than four-fifths of the total sample households. Little more than three-fifth households have the asset of refrigerator, while it was not available in any of the household belonging to the castes like Kashyap, the Maniyar and the Dhobi. It may be noted that a little less than one-fifth of the sample households have radio and half of the households belonging to the Rajput and the Gujjar castes still enjoying the voice of radio. Conversely, it is not available in any of the household belonging to the castes such as the Kashyap, the Mali, the Darji, the Maniyar and the Dhobi in the study area. Furthermore, about 85 percent of the surveyed households among non-scheduled castes have television and castes like the Mali and the Muslim have the asset of television less than half of the households. On the other hand, nearly 90 percent households have mobile and it is available in all the households belonging to the Bania, the Kamboj, the Gujjar, the Sunar, the Kashyap, the Mali, the Darji and the Dhobi castes and the least is found in the Maniyar caste. Only 16 percent households among non-scheduled castes have the asset of computer and laptop. However, nearly 24 percent and seven percent households have computer/laptop among the general castes and other backward castes respectively. It is not found in any of the household except the castes like the Ahir, the Kamboj, the Gujjar, and the Sunar at the time of survey in the study area.

It may be noted that more than three-fifth of the sample households still have used the cycle, but it is not found in any of the household belonging to the Maniyar and the Dhobi castes. About 48 percent households have scooter/motor cycle in the study area. All castes among the general castes and the Ahir and the Sunar among the other backward castes have scooter/motor cycle above the average percentage. Scooter/motor cycle is not found in any of the household among the caste like the Mali, the Darji, the Maniyar, the Dhobi, and the Muslim. Similarly, a little more than one-fifth of the households have own car. Half of the households belonging to the Rai Sikh caste has own car, followed by the Sunar and the Jatt Sikh castes, while the lowest is recorded among the Saini caste. On the other hand, car is not found in any of the household except the castes like the Sunar, the Ahir, the Kamboj and the Saini among the other backward castes in rural Haryana. In the preceding sections, the relative position in terms of individual variables of each of the castes among scheduled castes and non-scheduled castes of the selected variables has been discussed. In the present section, an attempt has been made to analyze the average composite weighted scores in the availability of amenities and assets of each of the caste among scheduled castes and non-scheduled castes in rural Haryana.

Caste-wise Average Composite Weighted Scores of Selected Amenities and Assets among Scheduled Castes

On the whole, based on sample households, the Odh caste has the highest average composite weighted scores in the availability of amenities like drinking water, sanitation and electricity, while the Ramdasia Sikh caste reports the lowest position followed by the Sapera and the Meghwal castes among the scheduled castes (Table-2). The castes like the Bazigar, the Khatik, the Sansi, the Majhabi Sikh and the Bawaria report above the average composite weighted scores that is 2.4. Table-2 also summarizes the caste-wise average composite weighted scores of selected assets among the scheduled castes in rural Haryana. It is found that the Odh caste has also obtained the highest average composite weighted scores of 15.8, followed by the Bazigar (13.4) and Meghwal (12.5) castes in the availability of various assets among the scheduled castes. Conversely, the Sapera caste reports the lowest position with average composite weighted scores of 3.8 and it is followed by the Sansi and the Doom castes with 5.2 scores. The other castes like the Dhanak, the Khatik, the Balmiki, and the Majhabi Sikh report below the average composite weighted scores (8.5) in the study area. Finally, it is also recorded that the first rank is obtained by the Odh caste with total composite average weighted scores of 18.5, followed by the castes like Bazigar (16.0) and Meghwal (14.6) in the availability

of various amenities and assets among the scheduled castes. On the other hand, the Sapera caste reports the lowest position with total average composite weighted scores of 5.8 and it is followed by the Doom and the Sansi with 7.4 and 7.8 scores respectively. However, the Bawaria, the Ramdasia Sikh and the Chamar castes have also better position in amenities/facilities and assets and obtained the total average composite weighted scores above from average scores in rural Haryana (Table-2).

Table-2: Average Composite Weighted Scores among Scheduled Caste

Castes	Based on Selected Amenities			Based on Selected Assets		Based on Selected Amenities and Assets	
	Total HHs	Total CWS	AC WS	Total CWS	AC WS	Total CWS	AC WS
Chamar	527	1283.5	2.4	4870.4	09.2	6153.9	11.6
Balmiki	184	0436.0	2.4	1138.6	06.2	1574.6	08.6
Dhanak	111	0268.0	2.4	0616.4	05.6	0884.4	08.0
Majhabi Sikh	39	0096.5	2.5	0262.9	06.7	0359.4	09.2
Odh	37	0098.5	2.7	0584.7	15.8	0683.2	18.5
Meghwal	23	0049.0	2.1	0287.3	15.5	0336.3	14.6
Bazigar	21	0055.0	2.6	0280.3	13.4	0335.3	16.0
Khatik	09	0023.0	2.6	0054.6	06.1	0077.6	08.7
Sansi	08	0020.5	2.6	0041.9	05.2	0062.4	07.8
Doom	05	0011.0	2.2	0025.9	05.2	0036.9	07.4
Ramdasia Sikh	05	0009.5	1.9	0049.5	09.9	0059.0	11.8
Bawaria	04	0010.0	2.5	0041.0	10.3	0051.0	12.8
Sapera	02	0004.0	2.0	0007.6	03.8	0011.6	05.8
Rural Haryana	975	2364.5	2.4	8261.1	08.5	10625.6	10.9

Source: ICSSR: ESCAC, Field Survey, 2012-14 (Haryana). Compiled by Authors.

Average Composite Weighted Score of Selected Amenities and Assets among Non-Scheduled Castes

Based on sample households, the average composite weighted scores has been recorded 2.9, 2.6 and 2.8 in the availability of amenities like drinking water, sanitation and electricity among the general castes, other backward castes and non-scheduled castes respectively. However, the Rai Sikh caste has the highest average composite weighted scores (3.3), followed by the Kamboj caste (3.0),

while the Kumhar caste reports the lowest position with 2.3 average composite weighted scores in the availability of amenities among non-scheduled castes. The study also reveals that only the Kamboj, the Sunar, the Jhinwar and the Saini castes have above the average composite weighted scores (2.6) among the other backward castes particularly. Further, it may be noted that except the castes such as the Rai Sikh, the Jat, the Bania, the Rajput among the general castes, and the Kamboj and the Sunar which includes in the category of other backward castes report above the average composite weighted scores (2.8) among non-scheduled castes (Table-3). The caste-wise average composite weighted scores of selected assets among general castes, other backward castes as well as non-scheduled castes in rural Haryana has also been summarized in Table-3.

The average composite weighted scores have been recorded 50.4, 23.7, and 38.6 in the availability of various selected assets among the general castes, other backward castes and non-scheduled castes respectively. The Rai Sikh caste has also obtained the highest average composite weighted scores of 75.6, followed by the Sunar and the Jatt Sikh with average composite weighted scores of 63.8 and 60.6 respectively in the availability of various assets among the non-scheduled castes in rural Haryana. On the other hand, the Maniyar caste reports the lowest position with average composite weighted scores of 2.9, and it is followed by the Muslim and the Mali castes with 3.6 and 4.3 scores. The Bania and the Brahman castes reports below the average composite weighted scores of 50.4 among the general castes. While except the castes such as Sunar, the Kamboj, the Ahir and the Dhobi, all other select castes belong to other backward castes have below the average composite weighted scores of 23.7 in the study area. Finally, it is also recorded that the households belonging to Rai Sikh caste has comparatively better condition in availability of amenities and assets with total average composite weighted scores of 78.9, followed by the Sunar (66.5) and the Jatt Sikh (63.3) castes among select non-scheduled castes in rural Haryana.

Table-3: Average Composite Weighted Scores among Non-Scheduled Castes

Selected Castes	Based on Selected Amenities			Based on Selected Assets		Based on Selected Amenities and Assets	
	Total HHs	Total CWS	AC WS	Total CWS	AC WS	Total CWS	AC WS
				General Castes			
Jat	99	291.0	2.9	5212.9	52.7	5503.9	55.6

Contd...

Brahman	57	160.5	2.8	2422.3	42.5	2582.8	45.3
Jatt Sikh	24	064.5	2.7	1454.2	60.6	1518.7	63.3
Panjabi	16	043.0	2.7	0818.9	51.2	0861.9	53.9
Bania	12	035.0	2.9	0438.4	36.5	0473.4	39.4
Rajput	06	017.5	2.9	0328.1	54.7	0345.6	57.6
Rai Sikh	04	013.0	3.3	0302.2	75.6	0315.2	78.9
General Castes	218	624.5	2.9	10977.0	50.4	11601.5	53.3
Other Backward Castes (OBC)							
Ahir	40	105.5	2.6	1954.3	48.9	2059.8	51.5
Jhinwar	14	038.0	2.7	0102.1	07.3	0140.1	10.0
Khati	14	035.5	2.5	0160.5	11.5	0196.0	14.0
Joginath	11	028.0	2.5	0094.9	08.6	0122.9	11.1
Kamboj	11	032.5	3.0	0547.6	49.8	0580.1	52.8
Lohar	11	028.0	2.5	0079.4	07.2	0107.4	09.7
Nai	11	028.0	2.5	0132.4	12.0	0160.4	14.5
Saini	10	027.0	2.7	0192.4	19.2	0219.4	21.9
Gujjar	08	020.0	2.5	0133.4	16.7	0153.4	19.2
Kumhar	08	018.5	2.3	0078.9	09.9	0097.4	12.2
Sunar	07	020.0	2.9	0446.5	63.8	0466.5	66.5
Kashyap	05	013.0	2.6	0041.7	08.3	0054.7	10.9
Mali	05	013.0	2.6	0021.3	04.3	0034.3	06.9
Darji	04	010.0	2.5	0024.2	06.1	0034.2	08.6
Maniyar	02	005.0	2.5	0005.8	02.9	0010.8	05.4
Dhobi	01	002.5	2.5	0025.5	25.5	0028.0	28.0
Muslim	10	025.0	2.5	0036.4	03.6	0061.4	06.1
Total OBC	172	449.5	2.6	4077.3	23.7	4526.8	26.3
Total Non-SC	390	1074.0	2.8	15054.3	38.6	16128.3	41.4

Source: ICSSR: ESCAC, Field Survey, 2012-14 (Haryana). Compiled by Authors.

On the other hand, the Maniyar caste reports the lowest position in availability of amenities and assets with total average composite weighted scores of 5.4 and it is followed by the Muslim (6.1), the Mali (6.9), the Darji (8.6) the Lohar (9.7), the Jhinwar (10.0), the Kashyap (10.9) Joginath (11.1) and the Kumhar (12.2) respectively have less than half of the total average composite weighted scores among the other backward castes particularly. However, it may also be noted that the households belonging to the Brahman, the Ahir, the Punjabi, the Jat and the Rajput castes have also better position in availability of amenities and assets among non-scheduled castes in rural Haryana.

Conclusion

It is concluded that the household's quality of life among various social groups is influenced by the availability of household amenities and assets and very large variations still exist among scheduled castes and non-scheduled castes in the study area. It is recorded that Odh caste has better access to the availability of amenities and assets as compared to other scheduled castes. The first rank is obtained by the Odh caste with total composite average weighted scores of 18.5, and followed by the castes like Bazigar and Meghwal, while the Sapera caste reports the lowest position with total average composite weighted scores of 5.8 and it is followed by the Doom and the Sansi castes. The Bawaria, the Ramdasia Sikh and the Chamar castes have also better position in amenities and assets and obtained the total average composite weighted scores above from average scores (10.9) among scheduled castes in rural Haryana. Likewise, among the backward castes except the castes such as the Sunar, the Kamboj, the Ahir and the Dhobi, all other select castes have below the average composite weighted scores (26.3) in the study area. Similarly, only Brahman and the Bania castes among general castes have below the average composite weighted scores of 53.3 in the study area. Further, it may be noted that very large difference (30.5) has been observed in the average composite weighted scores between the scheduled castes (10.9) and non-scheduled castes (41.4) in the study area. Finally, it is suggested that the government should provide incentives to enhance their income level for minimizing the inter castes variations in respect of availability of household amenities and assets among scheduled castes and non-scheduled castes in particularly rural areas of Haryana state. Secondly, proper implementation and regular monitoring of schemes and programmes launched by government for better housing conditions and poverty alleviations.

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WOMEN AT MARGIN: EXPLORING THE VILNERABILITY OF WOMEN IN UNORGANISED SECTOR OF JAMMU CITY

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Abstract

The unorganised sector also known as informal sector is an important stakeholder in Indian economy. It not only contributes a significant proportion to the GDP but also provides employment to large number of low and unskilled workers. However, despite its major contribution the unorganised sector is characterised by plethora of issues such as meagre wages, poor working conditions, lack of job security etc. Further, women in this sector are more vulnerable as they face various types of exploitation owing to both economic and social status. The present paper aims to analyse the condition of women in unorganised sector of Jammu city. For the purpose of study, the workers have been categorised into various categories such as domestic, agricultural, construction and others. The study is based on primary survey where 50 respondents have been interviewed. The collected data has been tabulated with the help of MS Excel. Simple statistical tools have been used to draw the analysis. Moreover, composite index has been used to examine the vulnerability of females in this sector. It has been found that the females in this sector are more vulnerable as they are exploited in various forms such as delayed payments, physical and verbal abuse.

Introduction

In India, the unorganized sector refers to economic activities that operate outside the scope of formal labour regulations and social protection programs. This industry is characterized by its informal nature, lack of fixed hours, lack of job security, and restricted access to benefits such as health insurance, pension, and paid vacations. It includes, among others, street vendors, domestic workers, construction workers, agricultural labourers, and artisans (Rani, 2016). Despite its informal nature, the unorganized sector employs a substantial portion of the country's workforce, including a large number of women. Women's participation in this sector is driven by various factors, including the need to contribute to household income, lack of formal education and skill opportunities,

and social norms that confine them to certain occupations (Monisha & Rani, 2016). The Periodic Labour Force Survey (PLFS) 2018-2019 data reveals that approximately 96 percent of employed women in India work in the informal or unorganized sector. This staggering statistic underscores the magnitude of women's presence in this vulnerable labour market segment (Masood, 2015). While women's participation in the unorganized sector is significant, they face numerous vulnerabilities and challenges. Indeed, in the unorganized sector, both male and female workers experience exploitation, but women are particularly vulnerable due to their gender (Manju, 2017). The lack of formal employment contracts often leads to lower wages and exploitative working conditions. The women situated at the lower end of the social and economic hierarchy rely on low-paying occupations that lack recognition and job security, commonly referred to as "informal" employment (Dubey, 2016). Many women in this sector work as daily wage labourers, facing uncertainty in income and job stability. Additionally, they often lack access to maternity benefits, paid leave, and safe working conditions. Women in the unorganized sector also confront social biases and gender discrimination. Women workers are more susceptible to the dangers of sexual harassment and exploitation (Saradamoni ,1995). In some occupations, they are paid less than their male counterparts for similar work. The lack of formal recognition and protection leaves them vulnerable to harassment and abuse, with little recourse to legal support.

Study Region

Because of its historic temples and Hindu shrines, Jammu is referred to as the "City of Temples". It is the biggest city in the Jammu division of Jammu and Kashmir's union territory. This city functions as both the administrative centre for the Jammu district and the winter capital of the J&K UT. Its longitudinal extension is from 740 24' E to 750 18' E, while its latitudinal extension is between 320 50' N and 330 30' N. Situated on the banks of the Tawi River, it occupies an area of 240 square kilometres. Jammu is tucked away among the jagged, lower-elevation slopes of the Shivalik hills (Kumari et al, 2019). It is bordered to the north, east, and southeast by the Shivalik Range, to the northwest by the Trikuta Range, and the south by the northern plains. Jammu is the second most populous city in the union territory, with a sizable population. Jammu city had 502,197 residents as of the 2011 census, with 8.47% of those under the age of six. 52.7 percent of the population was male, and 47.3 percent was female. Compared to the 940 national average sex ratio, there were 898 females for every 1,000 males in the city. With a male literacy rate of 93.13% and a female literacy rate of 85.82%, Jammu's average literacy rate was

significantly higher than the 74.4% national average literacy rate. It is located in the province of Jammu's largest urbanised district (Kumari & Singh, 2024). In J&K UT, almost 85% of the workforce is employed in the unorganised sector.

Objectives

(1) To assess the socio-economic status of women workers in the unorganised sector and conditions of their work environment.

(2) To understand and analyse the level of vulnerability among different categories of women workers in the unorganised sector and issues involved.

Database and Methodology

This study was purely based on primary data collected through well-prepared schedules. To achieve the objectives, 50 women respondents were selected from different categories of informal workers based on the categorization done by the Ministry of Labour, Government of India. They have categorized the unorganized labour force into four groups in terms of occupation, nature of employment, specially distressed categories and service categories. Under the Terms of Occupation, we had taken agricultural labourers and construction workers. Under the Terms of Nature of Employment and Terms of Service Category, migrant workers and domestic workers & vendors, had been taken respectively (Dhas & Helen, 2008). To find out the level of vulnerability among different categories of informal workers, different indicators were taken i.e., physical harassment, verbal harassment, sexual harassment, mental harassment, low wage, delayed payment and irregular payment. Scores have been assigned to the frequency of harassment faced by them. Based on the above criteria, the level of vulnerability has been calculated using the composite index

Results and Discussions

Socio-economic characteristics

Table-1 shows the socio-economic profile of the unorganised workers in the Jammu city. 42 percent of women working in the unorganised sector are between the ages of 30 and 40 years, 34 percent of the respondents were between 18-30 years of age, and 24 percent were above 40 years. The unorganised sector in Jammu city constitutes 90 percent of women respondents who are married. Only 6 percent of respondents have completed the 10th standard whereas 66 percent of respondents have studied only up to the primary level in this sector.

Low level of education is one of the factors responsible for engagement in the unorganised sector. Only 19 percent of women workers in the informal sector are domiciled in J&K and the remaining 81 percent are migrants from other states, thus, making them more vulnerable to abuse, exploitation, and discrimination in unfamiliar settings. Income varies for different categories of unorganised workers according to their average daily working time. Vendors have the highest average daily working hours of 11 hours and thus the highest average monthly income of Rs. 22,300 whereas domestic workers have the lowest average monthly income of Rs. 7000 because they work for only 5 hours a day (Table-1 and Fig.-1).

Table-1: Socio-economic Characteristics of Respondents (%)

Age			Domicile		Educational level			Marital status		
18-30	30-40	More than 40	Yes	No	Primary	Middle	Secondary	Married	Unmarried	Widow
34	42	24	38	62	65.7	28.6	5.7	90	2	8

Source: Primary Survey, 2022

People may be involved in informal work because of many reasons such as lack of formal job opportunities, limited education and skills, poverty and economic necessity, lack of legal documentation, seasonal and temporary work, etc. 38 percent of the respondents reported that they are forcibly involved in the informal sector while 62 percent comes in this sector willingly. Poor educational background is the most significant factor contributing to involvement in the informal sector as 60 percent of the respondents are involved in this sector due to this reason. This suggests that individuals with limited education may find it challenging to access formal job opportunities requiring higher qualifications, leading them to opt for informal work to earn a living. Family issues combined with poor educational background are responsible for 20 percent of the respondents for involvement in this sector. This indicates that family circumstances and responsibilities can compound the challenges faced by individuals with inadequate education, making it even more difficult for them to secure formal employment. The lack of jobs in the formal sector, combined with family issues, is responsible for another 10 percent of the respondents. This suggests that in some instances, individuals may be forced into the informal sector due to a lack of available formal job opportunities in their

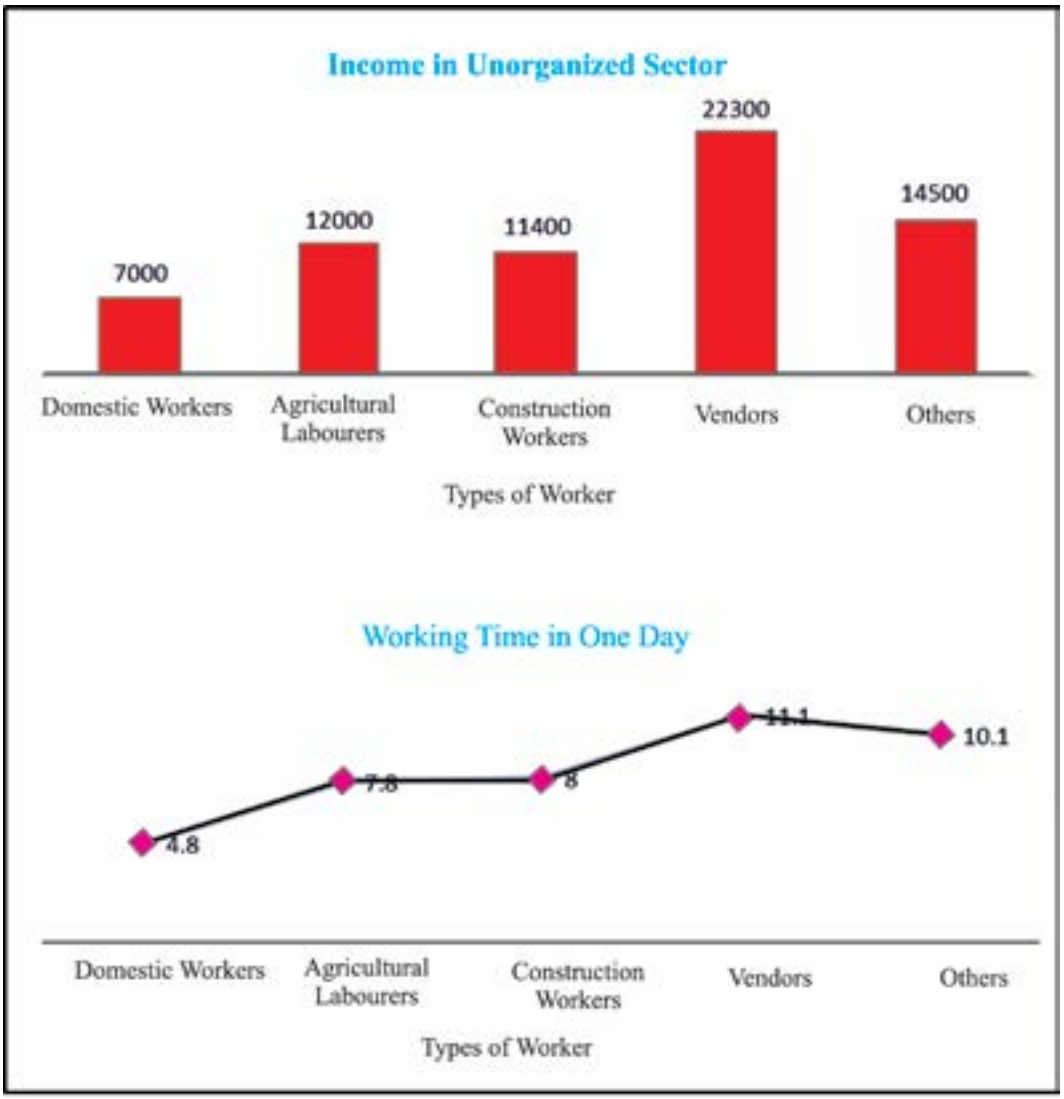

Income in Unorganized Sector
7000
12000
11400
22300
14500
Domestic Workers
Agricultural Labourers
Construction Workers
Vendors
Others
Types of Worker
Working Time in One Day
4.8
7.8
8
11.1
10.1
Domestic Workers
Agricultural Labourers
Construction Workers
Vendors
Others
Types of Worker

Fig. 1

region or sector of expertise. The involvement of the remaining 10 percent was attributed to other reasons such as lack of legal documentation, discrimination, and preferences for the flexibility and autonomy offered by informal work. Informal workers often face challenges when accessing different facilities such as loans or credit, medical, and child care facilities. The data reveals that 28 percent of women workers have access to credit facilities, 8 percent reported that they occasionally receive credit and 64 percent of them don't get credit in times of need. Moreover, these informal workers receive credit from either their employers or private lenders rather than from banks or any other financial institutions as loans. None of the respondents had access to on-site medical facilities or any kind of medical insurance. Also, all the respondents don't have access to basic amenities like toilets and child care. Only 12 percent of the respondents have child-care facilities at their workplace. It is important to mention here that they don't have proper child-care facilities but only they are allowed to bring their child to work. Additionally, 88 percent of the respondents have access to the toilet, and the remaining 12 percent that don't have toilet facilities at work mostly belong to agricultural labourers and vendors (Mishra, 2018).

Vulnerability among Different Categories of Workers in Unorganised Sector

The level of vulnerability was assessed among the five categories of informal workers based on different parameters such as physical harassment, verbal harassment, sexual harassment, mental harassment, low wage, delayed payment, and irregular payment. The index value ranges from 0.25 to 0.41, with vendors having the highest value (0.41), making them the most vulnerable group of informal workers, and agricultural labourers having the lowest value (0.25), making them the least vulnerable (Fig. 2).

Vendors

Vendors are the most vulnerable among the other categories of informal workers with an index value of 0.41. One of the major reasons that contribute to their vulnerability is that they have no fixed working hours (Vara & Subhashini, 2019). Vendors work an average of 11 hours each day, which is the most among all categories of informal workers. Firstly, the indicator which adds most to their vulnerability is the verbal harassment they face at their work being it from customers or fellow vendors, especially from male vendors (George, 2024). Vendors work in public spaces, such as streets or open markets,

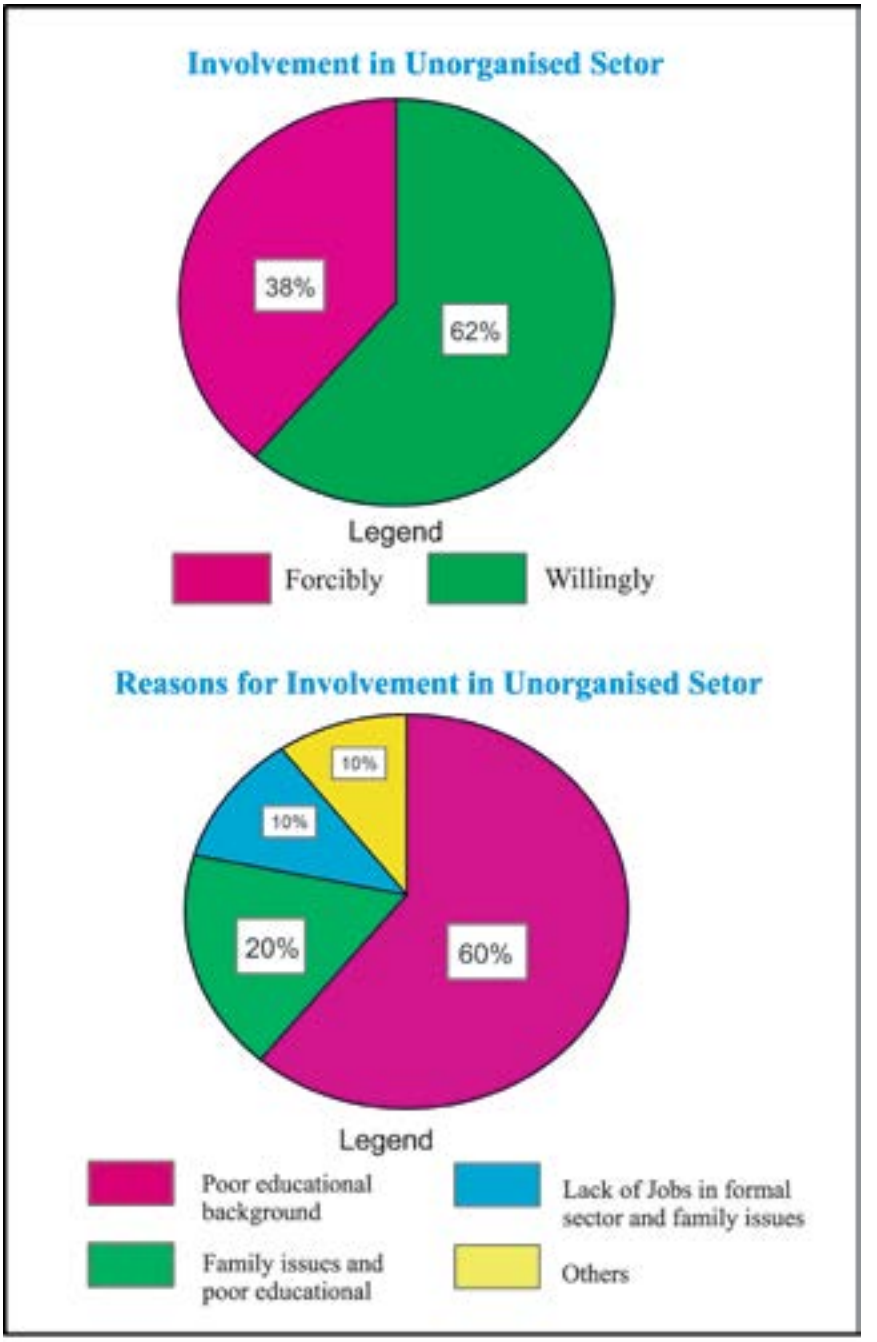

Involvement in Unorganised Setor
38%
62%
Legend
Forcibly
Willingly
Reasons for Involvement in Unorganised Setor
10%
10%
20%
60%
Legend
Poor educational background
Lack of Jobs in formal sector and family issues
Family issues and poor educational
Others

Fig. 2

where they are exposed to various risks, including accidents, theft, and harassment from local authorities or law enforcement, leading to constant fear and insecurity in their work environment. Secondly, irregular payments make them economically vulnerable. Although among the different types of informal workers, vendors earn the most money still they are the most vulnerable because their income is highly dependent on daily sales and fluctuations in demand.

Domestic Workers

Among the different categories of informal workers, domestic workers rank as the second most vulnerable category with an index score of 0.36. Domestic workers work in private homes, isolated from public view, which can lead to increased vulnerability to abuse, harassment, and exploitation (SEWA, 2014). The lack of visibility also makes it difficult to monitor working conditions and enforce labour standards (Neetha, 2023). The main indicators that make them vulnerable are low wages and delayed wages (Singh, 2023). They have the lowest average wages among all categories of informal workers. Domestic workers often depend entirely on their employers for their livelihood, accommodation, and often food and other basic necessities (Singh, 2023). This dependency can make it difficult for them to assert their rights or report abuses for fear of losing their jobs or being evicted. Additionally, the fact that they don't take enough breaks and off days makes their job more exploitative. They may be expected to be available 24/7, with little regard for their well-being.

Construction Workers

Construction workers are more vulnerable than agricultural labourers with an index value of 0.28. The indicator that adds the most to their vulnerability is mental harassment. Construction work can be physically demanding, and the strain on the body can take a toll on the mental health of workers, especially when they do not have access to proper healthcare or recovery time (Banu & Sampath, 2018). They got minimal time for rest and relaxation and thus fatigue and stress can build up, affecting the mental well-being of workers. Low wages and the uncertainty of finding continuous work can cause financial stress and job insecurity among construction workers, leading to anxiety and depression. Moreover, women involved in construction work are migrants who are away from their families and communities, feelings of isolation and loneliness can also lead to mental health challenges.

Agricultural Labourers

Agricultural labourers are the least vulnerable category among the other categories of informal workers with an index value of 0.25. They have fixed working hours in a day and fixed wages which at least ameliorates their vulnerability a little. Despite their low wages, they believe that they have stable incomes because of the timely disbursement of wages. Moreover, they are less prone to verbal and physical harassment as their interaction with their employer and fellow workers is quite less. Their work is of seasonal and temporary nature depending on the crop cycles which leaves them vulnerable because of lack of job security and income stability resulting from their uncertain employment (Dineshkumar, 2017), (Kiranekumar, 2022).

Others Workers

Other informal work categories include women working in shops, parlours, boutiques, etc. This category is also the second most vulnerable group among the other categories of informal workers. Like vendors, their job is also interactive which makes them vulnerable to verbal abuse. They work for an average of 10 hours every day. They work long hours with no set schedule, which leaves them with little time for rest. Additionally, they also face problems of delayed and irregular payments. Informal workers face a range of challenges and issues due to the nature of their employment and the lack of formal protections. They face issues such as difficulty in managing family life, not enough income, health issues, not enough time for rest, etc (Ansari, & Mehaboob, 2018). Different categories of informal workers face different issues due to their work as shown in Figure 3. 40 percent of domestic workers reported that they face issues of difficulty in managing family life, low income, health issues, and not enough time for rest. 10 percent of them reported that they feel their income is low and also face health issues especially backaches due to the nature of their work. Moreover, 10 percent of them don't face any such issues. In case of agricultural labourers, 40 percent of them reported issues of difficulty in managing family life and not enough time for rest. It is interesting to note here that agricultural labourers don't feel that their wages are low. This may be due to the reason that they get their wages timely. 20 percent of them reported that they don't get enough time for rest due to which they face health problems. 60 percent of construction workers reported that they face difficulties in managing family life, do not have enough income to meet their needs, and also do not have enough time for rest (Kumar & Banu, 2018).

Due to all these issues, 20 percent of these workers face issues related to their health. Moreover, construction sites are also not completely safe for work and if they meet any accident, they do even not get any insurance. Three main issues that are faced by 60 percent of vendors: low income, health challenges, and difficulty juggling family responsibilities. It is noteworthy to mention that all surveyed vendors have issues that make vendors the most vulnerable among the other categories of informal workers. The category of "Others" includes women working in shops, parlours, boutiques, etc. 50 percent of such workers stated that they face difficulty in managing their family with their work. This is due to their long and not fixed working hours. Thus, 10 percent stated that they don't get enough time for rest. Additionally, 10% of them believe that their income is insufficient given their long work hours and also, they face different health problems.

Conclusion

It has been found that the women working in unorganised sector face the dual pressure of balancing work and family life. Due to lack of security, women in this sector have to work for longer hours with limited wages. Moreover, women in this category are not skilled as a result they are employed in low-income jobs. The women in this sector do not get facilities for medical care and child care. Although the women working in this sector feel that they are willingly doing this job, still they are forced by external conditions such as poor educational background, family issues and lack of jobs in the formal sector. Currently, there is a lack of official statistics on this particular sector. The govt. has come out with a good initiative called the e-shram portal for collecting and organising the data of informal workers. Skill development programmes can be organised for women working in this sector so that they can get better remuneration. There should be some provisions for insurance and medical facility for workers in this sector.

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SPATIO-TEMPORAL ANALYSIS OF CROPPING PATTERN IN NILAKOTTAI TALUK OF DINDIGUL DISTRICT, TAMIL NADU

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Abstract

The concept of agricultural regionalization is not dividing a land into different fragments but also a method of understanding the agricultural patterns. The existing patterns will strongly show the combinations of physical and socio-economic balance of an area. To map the cropping pattern the following analysis were required they include crop combination, crop diversification and crop combination. The results suggest that there are seven crops widely occupies in the study area. Among the Seven crops Flowers, Vegetables, cereals, e were the top three crops. (The high Crop diversification is observed in 23 Villages of the study area. Majority of villages are in Nilakottai block they are Kolladipatty (0.71), Nilakottai (0.75) Kullalakundu (0.71), the low crop diversification is observed Viralimayanpatti (0.17) and Kanavaipatty (0.34) in north and north eastern part of Batlagundu blocks shows lower crop diversification, other blocks in the study area have the index value more than 0.7 which indicates that the blocks have high diversification. The crop combination analysis also sight that Flowers, Vegetables, as fist ranking crop in several blocks, similarly cereals, paddy, founds as second ranking crop and paddy is found as third ranking crop in the study area. The cropping pattern analysis will provide the agricultural and agro-climatologist to suggest better land use planning of an area.

Introduction

Cropping patterns are defined as the sequence and spatial arrangement of annual crops on a piece of land. Knowledge of cropping patterns is crucial for crop production and land-use intensity. (Mahlayeye et al., 2022: Osama et al 2017). Crop concentration means the variations in the density of crop in an area/region at a given point of time (Mazid Hussain, 1965), Crop combination is a technique used to establish the boundaries of agricultural regions based on statistical comparison of acreages Florence (1948), Compared the share of a region with that of the

entire nation with the help of a location quotient method. Vivekananda M. and Sathyapriya V. S., (1994). Similarly, Bhatia (1965) used the quotient method to determine the regional concentration of crops. In the present work Jasbir Singh's (1976) technique has been adopted to identify the regional concentration of crops. Overall development depends on food production in service of existing or growing population with maximum benefits and optimal utilization of water and land resources. (Alabdulkader et al., 2012: Shreedhar et al., 2015: Vinothini et al 2019). The introduction of these crop combination methods by Bhatia (1960), Athawale (1966),). Vivekananda M. and Sathyapriya V. S., (1994). Kalaiselvi, V. (2009). In the present study Weaver's method of crop combination technique has been used to identify the temporal changes in the study area. The production has increasing trend for major crops. Productivity has increased and state agricultural growth rates are more satisfactory than national averages. (Goyal et al 20113: Peng et al., 2011: Aghajani et al 2013). The study of crop diversification is essential to the rotation of crops and the area under different crops. (Akhtar, R., & Acharya, 2015: Sun et al., 2015). . (Singh et al., 2001: Chen et al., 2018: Nematollahi et al., 2017,In order to identify the crop diversification, in present study, Gibb's Martin's Index has been applied and computed for Nilakottai Taluk ,This Journal also analysis the Nilakottai taluk ,Cropping pattern that happened between 2008-09 and 2017-18.

Study Region

The present study area Nilakottai taluk is in Dindigul district located between 1000'N to 100 17'North latitude and 77040'E to 770 68'East longitudes. Nilakottai taluk is found in the southern most part of Dindigul district. Nilakottai taluk shares borders with Kodaikanal, Aathur and Dindigul taluk in North and East Madurai district in the South of Nilakottai, Theni district is in the west. The NH 7 and state high passes through this taluk. The taluk is divided into two community block and 40 villages and 5 town panchayats of urban area for the implementation of development activities. The panchayats are grouped into two development Blocks.

Objectives

(1) To describe the crop concentration of the study are

(2) To bring out the crop combination

(3) To identify the crop diversification Disparity in Nilakottai taluk.

(4) To analysis farmers cultivated crops and their benefits

Database and Methodology

The present study is based on primary and secondary data sources. Primary data was collected at household surveys through questionnaires. A number of statistical techniques have been evolved and applied for the demarcation of crop concentration regions of which the location quotient method has been adopted by Bhatia (1965)

$$\frac{\text{Area of "x" Crop in a component aerial unit}}{\text{Area of all crops in a component aerial unit}}$$

Concentration Index of "x" Crop = Area of "x" Crop in entire region

The crop data has been computed with the help of Weaver's technique of crop combination. This is expressed as:

$$SD= \sum d2n$$

Where, d= Difference between actual crop percentage in the study region and the percentage in the theoretical distribution. n= number of crops in the given combination. The theoretical curve for the standard measurement was employed as follows; Monoculture = 100 % of the total harvested cropland in one crop. Two crop combinations = 50 % in each of two crops. Three crop combination = 33.3 % in each of three crops Four crop combination =25 % in each of four crops Five crop combination = 20 % in each of five crops Ten crop combination = 10 % in each of ten crops -Area of all crops in entire region. In present study, Gibb's Martin's Index has been applied and computed for Nilakottai Taluk. The formulas used to calculate area, as follows

$$\text{Index of Diversification} = 1-\sum x2/(\sum x)2$$

Here x is the one hundredth of total cropped area occupied by an individual crop. According to this method crop diversification varies between 0.1 - 0.9. This method is directly related to the magnitude of diversification. Here higher the index higher the diversification and lower the index lower the magnitude of diversification. where x is the percentage of total cropped area occupied by each crop under an individual crop ,if the index of diversification value close to I, the diversification is relatively high and the value not close to one ,it indicates the areal units have low diversification, If the total area in a region is devoted to one crop.

Result and Discussion

Crop Concentration in Nilakottai Taluk (2008 to 2018)

Cereals and Spices

When comparing the temporal years 2018 and 2008, it is to be noted that, the percentage of area occupied by cereals is varies from -6.50 to +37.64 per cent in that minimum is noted in Sevugampatty village of Bathalagundu block and maximum is noted in Kanavaipatty village of Bathalagundu block. Based on the data, it was observed that nearly 28 villages in the study area have decrease in area under cereals cultivation and 15 villages have notable increase in cereals cultivation. These cereals cultivation are high in Nilakkotai block than Bathalagundu block. Mean while decrease is also maximum in Bathalagundu block compared to Nilakottai block. The area under spices is not found in 5 villages in the study area, namely, Bodiakoundenpatti village of Nilakottai block, Kolladipatty village of Nilakkotai block, Kullichettipatty village of Nilakottai block, Mattaparai village of Nilakottai block and Pannaipatty village of Nilakottai block. The percentage of change is varies from -16.82 (Kanavaipatty village of Bathalagundu block to +23 per cent (Viralipatti village of Bathalagundu block). The area under cultivation of spices is decreased in 28 villages mainly distributed in the blocks of Nilakkotai and the area is increased in 10 villages distributed in the Bathalagundu blocks.

Sugar and Vegetables

Among the total 43 villages, the area under sugar crops is decreased in 22 villages and increase is noted in 5 villages namely (Nakkaluthu, pillyar natham, Malayagoundanpatti, Kullakundu, kolladipatty in southern side of Nilakotai block). The distribution of sugar crops is not found in 17 villages when comparing the temporal years. The area under change in sugar crops are varied from -16.71 per cent in Kullalakundu village of Nilakottai block to +44.8 per cent in Kanavaipatty village of Bathalagundu block. When comparing both the blocks, the sugar crops cultivation is increased in Nilakottai block than Bathalagundu block. The sugar crops cultivation is not found or no change is distributed mainly in Bathalagundu block. The cultivation of vegetables is increased in 21 villages in the study area when comparing both the years 2018 and 2008. Spatially these areas are distributed high in Bathalagundu blocks compared to Nilakottai block. The decrease is

noted in 22 villages mainly spread in the Nilakottai blocks than Bathalagundu blocks. The area under cultivation of vegetables is varies from -32.5 per cent in Ramarajapuram village of Nilakottai block to +23.73 per cent in Kanavaipatty village of Bathalagundu block.

Fibre Crops and Oil Seeds

Among the total of 43 villages, 21 villages in the study area have no cultivation of fibre crops. These villages are distributed high in Bathalagundu block than Nilakottai block. The area under fibre crops in the study area is varies from -12.02 per cent to +17.01 per cent. The minimum is noted in Viralipatti Batlagundublock and Ramarajapuram village inNilakkotai block. It is to be noted that 11 villages have increase and decrease of fibre crops in the study area. When comparing both the blocks the changes are high in Bathalagundu block than Nilakottai block. The change in area under cultivation of oil seeds is varies from -22.97 per cent in Viralimayanpatti village of Bathalagundu block to +16.63 per cent in kanavaipatty village of Bathalagundu block. From the changes data it has been observed that, increase in oil seed crop cultivation is noted in 21 villages and decrease is noted in 22 villages. The changes are noted high in Bathalagundu block compared to Nilakottai block in oil seeds cultivation during the two temporal years over the study area. (Table-1)

Flowers

The change in flower cultivation in the study area varies from -11.31 per cent in Chinnamanaickankottai village of Nilakottai block to +12.86 per cent in Musuvanuthu village of Nilakottai block. The increase in flower cultivation is noticed in 23 villages spread spatially high in _ Nilakkotai block compared to Bathalagundu block. The decrease is noted in 20 villages which are distributed high in Bathalagundu block than Nilakottai block. So, the changes in area under flower cultivation is high in Nilakottai block than block.

Crop Combination

The crop data has been computed with the help of Weaver's technique of crop combination. This is expressed as:

$$SD= \sum d2n$$

In the present study an attempt has been made to show the changes in the crop combination regions, during the period of 2008-09 and 2017-18.

Table-1: Changes in Crop Concentration (2008 to 2018 (Area in percent)

Sl. No	Village Name	Cereals	Spices	Sugar crops	Vegetables	Fibre crops	Oil seeds	Flowers
1	Bangalapatti	-0.618	-0.03	0	-1.99	0	-0.07	-0.02
2	Batalgundu	-2.4	5.77	-1.7	0.18	1.03	-7.93	0.05
3	Bodiakounden-patti	-0.369	0	0	0.35	0	-3.99	3.75
4	Chandaiyur	-0.817	8.91	-1.9	4.36	17.01	2.03	-0.58
5	Chinnammana-ickenkottai	-0.298	-2.86	0	-0.68	-2.55	-0.49	-11.31
6	Ethilode	0.413	-4.25	0	-0.42	0	2.16	4.42
7	Jampuduraikot-tai	0.936	-6.24	-1.49	2.12	0	-1.07	0.97
8	Kalladipatti	0.006	0	-9.28	0	0	-0.02	-0.58
9	Kanavaipatti	37.64	-16.82	44.8	23.73	-0.38	16.63	-3.32
10	Kodenginaick-enpatti	-2.216	-0.05	-4.89	-0.11	0	0.07	9.99
11	Kompaipatti	-4.739	-4.05	0	0.1	-0.41	1.68	-2.46
12	Koovanuthu	0.372	-0.31	0	-0.56	1.38	0.3	0.17
13	Kottur	-1.168	-5.05	-0.11	-2.46	-0.3	-0.97	0.93
14	Kullalakundu	-0.687	-0.13	-16.71	-0.71	0	0.91	-3.04
15	Kullichettipatti	-0.06	0	0	-0.51	0	-0.92	0.97
16	Kunruvarankot-tai	-1.54	2.38	0	0.01	0	3.63	-4.29
17	Malaiyakound-enpatti	0.12	-2.3	-10.91	-0.02	-5.9	-2.73	-0.33
18	Mallanampatti	-0.097	-0.27	0	0.53	2.78	-1.38	4.2

Contd...

19	Mattapparai	1.454	0	39.29	0.4	0	-10.9	-3.93
20	Musuvanuthu	-0.117	-0.28	0	1.26	0	-0.37	12.86
21	Nadakottai	-1.116	0.37	0	1.92	2.07	0.23	-1.28
22	Nakkaluthu	-0.022	-0.2	-10.13	-0.34	0	-0.22	3.41
23	Nariyuthu	-0.549	-5	0.32	-4.57	-5.91	-0.36	-2.43
24	Nilakottai	-0.105	-0.23	0	-0.03	0	0.6	-2.29
25	Nuthalapuram	-2.553	-0.53	0	4.37	0	1.91	0.53
26	Oruthattu	-2.59	-11.79	-1.41	0.58	0	4.47	-2.5
27	Pachamalay-ankottai	0.455	-1.62	0	0.27	0	0.15	-1.23
28	Pallapatti	0.034	-1.2	-1.4	3.39	0	5.19	-1.59
29	Pannaipatti	-0.943	0	-2.55	-0.37	2.76	-0.82	-5.04
30	Pillayarnatham	0.374	-0.79	-10.05	-0.16	0.14	1.81	0.26
31	Ramarajapuram	1.515	-0.18	3.02	-32.5	0	-0.78	1.69
32	Rengappanai-ckanpatti	-0.936	5.21	-0.51	7.8	2.76	0.94	-0.51
33	Sekkapatti	-3.092	4.75	-1.84	1.01	4.23	1.89	0.04
34	Senkattanpatti	-3.08	-0.94	-5.2	-1.45	13.8	0.64	3.95
35	Sevukampatti	-6.504	10.2	-0.15	-0.53	-12.02	11.51	-0.1
36	Silukkuvarpatti	1.72	-6.76	-1.23	-3.61	0	-0.04	-3.28
37	Sithrkalnatham	0.868	-0.72	-4.12	0.39	0	3.07	-2.77
38	Sivagnana-puram	0.205	-0.4	0	0.07	-1.53	0.93	-1.09
39	Veelinaicken-patti	-0.14	-0.2	0	-7.2	-5.39	-4.14	9.55
40	Vilampatti	1.97	-0.27	-0.4	-0.12	0	-0.38	0.15
41	Viralimayan-patti	-2.762	5.49	-0.04	5.03	4.82	-22.97	-0.52
42	Viralipatti	-4.854	23	-1.42	-0.5	-12.02	1.2	1.24
43	Viruveedu	-3.703	7.38	0	0.98	-1.21	-0.02	0.34

Source: Computed by Authors

Mono and Double Crop Combination

Crop combination is one of the important aspects in farming. It will help to rotate the crop and enrich the nutrients in the soil. Among the 43 villages in the taluk during 2008 and 2018, mono crop cultivation is dominated only in 5 villages of the study area. The major dominant groups of crops cultivated in the taluk are cereals, flowers and paddy. In cereals, the major crop cultivated is Bajra mainly found in Batlagundu village covering an area of 20.21sq.km constitutes 4.16 per cent of total land area of the taluk is noted in both the time periods. Among the flowers, Rottana flowers, Jasmine and Tuberose are cultivated widely in Ethilode, Malayagoundanpatti and Nadakottai villages respectively in 2008 but in 2018, Rose, Jasmine and Tulip rose are cultivated widely in Ethilode, Malayagoundanpatti and Nadakottai villages respectively. About, 31.55 sq.km of the land area was under flower cultivation covering 6.15 percent of the total land area of the taluk. The Ramarajapuram village is dominated by paddy cultivation covering the land area of 11 sq.km in both time periods. In the double crop combination, flowers, cereals, fruits, vegetables and cotton in 2008 and flowers, cereals, fruits, paddy and coconut are mixed widely in 2018 by the farmers in the study area.

It is to be noted that even though, varieties in flowers are dominantly cultivated as double crops, Rottana flowers and pitchy in Bangalapatti village, jasmine and pitchy in Kodainaickanpatti village where flowers are dominated covering the land area of 1.57 and 5.39 sq.km respectively, constitutes 1.43 per cent of the total land area of the taluk in 2008. But in 2018, along with the above said flower combinations, Charisanthiyam and Jasmine in Sivagnanapuram were also included and the total land area under flowers is 11.92 sq.km. The cereals and flowers combinations of crops cultivated in an area of 14.42 sq.km distributed in Chinnamanaickankottai and Kullalakundu villages are noted in both time periods. The double crop combination such as, flowers and fruits (Jasmine and Sapota) in Silukkuvarpatty village (9.23 sq.km), flowers and vegetables (Flag him and Olinder) combination in Koovanuthu (8.54 sq.km), paddy and vegetables (Paddy and Banana) combinations (24.02 sq.km) in Kunnuvarayan kottai and Mattaparai and Vegetables and cotton combinations (Cotton and Banana)is found in 3 villages namely Sithargal Natham, Sivagnanapuram and Pannaipatty cultivated in an area of 31.32 sq.km constitutes 6.45 per cent of the total land area of the taluk during the year 2008. But in 2018, the double crop combination such as, flowers and fruits (Jasmine and Sapota) in Silukkuvarpatty village (9.23 sq.km), flowers and fruits (Sapota and Olinder) combination in Koovanuthu (8.54 sq.km) are dominantly

found in the study area. The fruits and paddy group mainly banana and paddy are cultivated in Kunnuvarayan Kottai and Mattaparai village. The banana and coconut are cultivated in Sithargal Natham and Pannaipatty village of the study area.

Three and Four Crop Combination

The increase in the number of crops for cultivation indicates the diversification in crop combinations. The crop group under triple crops are, flowers, vegetables, fruits, paddy, cereals, cotton, oil crops and coconut are the combination widely distributed in the study area in the year 2008. But during the year 2018, the triple crop combinations are flowers, vegetables, fruits, paddy, cereals, cotton and coconut. In three crop combinations, most of the farmers cultivated flowers and vegetables as one of the mixed crops in most of the villages under triple crop in both the temporal years. The crop varieties such as, paddy, jasmine, bajra, cotton, coconut, millets, tomato, pitchy, Chrychantum, oleander, tupe rose, rose, mango, lemon, flag him and drumstick in 2008 and the crops such as paddy, jasmine, banana, coconut, lemon, tomato, millets, Chrychantum, pitchy, oleander, rose, mango, tulip, snake guard, pomegranate, flag him and drumstick are dominantly cultivated by the farmers in trip crop combinations in the study area by the year 2018. About 20 similar villages in both time periods have three crop combinations distributed in the total land area of 254 sq.km constitutes 52 per cent of total land area of the taluk but the combination of crops differs only in few villages during the study period. In the year 2008, in four crop combinations flowers, vegetables, cereals, cotton and mango are the dominant crops but in 2018, flowers, vegetables, cereals, fruits and coconut cultivated are the dominant crops by the farmers of the study area. The important crops cultivated in the four crop combinations are jasmine, oleander, drumstick, flag him, pitchy, Bajra, sorghum, mango, rose and coconut in both the time period meanwhile snake guard were added additionally in the year 2018. Only four villages in the study area have four crop combinations namely, Jambudurai kottai, Musuvanuthu, Nakkaluthu and Pallapatti. About 53.17 sq.km of the area under four crop combinations constitutes 11 per cent of the total land area of the taluk. Flowers are cultivated in four crop combinations in all the four villages of crop combinations in both time periods of study.

Five Crop Combination

Viralimayanpatti is the only village in the study area that has had five crop combinations in the past few years. The major crops group under five crop combinations are cotton, vegetables mainly tomato, paddy, cereals mainly sorghum

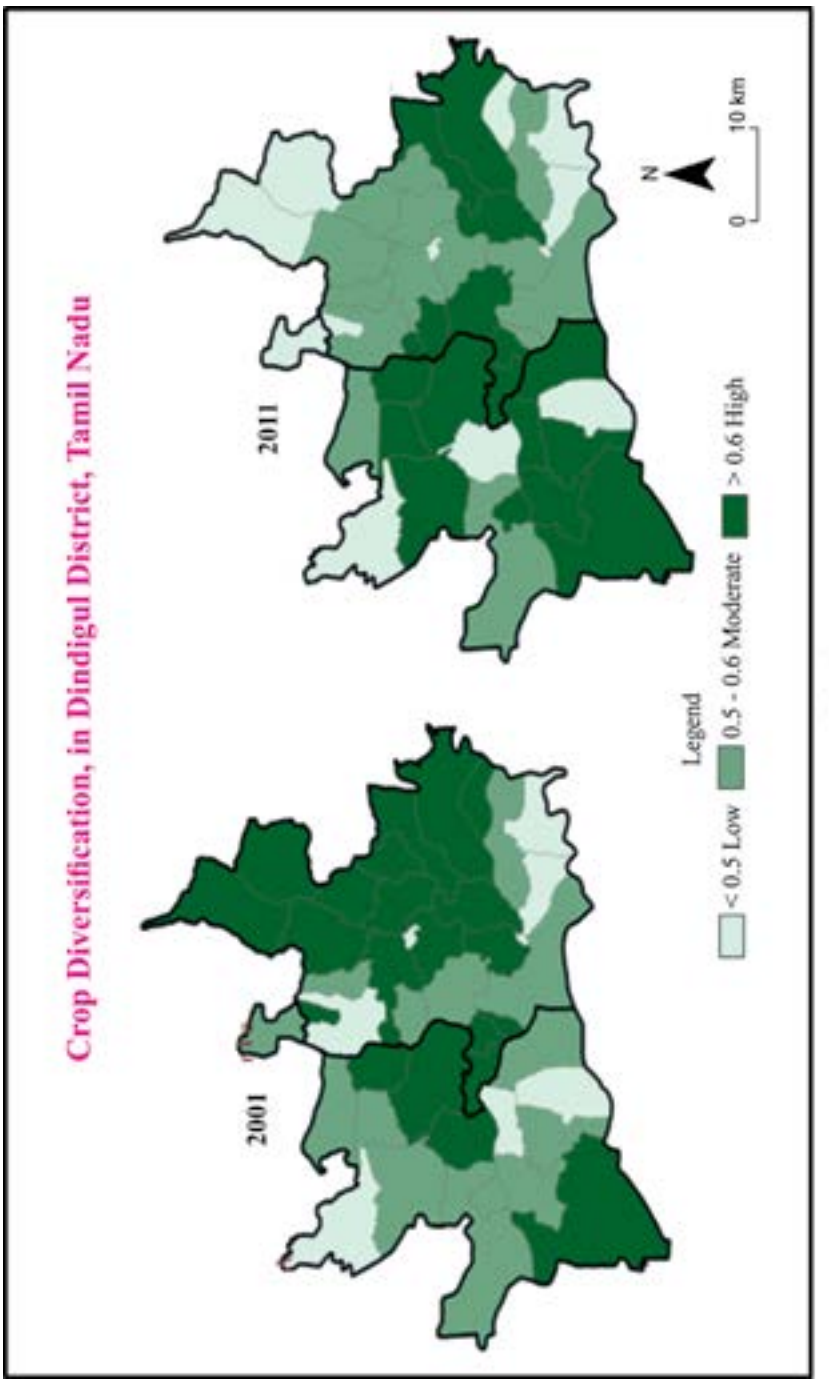

Crop Diversification, in Dindigul District, Tamil Nadu
2001
2011
N
0
10 km
Legend
< 0.5 Low
0.5 - 0.6 Moderate
> 0.6 High

Fig. 1

and fruits particularly banana. The total area under five crop combinations of 12.81sq. km constitutes 2.64 per cent of the total area of the taluk in both the time period. The application of Weaver's methods shows the realistic picture of crop combination. Three Crop Combination regions have found rice with a study area. Monoculture is in one village out of five villages in our study area. Two crop combinations are found in eleven villages. Three crop combinations are found in twenty villages in the study area .Four crop combinations are found in four villages in the study area. Five crop combinations are found in one village in the study area.

Crop Diversification

The whole study area is divided into three type of crop diversification regions, identified as (a) High crop diversification area, (b) Moderate crop diversification area and (c) Low crop diversification area (Fig. 1). The high Crop diversification is observed in 23 Villages of the study area. Majority of villages are in Nilakottai block they are Kolladipatty (0.71), Nilakottai (0.75) Kullalakundu (0.71), Pachamalayankottai (0.61), in southern side of Nilakottai block, Kottur (0.62), Ethilode (0.63), Pillaiyarnatham (0.65), Jambuduraikottai (0.65), Pallapatti (0.66), Bodiakoundenpatti (0.66), Silukkuvarpatty (0.66) in eastern part of the Nilakottai block, and the remaining five villages situated in south and south eastern side of Nilakottai block at Kulli Chettipatti (0.67), Koovanuthu(0.67), Malaiyakoundenpatti (0.68), Kompaipatti (0.68), Nariyuthu (0.69), Sivagnanapuram (0.69), Chinnamanaickankottai (0.70) and the Batlagundu block villages at eastern side of the study area in Rengappanaickanpatti (0.70), Mallanampatty (0.71), Kuruvankottai (0.64), Bangalapatti (0.66), Chandaiyur (0.60) ,Moderate Crop Diversification is found in 17 villages of both block, in that Nilakottai block only eleven villages identified in eastern side of Nilakottai block of Mattaparai (0.60), Vilampatti (0.42), Viralimayanpatti (0.42), Kanavaipatty (0.46), Nuthulapuram (0.47), Oruthattu (0.51), Sithargal natham (0.52),Veelinaickanpatti (0.53), Kodenginaickenpatti (0.53), Musuvanuthu (0.55), Viruveedu (0.58) in Nilakottai block south and south western side of cultivable land, remaining six villages were observed in Batlagundu block villages of Batlagundu (0.56), Viralipatti (0.57), Pannaipatty (0.58), in eastern side and Senkattanpatti (0.58), Nadakottai (0.59), Sevugampatty (0.59), in northern side of Batlagundu block, Ramarajapuram (0.09), Sekkapatti (0.32), Nakkaluthu (0.37) in southern side of Nilakottai block were observed low crop diversification region during the period. During the year 2017-18, the maximum crop diversification appears in Nadakottai (0.77) village of Batlagundu block, and the lowest crop diversification also identified in (Batlagundu block), where it is Senkattanpatti

(0.06) village. The region under high crop diversification is observed in 17 villages, Oruthattu (0.61), Kullalakundu (0.61), Sivagnanapuram (0.61), Veelinaickanpatti (0.61), Musuvanuthu (0.64), Ethilode (0.64), Bodiakoundenpatti (0.65), Pallapatti (0.66) Kompaipatti (0.69) and Bangalapatti (0.67) all these villages located at the south and south eastern part of the Nilakottai block. Pannaipatty (0.65), Batlagundu (0.66), Mallanampatty (0.70), Chandaiyur (0.71), Rengappanaickanpatti (0.72), Viruveedu (0.73) and Sekkapatti (0.74) villages are located in east and central part of the study area in Batlagundu block.

Moderate crop diversification is noted in 16 villages of Kolladipatty (0.43), Nakkaluthu (0.45), Chinnamanaickankottai (0.47), Silukkuvarpatty (0.52), Kottur (0.52), Nuthulapuram (0.52), Kullichettipatty (0.53), Nilakottai (0.53), Pillyarnatham (0.54), Mattaparai (0.54), Kodenginaickenpatti (0.56), Koovanuthu (0.56), Malaiyakoundenpatti (0.58), Sithargal Natham (0.59) and Nariyuthu (0.59) in all direction of the study area in Nilakottai block. Viralipatti (0.60) and Sevugampatty (0.60) are the two villages found in Batlagundu block that are noted as moderate crop diversification. The low crop diversification is observed four villages of Nilakottai blocks, it have identified in south and western part of Vilampatti (0.38), Ramarajapuram (0.38), Jambuduraikottai, Pachamalayankottai (0.28) and Senkattanpatti (0.06), Kunruvarankottai (0.08), Viralimayanpatti (0.17) and Kanavaipatty (0.34) in north and north eastern part of Batlagundu blocks (Fig No.3.19).

Conclusion

When comparing the temporal years 2018 and 2008, Spatial and temporal distribution crop indicates that increase in area under cultivation is noted These cereals, spices, sugar crops, oil seeds cultivation are higher in Nilakottai block than Bathlagundu block. Mean while decrease is also maximum in Batlagundu block compared to Nilakottai block, the decrease is noted in 22 villages mainly spread in the Nilakottai blocks than Batlagundu block the increase in flower cultivation is noticed in 23 villages spread spatially high in Nilakottai block compared to Batlagundu block. . Monoculture is in one village out of five villages in our study area. Two crop combinations are found in eleven villages. Three crop combinations are found in twenty villages in the study area. Four crop combinations are found in four villages in the study area. Five crop combinations are found in one village in the study area. The availability of irrigation facilities and the soil favoured more crop cultivation in this region. Crop diversification clearly denotes the low crop diversification area is decreased and high crop diversification is increased during

2017-18 especially in Nilakottai block in eastern side of the taluk than Bathalagundu block it clearly brought out that the cropping pattern, crop combination, crop diversification of the study area is highly influenced by the physical and socio-economic factors of the taluk.

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EXAMINING STATE'S ELECTORAL POLITICS THROUGH THE REGIONAL EYE- A CASE STUDY OF AHIRWAL REGION IN HARYANA

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Abstract

In Indian federal union, different states act as separate political arenas for both political parties and voters. For political parties these are the electoral battlegrounds to contest for gaining the seat of power and for the voters to make their choices felt in the elections either held for the parliament or state assemblies or local bodies. However, over the period of time, it is also being felt that state in itself is not a homogeneous unit for analyzing the electoral contests. States also constitute different regions, each come up with its own unique genesis and preference in favour of or against a political party. The bonds of liking or disliking for a particular party by majority of the voters of a region may remain stable or change with the passage of time. In the present research paper the above stated proposition is tested by taking a case study of Haryana wherein the electoral analysis was done at two levels, i.e. Haryana state and the Ahirwal region of Haryana. For analyzing the fact whether the Ahirwal region vote in favour/against a political party en masse and whether the voters in the region go as per the general trends in the state, the electoral analysis of two political parties in the last three assembly elections (2009, 2014, 2019) in Haryana vis-à-vis the Ahirwal region was done. The electoral performances of the selected parties were measured in terms of percent vote polled, and seats won in the selected elections.

Introduction

The Indian federal democratic structure permits electoral analysis to be carried out at various levels, viz., national, state and local. Although one can analyze the patterns of electoral politics independently on any of these levels or a combination of these levels, however, the fact remains is that the politics is being constructed as a consequence of innumerable events working in combination to each other from national to local level. To simplify the fact, the national politics (i.e. politics viewed at the national level) is not something which is being constructed at that level only;

rather it is an assemblage of politics constructed at various geographical levels. This argument, however, does not mean to underestimate the national level political happenings that play their own role in the making of national politics. In terms of electoral analysis in India, it was the analysis of electoral politics at the national level that was given pre-eminence for quite a long time, especially the decades that followed the independence. During the phase of the Congress System (i.e., the period when the Congress was at the centre of all levels of politics and the regional voices were subtle) even studies carried out at the state level were looked at from the national perspective (Yadav and Palshikar, 2003). This viewpoint had changed to some extent after the 1967 State Assembly elections, when in many states, non-Congress governments were formed. With this, the era of unchallenged supremacy of the Congress came to an end. This political change had led to advancement of the idea that state specific politics is different from the national politics. With this consideration, state specific election studies became important. Henceforth, various important state specific election studies were carried out and published (Weiner, 1968; Narain, 1976; Jenkins, 2004). In fact, as we scale down our analysis of understanding the Indian politics from the national level, we find construction of politics at varied scales. If we view politics at the level of state, each state emerges with its own distinct patterns of politics that is going on therein at a moment of time.

However, close analysis will further show that even state politics is not homogeneous in itself. Each state consists of various regions of unique political identities formed in the name of caste, language, religion etc. Recently we are witnessing this shift in electoral studies from national/state level to the study about construction and analysis of electoral politics at the level of region. This changeover came with the realization that states constitute different regions, each with its own unique genesis and preference about a political party. The way majority of the voters of a region vote in favour or against a political party may remain stable or change with the passage of time. The focus on study of electoral politics at the level of region is in tune with unique voices emerging from different social-cultural regions of the country, i.e. the emergence of identity politics. Historically, in some parts of the country these regional voices were so strong that had even led to the creation of separate states and many of such demands are still keeping alive. In fact, the "process by which subaltern groups have politicized has varied enormously from state to state" (Jenkins, 2004:2). In a large federal country like India, this construction of politics at the level of region takes place some way in-between the national/state politics on the one hand and locality politics on the other. It retains the characteristics of both higher and lower levels of politics without losing the regional identity.

This construction of politics at the level of region is unique in the sense that a region is constructed and re-constructed in social-political-economic terms in a time framework. It is a very slow and gradual process of developing a unique culture of politics. The regional identity may be dormant or active in political terms. It depends on the aspirations and participation of people living therein. How politics is being constructed and re-constructed at the unit of region is always going to be an imperative exercise for unraveling the complex nature of national and state level politics in India. However, despite having so much unique regional electoral politics in the country "there has been a dearth of literature that focuses on the region within states…" (Kumar, 2011:11). This is despite being the fact that cultural heterogeneity of the regions within states over the years has been sharpened as a result of unevenness of development and unequal access to political power (Sathyamurthy, 2000:33). The proposed study intends to fill this academic gap, especially by taking a case study from the state of Haryana. Despite being a small state in terms of geographical area, Haryana has its own socio-cultural regional framework wherein certain castes and religious groups are dominant and have their say in the electoral contests. One such socio-cultural region is the Ahirwal region of Haryana which was in news for having an important say in the formation of the BJP government in the state in 2019. There is hardly any study in terms of analyzing the electoral politics of the region. Yadav (2000) had discussed about the Ahirwal region in historical perspective. Similarly Yadav (2003) has briefly discussed about the Ahirwal region in his study on the social coalitions and power strategies made by different political parties to capture power in the state

Study Region

Despite Haryana being a small state in terms of geographical area, there are various specific regions where different religious/caste groups (Sikhs, Muslims, Jats, Ahirs etc.) dominate in terms of their numerical strength. One of such regions is the Ahirwal or the 'Land of the Ahirs'. Broadly it is a region which lies in both Haryana (southern parts) and neighbouring state of Rajasthan (north-eastern parts). It was described at length by Joseph E. Schwartzberg in his study of Folk Regions of Northwestern India as a 'folk region' (Schwartzberg, 1978, 1985). The history and culture of this region is mentioned in an exclusive study by K.C. Yadav (Yadav, 2000). It was also mentioned by Lucia Michelutti in her study as a 'cultural-geographical region' (Michelutti, 2008: 42). Broadly the region includes the districts of Alwar and Bharatpur in Rajasthan, and districts of Mahendragarh, Rewari and Gurgaon in the state of Haryana. In the present study,

Ahirwal region of Haryana only is undertaken for the study. It was on two accounts. One, assembly elections in the two states were held at different dates, and two, the issues that had emerged and affected the voters' preferences were different. Ahirs are commonly known with different names such as Hir, Yadav, Rao ji, Rao Sahib. In Haryana their area of concentration is known as Ahirwal region. Although Ahirs are one of the backward castes in the state but "they have the self-perception of being a Kshatirya upper caste" (Yadav, 2003:147). There are "three main categories among the Ahirs of Haryana and the neighbouring states" (Sangwan, 1994:14). These are Afaria Ahirs, Gwala Ahirs, and the peasants. The Afaria Ahirs belong to the category of big landlords and used to live in small fort like structures. They consider themselves as Rao Sahib and their fort like structures in Haryana are found in villages like "Kila Pathani, Ahi Bharwi, Tirpur and Jaitpur near Rewari…" (Sangwan, 1994:13). Gwala Ahirs are those whose main occupation is that of rearing of animals and related activities. The third category belongs to peasants who are in large number. Over the period of time, although this class division among the Ahirs has narrowed down but not diminished. In Haryana, the Ahirwal region has 11 assembly constituencies. Such a spatial concentration of a particular caste in a state assists the people in creating and retaining a kind of separate identity.

Till recently, the nature of electoral contests in the region largely remained between the Indian National Congress (the Congress) and the Indian National Lok Dal (INLD). However, the dramatic success of the Bharatiya Janata Party (BJP) in the last two assembly elections has changed the political scenario of the state and that of the region as well. Whereas, the BJP had failed to win any of the eleven assembly constituencies in the region in 2009 assembly elections, it won all the eleven assembly seats in 2014 elections. In 2019 assembly elections, when there was decline in the total number of seats won by the BJP in the state (47 in 2014 to 40 in 2019), it managed to retain eight seats (out of eleven) in the region. This was despite being the fact that the electoral scenario for the party was different in surrounding socio-cultural regions of the state in 2019 assembly elections. The party could win one (i.e. Hathin) of the four Meo-Muslims dominated seats of Nuh, Ferozepur Jhirka, Punhana, and Hathin. Similarly in the 14 assembly constituencies of the neighbouring districts of Bhiwani, Rohtak and Jhajjar (a part of the Jatland) the party seats tally declined from six in 2014 to three in 2019. The eight assembly seats that the party had won from the Ahirwal region were one of the main determining factors that the BJP was able to form the government in the state in 2019.

Objectives

(1) The electoral performance of selected political parties in Haryana state in general and Ahirwal region in particular; and,
(2) The impact of switching over of Rao Inderjit Singh on February 13, 2014 from the Congress to the BJP in Ahirwal region in general and Kosli assembly segment of the Rohtak Lok Sabha in particular.

Database and Methodology

For analyzing the electoral dynamics in Haryana state in general and Ahirwal region in particular, assembly constituency wise data for the last three assembly elections of 2009, 2014, and 2019 were taken. These elections were held as per the Delimitation Order of Constituencies, 2008. In the study, special focus is on the eleven assembly constituencies of the Ahirwal region: Ateli (68), Mahendragarh (69), Narnaul (70), Nangal Chaudhary (71) of district Mahendragarh; Bawal (SC) (72), Kosli (73), Rewari (74) of district Rewari; Pataudi (SC) (75), Badshahpur (76), Gurgaon (77) and Sohna (78) of Gurgaon district (Fig. 1). The assembly constituencies of Ateli, Mahendragarh, Narnaul and Nangal Chaudhary are part of the Lok Sabha seat of Bhiwani-Mahendragarh; and Bawal (SC), Rewari, Pataudi (SC), Badshahpur, Gurgaon and Sohna are part of Gurgaon Lok Sabh seat. Kosli is one of the assembly segments of Rohtak Lok Sabha seat .Two national parties, viz. the Congress and the BJP were chosen for the analysis. The justification behind selecting these two political parties was twofold. One, these were the only political parties which had contested all the ninety assembly seats in the state during the three elections taken for the analysis. Two, the contest for gaining the seat of power basically remained between these two political parties. The Congress formed the government after 2009 assembly elections, whereas, the BJP formed the government after the 2014 assembly elections and also after the 2019 assembly elections. The electoral performances of both the parties were measured in terms of percent vote polled, average vote, seats won and co-efficient of variation (CV). Assembly constituency wise data were taken from the reports published by the Election Commission of India.

Result and Discussion

Historical background of politics in Ahirwal region

To begin with, the politics in the region was divided among the followers of three political parties, viz. the Congress, the Unionist Party, and the Punjab Hindu

Mahasabha. The real contest, however, was between the latter two. In electoral terms, the Congress was comparatively stronger in the urban areas. The Unionist Party, on the other hand, was comparatively more popular in rural areas. It was led by Sir Chhotu Ram and Sir Fazl-i-Husain (for details see, Wallace, 1980; Chowdhry, 1991). Although Chhotu Ram "began his political career as a congressman but soon discovered that this organization had no agrarian programme worth the name and secondly it was dominated by the well-to-do urbanites who flourished on the exploitation of peasantry" (Choudhry, 1985:120). For the welfare of peasants he, along with Fazl-i-Husain had formed the Unionist Party and was able to enact various agrarian laws in their favour. This had, however, further deepened the rift between the urban and rural elites. This social rift started emerging during the Non-Cooperation Movement (1923). In fact, the "rural agriculturalist elite was not prepared to cooperate with the urban elite on the issue of non-payment of land revenue as they considered it very harmful to the interests of agriculturalists" (Singh, 1977: 65). At that time, the main contest for gaining the seat of power in the region was between the Punjab Hindu Mahasabha and the Unionist Party.

The prominent political leaders were Rao Balbir Singh (from Punjab Hindu Mahasabha), and Rao Pohap Singh and Rao Mohar Singh (from the Unionist Party). Presently, the political legacies of Rao Balbir Singh and Rao Mohar Singh are popularly known as Rampura House and Budhpur House. In addition to these two Houses, the Captain House has its own importance in the region's politics. The nomenclatures of these houses are based on either the family name or on the basis of ancestral villages of these political families. Members of these houses have remained at the helm of affairs in various governments formed by different political parties in the state as well as in the central government. However, there remains a sort of political rivalry between these houses for gaining more and more political space of the region. It is also important here to mention that of the persons representing these houses, many have changed their alignments with different political parties. The death of Sir Chhotu Ram on January 9, 1945 was disastrous for the Unionist Party. The number of seats won by the party in the British Punjab came down from 98 seats (out of total 175) in 1937 to 11 seats in 1946. The Congress on the other hand, improved its seats tally from 18 seats to 51 seats during the same time period. The Ahirwal region also went for this change. The Ahirs also shifted their alliance to the Congress as it was expected that once independence is achieved, it would be the Congress led government in India. An overview of the three Houses around which politics in the region revolves is as under:

Rampura House

The politics in the region is influenced by the family members of Rao Tula Ram, the hero of the revolt of 1857. Rao Balbir Singh, a descendant of Rao Tula Ram, was founder of Rampura House. He was the Head of the Election Board of the Hindu Mahasabha for the Punjab Legislative Assembly (see, Yadav, 2002:185). He was "the first Ahir to contest election to the provincial legislative council in 1916 against Ch. Lal Chand. The Ahirs solidly backed Balbir Singh…but being in a minority they failed in getting Balbir Singh elected" (Yadav, 1980:9). However, things changed after the introduction of the Montague Chelmsford reforms of 1919 under which the right to franchise was liberalized and constituencies were delimited separately as urban and rural. Now the chances of winning an Ahir candidate from a rural constituency got enhanced as Ahirs were mainly rural. And when the first election after these reforms was held in 1920, Rao Balbir Singh was elected to the Council from Gurgaon (Non-Mohammedan) Rural seat. He was colleague of Rao Mohar Singh (of Budhpur House) in the Punjab Legislative Council. Rao Balbir Singh remained member of the Punjab Legislative Council and Punjab Legislative Assembly on many occasions in the United Punjab from 1921 to 1941. In the mid, he was defeated by Rao Pohap Singh (a young lawyer and a big landlord) of the Unionist Party in 1923.

He, however, came back in 1926 and 1930 elections on the Hindu Mahasabha Ticket. He was elected again in 1937 from the same seat. The Unionist Party led by Sir Chhotu Ram could recover the lost ground in the region only after the death of Balbir Singh in 1941. Rao Balbir Singh was also instrumental in establishing Ahir Yadav Kshtirya Mahasabha in Rewari as early as 1910. After his death, it was in 1945 that Rani Nihal Kaur (wife of Rao Balbir Singh) had adopted Rao Birender Singh as Head of the Rampura House. Rao Birender Singh, a graduate from St. Stephen College, Delhi, was enrolled in the Territorial Army during the World War II. In 1947 he resigned from the Army as a Captain and returned back to Rampura. He established various educational institutions: Ahir College, Rewari; R.B.S. School, Rewari; Rao Tularam School, Rewari; Rao Tularam Technical College, Delhi; R.B.S. College of Education, Rampura. He became a member of the legislative council in 1954 and was a minister in the Punjab government. After the formation of Haryana as a separate state in 1966, he became the first speaker of the Haryana State Assembly. Owing to his differences with first Chief Minister of Haryana (Bhagwat Dayal Sharma) he left the Congress which ultimately led to fall of the government. He was instrumental in forming Samyukta Vidhayak Dal (SVD)

and became second Chief Minister of the state (March 24 to Nov. 2, 1967). After dissolving SVD, he formed his own political party as Vishal Haryana Party (VHP, first regional political party of Haryana) in 1967 (Singh, 1971). The party was, however, merged with the Congress (I) on September 23, 1978. "The Ahirs have mostly been voting for the Congress (I) after the merger…" (Singh, 2003:353). Thereafter he played his role in the central politics as a Member of Parliament on a few occasions. In 1989 he left the Congress and joined Janata Dal. He remained president of All India Yadav Mahasabha many a times. Another important personality of the House was great granddaughter of Rao Tula Ram, the then ruler of Rewari, and daughter of Rao Balbir Singh, Rajkumari Sumitra Dev (Bai Ji as popularly known). A Padma Shri awardee in 1968, she is still known for her untiring efforts for social service and especially for upliftment of women and children, and animal protection. She was President, District Congress Committee, and Vice President of Punjab Congress Committee (for details see, Government of Punjab, 1964:104). She was elected unopposed to the second Punjab Vidhan Sabha on the Congress ticket in 1957 from Rewari assembly constituency. In 1962 and 1967 she was re-elected from Rewari assembly seat as a Congress party candidate by huge winning margin of 33.81 and 16.27 percent vote respectively. In 1968, she contested the Rewari seat on VHP seat and won by a margin of 10.76 percent vote. For devoting all her time for the social cause, she remained unmarried. After the death of Rao Birender Singh, his political legacy was continued by his son, Rao Inderjit Singh, a product of Lawrence School, Sanawar and Delhi University. Like his father he has played his role both in the state and central politics as minister of different portfolios.

On September 23, 2013 he gave his decision of quitting the Congress and floated a non-political outfit Haryana Insaf Manch. His daughter Arti Singh Rao was also associated with this non-political outfit. The formation of this Manch was an attempt to raise the issues related to discrimination in development in the state. It was alleged that Bhupinder Singh Hooda led Congress government had favoured the districts of Rohtak, Jhajjar and Sonepat at the cost of other districts and there was discrimination in canal water allocation. He also stated that farmer's land was acquired forcefully by the state government and people were avoided in employment opportunities and development projects. On 13 February, 2014 in the presence of BJP National President, Sh. Rajnath Singh, he joined the BJP on the Martyrdom Day of Rao Tularam. He became a Member of Parliament on BJP ticket from Gurgaon parliamentary constituency.

Rao Inderjit Singh's two brothers (Rao Yadavendra and Rao Ajit Singh) and his daughter Arti Rao are also actively playing their role in the politics of the region. Although, Rampura House is now a divided house, as many of the extended members of the family are in different political parties, but Rao Inderjit Singh is the most important face of the house. It would be interesting to analyse the impact on voters of Rao Inderjit Singh quitting the Congress and joining the BJP. This is especially in regard to his public statement on April 3, 2014 that 'I know that people love me and not the flag I carry'. Interestingly Rao Inderjit Sigh joined the party he kept on criticizing for more than three decades. The impact of Rao Indejit Singh joining the BJP would be of special interest in the case of the electoral performance in the Kosli assembly constituency. Here it is important to mention that the Kosli assembly constituency is a part of the Ahirwal region of Haryana but if falls in the Rohtak parliamentary seat. Rao Inderjit Singh remained member of legislative assembly from Jatusana seat four times (1977, 1982, 1991, 2000).

Budhpur House

The Budhpur House was founded by Rao Mohar Singh (born in July 1903 in Budhpur village). His father, Rao Ramji Lal was the first person from Gurgaon district who cleared the Punjab Civil Services and became administrator of Nalagarh state during the British times. Rao Mohar Singh did his graduation from St. Stephen College, Delhi, and education of law from Lahore Law College in 1930. It was during his practicing day in Gurgaon that he came in close contact of Rao Pohap Singh and joined the Unionist Party (popularly known as Zamindara Party). However, it was only after the death of Rao Balbir Singh in 1941 that the Unionist Party could break the dominance of Punjab Hindu Mahasabha. Its candidate, Rao Mohar Singh won the North West Gurgaon General Rural seat in the by-election held in 1941 (due to death of Rao Balbir Singh). He won again in 1946 by defeating Rao Gajraj Singh (a member of Rao Balbir Singh's family). His son Rao Mahabir Singh was elected member of legislative assembly on three times and was minister in the state. He also contributed in the field of education by establishing Kamla Nehru College, Jatauli, and Rao Mohar Singh College of Education, Behrampur. The grandson of Rao Mohar Singh, Rao Narbir Singh is also in the field of politics and remained minister in the state government. Narbir Singh had defeated Rao Inderjit Singh from Jatusana assembly constituency in his debut election of 1987. In his turn, however, Inderjit Singh defeated Narbir Singh in 2009 Lok Sabha election from Gurgaon.

Captain House

To begin with, Rao Abhay Singh who became MLA three times was head of this house. However, this house is known after Captain Ajay Yadav, son of Rao Abhay Singh. Before joining politics, Ajay Yadav served the Indian Army as a Captain. He is playing a very important role in the politics of the region. It needs to mention here that he was elected on the Rewari assembly constituency consecutively for six times and that shows his popularity. Now his son, Chiranjeev Rao who is MLA from Rewari is leading his legacy. Among the three houses, the Rampura House is certainly the most important in terms of influencing the choices of voters in the region and there are certain reasons for that: one, this house belongs to the legacy of Rao Tula Ram and that legacy still works in the region. Two, this house had played an important role in the process of recruitment of local youth during the World War-I. In fact, this region belonged to arid/semi-arid climatic conditions with limited agricultural opportunities at least to begin with. In that scenario, the World War-I brought about a big change in improving the socio-economic conditions of the people here. The enrolment of local youth in the armed forces not only provided employment opportunities but also acted as a gateway to occupational mobility and modern world exposure. This had also awakened them as social and political being. At that time "Rao Balbir Singh, the second descendant of Rao Tula Ram acted as a recruiting agent of the British Government, and since then many Ahirs have joined the Army in increasing numbers" (Rao, 1964:1440). This had created a linkage of local people with this House. Even the big landlords were in favour of the British as they took the event as a means of future rewards. Three, many members of this house have remained on top positions both in the state and central governments. Four, the establishment of various educational and other social welfare institutions by the representative of this house have had worked at the grass root level in strengthening the people's bond with the house. Five, constant rise of voice by the representatives of this house at various platforms about the neglect of this area in development process has further built up their image as that of region's representative.

Electoral Performances of Congress and BJP

Assembly Election in 2009

In 2009 Lok Sabha elections that were held prior to assembly elections in the state, the Congress was the leading party in the Ahirwal region.

In terms of percent vote share, it was first ranking party in six of the total eleven assembly segments. It is interesting to note that of these six assembly segments, five were only from the Gurgaon lok sabha seat from where Rao Inderjit Singh of the Congress was the candidate (Fig.-1). The other lone assembly segment from where the Congress the leading party was the Kosli assembly segment of the Rohtak lok sabha seat. In the remaining four assembly segments which are part of Bhiwani-Mahendragarh lok sabha seat, in three assembly segments (Ateli, Mahendragarh, and Narnaul) the Haryana Janhit Congress Bhajan Lal (HJCBL) was the leading party, whereas, in Nangal Chaudhary, the INLD was the leading party. The BJP remained underperformer in the lok sabha elections. It did not contest the lok sabha seats of Bhiwani and Mahendragarh, and that of Rohtak. It had contested the Gurgaon lok sabha seat and of its six assembly segments falling in the region, it was second ranking party in three assembly segments (Pataudi—SC, Badshahpur, and Gurgaon) and in the remains three segments (Bawal—SC, Rewari, and Sohana) it was third ranking party. In 2009 assembly elections, the Congress had polled 35.08 percent vote in Haryana. Its average vote was 35.41 percent and CV was 33.32 percent. The party won 40 of the total 90 assembly seats, i.e. 44.44 percent. In its comparison, the party had polled 30.12 percent vote in the Ahirwal region. Its average vote in the region was 29.28 percent and CV was 26.50 percent (Table-1). It shows that although the average percent vote for the party was lower in the region but its votes were more uniformly distributed in the region. (Table-1)

The party vote in the region ranged from 17.23 percent in Narnaul assembly constituency to 40.35 percent in Rewari assembly constituency. In total the party had won six assembly seats (Ateli, Mahendragarh, Rewari, Badshahpur, Sohna and Kosli) (Fig. 2a). It shows that the party was able to confirm its dominance of lok sabha elections in the assembly elections in the constituencies of Rewari, Badshahpur and Kosli. It had further improved its performance of lok sabha elections in assembly elections and won the seats of Ateli, Mahendragarh, and Sohana. The party was not out of competition in rest of the five assembly seats of the region where it was defeated. It was runner-up in four constituencies (Nangal Chaudhary, Bawal—SC, Pataudi and Gurgaon) and third ranking party in Narnaul. In terms of percent seats won, the electoral performance of the Congress was better in the Ahirwal region (i.e. 54.54 percent) than the state (44.44 percent). In this election, three seats (Nangal Chaudhary, Bawal—SC, and Pataudi—SC) were won by the INLD, and one seat each by the HJCBL (Narnaul), an independent candidate (Gurgaon).

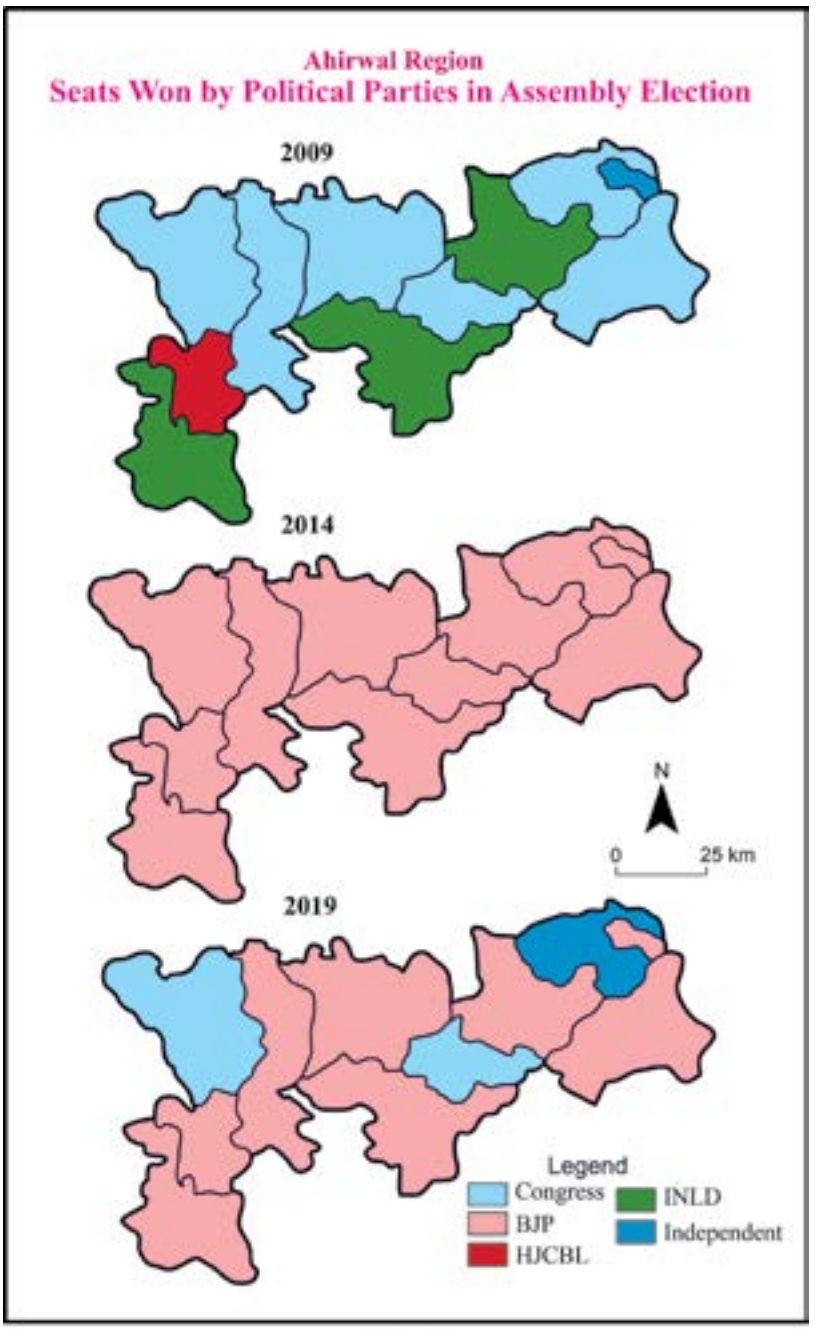

Ahirwal Region
Seats Won by Political Parties in Assembly Election
2009
2014
2019
N
0
25 km
Legend
Congress
INLD
BJP
Independent
HJCBL

Fig. 1

Table-1: Assembly Election: Electoral Performance of BJP and Congress in Haryana and Ahirwal Region

Political party	Electoral Statistics	2009		2014		2019	
		Haryana	Ahirwal	Haryana	Ahirwal	Haryana	Ahirwal
BJP	Seats Contested	90	11	90	11	90	11
	Seats Won	04	00	47	11	40	08
	Per cent Vote polled	9.04	12.80	33.20	46.75	36.49	41.37
	Mean vote (%)	9.44	12.50	32.92	46.25	36.52	41.79
	SD (%)	11.00	9.20	14.20	9.60	11.00	8.67
	CV (%)	116.52	73.60	43.13	20.76	30.12	20.75
INC	Seats Contested	90	11	90	11	90	11
	Seats Won	40	06	15	00	31	02
	Per cent Vote polled	35.08	30.12	20.58	11.81	28.08	16.41
	Mean vote (%)	35.41	29.28	21.07	12.08	28.51	16.97
	SD (%)	11.80	7.76	12.10	8.72	15.40	10.19
	CV (%)	33.32	26.50	57.43	72.18	54.02	60.05

Source: Election statistics, Haryana

The electoral performance of the BJP In this assembly election was very dismal. It had polled only 9.04 percent vote and won only 4 seats (4.44 percent) in the state. Its average vote was 9.44 percent and CV was 116.52 percent (Table-1). It shows large scale variations in the party's vote across the state. In comparison to the overall picture in the state, the vote share of the party vote in the region was marginally better. It had polled 12.80 percent vote in the region. Its vote share in the region ranged from 2.9 percent in Kosli assembly constituency to 21.53 percent in Ateli assembly constituency. The average vote for the party in the region was 12.50 percent and CV was 73.60 percent. The party, however, failed to win any assembly seat in the region. In terms of percent vote received, it was second ranking party in two assembly constituencies (Ateli, Mahendragarh), third ranking party in three

assembly constituencies (Bawal—SC, Rewari and Gurgaon), fourth ranking party in four assembly constituencies (Narnaul, Pataudi—SC, Badshahpur, and Kosli), fifth ranking party in one constituency (Nangal Chaudhary), and eight ranking party in one constituency (Sohna).

Assembly Election in 2014

Prior to the Lok sabha elections that were held in 2014, a political upheaval took place in the state with its serious implications in the state politics in general and that of Ahirwal in particular. Rao Inderjit Singh, one of the most powerful leaders of the Ahirwal, quit the Congress on September 23, 2013 and joined the BJP. He alleged the Congress for discriminating the region in all spheres of development. Keeping in view his political family background and his long standing in the politics of the region, there were all possibilities that his decision would make serious implications for the Congress. He has remained Member of Parliament from Mahendragarh lok sabha seat (1998, 2004), and Gurgaon lok sabha seat (2009), and Member of Legislative Assembly from Jatusana (now largely part of Kosli) in 1977, 1982, 1991, and 2000. Besides, he has also remained as Cabinet Minister, and Minister of State (various portfolios). In addition to the above, the political legacy of the Rampura House he is carrying clearly indicates that his decision could influence the voters across the length and breadth of the region. The other fact that might have influenced the voters of the region in favour of the BJP was that in 2013 the prime ministerial nominee of the BJP, Narendra Modi chosen the Ahir belt to start his national poll campaign. He addressed a rally of ex-servicemen. The political show and the place were rightly chosen as the region is dominated by villages having large number of persons in defense services. Amit Shah followed Narendra Modi when he held his first rally in Mahendragarh on August 14, 2013. The elections results of the lok sabha elections in different assembly segments of the region showed a complete transformation in the electoral fortunes of different political parties.

The BJP had emerged as the first ranking party in all the eleven assembly segments of the three lok sabha seats. The Congress was either pushed to either second place (Nangal Chaudhary, Rewari, Badhahpur and Kosli), or third place (Ateli, Mahendragarh, Narnaul, Pataudi—SC, and Gurgaon) or fourth place (Bawal—SC, and Sohana). In the 2014 assembly elections, the electoral scene in the region had changed completely for both the Congress and the BJP. In fact, the assembly election results broadly followed the patterns of lok sabha election results. From no seat in the assembly elections from Ahirwal in 2009 assembly election, the BJP won all the eleven assembly seats in 2014 assembly elections. As mentioned above,

the BJP was the first ranking party in all the assembly segments of the region. It clearly indicates that the BJP was able to transfer its electoral success of lok sabha elections completely to assembly elections in the region. In this assembly election, in the Ahirwal region, the percent vote share for the Congress had experienced a negative swing of 18.31 percent in its vote share (from 30.12 percent in 2009 to 11.81 percent in 2014). The BJP, on the other hand, had gained a positive swing of 33.95 percent (from 12.80 percent in 2009 to 46.75 percent in 2014) in the region (Table-1). It was basically as a consequence of this change in the vote percentage received that the Congress failed to win any seat, whereas, the BJP won all the eleven assembly seats. There was negative vote swing for the Congress in all the assembly constituencies of the region. It ranged from 2.55 percent in the case of Mahendragarh assembly constituency to 29.54 percent in the case of Badshahpur assembly constituency. Barring Mahendragarh and Narnaul wherein the party had recorded a negative swing of less than three percent, in all the remaining nine assembly constituencies, the negative vote swing for the party was huge. In this assembly election, the percent vote polled by the party was much higher at the state level (i.e. 20.58 percent) than at the level of region (i.e. Ahirwal) (i.e. 11.81 percent). The CV in the party vote was much higher at the level of region (72.18 percent) than at the state level (57.43 percent). It shows much heterogeneity in the party vote at the level of region. On the other hand, it was the otherwise picture for the BJP. The party's percent vote share at the state level was 33.20 percent, whereas, it was 46.75 percent in the case of Ahirwal. The CV for the party vote was lower at the level of region (20.76 percent) than at the state level (43.13 percent) (Table-1). It indicates much homogeneity in the party vote in Ahirwal region.

Assembly Election in 2019

In the 2019 lok sabha elections that preceded the assembly election, the BJP again emerged as the first ranking party in all the assembly segments of the Ahirwal region. The Congress, on the other hand, had improved its electoral performance than the previous lok sabha elections. It had emerged as the second ranking party in all the assembly segments. Despite emerging as the first ranking party in all the assembly segments of the region, the BJP, however, was not able to transfer its huge electoral success completely in the subsequent assembly election. In 2019 assembly elections, the party won eight of the eleven seats in the region, i.e. Ateli, Narnaul, Nangal Chaudhary, Bawal—SC, Pataudi—SC, Gurgaon, Sohana, and Kosli. The party, however, was not out of battle in the three seats it was defeated (Mahendragarh, Rewari and Badshahpur) and was runner-up in all the three.

Two seats (Mahendragarh and Rewari) were won by the Congress and on one seat (Badshahpur), an independent candidate was elected (Fig. 2c). Whereas, at the state level, the BJP had recorded a positive swing of 3.29 percent (from 33.20 percent in 2014 to 36.49 percent in 2019), there was a negative swing of 5.38 percent (from 46.75 percent in 2014 to 41.37 percent in 2019) for the party in the region in 2019 assembly elections (Table-1). In the case of the Congress, on the other hand, there was a positive swing at both state level and that of the region, i.e. Ahirwal. At the state level, its vote rose from 20.58 percent in 2014 to 28.08 percent in 2019—a positive swing of 7.5 percent) and in the case of Ahirwal, it rose from 11.81 percent in 2014 to 16.41 percent in 2019—a positive swing of 4.6 percent). The CV in the case of the BJP, however, was much lower than the Congress at both state and at the level of region.

Impact of switching over of an important political leader and its impact on the electoral performances of the Congress and the BJP

The impact of switching over of an important political leader, Rao Inderjit Singh, from the Congress to the BJP and its impact on the preferences in favour of or against a political party by majority of the voters of an area/region can be judged on two accounts: one, the electoral performances of the two selected parties in the six assembly segments of Gurgaon Lok Sabha seat (Bawal, Rewari, Pataudi, Badshahpur, Gurgaon and Sohana) from where Rao Inderjit Singh contested the seat on the Congress ticket in 2009 lok sabha election, and on the BJP ticket in 2014 and 2019 lok sabha elections; and two, the Kosli assembly segment, one of the assembly segments of Rohtak Lok Sabha seat, from where Deepender Singh of the Congress was the contestant. In 2009 lok sabha elections, the Congress was the first ranking party in five assembly segments of the Gurgaon Lok Sabha seat when Rao Inderjit Singh had contested the seat from the Congress party, however, when in 2014 and 2019 Lok Sabha elections, Rao Inderjit Singh contested the same seat on the BJP ticket, in all the six assembly segments falling in the region, the BJP became the first ranking party.

The Kosli assembly segment is a part of the Rohtak Lok Sabha seat, however, it is a part of the Ahirwal region and majority of the voters are Ahirs. In the last three Lok Sabha elections, Deepender Singh was the candidate from Rohtak Lok Sabha seat on the Congress ticket. In 2009 Lok Sabha elections, Deepender Singh won the Lok Sabha seat by a huge margin of 4,45,736 votes. He had polled 53.30 percent vote from the Kosli assembly segment. During the subsequent assembly election, the Kosli seat was won by the Congress.

However, things took a dramatic shift during the last two Lok Sabha elections. In the 2014 Lok Sabha elections, although Deepender Singh from the Congress won the seat but the margin of victory was reduced from 4,45,736 votes in 2009 lok sabha election to 1,70,627 votes in 2014 lok sabha election. More importantly, in Kosli segment his percent vote share was reduced from 53.30 percent in 2009 Lok Sabha election to 27.32 percent in 2014 Lok Sabha election. In the assembly election of 2014 that followed the Lok Sabha election, the BJP won all the seats of the Ahirwal region (including that of Kosli) and in terms of percent vote polled, the Congress was shifted to third place with 12.14 percent vote. In 2019 Lok Sabha elections, Deepender Singh of the Congress was defeated by the BJP candidate, Arvind Kumar Sharma by a margin of 7,503 votes. At aggregate level in eight assembly segments, Deepender Singh was leading with a margin of 72,344 votes (excluding postal), however, the difference of 74,980 votes alone in the Kosli assembly segment led to his defeat. The analysis at booth level data for Deepender Singh in Kosli assembly segment alone explains the story. Of the 199 booth in Kosli, in 2009 Lok Sabha elections, there were 89.53 percent booths where the Congress percent share was 40 percent and above. However, the number of such booths was reduced to 18.50 percent in 2014 Lok Sabha elections, and 17.65 percent in 2019 Lok Sabha elections. This is all about the fact that how in adverse conditions only one assembly segment can change the fortunes of a political party in a Lok Sabha seat.

Conclusion

The study concludes with the fact that electoral politics in a federal country like India is constructed at different geographical scales. Even the states constitute different regions, formed with time, on the basis of their unique socio-economic characteristics. This constructs a different kind of electoral politics at the level of region. In the study, this proposition was tested by analyzing the electoral performances of the Congress and the BJP during the last three assembly elections in Haryana (i.e. state level) in general and Ahirwal (i.e. regional level) in particular. The study finds the fact that the Ahirwal region not only retains a different kind of electoral-political character but also plays its own role in the formation of state electoral politics. The study also concludes the fact that the electoral preferences of majority of voters changes if an influential leader of the region changes his alignment from one political party to another. The impact of Rao Inderjit Singh switching over from the Congress to the BJP was certainly one of the crucial factors that had improved the electoral performance of the BJP in Haryana in general and

Ahirwal in particular. It would be an academically enriching exercise if a field-based study is conducted to further analyse the impact of Rao Inderjit Singh's on the voters' choices in the Ahirwal region.

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GEOSPATIAL ANALYSIS OF HOUSING AMENITIES IN INDIA

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Abstract

A housing unit refers to a physical structure in which people can live (e.g., a house, apartment, condo, mobile home, etc.), whereas a household refers to a group of people who occupy a housing unit as their residence. The National Family Health Survey (NFHS) sample describes key housing characteristics of the household population. Information on household characteristics and housing amenities provides context for understanding socio-economic status of the population. The research paper aims at examine some of the housing characteristics in India and its states based on secondary data collected from NFHS-3 and NFHS -5. The results shows that the housing characteristics such as electricity, improved source of drinking, toilet/latrine facility and using fuel for cooking had significantly augmented in India and its states over a period of 15 years and the housing characteristics are found considerable variations in India and its states.

Introduction

Every family has basic, physiological, and additional needs. Food, clothing and shelter are basic necessities. Of his three basic needs of a human being, protection is one of the basic needs of human existence. It protects us from the vagaries of nature and threats, natural or otherwise. Housing with better characteristics not only provides socio- economic status/condition in society, but also a sense of security and well-being, and high-quality housing provides safeguard. Housing with better amenities are important to mankind because, it provides residents with a safe place and makes it easier to achieve life goals. For centuries, people have been creating homes for themselves, which is a basic need for everyone. Access to basic amenities such as adequate housing, electricity, clean drinking water and sanitation/toilet, and clean cooking fuel is not only an important indicator of a household's socio-economic status, but also an important indicator of the health condition of household members. Improving water supply and sanitation, as well as better management of water resources, can boost economic growth and make a significant contribution to poverty reduction in countries.

Clean water is essential for healthy life among the people. From drinking water to disinfection to modern technology such as gowns, it's so important. Humans and animals require water every day for survival and well-being. Without safe water for just three days, we would all suffer greatly. According to the World Health Organization, more than 2 billion people lack access to safe drinking water and more than 8,00,000 people die from water-related diseases each year (Comer et al, 2018).The National Family Health Survey (NFHS) provides information on a variety of household characteristics that represents living conditions. This research paper describes the housing characteristics of households, including access to electricity, improved source of drinking water, sanitation/toilet /latrine facilities, and fuel used for cooking. Information on household characteristics is based on questions that household survey respondents are required to answer when surveyed by enumerators. Housing provides physical safety and protection from the elements and plays a central role in determining a person's physical and social risk environment (Weir BW et al., 2007). Research results by Soebiyan. V and Bsakina (2021) showed that the main factors influencing household electricity consumption are floor area, number of family members, household income, and number of air conditioners. Access to water is one of the main goals of the United Nations Millennium Development Goals (UN-MDGs) and one of the main goals of the Sustainable Development Goals (SDGs). Fundamentally, everyone needs access to sufficient amounts of clean water for drinking, cooking, personal hygiene and hygiene without putting their health or dignity at risk. Therefore, access to safe and reliable (clean and fresh) water is a fundamental human right (Samra SCJ and Fawzi SCM, 2011). According to the study by Swachh Survekshan Grameen 2022, 95.4 percent of surveyed households have access to a toilet, and 95.4 percent of households with a toilet use it regularly. The 2030 Agenda of Sustainable Development Goals (SDGs) emphasizes the importance of sanitation and sets Goal-6 to "Ensure the availability and sustainable management of water and sanitation for all." Although India's rural households have seen modest improvements in access to toilet facilities in recent decades, they still face high levels of disadvantage, spatial and socio-economic inequality, and exclusion.

Study Region

India is a country that occupies the greater part of south Asia. It is consisting of 28 states and eight union territories, in addition to its national capital is New Delhi, built in the 20th century just south of the historic hub of old Delhi to serve as India's administrative centre. It lies completely in the Northern hemisphere and

Eastern hemisphere between latitudes 84′ N and 37°6'N and longitudes 68°7′ E and 97°25′ E. Prior to independence, Indian mass was under British rule for centuries and neglected the vital housing amenities, which are essentials for survival of humankind. After independence, there is remarkable improvement in basic housing amenities in majority of the states, but in some of the states the condition of housing amenities is still poor. In the present study, all the states were considered in panorama perspective which will be guide administrators to focus on framing the policies decisions on housing amenities. The present study area is Indian union and its 28 states excluding National capital of Delhi. However, the Telangana state value is included in Andhra Pradesh because; the state was not formed at the time of N.F.H.S-3 survey period. Hence, the averages of the amenity value aspects in N.F.H.S-3 and 5 contain combined Andhra Pradesh.

Objectives

The aim of the research paper is to study dynamics of some of the housing characteristics such as electricity, improved source of drinking; toilet/latrine facility and solid fuel used for cooking in India and states between N.F.H.S-3 of 1992-93 and from NFHS-5 of 2019-21.

Database and Methodology

The research paper is based on descriptive research design and data collected from of NHHS-3 (1992-93) and from NFHS-5 of phase-I (2019-20) covers states such as Andhra Pradesh, Assam, Bihar, Goa, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim, Tripura and West Bengal and NFHS-5 of Phase-II (2019-21) for India and 11 States (Arunachal Pradesh, Chhattisgarh, Haryana, Madhya Pradesh, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand and NCT Delhi). NFHS-3 collected information from a nationally representative sample of 109,041 households, while, in NFHS-5 phase-I and phase-II, data gathered information from 6,36,699 households. However, the NFHS-5 survey in of phase-II got delayed because of sever COVID-19 pandemic. Arc GIS 10.5 version is applied to trace the dynamics in household amenities in India and its states.

Results and Discussion

The housing characteristics/ amenities in India and its states during the period of NFHS-3 and NFHS-5 have been presented briefly hereunder.

Households with Electricity

Electricity is an essential energy for day today human life. Power shortages not only cause inconvenience to individual consumers due to malfunction of electrical appliances. In the residential sector, it is very important for all consumers to properly manage their daily electricity consumption. Therefore, electricity is an important aspect of modern life and economy. It is used to operate home appliances such as room lighting, fans, electric stoves, air conditioners, computers, electronic devices, and machinery. All these things bring comfort to people. Yunqing Lu et al (2022) focused on studying energy consumption and household characteristics through a dynamic price experiment in communal housing in a smart community in Japan. An interstate comparison of households with electricity amenity is presented (Table-1). In NFHS-3, Delhi being capital city of the nation, the highest per cent (99.3) is noticed, while lowest (27.7) household electricity is observed in Bihar. Based on the highest and lowest house hold electricity amenity the Indian states are grouped into three categories as less than 45 per cent, 45-80 per cent and above 8 per cent More than 90.0 per cent of households have electricity in eight states (Delhi, 99.3, Goa, 96.4; Punjab, 96.3; Jammu & Kashmir, 93.2; Mizoram, 92.3; Haryana, 91.5; Sikkim, 92.1 and Kerala, 91.0) and in the highest category (>80 per cent) there are 16 states showing the high percentage of household amenity. (Table-1 and Fig.-1)

In second category, there are 9 sates distributed in central and northeastern part of the country. There are four states where fewer than half the households have electricity (Uttar Pradesh, 42.8; Jharkhand, 40.2, Assam 38.1 and Bihar, 27.7 per cent) and these states are categorically located in north and northeastern part of the country. The analysis shows that, the physiographic and socio-economic conditions of the states influenced the low rate of electricity amenity. However, in NFHS-5, except Arunachal Pradesh (94.7), Jharkhand (93.8), Assam (92.7), Meghalaya (92.0) and Uttar Pradesh (89.8), all other states possess more than 97.0 percent of the households with electricity amenity and Goa state achieved cent per cent electrification. Country's average household electricity facility also rapidly enhanced from 67.9 to 96.5 per cent which encountered the remarkable improvement in electricity amenity. Thus, rapid improvement in households with electricity found from the period of NFHS -3 of 2005-06 to NFHS -5 of 2019-21, which reflecting within fifteen years.

Households with Improved Source of Drinking Water

Safe drinking water means clean water that does not cause any harm to humans if it comes into contact with it (Fig. 1 and Table-1 and 2).

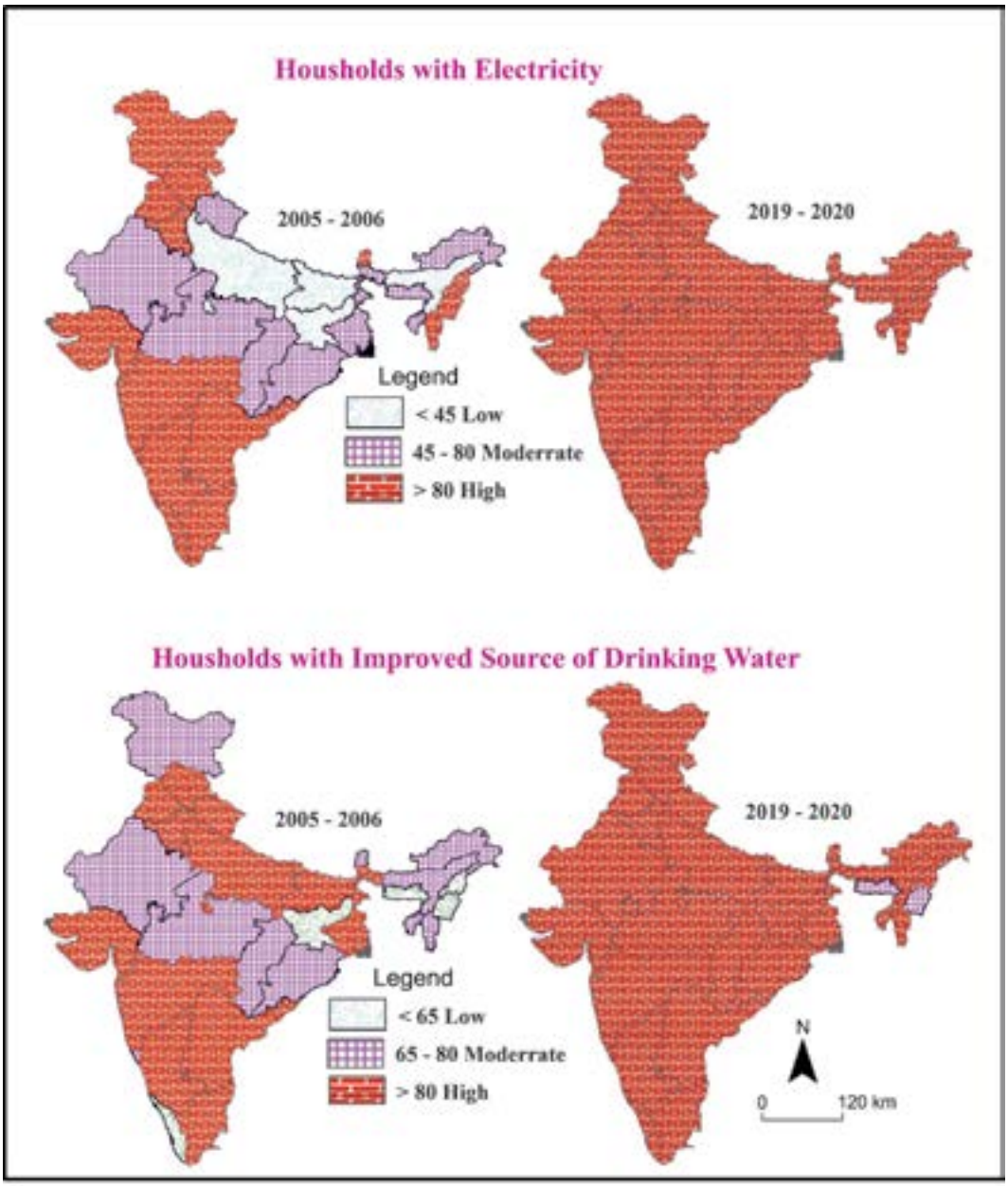

Housholds with Electricity
2005 - 2006
2019 - 2020
Legend
< 45 Low
45 - 80 Moderrate
> 80 High
Housholds with Improved Source of Drinking Water
2005 - 2006
2019 - 2020
Legend
< 65 Low
65 - 80 Moderrate
> 80 High
N
0
120 km

Fig. 1

Table-1: Percent of Households Having Electricity

Sr. No	India/State	NFHS-3	NFHS-5
(1)	NCT of Delhi	99.3	99.9
(2)	Haryana	91.5	99.5
(3)	Himachal Pradesh	98.4	99.4
(4)	Jammu & Kashmir	93.2	99.3
(5)	Punjab	96.3	99.6
(6)	Rajasthan	66.1	97.9
(7)	Uttarakhand	80.0	99.4
(8)	Chhattisgarh	71.4	98.5
(9)	Madhya Pradesh	71.4	98.1
(10)	Uttar Pradesh	42.8	89.8
(11)	Bihar	27.7	95.6
(12)	Jharkhand	40.2	93.8
(13)	Odisha	45.4	96.3
(14)	West Bengal	52.5	97.0
(15)	Arunachal Pradesh	76.9	94.7
(16)	Assam	38.1	92.7
(17)	Manipur	87.0	97.8
(18)	Meghalaya	70.4	92.0
(19)	Mizoram	92.3	98.0
(20)	Nagaland	82.9	98.6
(21)	Sikkim	92.1	99.3
(22)	Tripura	68.8	97.9
(23)	Goa	96.4	100
(24)	Gujarat	89.2	97.2
(25)	Maharashtra	83.5	97.4
(26)	Andhra Pradesh	88.4	99.1
(27)	Karnataka	89.3	98.8
(28)	Kerala	91.0	99.5
(29)	Tamil Nadu	88.6	99.0
	India	67.9	96.5

Source: National Family Health Survey-3 and 5

Table-2: Improved Source Drinking Water

Sr. No	India/State	NFHS-3	NFHS-5
(1)	NCT of Delhi	92.1	99.5
(2)	Haryana	95.6	98.6
(3)	Himachal Pradesh	88.4	96.4
(4)	Jammu & Kashmir	80.4	92.3
(5)	Punjab	99.5	98.8
(6)	Rajasthan	81.8	96.4
(7)	Uttarakhand	87.4	95.5
(8)	Chhattisgarh	77.9	95.6
(9)	Madhya Pradesh	74.2	88.9
(10)	Uttar Pradesh	93.7	99.2
(11)	Bihar	96.1	99.1
(12)	Jharkhand	57.0	86.8
(13)	Odisha	78.4	90.8
(14)	West Bengal	93.7	97.5
(15)	Arunachal Pradesh	85.0	94.2
(16)	Assam	72.4	86.4
(17)	Manipur	52.1	77.0
(18)	Meghalaya	63.1	79.2
(19)	Mizoram	85.0	95.7
(20)	Nagaland	62.8	91.0
(21)	Sikkim	77.6	94.0
(22)	Tripura	76.1	88.5
(23)	Goa	80.1	98.2
(24)	Gujarat	89.8	97.5
(25)	Maharashtra	92.7	93.8
(26)	Andhra Pradesh	94.0	96.7
(27)	Karnataka	86.2	95.6
(28)	Kerala	69.1	94.9
(29)	Tamil Nadu	93.5	98.6
	India	87.9	95.9

Source: National Family Health Survey-3 and 5.
Note: Improved sourse drinking water for households.

To be safe, water must have sufficiently low concentrations of harmful contaminants. Safe and readily available water is important for public health, whether used for drinking, domestic use, food production, or recreational purposes. In India, widespread access to safely managed drinking water could prevent nearly 14 million Disability-Adjusted Life Years (DALYs) from diarrheal diseases, resulting in an estimated cost of up to $101 billion. It is estimated that this will lead to a reduction in drinking water, which is one of the most important and basic needs of humans. It is the most basic and important element necessary for humans to survive. Access to safe and clean drinking water is critical to maintaining health and well-being. Drinking water has many important functions in the body, including regulating body temperature, maintaining healthy skin, and promoting digestion (Amend, Sarah R et al., 2016). As per NFHS improved safe drinking water means "tap water in the apartment/garden/property, pipes to neighbors, public taps/standpipes, tube wells or boreholes, protected boreholes, protected springs, rainwater, tanker trucks, small tanker trucks, bottled water, and local communities, reverse osmosis (RO) system ". An interstate comparison of households with improved source drinking water is presented (Table-2 and Fig.-1).

The household access found to improved highest source of drinking water (piped water or water from hand pump) is found highest in Bihar (96.1) state and lowest percentage of drinking water amenity is observed in Manipur (52.1). By considering the highest and lowest household drinking amenity the Indian states have been grouped into three categories as less than 65, 65-80 and above 80 per cent and the same range group is adopted for NFHS-5 also. In this amenity, three states (Bihar 96.1, Haryana, 95.6 and Punjab, 99.5) exceed 95 per cent. In lower category, there are four states (Manipur, 52.1; Jharkhand, 57.0; Meghalaya, 63.1; and Nagaland, 62.8) in low category in which more than one-third of households obtain water from an unimproved sources like cannels, rivers, streams, ponds, lakes tanks and open dug wells. In seven states such as the available amenity is moderate ranging from 65-80 percent and remaining percent of households obtain their drinking water from unsafe sources, which in many cases declaim the health conditions. Majority of Indian states possess with high percent of improved source of drinking facility around 18 states come under this category. While in NFHS-5, majority of states have access to improved source of drinking water (Table-3). Therefore, substantial raise in the household access to improved source of drinking from NFHS-3 of 2005-06 to NFHS-5. Thus, in NFHS-5 the least percent improved source of drinking water facility is found in Manipur (77.0) and highest per cent (99.50) is noticed in NCT of Delhi state.

Table-3: Households having Toilet/Latrine Facility

Sr. No	India/State	NFHS-3	NFHS-5
(1)	NCT of Delhi	92.4	98.7
(2)	Haryana	52.4	96.6
(3)	Himachal Pradesh	46.4	93.5
(4)	Jammu & Kashmir	61.7	94.3
(5)	Punjab	70.8	97.2
(6)	Rajasthan	30.8	77.5
(7)	Uttarakhand	56.8	93.6
(8)	Chhattisgarh	18.7	84.7
(9)	Madhya Pradesh	27.0	73.8
(10)	Uttar Pradesh	33.1	77.1
(11)	Bihar	25.2	61.1
(12)	Jharkhand	22.6	66.4
(13)	Odisha	19.3	66.1
(14)	West Bengal	59.6	88.0
(15)	Arunachal Pradesh	80.6	98.5
(16)	Assam	76.4	95.8
(17)	Manipur	95.6	99.5
(18)	Meghalaya	71.3	95.8
(19)	Mizoram	98.0	99.9
(20)	Nagaland	85.6	99.6
(21)	Sikkim	89.0	99.6
(22)	Tripura	96.7	98.9
(23)	Goa	76.0	96.3
(24)	Gujarat	54.6	80.7
(25)	Maharashtra	52.9	82.6
(26)	Andhra Pradesh	42.4	83.7
(27)	Karnataka	46.5	82.3
(28)	Kerala	96.1	99.7
(29)	Tamil Nadu	42.9	77.5
	India	44.6	80.6

Source: National Family Health Survey-3 and 5.
Note: Figures are given in percent.

It is interesting to present that possess above 90 per cent and about achieved more than 95 per cent in possessing improved source of safe drinking water. Geographically, all the sates achieved tremendous achievement except a few states which located in hilly terrain.

Households with Toilet/Latrine Facility

Sustainable Development Goal (SDG) 6.2 calls for universal access to safely managed sanitation by 2030. Ensuring universal access to safe sanitation by 2030 is a development priority for India. It helps to achieve better physical and mental health results. While, the proportion of people in India with access to safe sanitation has been increased dramatically over the past three decades. However, in some of the Indian states are at the highest risk of not having access to safe sanitation during this period. The most disadvantaged and excluded are households from backward areas belonging to weaker sections of society, such as Poor wage earners, Scheduled Tribes and Scheduled Castes. Therefore, in addition to accelerating rural sanitation development efforts to achieve the SDGs, there is an urgent need for complementary measures that focus on the socio-spatial conditions of backward areas, vulnerable groups, and households in rural India. According to Jain, A et al. (2023), the prevalence of zero hygiene (defined as people defecating in the open due to lack of access to a household toilet) across India has increased. During NFHS-5, considered uses an improved sanitation facility (toilet facility) as "flush to piped sewer system, flush to septic tank, flush to pit latrine, flush to don't know where, ventilated improved pit (VIP)/biogas latrine, pit latrine with slab, twin pit/composting toilet, which is not shared with any other household". State wise comparison of households with any toilet/latrine facility is presented (Table-3 and Fig. 2).

Table-3 reveals that, the substantial variations across states in access to any toilet/latrine facility. As per NFHS-3, the proportion of households with access to any toilet/latrine facility ranges from 25.0 per cent or less in four states (Bihar, 25.2; Jharkhand, 22.6; Odisha, 19.3 and Chhattisgarh, 18.7) to over 95.0 per cent in Manipur, Kerala, Tripura and Mizoram. Based on these observations, the Indian states have been grouped as less than 45, 45-70 and more than 70% classes. The analysis designates that, majority households with low toilet facility are found in central part of the country and interestingly high facility is noticed in north eastern states except Rajasthan. However, the Swachh Bharat Mission, Swachh Bharat Abhiyan, or Clean India Mission is a country-wide campaign initiated by the Government of India on 2nd October 2014 to eliminate open defecation and improve solid waste management and to create Open Defecation Free (ODF) country.

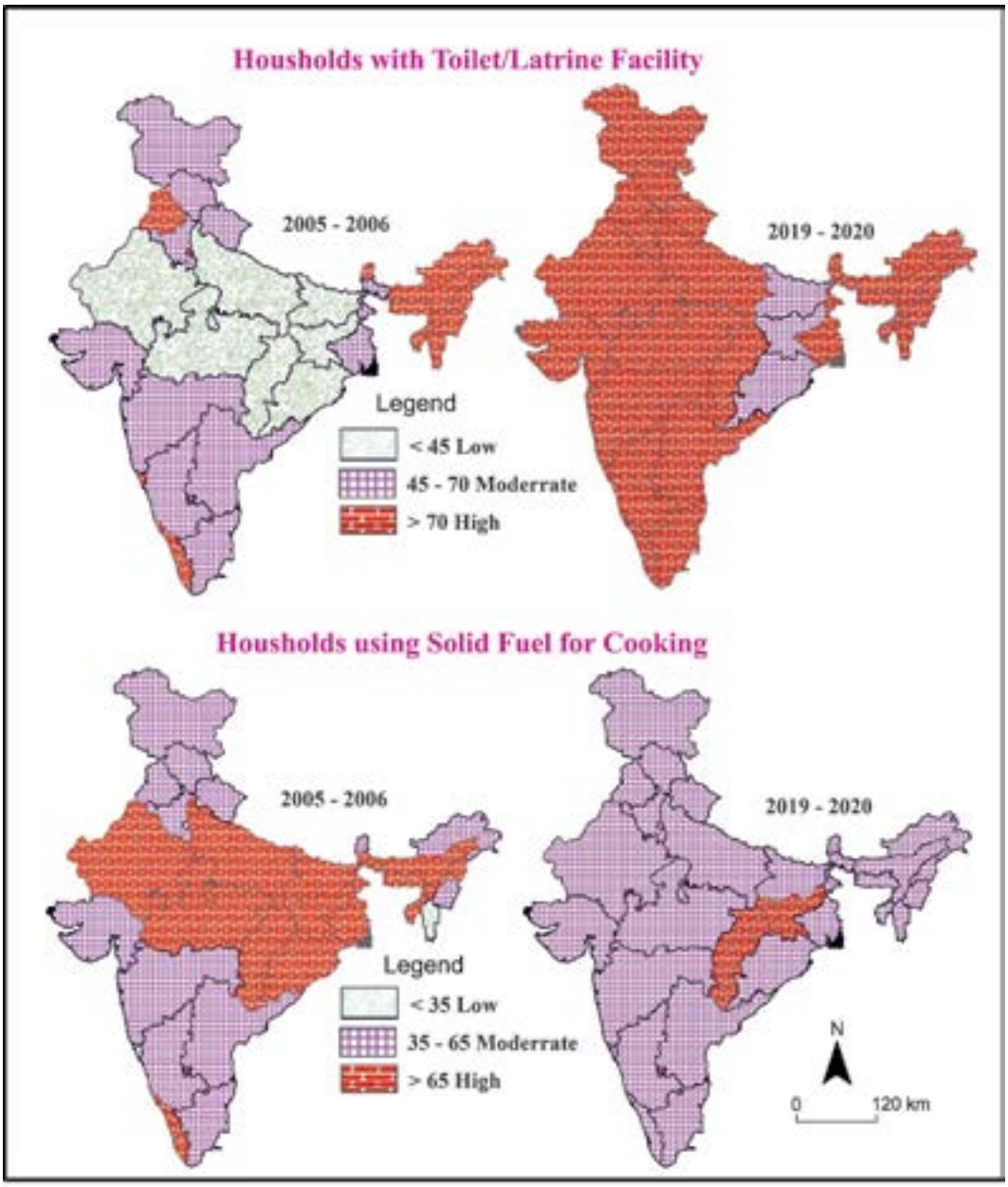

Housholds with Toilet/Latrine Facility
2005 - 2006
2019 - 2020
Legend
< 45 Low
45 - 70 Moderrate
> 70 High
Housholds using Solid Fuel for Cooking
2005 - 2006
2019 - 2020
Legend
< 35 Low
35 - 65 Moderrate
> 65 High
N
0
120 km

Fig. 2

As a result, the improved sanitation/toilet/latrine facility India and its states significantly improved. The NFHS-5 reveals that in sixteen states (NCT of Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Uttarakhand, Chhattisgarh, Arunachal Pradesh, Meghalaya, Mizoram, Nagaland, Sikkim, Goa, Andhra Pradesh, Karnataka and Kerala) over 70.0 percent (high) of households have access to improved sanitation facility and no state falls under low percent group and only three states namely Bihar, Jharkhand and Odisha have come in moderate group. Even though, 22 states possessed above national (80.6) average percentage, there is dire need to a take steps to achieve open defecation free country by 2030.

Households Using Solid Fuel for Cooking

A fuel is a type of substance that burns to produce heat or electricity. It can be in solid, liquid, gaseous or natural form. Reliance on cheap and dirty solid fuels such as firewood and other dry biomass, cow dung and coal for cooking exposes millions of Indians to dangerous air pollution, leading to significant health risks. Clean cooking fuels provide access to energy for the country's poor. This will minimize health problems and premature deaths especially among women and children, and help India reach its net-zero targets by reducing carbon emissions. As far as India's energy scenario is concerned, the most commonly used fuels in India are LPG, PNG, coal, kerosene, dung meal, firewood, crop residue, and to some extent electricity. As per NFHS, solid fuels used for cooking considered such as “coal/lignite, charcoal, wood, straw/shrub/grass/crop waste, and dung cakes”. Balakrishnan et al. (2019) found that of the 1.24 million deaths caused by air pollution in India in 2017, 6,70,000 were due to ambient particulate pollution and with an additional of 4,80,000. This is due to household air pollution as point out by people. Although the main sources of particulate pollution in the environment are external, domestic air pollution is primarily caused by the combustion of solid fuels for cooking and heating. An interstate comparison of households with using solid fuel for cooking is presented in Table-4 and Fig 2.

The smoke from solid fuels poses a health hazard when inhaled. As per NFHS-3, the proportion of households relying on solid fuels for cooking range from a lowest in Delhi (9.3 per cent) to a highest in Bihar (89.7 per cent) and over 85.0 per cent observed in four states: Chhattisgarh, Orissa, Jharkhand, and Bihar. Other states with particularly low use of solid fuels are: Mizoram and Goa, where around one-third of households rely on solid fuels for cooking. In fact, with the exception of Delhi, in all other states, significant per cent of households relies on solid fuels for cooking.

Table-4: Households having Using Solid Cooking Fuel

Sr. No	India/State	NFHS-3	NFHS-5
(1)	NCT of Delhi	9.3	0.8
(2)	Haryana	69.1	40.1
(3)	Himachal Pradesh	68.9	47.7
(4)	Jammu & Kashmir	59.5	30.2
(5)	Punjab	54.9	22.1
(6)	Rajasthan	77.2	58.5
(7)	Uttarakhand	61.7	40.5
(8)	Chhattisgarh	86.7	66.4
(9)	Madhya Pradesh	80.3	59.3
(10)	Uttar Pradesh	81.7	50.3
(11)	Bihar	89.7	62.0
(12)	Jharkhand	89.1	67.8
(13)	Odisha	88.6	64.9
(14)	West Bengal	79.2	59.1
(15)	Arunachal Pradesh	67.7	46.6
(16)	Assam	75.8	56.4
(17)	Manipur	64.7	29.6
(18)	Meghalaya	72.2	63.4
(19)	Mizoram	34.1	16.0
(20)	Nagaland	76.0	56.5
(21)	Sikkim	52.4	20.7
(22)	Tripura	80.4	53.0
(23)	Goa	33.3	2.8
(24)	Gujarat	52.3	32.2
(25)	Maharashtra	48.1	18.2
(26)	Andhra Pradesh	66.3	15.6
(27)	Karnataka	63.8	19.4
(28)	Kerala	71.4	27.4
(29)	Tamil Nadu	60.5	15.4
	India	70.8	40.6

Source: National Family Health Survey-3 and 5.
Note: Figures are given in percent.

By considering the lowest and highest solid fuel consumption the states were grouped as less than 35, 35-65 and more than 65 per cent. In low category, only two states namely NCT of Delhi, Mizoram and Goa represented less than 35 per cent, which shows, high dependency on other than solid fuels for cooking (i.e. clean fuel such as Electricity, LPG/natural gas, biogas). However, in NFHS-5, nearly all of the households in NCT of Delhi (99.2 percent) and Goa (97.2 percent) are relying on clean fuels for cooking. In seven states (Punjab, Mizoram, Sikkim, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu) over 75.0 per cent of households using clean fuel for cooking. Only in the states of Chhattisgarh and Jharkhand, more than 65 per cent (high category) households using solid fuel and in rest of the states, households are using clean fuel. Thus, findings reveal that substantial change has been noticed in the use of solid fuel (coal/lignite, charcoal, wood, straw/shrub/grass/ crop waste, and dung cakes) to clean fuel (electricity, LPG/natural gas, and biogas) indicates country's advancement in cooking fuel and in a line to conserve natural vegetation and minimize the air pollution which has been leading to overcome from health hazardous conditions to safe health positions.

Conclusion

Based on the findings, it can be concluded that, a substantial variation exists across states in the basic housing characteristics such as electricity, improved source of water, toilet facility and using solid fuel for cooking. However, a significant increase in housing characteristics such as households with electricity, an improved source of drinking water, sanitation/toilet facility and clean fuel for cooking has been noticed from NFHS-3 of 2005-06 and NFHS-5 of 2019-21 in India and its states, which resembles the government initiations and societal transformation from traditional to modern and health hazardous to safe and leading comfortable life.

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ASSESSMENT OF LANDUSE AND LANDCOVER CHANGES USING GIS ANALYTICS OF RIVER KALJANI BASIN IN DOOARS, NORTH BENGAL

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Abstract

The need of studying Land use and the existing Land Cover situation has got tremendous impetus after Second World War conditions and was highly geared during the 1960s though a handful of methodological approaches started flourishing from 1980s. With the advent of satellite imageries and legacies of air photographs resulted in precise computation of land use patterns. The novelty of such studies lies in the fact of assessment of human civilization and development. The present work has been framed taking the Kaljani river basin in the Sub-Himalayan North Bengal plains of Duars of West Bengal (India) and to compute the changes in view of environmental loss and alterations of land using GIS techniques for a 20 years temporal frame and satellite imageries especially to document the facts. The authors have used Landsat 8 OLI/TIRS, Landsat 5 TM, and also Landsat 5 TM for situations of 2019, 2010 and 2000 periods respectively. Supervised classification has been used as a user guided approach involving selection of training sites as reference for the class categorization associated with pixel selection. Authors followed four types of accuracy evaluations for land use class derivations like User accuracy, Producer accuracy, Overall accuracy and Kappa coefficient (K) and thereby to frame the Error matrix calculations to assess the overall condition and in all cases the Kappa coefficient qualified the degree of accuracy becoming more than 80% for all the three time series data. As a major finding seven types of land use classes were derived and the authors have tried to find out the socio-environmental implications. The study may be fruitful to document the land use variations within the basin and identify the land cover alterations.

Introduction

Land is a valuable natural resource on which human activities have taken place and is highly influenced by the management practices. Although the words "landuse change" and "landcover change" are sometimes employed interchangeably, they

have distinct meanings. The 'human activity or economic function connected with a site specific section of earth's surface' is referred to as land use (Lillesand et al., 2013; Das et al., 2019), they are typically not visible immediately on satellite photos' (Bhatta, 2011), while land cover alludes to "the vegetation, water bodies, and man-made structures that cover the earth's surface" (Alam et al., 2019; Burley, 1961). Multiple changes in land use are the result of rising human population and the associated demand for more resources, the most important of which are minerals, soil, and water. The long-term sustainability issue is more significant than climate change, yet it is amplified by it (Das et al., 2019). The rate (temporal) and geographical scale modifications of land surface, mostly in the form of LULC change, are unprecedented and, influence some components of earth systems like-biodiversity, physical components of biosphere, lithospheric characteristics etc. Two basic features of land transformation are Land Use Alteration (LUA) and Land Use Intensification (LUI) (Das et al., 2019). LULC change has a great impact on even biogeochemical cycle. Humans' ability to influence the rate and pattern of LULC change is largely determined by their social, economic, and political traits (Ojima et al., 2019). Land Use Land Cover Change (LULCC) is an important component of global environmental change studies now (Jensen, 2009).

Landuse and landcover is a local and site-specific system that focuses on global environmental issues as a whole. These changes have negative implications on loss of biodiversity (at three levels: genetic, species, and ecosystem), desertification, climate change, and changes in human behaviour, among others. LULC change studies attempt to interpret (i) where change is occurring, (ii) what types of land cover are changing, (iii) the types of transformation occurring, (iv) the rates or amounts of land change, (v) the driving forces and proximate causes of change, (vi) the adverse effects on lithosphere, biosphere and atmosphere if over use of land is questioned commissioning excessive cropping practices and (vii) what are the sustainable management practices with spatio-temporal changes on the earth surface (Lillesand et al., 2015; Loveland et al., 2000; Reddy, 2008). The future change patterns or trends of the LULC, which are generally generated by simulation modelling, are also an important aspect of such analyses. Models frequently include empirically fitting the evaluation system to a historical pattern of change, then extending that pattern analysis for future projections to determine when, where, and why LULC changes occur (Brown et al., 2000). That’s why more reliable/accurate LULC data for time points will be a very crucial need for imposing any local or regional and consistent policy in respect to sustainability and to initiate accurate monitoring of LULC change (Belward et al., 1999).

There are many scientific ways to monitor or detect LULC changes on the earth surface over time (Bhatta, 2011; Campbell & Wynne, 2011; Jensen, 2009; Li et al., 2014; Lillesand et al., 2013; Nelson, 1983). In the past, academies mapped LULCC over smaller areas using field data and aerial images but less suitable for larger areas. As satellite images have high temporal coverage, remote sensing (RS) has become a more dependable one for spectrally sensitive changes of the planet since the last decade of the twentieth century especially inevitable for inaccessible places. The information executed through the digital technology (Space based technology) is also crucial for model building and other natural and cultural processes (Jensen, 2009). Such Remote sensing data with varying resolutions and descriptive models, provide a unique opportunity to record past and present LULC patterns for detail study (Bhatta, 2011; Lillesand et al., 2013; Lillesand et al., 2015; Reddy, 2008). Over the years, LULC switch assessment has been accomplished efficiently and cost-effectively using satellite data (Landsat OLI/ETM+/TM/MSS). Assessing LULC changes has been the most widely used and well adopted application of satellite data from an operational standpoint (Nelson, 1983; Singh, 1989; Turner & Meyer, 1994). The present study is taken up to delineate LULC zones over a volatile riverine trajectory.

Study Region

The research area is mainly situated in the newly formed Alipurduar district (25th June, 2014). This is the northeast corner of the state bordering Assam on the East, Bhutan on the North and Bangladesh on the south of West Bengal and comprises some part of Jalpaiguri district (West Bengal) and a little bit of portions of Southern Bhutan which covers an area of 1,190 km2. Kaljani basin is the sub-basin of Torsa drainage system (sub-basin of Brahmaputra drainage system). Areal extension of Kaljani basin is 26o16/30// N to 26o55/20// N and 89o21/17// E to 89o37/10// E. Kaljani basin is the part of Darjeeling Sub-Himalaya and comes under piedmont tract of North Bengal Dooars. Upper catchment of this basin comes under hilly areas (highest elevation approximately 2,200 m above M.S.L.) and lower catchment comes under plain areas known as Tarai-Dooars region (lowest elevation approximately 50 m above M.S.L.). The total basin area sub-divided into three geomorphic units i.e. upper hilly or mountain area; middle piedmont area and lower plain area. In every part of the basin distinct hydro-geomorphologic characteristics are visible.

Objectives

This research work aims to examine the land use and land cover changes in the Kaljani River Basin (KRB) between the time periods from 2000–2010–2019 and its impact on the river.

Database and Methodology

In this study three satellite images have been taken from 2000 to 2019 with a 10 years interval. It is required to have at least two time periods of data to compare in order to monitor LULC change. For assessing LULC changes in any area, a remote sensing technique generally requires the use of satellite images from two or more dates. The imageries used in this investigation were chosen based on their spatial resolution compatibility (30 x 30 m). The LANDSAT data archive, which contains pictures that are sufficiently consistent with data from previous missions, enables for long-term regional and global LULC change analysis (Irons et al., 2012). For LULC change analysis in the Kaljani basin, we employ cloud free scenes from LANDSAT-TM (2000 and 2010) and LANDSAT-OLI (2019). Because the imagery had previously been pre-processed, no radiometric calibrations or atmospheric adjustments were needed. (Table-1)

Table-1: Characteristics of Satellite Imageries

Sl. No.	Satellite Data	Path	Raw	Date of acquisition	Spatial resolution
1	Landsat 8 OLI/TIRS	138	41,42	November 14, 2019	30 x 30
2	Landsat 5 TM	138	41,42	October 12, 2010	30 x 30
3	Landsat 5 TM	138	41,42	November 17, 2000	30 x 30

Source: USGS Earth Explorer

Error Correction before Utilizing Raster Data

Multi-spectral satellite imagery (raster data) having various kinds of error like cloud cover, sun inclination, poor reflectance etc. Therefore, error correction (radiometric and atmospheric correction) is very essential before utilizing the data. In this context, the researchers have been proceed system provided atmospheric correction, raster image enhancement (linear), high pass filtering with edge sharpening (filter level size: X=3 and Y=3) for better identifying the pixel character.

Results and Discussion

LULC Classification

Through the digital process of feature recognition and classification, the changing nature of LULC was acquired from multiband raster imageries. Spectral information such as colour band is one of the main types of information used for the purpose of image classification as well as interpretation. In this context, image conversion from FCC (False colour composite) to TCC (True colour composite also called natural colour composite) map has been developed through the systematic image classification technique. Image classification is designed for an automatic categorization of pixels with a common reflectance range into a specific LULC class (Lillesand et al., 2015). It is noticed that image classification method has been used as a tool in mapping from remotely sensed data. Supervised classification is a user-guided classification technique that involves selecting training sites as category references (Lillesand et al., 2015). Many approaches, such as parallelepiped classification, K-nearest neighbour, minimal distance to mean classification, Gaussian maximum likelihood, linear discriminant, features space, and others, are used to accomplish supervised image classification (Lillesand et al., 2015; Reddy, 2008; Bhatta, 2011). Using ArcMap (10.5) software, we employed a frequently used maximum likelihood classifier (Foody et al., 1932) for LULC classification in this work. The maximum likelihood/Bayesian classifier method examines both the variance and covariance of spectral response patterns quantitatively, and each pixel is allocated to the class with the highest likelihood of connection (Alam et al., 2019; Shalaby & Tateishi, 2007). A total of 7 LULC classes i.e. water body, sand deposit, dense forest, open forest, agricultural land, bare soil and settlement area were determined. Post-classification of the LULC raster layer was cross verified with the help of Google Earth pro software in a systematic statistical way. (Table-2)

Accuracy Checking

Any map is nothing more than a model or a generalization, so it has some oversight (Dicks & Lo, 1990; Maling, 2016; Smits et al., 1999) because primarily derived LULC map from satellite data is not standard one due to error in remote sensing data (Hord & Brooner, 1976; Congalton, 1991). Because LULC classification is prone to mistakes, the output (maps) must be submitted to the test for correctness using a trustworthy statistical approach (Foody, 2002).

Table-2: Description of LULC Categories

Class	Description
Agricultural land	This class represents the cultivated land (Rabi and kharif crops).
Settlement area	The residential areas are represented under this class, road, bridge, industrial area and other paved surface.
Dense forest	This classification refers to the coniferous forest that covers the surrounding mountains.
Open forest	This class includes tea plantation (Tea garden), small deciduous forest and sparse vegetation etc.
Sand deposit	This class represents the dry river channel with full of sand, gravel and boulders etc.
Bare soil	This class represents the bare land and other soil surface that are bare of greenery throughout the entire year, bank soil, landslide area etc.
Water body	This class represents the open water bodies such as river, ponds, cutoffs, pools etc.

Source: Prepared by Authors

As a result, LULC maps frequently come with an accuracy assessment index that includes a detailed description of the sampling design (including sample size and, if applicable, stratification details), an error matrix, the area or proportion of area of each category according to the map, and descriptive accuracy measures like user, producer, and overall accuracy (Congalton, 1991; Lillesand et al., 2015; Olofsson et al., 2013; Trodd, 1995). Cohen's kappa (k) is a frequently used statistical measure for determining inter-rater concurrence between categorical variables that was introduced by Cohen in 1960 (Alam et al., 2019). The accuracy of all raster layers (2000, 2010, and 2019) was evaluated in this study by the production of an error-matrix (Stehman, 1997; Lard, 1995; Foody, 2002; Congalton, 1994). The sample design used in accuracy testing has an impact on the accuracy assessment's dependability (Muller et al., 1998; Stehman, 2001). In order to test accuracy, a stratified random sample design was used (Stehman & Czaplewski, 1998). Geo-statistics has been used to design an efficient sample (Atkinson et al., 2000). For this purpose, 50 samples for each LULC category have been selected.

Sample points have been selected with proper care and significant ways to provide a representative and meaningful basis (Hay, 1979). So, ground truth validation is the main standpoint (Campbell & Wynne, 2011). The generated maps of the time periods - 2000, 2010 and 2019 revealed an overall accuracy of 85.14%, 89.14%, 89.14% and kappa coefficient of 0.8267, 0.8733 and 0.8732 respectively. The precision of all three raster layers is satisfactory in general. The overall accuracy of LULC maps is estimated to be between 85 and 90% (Anderson, 1976; Shalaby & Tateishi, 2007). In case of Kappa coefficient, results are also reliable and standard one (Lillesand et al., 2015). As a result, the acquired results can be regarded as more dependable to a greater extent. The Eq. was used to calculate the overall accuracy and kappa coefficient (4) (for details see Table-6).

UA (%) = No. of correctly classified pixels in each category/Total no. of classified Pixels in that category (Row total) × 100 (Eq. 1)

PA (%) = No. of correctly classified pixels in each category/Total no. of Reference pixels in that category (Column total) × 100 (Eq. 2)

$$OA = \frac{\sum_{=1} xii}{x} \text{(Eq. 3)}$$

Note: Where xii is the diagonal elements in the error matrix, x is the total number of samples in error matrix.

$$\text{Kappa coefficient } (\text{K}) = \frac{n\sum_{i=1}^{r} xii - \sum_{i=1}^{r} xi + x + i}{n^2 - \sum_{i=1}^{r} xi + x + i} \text{(Eq. 4)}$$

Note: where r is the number of rows in the matrix, r_ii is the number of observations in row i and columni, xi+ x_(i+) and x_(+i) are marginal totals for row i and column i respectively and n is the total number of observations. (Table-3, 4, 5 and 6 and Fig. 1)

Table-3: Error Matrix Resulting from Classifying Randomly Sample Test Pixels, 2019

2019	WB	DF	AL	SD	BS	OF	SA	RT	UA (%)
WB	50	00	00	00	00	00	00	50	100.00
DF	00	47	00	00	00	03	00	50	94.00
AL	00	00	44	01	02	02	01	50	88.00

Contd...

SD	00	00	01	48	02	00	00	50	96.00
BS	00	00	03	03	43	01	00	50	86.00
OF	00	05	02	00	01	41	01	50	82.00
SA	00	00	03	01	03	04	39	50	78.00
CT	50	52	53	53	51	51	41	350	
PA (%)	100.00	90.38	83.01	90.56	84.31	80.39	95.12		

Source: Calculated by Authors

Table-4: Error Matrix: Randomly Sample Test Pixels, 2010

2010	WB	DF	AL	SD	BS	OF	SA	RT	UA (%)
WB	50	00	00	00	00	00	00	50	100.00
DF	00	43	01	00	02	04	00	50	86.00
AL	00	00	47	00	02	01	00	50	94.00
SD	00	00	00	48	01	01	00	50	96.00
BS	00	01	04	02	41	02	00	50	82.00
OF	00	02	00	01	01	45	01	50	90.00
SA	00	01	03	02	03	03	38	50	76.00
CT	50	47	55	53	50	56	39	350	
PA (%)	100.00	91.48	85.45	90.56	82.00	80.35	97.43		

Source: Calculated by Authors

Table-5: Error Matrix: Randomly Sample Test Pixels, 2000

2000	WB	DF	AL	SD	BS	OF	SA	RT	UA (%)
WB	49	00	00	01	00	00	00	50	98.00
DF	00	44	01	01	02	02	00	50	88.00
AL	00	00	41	02	03	02	02	50	82.00
SD	01	00	01	45	01	01	01	50	90.00
BS	00	00	02	05	41	01	01	50	82.00
OF	00	02	02	01	01	42	02	50	84.00
SA	00	01	04	02	03	04	36	50	72.00

Contd...

CT	50	47	51	57	51	51	42	350
PA (%)	98.00	93.61	80.39	78.94	80.39	82.35	85.71	

Source: Calculated by Authors

Note: WB=Water body, DF= Dense Forest, AL= Agricultural land, SD= Sand deposit, BS= Bare soil, OF= Open forest, SA= Settlement area, RT= Row total, UA= User's accuracy, CT= Column total, PA= Producer's accuracy Diagonal Italic numbers represent correctly classified samples for each LULC class.

Table-6: Overall Accuracy and Kappa coefficient of LULC Maps (2019, 2010 and 2000)

Satellite data	LANDSAT 8 OLI/ TIRS C 1 Level-1	LANDSAT 5 TM C1 Level-1	LANDSAT 5 TM C1 Level-1
Year	2019	2010	2000
Sum of Diagonal	312	312	298
Total	350	350	350
Overall accuracy (%)	89.14	89.14	85.14
Kappa coefficient (K)	0.8732 (87.32%)	0.8733 (87.33%)	0.8267 (82.67%)

Source: Calculated by Authors

In remote sensing, primarily obtained multi-spectral raster data is associated with several errors (Both radiometric as well as atmospheric error) (Lillesand et al., 2013; Bhatta, 2011) (Fig. 1). The egregious disadvantages of remote sensing include the incapability of many sensors to acquire data and information over the earth surface due to cloud cover, inclined sun angle, distinct phenomena can be pixelated (Bhatta, 2011) if they appear the same to the sensors, and satellite imagery resolution may be too coarse for detailed mapping and exclusive tiny contrasting areas; on the other hand, high-resolution satellite imagery is more cost effective. Despite these disadvantages, remotely sensed satellite data (LANDSAT OLI/ETM+/TM/MSS) have been used to identify changes on the earth surface over time in a variety of land use (crop land, building construction, paved surface etc.) and land cover (Forest, water body etc.) attributes (Bhatta, 2011; Lillesand et al., 2015; Reddy, 2008). This is especially true in distant areas, which are frequently inaccessible and hence difficult to obtain data from using standard approaches.

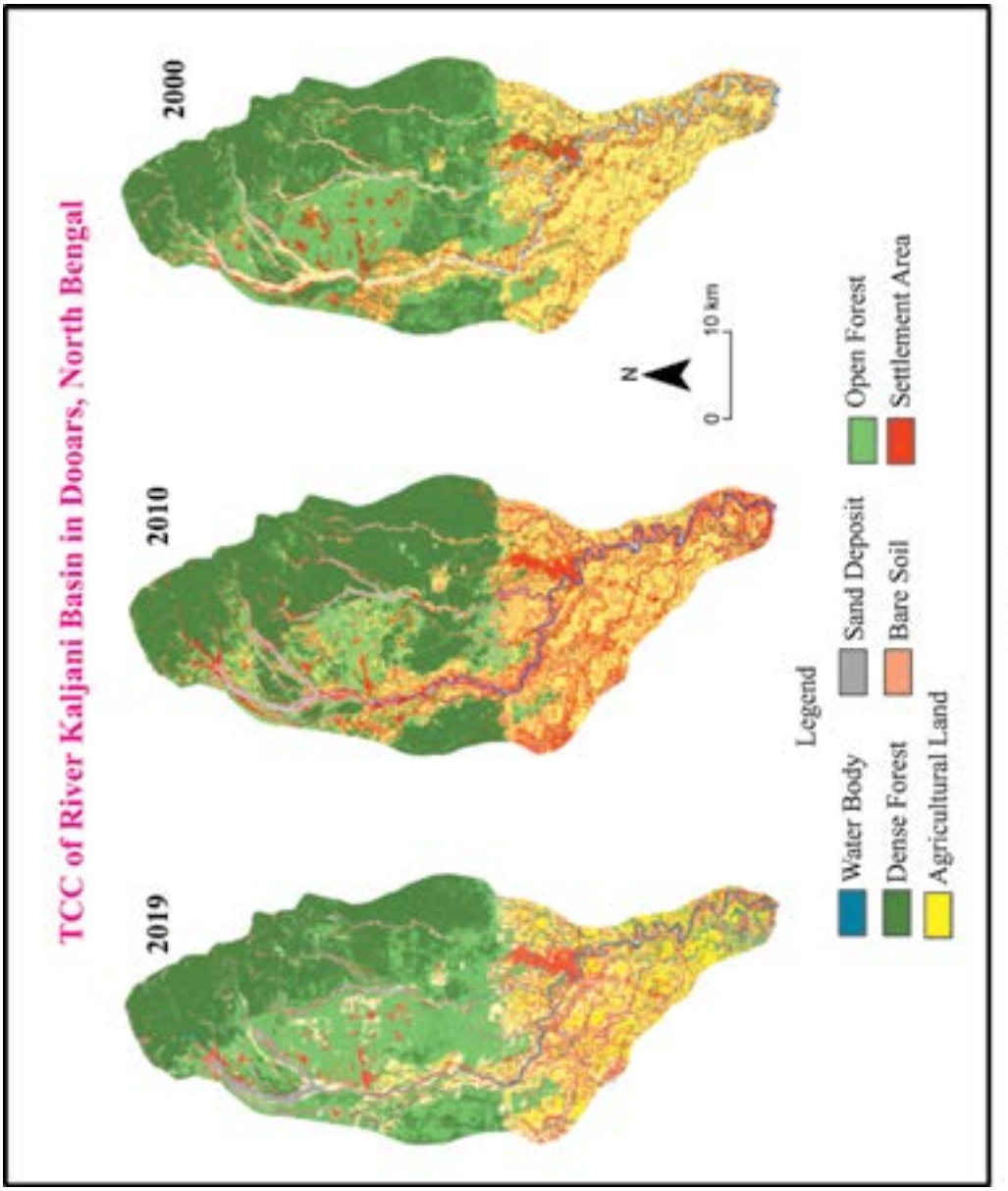

TCC of River Kaljani Basin in Dooars, North Bengal
2019
2010
2000
N
0
10 km
Legend
Water Body
Sand Deposit
Open Forest
Dense Forest
Bare Soil
Settlement Area
Agricultural Land

Fig. 1

In this situation, researchers/learners/planners frequently employ remotely sensed data in a scientifically sound manner to give data on resource inventory and land use, as well as to discover, monitor, and quantify evolving landscape patterns.

Landuse Change Analysis

Over the last three decades, the Kaljani basin has seen significant changes in LULC over its length and width. Figure 2 shows the changes in LULC within the research region across the specified time periods (2000–2010–2019). (Fig. 2)

Dense Forest

The research area's dense forest is the biggest of all the recognized classifications. Dense forest is very common in hilly/mountain areas. Upper catchment of Kaljani basin is mainly covered up with dense forest (like Buxa forest, Buxa hill forest, Gabour Bachhara forest, Dakshin Barajhar forest). The result shows that this LULC category shared 35.38% area of the basin in 2000 and decreased in 2019 (33.69%) but an exceptional case happened in 2010 (2.58%), resulting in a positive change. The present trend is normal due to population pressure, may be illegal logging and lack of sustainable management techniques in forest areas are the two reasons. Local people experienced such kind of LULC changes in their daily life. To be specific Forest is the house of primitive tribal people and must be saved. But over time they are losing their traditional forest based lifestyle due to destruction of forest land and it is very common in Buxa and surrounding forest areas. Figure 3 clearly stated that 144.93 sq.km areas have vanished in between 2010 to 2019 and also showed 38.35 sq.km area totally disappeared during the selected time periods (2000-2019).

Agricultural Land

The agricultural land revealed a continuously declining trend in the Kaljani basin area. The total area under this category has been 24.88 %, 23.71% and 16.60% of the total area in 2000, 2010 and 2019 respectively. There has been a decreasing trend of 13.81 sq.km area from 2000 to 2010, 93.47 sq.km from 2010 to 2019 and a collective reduction of 107.28 sq.km from 2000 to 2019 in agricultural land. It is noticeable that, considerable portion of agricultural land was lost and reduced due to rapid population growth with increasing demand for settlement areas and urbanization.

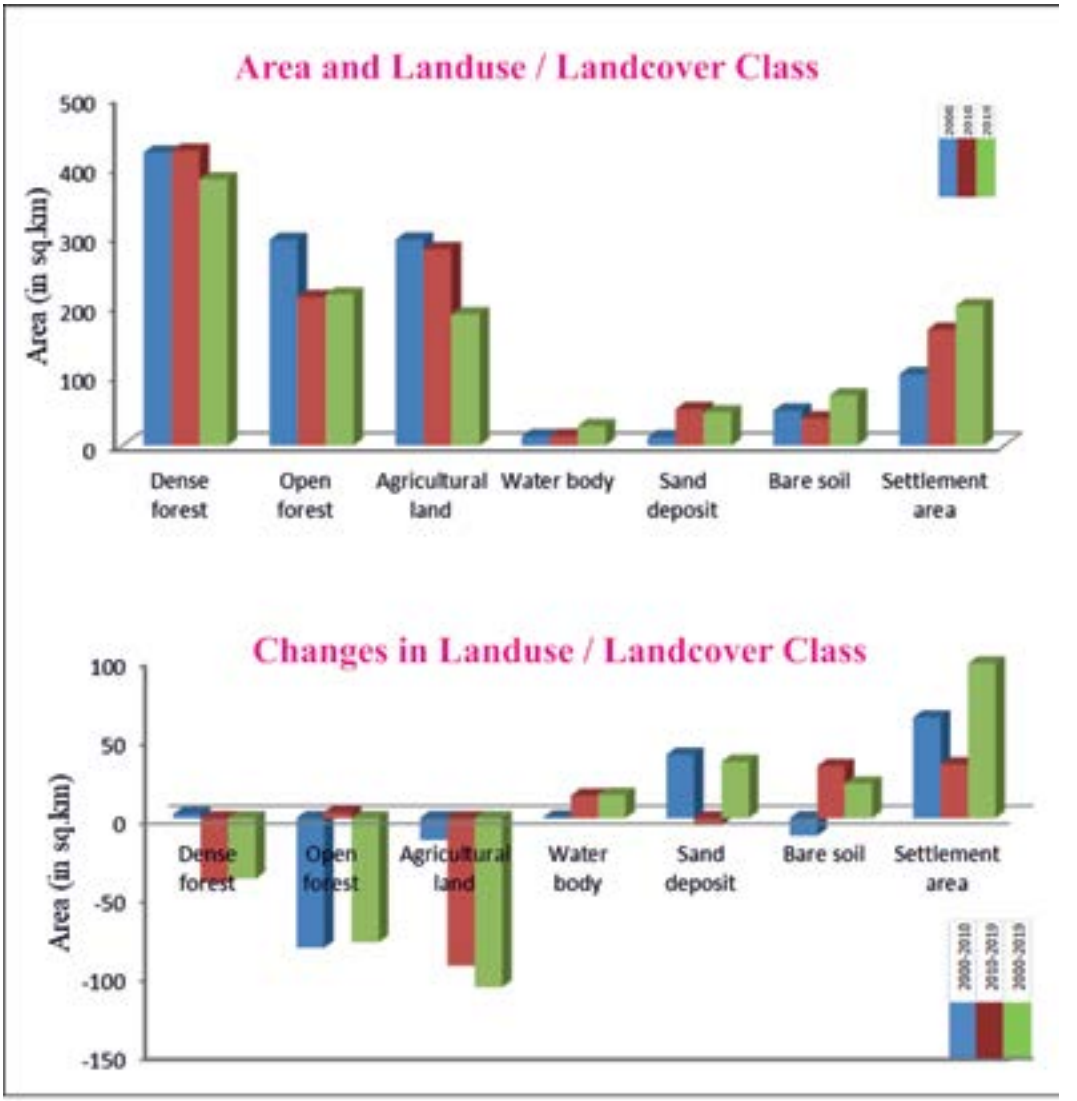

Area and Landuse / Landcover Class
Area (in sq.km)
500
400
300
200
100
0
Dense forest
Open forest
Agricultural land
Water body
Sand deposit
Bare soil
Settlement area
Changes in Landuse / Landcover Class
Area (in sq.km)
100
50
0
-50
-100
-150
Dense forest
Open forest
Agricultural land
Water body
Sand deposit
Bare soil
Settlement area

Fig. 2

Sand Deposit

Piedmont areas, even foothill plains have witnessed huge concentration of sand, boulders, cobbles, pebbles etc. throughout the year. In the studied basin, the upper part of Kaljani drainage network has been filled up with different sizes of particles and gradually increasing its bed elevation. The result shows 0.99% of total basin area covered with sand deposits and has been increased in 2010 (4.37%) and 2019 (4.19%). There has been increased of 40.18 sq.km from 2000 to 2010, little bit reduced from 2010 to 2019 (4.47 sq.km) but has witnessed net increase of 55.71 sq.km from 2000 to 2019. Unplanned circumstances (like population pressure and building construction in mountain regions, rudimentary practices of cultivation along the mountain slopes etc. are the main reasons for the supply of load and high concentration of sand and other types of particles in river bed. And various natural events e.g. torrential rainfall, earthquakes though very less, landslides etc. are also responsible for such a changing scenario. Excessive bed deposition and avulsions are the ecological problems of Kaljani River. It is noticeable that all the major rivers of North Bengal like Teesta, Torsa, Kaljani, Raidak, Lish and Ghish are suffering from unnatural siltation. Deforestation, civil construction, and several other increased human activities in hills are causing loosening of the top soil and increasing discharge of debris. Therefore, residential areas alongside the Kaljani River have witnessed worse flood events almost every year due to low carrying capacity of monsoon runoff.

Bare Soil

This class of LULC represents open uncovered fallow land. It may be unfertile agricultural land; wipe away lands by landslide or unplanned cutting process, bank soil etc. In the study area lands under this category have been found with 4.20%, 3.27% and 6.34% in 2000, 2010 and 2019 respectively. Statistics show that the amount of bare soil gradually increased in Kaljani basin over time, it's about 33.00 sq. km from 2010 to 2019 and 21.94 sq. km from 2000 to 2019. Deforestation in the Piedmont area, as well as an expansion in industry and building sites such as brick kilns and highways, have all contributed to the growth of this class.

Open Forest

Open forest especially in the form of plantation (Tea garden), social forestry and scattered vegetation is a LULC class of such a category that has reduced slowly. It is mapped through satellite data of 24.84%, 17.93% and 19.09% in 2000, 2010 and 2019 respectively under this category in Kaljani basin.

Open forest area has decreased about 82.17 sq.km in between 2000-2010 and increased by 3.57 sq.km from 2000 to 2019, encroaching the agricultural land, bare soil areas side by side, little bit of portion added from dense forest.

Waterbody and Settlement

Water body represents the open water surface (Table-2) area on the earth surface. This LULC category revealed a positive growth in the basin area. In 2000 total covered area of the water body was 13.12 sq. km (1.14%) and over time gradually increased about 1.14% and 2.45% in 2010 and 2019 respectively. In the Kaljani basin, LULC fluctuations are more obvious; one of them is the expansion of the settlement area. The majority of the structures are residential, although there are a few commercial ones as well, the total area under settlement has been 8.61%, 13.98% and 17.65% in 2000, 2010 and 2019 respectively, registering a total growth of 63.85 sq.km from 2000 to 2010, 34.12 sq.km from 2010 to 2019 and total net growth of 97.97 sq.km in the selected time period (2000 to 2019). The settlement areal expansion has been mostly encroaching the agricultural land, bare land, open forest areas etc. particularly expanding along the road and around the core area (e.g. Hamiltonganj and Alipurduar in Alipurduar district); the increasing settlement area adversely affects the environment quality, loss of biodiversity etc.

Conclusion

The study reveals some exodus results especially reduction of all three types of forest cover and which is indicative of probable misuse and natural loss of forest resources during the last 20 years period. More overwhelming scenario is probating the fact that agricultural lands have declined to a remarkable percentage and which is actually attributing to the volatile nature of seasonal submergences and pocket floods within the basin and that might be due to avulsion and an branching of the channels. Furthermore, huge bed filling scenarios and negligible bed slope characteristics have been attributed to the spate of the channel and occasional deluges. As a fact of provenance, the sand deposits and their percentage share is contravening influence of bank side submergences and diluvia of land under marginal cropping usage. Contextually development of settlement areas is also increasing keeping an incremental trend and dependency on land cum man-land share is turning into challenges over time especially agricultural production point of view. Increasing trends of water bodies are almost pointing out reappearances of channel off shoots and paleo channel features but excessive replenishments are reasonably resulting in their disfigurations for every next year from the year of appearance.

Multi thread channel patterns with anastomosing character or pattern is viewable in Kaljani basin and seriously approves the factuality of occasional flood scenarios.

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GROWTH PROFILE AND SIGNIFICANCE OF HERITAGE-RELIGIOUS TOURISM IN EASTERN REGION, UTTAR PRADESH

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Abstract

Growth and development of tourism primarily hinges on cultural factors including heritage and religious sites. Modern tourism is driven by and at the same time contributes towards the conservation and preservation of heritage-religious centers of tourism attraction. Drivers which affect influx of tourists at heritage sites include its cultural, religious, monumental significance and infrastructural improvements. There are many historical and heritage sites in state of Uttar Pradesh which attract a significant and few of them a majority of tourists including both domestic and foreign tourists. There are marked geographical variations in the tourists flow across the districts of the state. However, with a changing policy planning, a few of them are going through revitalization and redevelopment stages to further promote culture and tourism consequently contributing to economy of Eastern region. Based on secondary data, the present research paper focuses on to study trends, growth and spatial-temporal pattern of tourism in Uttar Pradesh especially in its Eastern region. Present study unravels and highlights the emerging challenges in tourism sector and why they need to be tackled for a sustainable tourism strategy in the state.

Introduction

Tourism has emerged as one of the most promising economic activities in modern times. It is now being actively integrated with economic development planning in most of developing countries (Rasool et al., 2021). A policy shift can be sensed in terms of developing all such potential places which can attract more tourists and consequently contribute to overall economy. The United Nations World Tourist Organisation (UNWTO) stated that "Tourism comprises the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes". In 2019, the global tourism peaked to 1464 million (UNWTO).

Tourism is well established part of heritage (Light, 2015) and it is interconnected since heritage is blend of cultural, social, historical and architectural image of a society. Heritage, being both tangible and intangible, has always been the point of attraction for tourists around the globe and "heritage tourism is a major economic activity in almost all countries of the world" (Light, Ibid). Thus, heritage places include ancient monuments, religious and spiritual sites, and places of cultural amalgamation which always remained preferred sites for tourists. Hall and McArthur (1998) illustrated that "[H]heritage is a part of a region's resource base, but only exists as such when it has been determined to have some utility function" (cited by Boyd 2002:212). The Organisation for Economic Co-operation and Development (OECD, 2009) highlighted that "[C]cultural tourism is one of the largest and fastest-growing global tourism markets. Culture and creative industries are increasingly being used to promote destinations and enhance their competitiveness and attractiveness." In a developing country like India, the rich and diverse cultural heritage and resources can act as the axle of tourism development. In India, cultural tourism is a sector that focuses on those geographical areas which reflect the art, architecture, religion and associated elements. Menon et al. stated that "cultural tourism is one of the biggest attractions for the tourist and it is a known fact that many travellers who plan to visit India focus their trip on cultural tourism" (2021). The fact is that the tourism industry thrives on the needs, tastes and perceptions of visitors.

Study Region

The study primarily focuses on the tourism development in Uttar Pradesh with special emphasis on its eastern region. The study also analyses the domestic and foreign tourism in India and the Empowered Action Group (EAG) States which include Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttaranchal, and Uttar Pradesh. Uttar Pradesh is one of the largest states in India which has a diverse cultural heritage. Uttar Pradesh comprises seventy-five districts with a population of 199.58 million as per the Census of India 2011. It's a fact that a few states in a country play an important role in attracting tourists for various purposes. Uttar Pradesh is one such state in the country which draws a huge number of tourists not form domestically but globally as well. The state has seen some sort of transition in tourism profile as tourists now turn to several places of religious and cultural importance rather than visiting recreational sites only. Thus, the share of religious places in attracting tourists has increased over the past few years in the state. In terms of tourist footfalls, the state is consistently ranked among the top five states in the country. Uttar Pradesh has emerged as the top destination for

attracting the highest number of domestic tourists in the year 2019. State's tourism significantly contributes to the state's economic growth and employment generation both direct and indirect, making it an important focus area for the government.

Objectives

The focus of the paper is to study the growth and development of tourism in eastern region of Uttar Pradesh (a) to analyse trends and growth of tourism in India and EAG states; (b) to study spatial concentration of tourism growth in districts of Uttar Pradesh; (c) to examine the growth pattern of tourism in Eastern Uttar Pradesh; (d) to critically discuss recent developments in tourism development policy and planning in Uttar Pradesh and their implications for sustainable tourism.

Database and Methodology

The present research adopts a descriptive and analytical framework. The entire study is based on secondary data collected from various sources such as published books, journals, reports, documents and websites. The secondary data is taken from Indian Tourists Statistics at a Glance-2020, Ministry of Tourism, Government of India; Annual Report 2019-2020/Annual Report 2020-2021, Ministry of Tourism, Government of India; Uttar Pradesh Tourism Statistics, Department of Tourism, Government of Uttar Pradesh; Statistics of Tourists Visits at Important Historical Places/Monuments in Uttar Pradesh (2014-2017/2015-2018), Department of Tourism, Government of Uttar Pradesh; Statistical Abstract Uttar Pradesh (Multiple Years), Economic and Statistic Division, State Planning Institute, Planning Department, Uttar Pradesh; Uttar Pradesh Statistical Diary (2019, 2022); Tourism Data Dashboard, UN World Tourism Organization (2018, 2019); Annual Research Highlights, World Travel and Tourism Council (WTTC, 2020); and Economic Survey of India and Uttar Pradesh Tourism Policy, 2018. The paper calculates the annual growth rate of multiple years and the share of tourists in each region to the total tourists influx in the country.

Results and Discussions

Tourism has a spatial and cultural difference in the way it takes place in different societies and regions. It is often known as the temporary movement of people to destinations outside their normal place of work and residence. India has a long tradition of people moving for various pilgrimage and religious sites. Thus, travel and tourism have been a part of Indian tradition and culture. The modern mass tourism is more organized and it adds significantly to the economic development.

The tourism industry in India plays a significant role in significant economic multiplier and it has more potential for the growth in employment sector. At a broader level "India accounts for a majority of South Asia's travel and tourism gross domestic product (GDP) and has also been the preferred destination for tourists from within the region" (Sinha and Sharma, 2020). The foreign exchange earnings from tourism in 2010 were Rs. 648.89 billion as compared to Rs.549.60 billion during 2009. The approach paper of the Twelfth Five Year Plan (2012-17) of the Planning Commission of India highlighted the need to adopt "proper tourism" to increase net benefits to the poor and ensure that tourism growth contributes to poverty reduction. India is divided into five tourist zones: northern, southern, eastern, western and central. Under the Ancient Monuments and Archaeology Sites and Remains Act, of 1958, the Archaeological Survey of India has declared three thousand six hundred and seventy-five monuments or sites to be of national importance which includes twenty-one properties that are inscribed as World Heritage Sites by UNESCO. By 2015, there were thirty World Heritage Sites in India, six were natural and the rest of the others are cultural wonders. The country India is endowed with rich physical landscapes including mountains, beaches, deserts, mangroves, rivers etc.

The celebration of fairs, festivals and manifold religious fabric gives support to wider tourism in India. In India, more attention is now being paid to the protection and conservation of the monuments including their cultural heritage such as performing art, visual art, festivals, languages, folk art and handicrafts. The major schemes in India are being aimed at Product/Infrastructure and Destination Development at certain places of tourism importance. Thus, to make these places as most tourist attractions, major redevelopment works and rejuvenations are being carried out at such heritage places of social, cultural and spiritual importance. Studies suggested that heritage can act as an important holistic development tool for the overall community development in India (see, Sharma and Sharma, 2017). The Uttar Pradesh Tourism Policy has the mission "to drive a sense of inclusive tourism development in the local community and make optimum use of tourism experiences across vibrant cities, attractions, nature, wildlife, adventure, food, heritage, religion and culture of state" (2018). Analysis of trends of domestic tourism in India over the past years offers an insight into the flow. In 2005, 392.04 million domestic tourists visited India which increased to 747.70 million in 2010. The number of domestic tourists further increased to 1431.97 million by 2015. It reached 2321.98 million in 2019. In terms of annual growth rate, it was 17.96% in 2006. It showed a decline in 2007 being at 13.90% and further declined to 6.90% percent by 2008.

However, there was a drastic growth of 18.79% in 2009, but it declined to 11.8% in 2010. Then there was a sudden growth in 2011 at 15.63% and it further grew to 20.88% growth rate in 2012. Then afterwards there has been a decline over the next year. The years 2014 and 2016 showed an increase in annual growth rates. It declined later in 2015 and grew in 2018. There was a drastic fall in growth rate in 2017 when it dropped to 2.61%. However, the year 2019 showed an annual growth rate of 25.26%. Thus, one can see that the trends of domestic tourist growth in India have been erratic during this period. The trend of foreign tourist arrival in India is similarly encouraging. The number of foreign tourists in India increased from 9.94 million in 2005 to 17.91 million in 2010. The period from 2005 to 2009 registered a declining trend in the annual growth rate of foreign tourists as the annual growth rate of 18.07% in 2006 declined to -0.06% in 2009. In 2010, the annual tourism growth rate bounced back to 24.62%. This further declined to -6.33% in 2012. The number of tourists visiting the country increased to 23.32 million in 2015. In 2019, this further increased to 31.40million. Though there was an overall growth in the number of tourists visiting the country, the annual growth rate pattern is very irregular.

The annual growth rate of domestic tourists in Empowered Action Group (EAG) states of India. The annual growth rate (AGR) of domestic tourists in Assam was 5.2% in 2010 which declined to 3.3% in 2014. It anyhow increased to 13.75% in 2015 but it again dropped to -6.03% in 2016. The growth rate further improved to 15.65% in 2019. The state of Bihar had an annual growth rate of tourism at -0.51% in 2011, which increased to 24.33% in 2015. The domestic AGR of Bihar reached 1.1% in 2019. Chhattisgarh had a domestic AGR of 13.8% in 2011, which declined to 5% in 2012. It drastically increased to 51.64% in 2013. It again declined sharply to 7.4% in 2014 and -25.16% in 2015. It dropped to -10.48% in 2019. The domestic AGR of Jharkhand was highest being at 62.97% in 2014. It declined and reached to 0.49% in 2019. Madhya Pradesh had the highest domestic AGR in 2010 with 64.8% of the domestic Annual Growth Rate. The domestic AGR of Odisha remained almost the same till it drastically dropped to 0.65% in 2019. Rajasthan had the lowest domestic AGR of -0.1% in 2010. It depicted an erratic pattern and reached 3.95% in 2019. Uttarakhand had a domestic AGR of 37.7% in 2010. It witnessed the lowest of ten years in 2013 with a domestic AGR of -25.67%. A gradual rise was reported later and it reached 5.55% in 2019. The annual growth rate of foreign tourists in Empowered Action Group (EAG) states of India. Overall, the growth rate of foreign tourists in EAG states has been fluctuating over the

years in the country. The Foreign AGR of Assam in 2010 was 1.4% which declined to -48.69% in 2016. It witnessed a sharp increase of 69.33% and 72.38% in 2018 and 2019 respectively.

The state of Bihar has a record of the highest foreign AGR of 52.97% in 2011 from 50.3% in 2010 and it declined to -30.18% in 2013. It grew by 11.36% in 2015. Its annual growth rate declined and reached 0.48% in 2019. In Chhattisgarh, the annual growth rate of foreign tourist arrivals has been showing signs of fluctuation over the years from 2010 onwards. The highest foreign growth rate of Chhattisgarh was recorded at 114.88% in 2018, which dropped sharply to rate of -52.66% in 2019. Jharkhand had the highest jump in foreign tourist growth rate at 361.72% in 2011 which declined again in the next two years. It suddenly jumped to 236.41% in 2014. It further went down and reached 0.14% in 2019. Madhya Pradesh had a lower growth all through the past years from 2010 onwards. The State's foreign tourist growth rate was lowest at -13.8% in 2016 and again it grew at -12.66% in 2019. Odisha had a lower growth rate in 2010 and 2011 compared to the EAG average. It showed signs of fluctuations over the next few years. The highest foreign tourist arrival growth in Odisha was recorded at 31% in 2017 and it again declined and grew at 3.89% in 2019. Uttarakhand in 2010 had an annual growth rate of 19.5%. Then afterwards it declined while growing at -2.05%, -0.08%, -21.57% in 2011, 2012 and 2013 respectively. It jumped to 14.2% in 2017 but declined later to 13.16% and 0.63% in 2018 and 2019 respectively. The state of Uttar Pradesh has not seen an impressive growth rate in foreign tourist arrivals in the initial years since 2010. It jumped in 2014 and grew at 41.63%, however, it declined in later years It again in 2017 grew at a 12.7% rate higher than the EAG average and declined later. Its growth rate was reported at 25.51% in 2019, again it was higher than the EAG average.

Heritage-Religious Tourism in Uttar Pradesh

Uttar Pradesh is popular for many historical monuments such as the Taj Mahal, Fatehpur Sikri, Dhamek Stupa, Bada Imambara etc. and also religious and spiritual places such as Varanasi, Prayagraj, Ayodhya, Kushinagar, Vrindavan, Mathura and others. Agra is one of the most populous cities in Uttar Pradesh and a major tourist destination because of its many Mughal-era buildings, most notably the Taj Mahal (one of the Seven Wonders of the World), Agra Fort and Fatehpur Sikri. It is included in the Golden Triangle tourist circuit, along with Delhi and Jaipur. Lucknow is a multicultural city that flourished as a North Indian cultural and artistic hub,

and the seat of power of Nawabs in the 18th and 19th centuries. Shravasti, located near the West Rapti River, is closely associated with the life of Gautama Buddha who is believed to have spent 24 Chaturmases here. Kushinagar is an important Buddhist pilgrimage site, where it is believed that Gautama Buddha attained Parinirvana after his death. The followers of Buddhism, especially from Asian countries, wish to visit this place at least once in their lifetime. Of course, Varanasi or Kashi situated on the banks of the Ganges is a major religious hub in India. It is the holiest of the seven sacred cities (Sapta Puri) in Hinduism and Jainism and played an important role in the development of Buddhism. Vindhyanchal is a renowned religious city in Mirzapur District. The city is a Hindu pilgrimage site with the Vindhyavasini Devi temple situated on the banks of the holy river Ganga. It is one of the most revered Shakti Peeths of the presiding deity, Vindhyavasini Devi. There are also physical and natural scenic attractions including the Ganga, the Yamuna, Dudhwa National Park, Chandraprabha Wildlife Sanctuary and other places. Unique archaeological sites such as Sinauli and Sarnath are also located in the state. They all offer a plethora of options to tourists who visit the state and attract tourists of domestic and foreign origin as well.

Table-1 shows the domestic tourist arrivals pattern in Uttar Pradesh. The domestic tourism arrival has seen an increasing trend in Uttar Pradesh. In 2005, 95.44 million domestic tourists visited Uttar Pradesh which further increased to 144.75 million in 2010The number of domestic tourists kept growing and reached 204.88 million in 2015 and 535.85 million in 2019. The annual growth rate of domestic tourists has been an erratic trend. The annual growth rate of domestic tourists was 8% in 2005, which increased in the next few years but came to 7.36% in 2010. Since then, the annual growth rate gradually accelerated over the next few years and highest ever recorded in 2013. The lowest growth rate was in 2014 at -19.3%. It reached to 12.07% in 2015. Further, it declined and reached 3.33% in 2019. In terms of the share of the state in total domestic tourists in India, it has been remarkable from 2005 to 2010, later showing signs of declining share. It was reported 23.08% in year 2019. Foreign tourism in Uttar Pradesh witnessed a different trend. In 2005, some 1.17 million foreign tourists visited Uttar Pradesh. The number of foreign tourists visiting the state increased to 1.67 million in 2010 and further increased to 3.10 million in 2015. The number of foreign tourists increased to 4.74 million in 2019. The annual growth rate was recorded at 13.24% in 2005. The lowest growth rate was in 2009 being at -3.71%/. It jumped and reached at 9.67% in 2010. It has grown over the next few years, the highest being recorded in 2014, it came to

Table-1: Share of Domestic and Foreign Tourists of Uttar Pradesh in India

Years	Domestic Tourists (%)	Foreign Tourists (%)
2005	24.34	11.81
2006	22.82	11.31
2007	22.07	11.49
2008	22.17	11.2
2009	20.16	10.79
2010	19.36	9.67
2011	17.98	9.68
2012	16.11	10.92
2013	19.83	10.3
2014	14.25	13.03
2015	14.31	13.31
2016	13.11	12.77
2017	14.12	13.23
2018	15.38	13.1
2019	23.08	15.11
2020	14.11	12.42
2021	16.19	4.24
2022	18.37	7.56

Source: India Tourism Statistics, Ministry of Tourism, Govt. of India

6.68% in 2015. It again showed fluctuation in the next few years reaching 12.65% in 2016. It came down to 6.31% in 2018 and a sudden jump was recorded in 2019 where it grew to 25.51%. Whereas the share of the state in overall foreign tourists in the country is concerned, it has been somehow constant over the years since 2005 onwards and showed a declining trend in 2010 and 2011. It further maintained its course and gradually bounced back over the next years and had 15.11% in 2019. The COVID-19 pandemic and subsequent lockdowns impacted tourism in the country. The number of domestic tourists dropped to 86.12 million registering a sharp decline of -83.93% in 2020. Similarly, foreign tourists also dropped by -81.22% to 0.89 million in this. The tourism industry showed resilience and tourism started growing again in 2021 with an increase of 27.89% in 2021. Although,

due to air restrictions, foreign tourism dropped further by -94.98% in 2021. In the year 2022 they witnessed rapid growth in terms of both domestic and foreign tourism. In Uttar Pradesh, the tourist destinations are grouped into nine Regional Tourist Office (RTO) Zones. These RTO zones include Agra, Jhansi, Bareilly, Prayagraj, Varanasi, Lucknow, Meerut, Ayodhya and Gorakhpur. Thus, the trend of tourism in all RTO zones over the past few years has been analyzed. The percentage share of domestic tourists in various RTO zones of Uttar Pradesh. Here Agra zone received the highest number of domestic tourists in Uttar Pradesh. The percentage share of domestic tourists in the Agra RTO zone was 19.8% in 2013, which increased to 25.27% in 2014 and 29.55% in 2015. Afterwards, the zone has shown signs of decline having come down to 29.09%, 28.16%, 26.82% and 15.20% in 2016, 2017, 2018 and 2019 respectively. Agra zone is followed by Prayagraj RTO zone with a 37.7% share in 2013 in total domestic tourists in Uttar Pradesh. It declined to 20.08% in 2014 and remained almost the same at 20.08%, 19.9%, 19.3% and 17.3% in 2015,2015,2017 and 2018 respectively. It increased to 53.8% in 2019. The next zone which received a higher share of domestic tourists is Ayodhya followed by Meerut, Jhansi and then Varanasi zones. Fig. 1 depicts the percentage share of domestic tourists in various RTO zones of Uttar Pradesh. Here Agra zone received the highest number of domestic tourists in Uttar Pradesh. The percentage share of domestic tourists in the Agra RTO zone was 19.8% in 2013, which increased to 25.27% in 2014 and 29.55% in 2015. Afterwards, the zone has shown signs of decline having come down to 29.09%, 28.16%, 26.82% and 15.20% in 2016, 2017, 2018 and 2019 respectively. Agra zone is followed by Prayagraj RTO zone with a 37.7% share in 2013 in total domestic tourists in Uttar Pradesh. It declined to 20.08% in 2014 and remained almost the same at 20.08%, 19.9%, 19.3% and 17.3% in 2015,2015,2017 and 2018 respectively.

It increased to 53.8% in 2019. The next zone which received a higher share of domestic tourists is Ayodhya followed by Meerut, Jhansi and then Varanasi zones (Fig. 1). It is quite clear here that a major share of foreign tourists visited the Agra and Varanasi zones in Uttar Pradesh. This trend is followed by Prayagraj and others. In 2013, 48.4% of total foreign tourists visiting the state of Uttar Pradesh visited Agra. It further increased to 50.7% in 2014, and 53.04% in 2015. It declined to 51.16% in 2016 but again bounced back and increased to 53.63% in 2017. However, it declined later to 53.4% in 2018 and 43.21% in 2019. This zone was followed by Varanasi which had 20.77% foreign tourist's share in 2013. It further jumped to 23.38% in 2014. The share of Varanasi in total foreign tourists

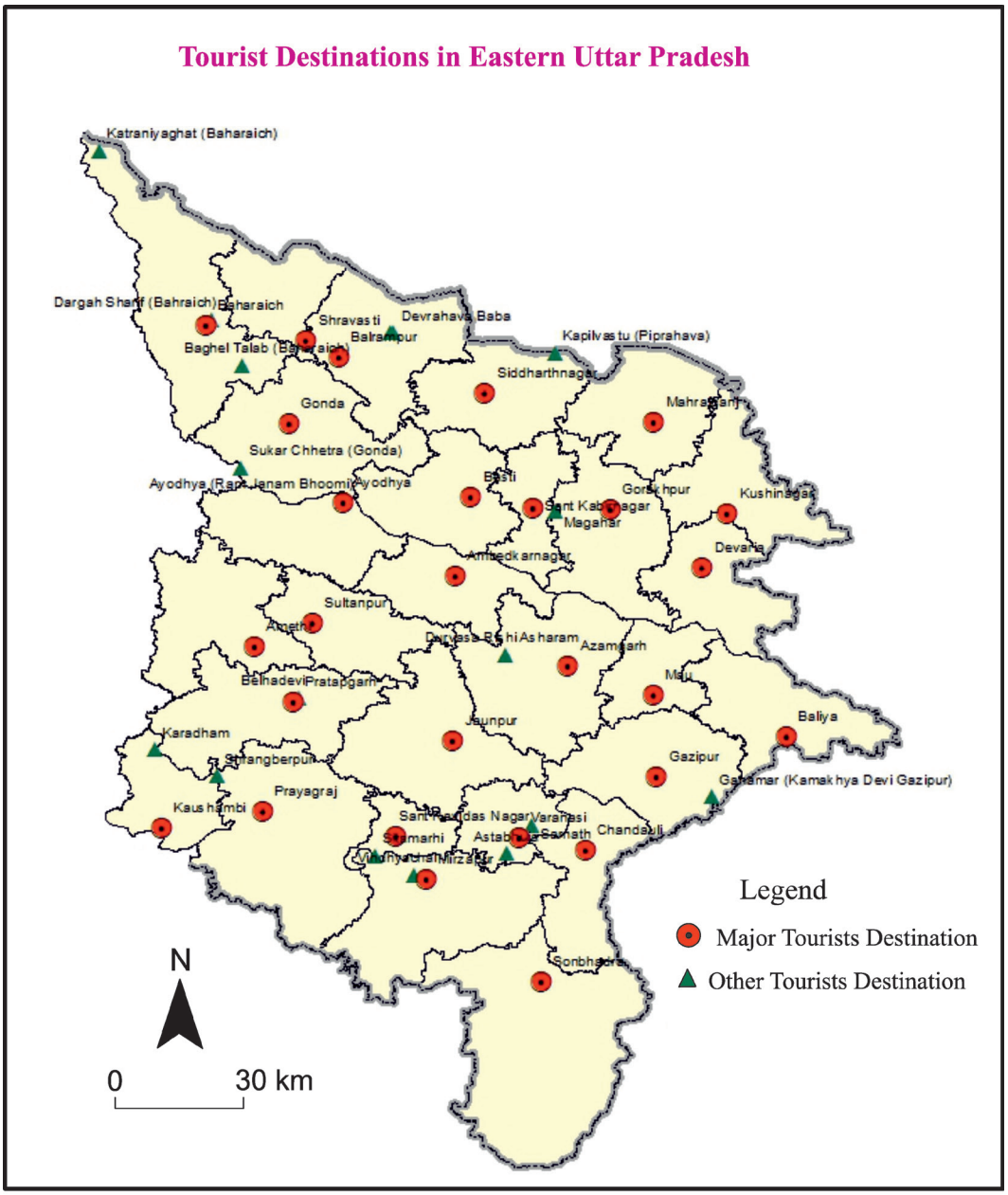

Tourist Destinations in Eastern Uttar Pradesh
Katraniyaghat (Baharaich)
Dargah Sharif (Bahraich)
Baharaich
Shravasti
Devrahava Baba
Balrampur
Baghel Talab (Baharaich)
Kapilvastu (Piprahava)
Siddharthnagar
Mahrajganj
Gonda
Sukar Chhetra (Gonda)
Ayodhya (Ram Janam Bhoomi)
Ayodhya
Basti
Gorakhpur
Kushinagar
Sant Kabir Nagar
Maghar
Devaria
Ambedkarnagar
Sultanpur
Amethi
Azamgarh
Belhadevi
Pratapgarh
Mau
Jaunpur
Baliya
Karadham
Shringerpur
Gazipur
Gahmar (Kamakhya Devi Gazipur)
Prayagraj
Kaushambi
Varanasi
Sitamarhi
Sarnath
Chandauli
Mirzapur
Legend
Major Tourists Destination
Other Tourists Destination
Sonbhadra
N
0
30 km

Fig. 1

visiting Uttar Pradesh remained at 22.84%, 23.45%, 22.06% and 21.30% in 2015, 2016, 2017 and 2018 respectively. Further, it declined by the year 2019. This zone is followed by Gorakhpur, Ayodhya, Jhansi, Prayagraj, Lucknow and the remaining zones. Prayagraj occupies a unique position in the tourist flow pattern in the state. Prayagraj zone received a higher share of foreign tourists in 2013, which was 12.6%. Afterwards, it slipped down more than fifty percent of this share reaching 4.1% in 2014, 4.19% in 2015, 4.1% in 2016, 3.7% in 2017 and 4.5% in 2018. However, with a congregation of Kumbh, the foreign tourist share shot up again and increased to 25.19% in 2019.

Growth Pattern of Tourism in Eastern Uttar Pradesh

The state of Uttar Pradesh has been divided into four sub-regions- Western Uttar Pradesh, Central Uttar Pradesh, Bundelkhand and Eastern Uttar Pradesh. The Eastern Uttar Pradesh sub-region is also known as 'Purvanchal'. The eastern portion comprises of Allahabad, Ambedkar Nagar, Amethi, Azamgarh, Ayodhya, Bahraich, Ballia, Balrampur, Basti, Chandauli, Deoria, Ghazipur, Gonda, Gorakhpur, Jaunpur, Kaushambi, Kushinagar, Maharajganj, Mau, Mirzapur, Pratapgarh, Sant Kabir Nagar, Sant Ravi Das Nagar, Shravasti, Siddharth Nagar, Sonbhadra, Sultanpur, and Varanasi. These RTO zones include Varanasi, Prayagraj, Gorakhpur and Ayodhya. At present, Eastern Uttar Pradesh has eight prominent tourist destinations where both domestic/local and foreign tourists visit to see and experience a blend of historical, cultural and heritage places. Here, Varanasi is believed to be the one of oldest cities- the ancient- of the world. Since her origin, the city has grown in the rich tradition of Hindufold. Now, it has a unique amalgamation of several religions such as Hinduism, Buddhism Jainism and other cultures. The city is famous for its region-cultural significance. The city is well known for the great Ganga Ghats (river fronts) and is known as the "City of Salvation". (Table-2)

The Lord Buddha gave his first sermon at Sarnath, a place located close to the city of Varanasi. The Ayodhya is located at the bank of river Sarayu and it is believed to be the birthplace of Lord Rama. The Prayagraj is considered as a holy city due to the confluence of sacred rivers such as Ganga, Yamuna and Saraswati. Gorakhpur is well known for the Gorakhnath Temple. Shravasti is believed to be where the Buddha taught many of his Suttas (sermons). Buddha attained his mahaparinirvana (salvation) in Kushinagar located in the region. Kaushambi is an important Buddhist tourist destination in Eastern Uttar Pradesh. Sant Kabir Nagar has a blend of natural, cultural and historical places to visit and attracts tourists. Table-2 shows the annual growth rate of tourists to the important tourist destinations

Table-2: Annual Growth Rate (%) of Tourist Destinations of Eastern Uttar Pradesh

Years	Varanasi	Ayodhya	Prayagraj	Gorakhpur	Shrawasti	Kushinagar	Kaushambi	Sant Kabir Nagar
2001	2.89	16.64	23.14	-0.7	-2.33	-2	32.61	6.25
2002	-0.85	-12.26	13.21	1.42	80.95	-17.69	1.64	5.88
2003	4.58	0.99	8.72	4.2	0	1.65	8.06	150
2004	5.02	0.04	12.27	28.86	14.47	0.81	10.45	53.33
2005	8.23	0.11	9.99	3.65	8.05	101.61	10.81	10.14
2006	5.1	6.02	7.17	718.09	82.98	110.8	8.54	68.42
2007	9.5	2.75	14.44	3.13	0.58	3.42	11.24	15.63
2008	5.88	2.38	18.11	14.06	8.67	3.3	10.1	4.73
2009	5.01	41.8	19.51	5.22	2.66	20.96	22.94	16.13
2010	6.63	20.23	6.84	6.7	-5.18	10.57	6.72	10.56
2011	8.12	20.63	3.91	2.14	10.93	2.92	4.2	12.06
2012	7.41	8.38	10.93	2.5	11.82	2.84	3.36	14.35
2013	3.75	8.12	143.07	1.78	-8.37	1.88	20.13	7.84
2014	4.53	0.68	-58.04	1.4	0.96	3.45	3.78	1.09
2015	4.14	7.46	14.83	1.12	1.9	4.05	7.81	2.88
2016	3.43	0.34	0.6	1.36	3.74	2.75	7.73	3.15
2017	6.34	13.35	1.5	2.52	16.22	4.34	873.54	-66.1
2018	2.5	9.51	7.02	14.38	338.76	4.27	0.23	11
2019	5.48	4.7	536.46	9.28	12.28	12.18	0	15.32
2019	67.97	201.49	2852.28	30.51	12.71	10.96	21.76	1.28
2020	-85.55	-70.11	-88.8	-	-	-	-76.24	-
2021	206.21	156.73	-64.89	-	-	-	11.03	-

Source: Statistical Abstract Uttar Pradesh, (Multiple Years) Economic and Statistics Division, State Planning Institute, Planning Department, Uttar Pradesh).

Note: Data is not available for a given destination is shown by symbol.

located in Eastern Uttar Pradesh. Some of these tourist places have witnessed the highest record of annual growth rates over the past two decades (Fig. 1). Ayodhya had an unusual growth, the highest ever, in 2009. Prayagraj recorded first highest annual growth rate (143.07%) in 203 and second highest (536.46%), ever recorded, recorded in 2019. Gorakhpur had a higher annual growth rate (718.09%) in 2006 after 2004 when it was 28.86%. Shravasti experienced the highest annual growth rate (338.76%) in 2018. Kushinagar had a high growth rate (873.54%) in 2017. Sant Kabir Nagar had a higher annual growth rate of tourists in the year 2006. These changes in some years are the result of many initiatives of state governments such as organizing fairs or other cultural and religious activities.

Development Policy, Planning and Recent Initiatives

Eastern Uttar Pradesh has seen a kind of revival of several historical, religious and heritage sites in the context of their religious and touristic importance in recent years. The political dynamics of the nation over the last few years have focused on that "destroying the existing structures is not the way but the emphasis should be on rejuvenation and preservation. This should be done in accordance with the requirements of modern times" (Kamal Sandesh, 2022). Primarily, Varanasi, Ayodhya, Prayagraj, Gorakhpur, Shravasti, Kushinagar, Kaushambi and Sant Kabir Nagar dominate the tourist landscape of the region. Efforts are being made towards several other places to be developed in the region. Of the many places, only a small number of places have been figuring in the tourist-destination profile of the state. There are many more places, found in almost every district, as identified by the Department of Tourism of Uttar Pradesh (see, Statistical Diary 2020, Annexure 24), where future tourism development can be directed in the eastern region. Initially, the state policy for tourism development is reflected in Uttar Pradesh's industrial policy. The two main objectives that came to light were: increasing employment in the region; and targeting high growth. In this context, there was a realization that the service sector must be promoted for the industrial and economic growth of the state. It was here that mention of imperatives for the preservation of the environment and cultural heritage as well as the need to promote specific geographic areas/corridors are highlighted (Uttar Pradesh Development Report, Vol.2, 2007).

A report on "20 Years Perspective Plans for Uttar Pradesh" by the Department of Tourism, Government of India (2002) highlighted the corollary objectives which focused on: i) promoting tourism development in harmony with local community involvement and employment, ii) protecting, preserve and conserve the monuments that a testimony to the past and are to be bequeathed to future generations; and

iii) to promote the highest possible standards of cleanliness, sanitation, and landscaping elegance. The report listed the following hubs of tourism in the state of Uttar Pradesh: Varanasi, Jhansi, Agra, Lucknow, and Greater Noida. The fact is that Uttar Pradesh has tremendous potential to attract both foreign and domestic tourists. The government of Uttar Pradesh has enacted Tourism Policy 2018 for the holistic development of tourism in the state. It aims to achieve the target "to become the most preferred tourist destination of the country by 2023" (Uttar Pradesh Tourism Policy 2018). This policy laid down six pillars to successfully achieve the targets of the policy: Strengthening Tourism Infrastructure; Promoting Investment and Employment Generation; Augmenting Brand Uttar Pradesh; Focus on Religious/Spiritual Tourism; Promoting Theme Based Tourism; and Sustainable Tourism through Community growth and upgradation of local skills.

The state has taken key steps to ensure better connectivity of districts and tourist places in the eastern region. Recently, Kushinagar International Airport has become operational, which will connect many countries especially South Asian and South East Asian countries where Buddhism is prominent. Now two international airports are functional in Eastern Uttar Pradesh in Varanasi and Kushinagar. Along with Taj Mahotsav at Agra, various events such as Rangotsav at Barsana, Dev Deepawali at Varanasi and Deepotsav at Ayodhya have contributed to transforming the state's image as an attractive tourist destination for both religious and leisure tourism. Religious and spiritual tourism contributes a prominent part of tourism in the state. Strengthening and upgradation of civic amenities, the establishment of shrine boards to manage religious places, creation of accommodation facilities has been the aims. The centrally launched schemes such as HRIDAY (Heritage City Development and Augmentation Yojana) under the Ministry of Urban Development, Government of India, and the objectives are heritage conservation, beautification, cleanliness, safety, accessibility and service delivery. Another scheme is the PRASAD (Pilgrimage Rejuvenation and Spiritual Augmentation Drive) scheme under the Ministry of Tourism, Government of India. It aims to integrate pilgrimage destinations in a prioritized, planned and sustainable manner to provide a complete religious tourism experience. There are two cities in Uttar Pradesh under these schemes: Mathura and Varanasi.

The former scheme focuses on infrastructure that preserves the heritage character, while the latter goes beyond this to include vocational training programmes and other things that make up the tourism ecosystem. The Kashi Vishwanath complex in the city of Varanasi has been undergoing an unprecedented transformation and

the site is being connected to the river Ganges. The project comprises of Shri Kashi Vishwanath Dham, Manikarnika Ghat and its Beatification. The operation of the project will provide value addition to the existing infrastructure, as due to the development of the project, the commercial facilities such as public transport, water supply, telecommunications, power lines, road maintenance etc. all to be upgraded. The growth of domestic tourism hugely depends on pilgrimage tourism. In Uttar Pradesh, heritage tourist circuits are being developed which would lead to holistic development of all the places sharing cultural or spiritual importance. Some of these tourist circuits in the state and the Eastern region are: i) the Buddhist Circuit connecting Kapilvastu, Kaushambi, Kushinagar, Sankisa, Sarnath, and Sravasti; ii) The Heritage Arch connecting Agra, Lucknow and Varanasi; iii) Braj Circuit connecting Agra, Vrindavan and Mathura; iv) Awadh Circuit connecting Lucknow, Devasharif, Naimisharanya, Ayodhya, Faizabad; v) Vindhya Varanasi Circuit connecting Varanasi, Chunar and Vindhyanchal; vi) Ramayana Circuit connecting Ayodhya with important places related with Lord Ram; vii) Bundelkhand Circuit connecting Bithoor, Chitrakoot, Jhansi, Kalinjar and Mahoba; viii) Mahabharat Circuit connecting Hastinapur, Kampilya, Barnava, Mathura and Gonds; ix) The Aadhyatmic Circuit connecting Gorakhpur, Balrampur, Ghazipur, Goriya and Sant Ravidas Nagar; and x) The Sufi/Kabir Circuit connecting Amethi, Maghar, Salim Chishti Dargah and Barabanki (see, Uttar Pradesh: A conglomeration of Culture, Religious and Heritage Tourism, FICCI-MRSS, 2018). Beautification of places has also been on the agenda of the government to promote tourism.

The new tourism policy also takes this into account and aims to promote theme-based tourism such as eco-tourism, agri-tourism, caravan tourism, adventure tourism, sports tourism, rural tourism, etc. In this way, the state aims to create a 'Brand Uttar Pradesh'. Uttar Pradesh is rich in handicrafts and handlooms. Gorakhpur's Terracotta, Varanasi's Silk, Bhadohi's Carpet, Agra's Zardoji, Khurja's Pottery, Firozabad's bangles, etc. have global demand and repute. The 'Hunar Se Rojgar' scheme of the Government of India and the 'One District One Product' initiative of the Uttar Pradesh government a medium to promote crafts and handloom in the tourism sector. The new Tourism Policy advances the idea of 'Weekend Tourism', under which potential tourist spots have been identified, where people living in and around the area can visit the place. These tourist sites can also act as major tourist attractions for foreign tourists. These weekend tourist spots have only been identified for a few districts. It is essential to identify such places in all the districts of Uttar Pradesh and connect these locations with major tourist

destinations. The Pro-Poor Tourism Growth Project of Uttar Pradesh is projected to offer far-reaching social, economic and environmental benefits at local and regional levels. The project aims to meet the expectations of both low and high-spending domestic and foreign tourists visiting each such destination by enhancing their overall experience. (Table-3)

Table-3: Features of Drivers-Pressures-State-Impacts-Responses Framework

Elements	Major Features
Drivers	Tourist attendance, urban traffic, hospitality structures, urbanization, status of environment etc.
Pressures	Air quality, production of urban solid waste, use of land, presence of tourists in protected areas etc.
State	The concentration of pollutants in the air, change of land use, state of the local host community tourist satisfaction etc.
Impacts	Adverse impact on heritage structures, local host community, profile of tourism industry etc.
Response	Awareness about sustainable tourism activities, promoting eco-friendly transport, promoting eco-tourism activities etc.

Source: EEA 1998: Guidelines for Data Collection and Processing, EU State of Environment Report

Emerging Challenges and Prospect of Sustainable Tourism

There are many grey areas which need to be identified and improved for the holistic development of tourism in the state. The major challenge is still the connectivity issue and availability of transport networks. The tourist concentration is only in a few districts and geographical regions of the state, other tourist places remain the least connected. The dedicated heritage or tourist corridors can also be made to cater for the specific needs of tourists and provide a seamless experience. The important tourist sports need to be connected by other important but now so well-known tourist spots of the state. Heritage tourism is usually promoted around tangible heritage and monumental sites. Though monument protection and conservation are important, the promotion and protection of intangible heritage such as folk art, dance and music forms, traditions and customs are equally important. Special attention should be paid towards intangible heritage also because if they are not supported, they may not be passed on to coming generations.

The intangible heritage is a unique feature of the place and can act as a major tourist attraction. Skill upgradation of people involved in the formal hospitality sector should be done periodically. The government can provide subsidies and incentives for opening accommodation facilities at tourist places. The government has planned to convert heritage buildings into hotels. This can also help to attract tourists but while doing this, the conservation of these heritage buildings must be assured. Uttar Pradesh is rich in water resources. The rivers can be used to promote tourism by promoting water transport. State Waterways can be developed on the theme of National Waterways. Identifying the opportunity and feasibility of water-based adventure sports and their promotion can help boost tourism in the region (Table-3). The feasibility of connecting various cities located at the bank of rivers by river cruise service should be analyzed. These steps can help to strengthen the position of Uttar Pradesh in the tourism sector (Jaiswal, 2021). To make tourism more sustainable and integrated in Uttar Pradesh, the DPSIR framework (European Environment Agency, 1999) can play an important and strategic part in tourism development and management. The tourism industry thrives on the kind of environmental, ecological and social-cultural conditions present at tourist destinations. Thus, an assessment of physical, accommodation, environmental and economic carrying capacity is inevitable for further planning of tourist destinations.

Conclusion

Study shows that tourism in India is growing in the terms of arrival of domestic and foreign tourists. The growth rate pattern indicates an erratic fluctuation in the country and state of Uttar Pradesh as well. Tourism and its growth rate in Empowered Action Group (EAG) states are relatively promising and at certain times it is found higher as compared to that of the country. This indicates the fact these states have immense opportunities in the tourism sector. Among them all, the state of Uttar Pradesh offers a hybrid experience to tourists. However, a few tourist destinations and places dominate the tourism flow in the state. Only a few places in the Eastern part of Uttar Pradesh have a cultural, historical, and heritage edge in tourism over the other places. Only a few of them are hubs for religious and spiritual tourism and attract a significant number of domestic and foreign tourist arrivals in the country and state. There is a need to work in the direction of making a shift from the conventional tourism development approach towards more inclusive tourism development in the state. This will create more economic opportunities in tourism in

the state and eastern region. For comprehensive planning for tourism development, there are certain factors such as a sense of security, affordable accommodation, better connectivity perception building etc. should be given place in further tourism development planning.

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SPATIAL ANALYSIS OF REGIONAL DISPARITY IN INDIA BASED ON NSSO 78TH ROUND DATA ON MULTIPLE INDICATORS OF DEVELOPMENT

Dr. Chhering Tandup and Sheezan Khursheed Kichloo

Abstract

Understanding regional disparities is crucial for addressing social and environmental factors that contribute to inequality and poverty. The study aims to analyze regional disparities in India using secondary data from the 78th round of the National Sample Survey (NSS) Multiple Indicator Survey (MIS) conducted in 2020–2021. The study has focused on state-wise disparities across multiple indicators as well as comparing disparities in urban and rural areas. The coefficient of correlation matrix has been used to determine the relationship between different socio-economic development indicators in both rural and urban areas. The Kandell Ranking Coefficient Method is also used to identify high-, medium-, and low-developed states or union territories based on socio-economic development indicators. GIS mapping and spatial analysis have been utilized to visualize and investigate regional disparities in India through a mixed-method approach.

Introduction

India is a country with vast diversities in terms of geography, culture, and economic development. Regional disparities refer to the differences in economic growth, social development, infrastructure, and living standards in different regions of the country. These disparities arise due to various factors, such as historical legacies, natural resource distributions, government policies, and infrastructure. The regional disparities in India are pronounced and can be seen in various aspects. Firstly, there are significant variations in economic growth and development between regions. States like Maharashtra, Tamil Nadu, Gujarat, and Karnataka have seen significant economic growth, while many states in the eastern and northeastern regions are still struggling with poverty and underdevelopment. Secondly, there are differences in social development indicators such as education, health, and gender equality. Southern states like Kerala and Tamil Nadu have high literacy rates and

good health indicators, while many states in North India have poor literacy rates and health indicators. Thirdly, there are also infrastructure disparities between regions. Cities like Delhi, Mumbai, and Bangalore have modern infrastructure and good connectivity, while smaller cities and towns in rural areas lack basic infrastructure like roads, electricity, and water supply. The reasons for regional disparities can be attributed to various factors. One of the major factor is the historic legacy of colonialism, which led to the concentration of economic and administrative power in certain regions. Additionally, natural resources like minerals and fertile land are unevenly distributed across the country, leading to disparities in economic growth. Sastry and Tripathi (2013) argue that MIS is an essential tool for data collection and analysis in the field of health research. Seneviratne, S. I., & Wickramasinghe, R. (2018). Regional disparities in Sri Lanka: A multidimensional perspective. Journal of Development Studies, 54(1), 1–16. This study uses MIS to analyze regional disparities in Sri Lanka across various dimensions, including economic, social, and environmental indicators. The authors highlight the importance of addressing social and environmental factors in reducing regional disparities. Kabeer, N., & Mahmud, S. (2019).

Study Region

India is surrounded by Bay of Bengal in the east, the Arabian Sea in the west, and the Indian Ocean to the south. Lying entirely in the Northern Hemisphere, the Country extends between 8° 4' and 37° 6' latitudes north of the Equator, and 68° 7' and 97° 25' longitudes east of it India is a vast and diverse country with a population of over 1.3 billion people. The country is located in the Indian subcontinent and is bordered by Pakistan, China, Nepal, Bhutan, Bangladesh, and Myanmar. The study region of India is vast and includes various geographical regions such as the Himalayas in the north, the Gangetic Plain in the north and northeast, the Deccan Plateau in the center, and the coastal regions in the south, east, and west. The climate varies significantly across these regions, with extreme temperatures and weather conditions in some areas. The economy of India is rapidly growing and is the fifth-largest economy in the world by nominal GDP and the third-largest by purchasing power parity (PPP). The country has a diverse mix of industries, including agriculture, manufacturing, services, and technology. The study region of India is significant due to its large population, rapid economic growth, and diverse geography, making it an important area for research in various fields such as economics, geography, politics, and culture.

Objectives

To examine regional disparities and analyze state and UT wise level of development in India based on NSSO 78th round data on multi-indicator basis at the rural and urban level for 2020-2021.

Database and Methodology

The present study relies solely on secondary data. In this dissertation, the secondary source of data was acquired from the 78th round of the National Sample Survey (NSS) Multiple Indicator Survey, which was conducted during the period of 2020–2021. The data included a wide range of variables and indicators related to socio-economic factors such as income, education, employment, health, etc. The main indicators are access to piped water, access to improved sources of drinking water, access to latrine, clean fuel as the primary source of cooking, heating, and lighting, the percentage of rural households reporting the availability of all-weather roads within 2 km from their place of residence, public transport facilities within 500 m from their place of residence, access to bank accounts, financial institutions, or mobile money services, and access to mass media. Indicators were categorized into rural and urban areas to compare disparities in different environments. The technique of analysis of the coefficient of correlation matrix has been used to determine the relationship between different socio-economic development indicators in both rural and urban areas. This technique has been used as a tool for quantifying the relationship between variables and has been an important part of the methodology used in this study. The Kandell Ranking Coefficient Method was used to identify high-, medium-, and low-developed states or union territories based on socio-economic development indicators. ArcGIS 10.8 software was utilized to create maps and visualize data, while MS Excel was used for charting and analysis.

Results and Discussion

Table-1 provides data on the percentage of rural and urban persons having access to an improved source of drinking water for each state or UT of India. The data highlights the regional disparity between rural and urban areas among different states and UTs in terms of access to clean and safe drinking water.

Rural Areas

The percentage of rural households with access to an improved source of drinking water ranges from as low as 54.4% in Kerala to as high as 99.3% in Uttar Pradesh. States like Kerala, Manipur, Nagaland, and Jharkhand have relatively low

percentages, indicating limited access to safe and clean drinking water in rural areas. States like Uttar Pradesh, Bihar, and Haryana have high percentages, indicating better access to clean drinking water in rural areas. (Fig 1)

Urban Areas

The percentage of urban households with access to an improved source of drinking water ranges from 55.9% in Kerala to 100% in many states and UTs such as Delhi, Chandigarh, Daman & Diu, and Lakshadweep. Urban areas generally have a higher percentage of households with access to improved sources of drinking water compared to rural areas. States like Kerala and Tamil Nadu have relatively low percentages in terms of urban access to clean drinking water, indicating a need to improve access in urban areas. Overall, the data demonstrates a significant disparity in access to clean and safe drinking water between rural and urban areas in different states and UTs of India. While some states have achieved relatively high percentages of access to clean drinking water, many states and UTs still face significant challenges in this regard. (Fig. 1)

Table-1: Percentage of Rural Access for Rural and Urban Population and Improved Source of Drinking Water

State/UT	Rural	Urban	All
Andhra Pradesh	96.8	99.2	97.5
Arunachal Pradesh	97.9	100.0	98.3
Assam	90.8	97.8	91.6
Bihar	99.2	99.9	99.3
Chhattisgarh	94.8	99.8	96.0
Delhi	100.0	100.0	100.0
Goa	99.6	100.0	99.8
Gujarat	94.8	100.0	98.0
Haryana	100.0	99.8	99.9
Himachal Pradesh	98.0	99.8	98.2
Jharkhand	86.5	97.2	88.8
Karnataka	95.6	98.3	96.6
Kerala	54.4	55.9	55.2
Madhya Pradesh	88.4	99.5	91.4

Contd...

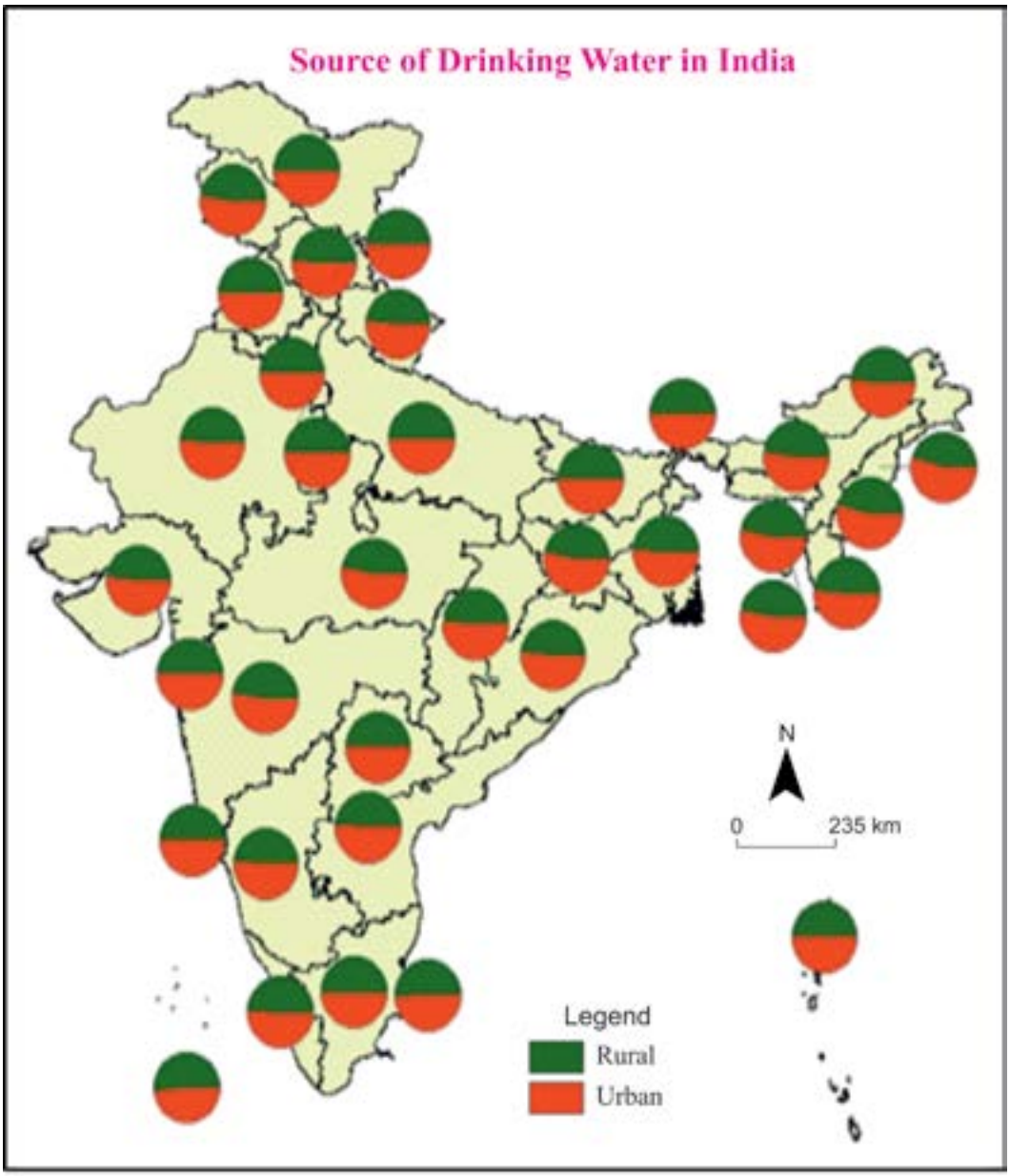

Source of Drinking Water in India
N
0
235 km
Legend
Rural
Urban

Fig. 1

Maharashtra	92.7	99.9	95.6
Manipur	72.4	82.5	75.6
Megahlaya	88.2	99.4	90.0
Mizoram	94.5	99.0	96.5
Nagaland	81.0	96.3	85.3
Odisha	91.8	98.4	92.8
Punjab	100.0	99.8	99.9
Rajasthan	93.7	98.5	94.8
Sikkim	98.5	100.0	98.9
Tamil Nadu	99.7	99.6	99.6
Telengana	98.3	99.7	98.9
Tripura	89.6	99.3	91.7
Uttarakhand	95.1	100.0	96.3
Uttar Pradesh	99.3	99.8	99.4
West Bengal	98.4	99.3	98.7
A & N Islands	98.1	99.7	98.7
Chandigarh		100.0	100.0
Dadra & Nagar Haveli and Daman & Diu	99.6	100.0	99.8
Jammu & Kashmir	92.5	99.7	94.1
Ladakh	99.8	100.0	99.8
Lakshadweep	76.5	72.8	73.8
Puducherry	100.0	98.7	99.2
All-India	95.0	97.2	95.7

Sources: NSS Report No. 589(78th Round 2020-2021): Multiple Indicator Survey in India

Sanitation Facility

The data highlights significant regional disparities in terms of access to sanitation facilities across different states and UTs.

Rural Areas

The percentage of rural households reporting access to a latrine ranges from as low as 58.7% in Jharkhand to 100% in Kerala, Manipur, Mizoram, and Nagaland.

States like Bihar, Odisha, and Rajasthan have a relatively low percentage of rural households with access to a latrine, reflecting inadequate sanitation facilities in these areas. States like Arunachal Pradesh, Assam, Himachal Pradesh, and Sikkim have relatively high percentages of rural households with access to a latrine, indicating better access to sanitation facilities in these areas. The all-India percentage of rural households reporting access to latrines is 78.7%.

Urban Areas

The percentage of urban households reporting access to a latrine range from 91.9% in Jharkhand to 100% in many states and UTs such as Arunachal Pradesh, Mizoram, Nagaland, and Sikkim. Urban areas generally have a higher percentage of households with access to a latrine than rural areas, reflecting better sanitation facilities in urban areas. Some states, such as Odisha and Tamil Nadu, have relatively low percentages of urban households with access to a latrine, indicating a need to improve access to sanitation facilities in these areas. The all-India percentage of urban households reporting access to latrines is 97.1%. Overall, the data shows that there are significant regional disparities in terms of access to sanitation facilities in India, particularly in rural areas. A lower percentage of rural households have access to a latrine compared to urban households.

Use of Clean Fuel

The national average for households using clean fuel as a primary source of energy is 16.4% in rural areas and 75.9% in urban areas. There is a wide variation in the percentage of households using clean fuel across different states and union territories. For instance, in Delhi, 91.4% of rural households and 82.6% of urban households use clean fuel. On the other hand, in Nagaland, only 0.8% of rural households and 24% of urban households use clean fuel. States and union territories with higher urbanization levels generally have higher percentages of households using clean fuel, with the exception of Mizoram, where 80.9% of rural households use clean fuel, compared to 13.9% of urban households. Puducherry has the highest percentage of urban households using clean fuel at 93.5%, and Sikkim has the highest percentage of rural households using clean fuel at 25.6%. Jharkhand has the lowest percentage of rural households using clean fuel, at only 3.8%. Overall, the data suggests that there is a significant disparity in access to clean fuel across various parts of India, with rural areas and some states having much lower usage rates.

Facilities for Connectivity

Overall, 92.5% of rural households in India have access to all-weather roads within 2 km from their place of living, while 89.6% of rural households have access to public transport facilities within 500 m from their place of living. There is a lot of variation in the availability of these facilities across different states and union territories. For instance, in Chandigarh, 100% of rural households have access to all-weather roads, and 99.5% have access to public transport within 500 m from their place of residence. On the other hand, in Meghalaya, only 64.7% of rural households have access to all-weather roads, and 82.6% have access to public transport facilities. States with higher levels of development and urbanization, such as Delhi, Goa, and Kerala, have higher percentages of rural households reporting the availability of these facilities. Surprisingly, some states with a lower level of urbanization, such as Manipur and Mizoram, also have high percentages of rural households reporting the availability of all-weather roads and public transport. In general, the data suggests that there is a significant disparity in the availability of facilities like all-weather roads and public transport across various parts of India, with some states and union territories having much better access than others.

Financial Institutions

Goa has the highest percentage of individuals with an account in both rural (97.9%) and urban (97.3%) areas. Nagaland has the lowest percentage of financial services in rural areas (66.5%), while Meghalaya has the lowest percentage in urban areas (79.5%). There are some States and Union Territories where the percentage of individuals with an account is higher in rural areas than in urban areas, such as Andhra Pradesh, Chhattisgarh, Himachal Pradesh, Jharkhand, Karnataka, Odisha, Rajasthan, Tripura, and Uttarakhand. On the other hand, there are some states and union territories where the percentage of individuals with an account is higher in urban areas than in rural areas, such as Assam, Gujarat, Telangana, and Uttar Pradesh. Overall, this table provides insights into access to financial services across different areas of India, highlighting the differences in account ownership between rural and urban areas and across different regions. Overall, the table highlights the disparities in access to mass media in different parts of India and can be a useful tool for policymakers and development practitioners to identify areas where interventions may be needed to improve access and reduce inequalities.

Coefficient of the Correlation Matrix of Indicators

The coefficient of correlation matrix has been analyzed to find out the relationship among various parameters of socio-economic development indicators in both rural and urban areas. It can be inferred from the coefficient correlation matrix in Figure 2 that access to piped water is positively correlated with access to improved sources of drinking water in both rural and urban areas, and the values lie at 0.88. It is very significant and highly correlated. It is natural that more access to pipe water will provide more sources of drinking water. Similarly, access to latrines is positively correlated with access to improved sources of drinking water; the value is 0.77, which highlights the importance of basic sanitation facilities for maintaining good health. However, access to a latrine is negatively correlated with all other indicators, which suggests that people who lack access to latrines tend to have worse socio-economic indicators overall. This highlights the importance of investing in basic sanitation facilities, particularly in rural areas where access may be limited. Access to clean fuel is positively correlated with access to improved sources of drinking water, which suggests that people who have access to clean fuel may also have access to other basic amenities. However, the correlation between clean fuel usage and other indicators is mixed, with positive correlations in some cases (e.g., access to improved sources of drinking water) and negative correlations in others (e.g., not in education, employment, or training).

The percentage of people who are not in education, employment, or training is negatively correlated with most indicators, particularly in rural areas. This indicates that people who are NEET tend to have worse socio-economic indicators overall and may require additional support to improve their standard of living. Access to facilities like roads and public transport is positively correlated with other socio-economic indicators in both rural and urban areas. Particularly, people who have access to transportation facilities may be more likely to have access to other amenities such as schools and markets (Table-2). The distribution of people with bank accounts is positively correlated with most other indicators in both rural and urban areas. This highlights the importance of financial inclusion in improving people's socio-economic status. Overall, this correlation matrix provides valuable insights into the relationship between various socio-economic indicators in both rural and urban areas. It may be useful for policymakers and development practitioners to identify areas for intervention and target resources towards improving access to basic amenities and promoting financial inclusion and education for all.

Table-2: Ranks of Selected Development Indicators for States/UT of India and Ranking Co-efficient according to Kendell's Method

State/UT	Access to piped water	Access to improved source of drinking water	Access to latrine	Clean fuel as primary source of cooking, heating and lighting	NEET	Percentage of rural households reporting availability of all-weather roads within 2 km from the place of living	Public transport facility within 500 m from place of living	Bank account	Access to mass media	Ranking Coefficient (Composite score)	Level of Development
	R1	R2	R3	R4	R5	R6	R7	R8	R9		
Andhra Pradesh	23	19	28	19	14	23	8	10	18	162	Low deloped
Arunachal Pradesh	13	16	1	33	35	35	12	25	28	198	Low developed
Assam	35	29	14	31	4	29	16	31	31	220	Least developed
Bihar	32	10	34	27	8	20	26	27	34	218	Least developed
Chhattisgarh	27	23	23	32	23	33	35	14	26	236	Least developed
Delhi	5	1	11	2	13	4	32	24	14	116	Medium developed

Contd...

Goa	3	5	12	3	19	12	26	2	3	85	Highly developed
Gujarat	8	18	29	18	8	31	28	33	23	196	Low developed
Haryana	14	3	16	9	15	19	34	30	17	157	Low developed
Himachal Pradesh	4	17	15	28	27	17	7	4	4	123	Medium developed
Jharkhand	34	32	36	30	18	32	33	25	35	275	Least developed
Karnataka	17	20	27	17	28	30	22	5	12	178	Low developed
Kerala	26	36	4	15	17	8	19	15	5	145	Low developed
Madhya Pradesh	24	30	33	25	12	22	24	20	30	220	Least developed
Maharashtra	10	24	25	11	24	18	23	22	19	176	Low developed
Manipur	21	34	4	35	33	15	3	34	10	189	Low developed
Meghalaya	29	31	13	34	30	36	31	35	21	260	Least developed
Mizoram	16	21	1	14	36	10	4	32	12	146	Low developed
Nagaland	25	33	10	36	34	26	11	36	24	235	Least developed
Odisha	31	27	35	24	3	25	21	17	32	215	Least developed
Punjab	9	3	18	7	10	8	18	28	8	109	Medium developed
Rajasthan	19	25	32	25	20	21	29	12	29	212	Least developed
Sikkim	7	12	4	13	21	24	36	19	7	143	Low developed
Tamil Nadu	22	8	30	10	16	11	17	11	6	131	Low developed

Contd...

Telangana	11	12	20	7	11	28	8	20	16	133	Low developed
Tripura	28	28	4	22	25	14	6	9	25	161	Low developed
Uttarakhand	18	22	16	21	7	34	25	23	20	186	Low developed
Uttar Pradesh	33	9	31	29	6	16	20	28	33	205	Least developed
West Bengal	30	14	26	20	5	13	8	18	27	161	Low developed
A & N Islands	6	14	19	5	2	7	2	1	11	67	Highly developed
Chandigarh	1	1	4	1	29	1	1	6	2	46	Highly developed
Dadra & Nagar Haveli and Daman & Diu	20	5	21	6	31	6	12	7	22	130	Low developed
Jammu & Kashmir	15	26	24	23	26	5	12	16	N/A	147	Low developed
Ladakh	12	5	4	16	32	27	4	13	15	128	Medium developed
Lakshadweep	36	35	1	12	1	3	15	8	1	112	Medium developed
Puducherry	2	11	22	4	21	2	30	3	9	104	Medium developed

Sources: NSS Report No. 589 (78th Round 2020-2021): Multiple Indicator Survey in India

Level of Development

It is one of the simplest and quickest methods of computing composite score involving multivariate data with different units of measurement. Kendall (1939) used this technique for finding out agricultural efficiency in England and Wales using productivity data of different crops. The composite score, called ranking coefficient, in this case is found out for each spatial unit by simply adding the corresponding rank values of all the indicators. Table-2 provides information on various development indicators for different States and Union Territories (UTs) in India. These indicators include Access to Piped Water, Access to Improved

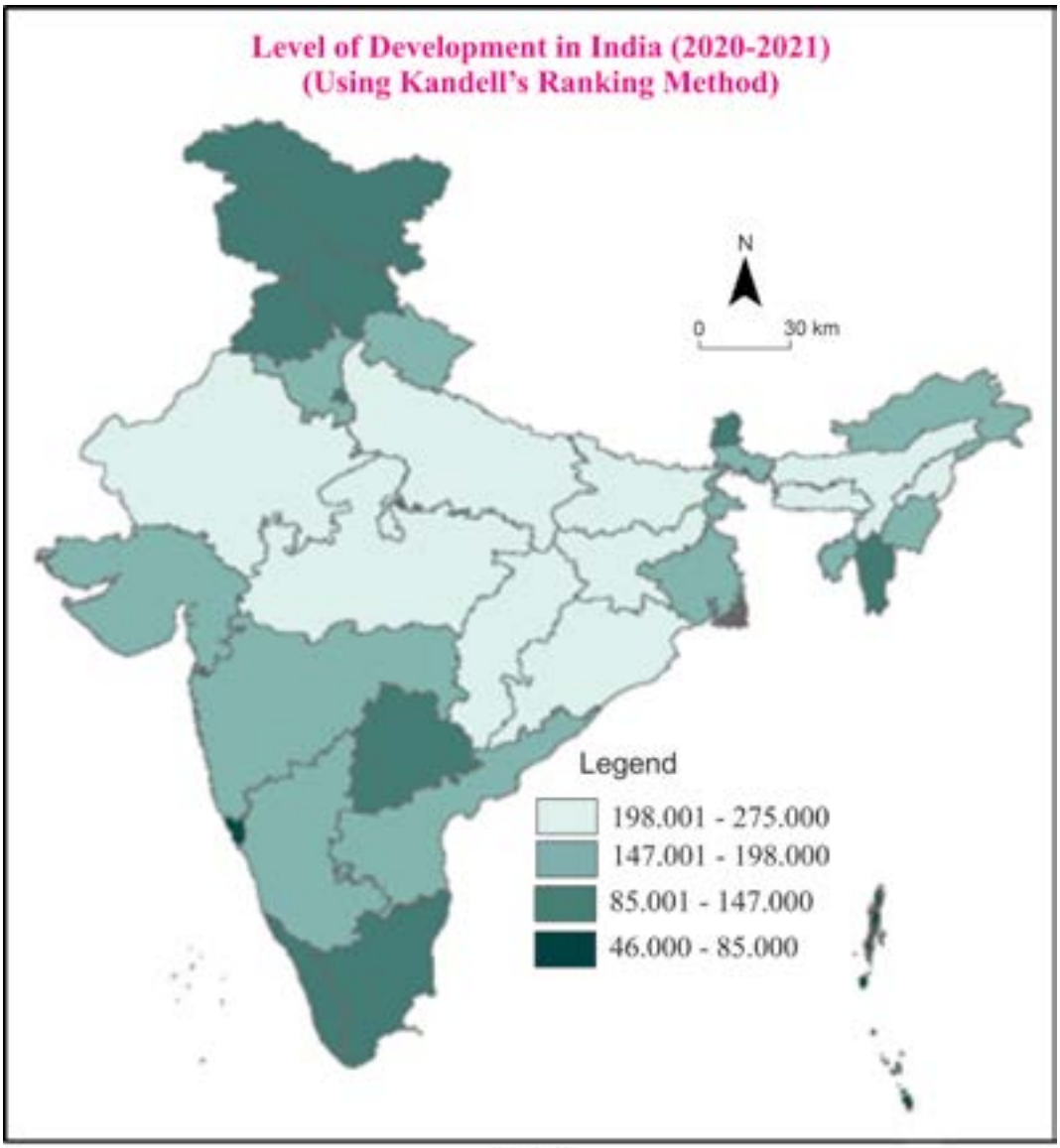

Level of Development in India (2020-2021)
(Using Kandell's Ranking Method)
N
0
30 km
Legend
198.001 - 275.000
147.001 - 198.000
85.001 - 147.000
46.000 - 85.000

Fig. 2

Source of Drinking Water, Access to Latrine, Clean Fuel as Primary Source of Cooking, Heating and Lighting, NEET, Percentage of Rural Households Reporting Availability of All-Weather Roads within 2 km from the place of living, Public Transport Facility within 500 m from Place of Living, Bank Account Access, and Access to Mass Media. In Andhra Pradesh, the state ranks 23rd in terms of access to piped water, while it ranks 19th in terms of access to improved source of drinking water. In addition, it ranks 8th in terms of having access to a public transport facility within 500 m from the place of living and 18th in terms of having access to a bank account.

The best ranking for any development indicator is found in Chandigarh, which ranks 1st in access to piped water, improved source of drinking water, latrine, and bank account access. The worst ranking for any development indicator is found in Arunachal Pradesh, which ranks 36th in access to clean fuel as a primary source of cooking, heating, and lighting and in Nagaland, which ranks 36th in access to latrine. Now, the Composite Score Value is calculated for each State/UT by adding up their rank values for each of the indicators. The State/UT with the highest composite score value is considered to be the least developed, while the State/UT with the lowest composite score value is considered to be the most developed. For example, the State/UT with the highest composite score value is Meghalaya with a score of 260, indicating that it is the least developed in terms of the indicators we have considered. On the other hand, Chandigarh has the lowest composite score value of 46, indicating that it is the most developed. Other states/UTs can also be ranked based on their composite score value; for instance, Jharkhand has a score of 275, which is the second highest, followed by Nagaland with a score of 235, and Chhattisgarh with a score of 236. Table-2 also showing the level of development of various States/UTs in India based on their composite score.

The States/UTs are categorized into four categories i.e highly, medium, least and low level of development (Fig. 2). The States/UTs with the highest composite score are Jharkhand, Meghalaya, Nagaland, Chhattisgarh, Bihar, and Odisha and are categorized as Least Developed. On the other hand, the States/UTs with the lowest composite score are Chandigarh, Puducherry, A&N Islands, Delhi, Ladakh, Goa, Lakshadweep, and Punjab and are categorized as Highly Developed. The other States/UTs with composite scores between the highest and lowest are categorized as Low and Medium Developed. The table gives an overview of the current state of development in different areas of the country and provides useful information for policymakers to identify areas for further development.

Conclusion

Based on the data presented in the tables, maps, and figures, it is evident that there are significant regional disparities in India, particularly in terms of access to basic necessities such as water, sanitation, education, and financial services. Rural areas tend to lag behind urban areas in terms of access to these necessities, with lower percentages of rural households having access to piped water, all-weather roads, public transport, bank accounts, and mass media. Similarly, rural areas have higher percentages of people not in education, employment, or training (NEET) compared to urban areas. These disparities are particularly pronounced in states such as Assam, Bihar, Jharkhand, Odisha, and Uttar Pradesh, which report lower levels of access to basic necessities across various indicators. It is therefore imperative for policymakers to prioritize and invest in improving access to basic necessities in rural areas, especially in states with high levels of regional disparities. This may involve providing infrastructure such as all-weather roads and public transport, promoting education and employment opportunities, improving access to financial services, and ensuring access to clean water and sanitation. Addressing these regional disparities can contribute to inclusive and sustainable development in India. In addition to regional disparities, the data in the tables also highlights other important issues. For example, the low percentage of households using clean fuel as a primary source of energy for cooking, lighting, and heating is a cause for concern, as this can have negative impacts on air quality and health. Similarly, the percentage of households reporting access to latrines by the majority of household members is relatively low in some states, highlighting the need for greater investment in sanitation facilities. Overall, the tables provide a useful overview of the various challenges and opportunities facing India. Addressing regional disparities and promoting greater access to basic necessities and financial services can contribute to inclusive and sustainable growth, improve the quality of life, and promote greater social and economic inclusion for all citizens.

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A GEOGRAPHICAL ANALYSIS OF TRIBAL EDUCATION IN JHARKHAND

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Abstract

Although the rate of literacy among the tribal population is only 59.1% in India, it is lower than the national average of 74.4% (Census 2011). Education is one of the main forces behind a society's transformation. The literacy rate of Jharkhand's tribal population (57.1%) is still lower than the country as a whole, which is 59 percent (Census 2011) of India's tribal population. Upon reviewing a variety of literature, it has been found that factors such as cultural customs, poverty, the absence of educational institutions in rural areas, the medium of instructions, parental education, and school location all significantly contribute to the low enrolments of tribal students. According to the 2011 Census, in Jharkhand, 20.4% of the tribal population 46.4% of male and 53.6% of Female (6-15 age group) had never attended an educational institution. The objective of the study is to address the factors preventing tribal children from access to education and also to know the percentage who never attended educational institutions in Jharkhand. Coefficient correlation method is used to analysis the factors which is affecting the educational attainment of a tribal children. The present paper is mostly based on secondary data from various research studies including census data, Annual reports of tribal welfare ministry, Districts report card 2011, Jharkhand economic survey 2021, UDISE-2011.

Introduction

Education for the tribal population in India has been challenged due to historical marginalization and geographical isolation. (Brahmanandam T & Bosu T.2016:70). Education plays a significant role in overall development of an individual in a holistic way. Tribal people often called as Adivasi, Aboriginal, Indigenous people, first nation, Hunter-gatherers are the original inhabitants of a particular region or a country. (Michael A. Peters & Carl T. Mika 2017:1). The term ‘Adivasi', is used in the Indian context which is refer to as the tribal community (Xaxa, V. 1999:1).

There is significant percentage of tribal population in India, which contribute about 8.6 per cent population. Tribal population's literacy rate (58.96%) which is 14% lower than the national average (72.99%). The female literacy rate of India is 64.6% while the ST female literacy rate is only 46.4% (Census 2011). But however tribal population's literacy rate increased significantly from 8.53 percent in 1961 to 58.96 percent in 2011. In India, the total dropout ratio (DoR) of the tribal population of India (class I-VIII) stood at 69 % in 2001, but it subsequently decreased to 55% in 2011. (Educational Statistics at A Glance, 2012). The most common causes of school dropouts among tribal children in primary school are identified as household work, lack of parental guidance in studies, family socioeconomic status, school discipline (Soren, D. 2010:1). In term of education, health and economy concern tribal communities are still deprived as compared to general population. (Z. A. Bhat and M. A. Khan 2021 :659). More than 20–30% of India's tribal population, aged 6 to 15, has never attended school in the states of Madhya Pradesh, Himachal Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Uttar Pradesh. (census of India 2011). In the year, 2007-08, Five states namely Rajasthan, Jharkhand, Odisha, Chhattisgarh, and Madhya Pradesh together accounted 48 percent of STs in India but together accounted for 55 per cent of illiterate among STs (India human development report 2011:184). In Jharkhand, 20.4 per cent of the tribal population (age group 6-15) has never attended school in which 46.4 per cent are male and 53.6 per cent are female. Factors such as household income, caste, location, gender, and the level of education of the head of the household can significantly influence a parent's decision to send their child to preschool (Choudhury, P.K., Joshi, R. & Kumar,2021: 21). Tribal representation is very low in the nation's human development index and high in the human poverty index when compared to other social groups. (Patil, R. R. 2020:1).

To ensure the overall development and integration of tribal population into the mainstream of the society, it is necessary to educate them which directly contribute economic upliftment, empowerment, cultural preservation, social inclusion, health and hygiene, awareness of right, and gender empowerment. Literacy is one of the basic parameters for the overall development which encompass societal progress, economic growth and the overall wellbeing of communities. But in Jharkhand, Education sectors depicts a very poor situation particularly in term of enrolment and dropout of tribal students. The GER for school education in Jharkhand for ST was 106 percent in primary level which decreases to 87 percent in upper primary and 38 percent higher level of education. (Jharkhand economic survey 2021). We can see the trend of declining of enrolment ratio of ST students as when they grow in the higher level of education.

Study Region

Jharkhand is a state is eastern India lies on the Chhota Nagpur plateau, part of a vast deccan plateau that occupies most of the peninsular India. Major rivers like Koel, Damodar, Brahmani, Kharkai, Subarnarekha etc. flow over it. The average elevation of the area is approximately 1000ft. The state has total five divisions, (North Chhota Nagpur, South Chhota Nagpur, Santhal Pargana, Kolhan and Palamu) and 24 districts with total population of 32,988,134 total tribal population of 86,45,402 (26.2%). (census 2011). The total ST population is highest in the district like Ranchi 10,42,016 (12.05%) followed by Paschimi Singhbhum 10,11,296 (11.70%) Gumla 7,06,754 (8.18%) and then Purbi Singhbhum 6,53,923 (7.56%).The tribal communities like Santhal, Oraon, Munda, Kharia and Ho constitute the majority of the total tribal population and they speak Austroasiatic and Dravidian language. District wise distribution of tribal population shows that Khunti district has the highest percentage tribal population (73.3%), followed by Simdega (70.8%), Gumla (68.9%), Paschimi Singhbhum (67.9%).

Objectives

(1) To determine the percentage of tribal children (age group 6-15) who have never attended educational institution in the states of India and the districts of Jharkhand.
(2) To identify the factors preventing tribal children from having access to an education.

Database and Methodology

The paper used Census of India 2011 C-series data for the analysis of educational status of ST population in India with special focus on Jharkhand state. Beside these several reports and Jharkhand state database like Unified Districts Information for Education System 2011, Educational statistics at glance, 2012, National Sample Survey Organization 2010. Jharkhand economic survey 2021-22, District report card 2011, Tribal committee report 2014, Statistical profile of scheduled tribes 2013, Ministry of tribal affairs Annual report 2021-22, District elementary education report card 2011-12 (UDIES 2011) data have been used for analysis purpose. Pearson's correlation coefficient is most efficient common method to use for statistical technique for examining the linear relationship between the variables.

Result and Discussion

The Tribal population for the age group (6-15) who has never attended an educational institution is given in the table 1. More than 20% of the tribal population in states like Rajasthan, Madhya Pradesh, Odisha, and Jharkhand, Bihar, Uttar Pradesh has never attended an educational institution. An analysis of data by gender reveals that the proportion of female than male has never attended school. The primary reason for never attending an educational institution is indicated by the cost of school fees, and a lack of interest in learning, school far away, education not necessary are some reasons behind not enrolling themselves in the school. (National family health survey, 1998-99). The factors such as household income, caste, location, gender, and the level of education of the head of the household can significantly influence a parent's decision to send their child to preschool (Choudhury, P.K., Joshi, R. & Kumar, 2021:21). There is a severe teacher shortage in areas where tribal people predominate, affecting both tribal and non-tribal schools (Choudhary. K 2018:6). Less than 10% of the population in states and union territories like Himachal Pradesh, Uttarakhand, Sikkim, Mizoram, Kerala, Lakshadweep, Goa, Daman and Diu has never attended school. These states and territories show a positive picture of school enrolment.

Thus, the enrolment of tribal population in these states is good as compared to other states. Numerous initiatives, such as the introduction of midday meals, the opening of alternative schools, encouraging the involvement of Parent Teacher Associations (PTAs), and large-scale enrolment drives, have all contributed to the rising enrolment rate (Singh, P. 2017:817). An important feature of schooling in India is that despite of high enrolment rate, attendance is much lower than enrolment, and the difference between the two increased at higher level of education. (India human development report 2011: 180). The tribes' emphasis on educating boys, interpersonal issues like child marriage, a lack of family support, pressure from peers, and a personal lack of value for education have all contributed significantly to the high school dropout rate among tribal girls (Sucharita, V. 2023). The students of India do not attend elementary school for a variety of reasons, including poverty, lack of funds, discriminatory mindset, lack of planning, and ignorance on the part of their parents (Table-1). The educational background and family background of parents significantly impact their children's performance (Li, Z., Qiu, Z. 2018:3). It is important to note that both Punjab and Haryana have a predominantly non-tribal population compared to some other states in India so there is no data been found regarding these states. The north eastern states like Nagaland, Manipur, Mizoram,

Tripura and Meghalaya showing good enrolment of children (age 6-15) whose population of school attending is above 80 percent. In comparison to other regions of India, the tribal population in the northeastern state is more literate, and these regions are also more urbanized. Among the states with the highest ST literacy rates Mizoram, Meghalaya, Nagaland, Sikkim, and Manipur rank first, second, fourth, sixth, and eighth, respectively. (NSSO, 2010). Ministry of tribal affairs, Government of India has introduced special educational schemes and residential facilities such as Ashram school, Eklavya mode, Kasturba Gandhi Balika Vidyalaya, Jawahar Navodaya Vidyalaya and various vocational training centers were open in the tribal areas.

Table-1: Scheduled Tribes and Educational Institutions in 2011

States	Age Group (6-15)					
	Population attending Educational institutions (%)			Population never attended Educational institutions (%)		
	Person	Male	Female	Person	Male	Female
India	75.8	77.2	74.28	18	16.5	19.6
Jammu & Kashmir	69.7	74.3	64.77	27.8	23.4	32.5
Himachal Pradesh	88.9	89.9	87.87	8	7.5	8.6
Uttarakhand	89.4	89.8	88.91	7.2	7.1	7.3
Rajasthan	69.1	74.4	63.24	24.6	19.7	30.0
Uttar Pradesh	69.6	71.1	67.98	24.9	23.0	27.0
Bihar	68.7	70.6	66.67	27.3	25.1	29.7
Sikkim	90.9	90.6	91.21	5.5	5.4	5.6
Arunachal Pradesh	79.8	80.8	78.81	18.5	17.4	19.5
Nagaland	82	82.0	81.92	13.9	13.8	13.9
Manipur	83.6	84.0	83.04	13.4	13.0	13.9
Mizoram	87.8	88.8	86.87	9.4	8.6	10.2
Tripura	84.8	85.9	83.69	10.8	9.8	11.7
Meghalaya	77.7	75.9	79.48	18.1	19.4	16.8
Assam	81.8	82.2	81.33	13.8	13.3	14.4
West Bengal	75.1	75.8	74.39	17.4	16.2	18.6
Jharkhand	74.8	76.2	73.27	20.4	18.7	22.3

Contd...

Odisha	70.3	71.9	68.81	20.7	18.7	22.7
Chhattisgarh	79.4	80.4	78.46	15.7	14.5	16.9
Madhya Pradesh	73.9	74.0	73.71	20.5	20.0	20.9
Gujarat	75.8	77.1	74.53	15.1	14.1	16.2
Daman & Diu	88.1	88.2	88.00	7.2	7.4	7.0
Dadra & Nagar Haveli	86.1	88.9	83.24	8.2	6.5	10.1
Maharashtra	79.6	81.0	78.02	13.4	12.2	14.6
Andhra Pradesh	78.4	80.4	76.36	14.8	12.9	16.7
Karnataka	80.1	81.6	78.59	12.3	11.2	13.5
Goa	90.2	90.4	90.02	6.4	6.3	6.5
Lakshadweep	94.4	94.4	94.31	4.1	4.2	3.9
Kerala	88.5	87.8	89.20	6.2	6.4	6.0
Tamil Nadu	81.5	82.1	80.83	10.5	9.7	11.3
Andaman & Nicobar Islands	82.2	80.6	79.38	13.4	11.5	13.0

Source: Census of India, 2011

These initiatives make easier for the tribal children to access to schools. One fifth of the children in the age group of 6-15 years were out of the school and financial constraint was an important reason for discontinuation of education. (India human development report, 2011:180). In order to provide the children with a high-quality pre-school education, the Anganwadi are inadequately trained in early childhood development techniques. As a result, most children are insufficiently ready to start school and pursue their education. As a result, learning standards are still low and dropout rates in the early grades of primary school remain extremely high. (India human development report 2011: Planning commission 2014:194). (Table-2)

Table-2 displays the proportion of the population in the district of Jharkhand that attends or has never attended an educational institution. The proportion of scheduled tribes who has never attended educational institution is higher than that of non-tribal population in Jharkhand. The districts like Koderma (41.9 %), Godda (30.5%), Sahibganj (30.1%), Pakur (31.5%) and Paschimi Singhbhum (28.8%) have higher percent of tribal population who has never enrolled in any educational institutions (6-15 age group). (Fig. 1) Less than 20% of the tribal population in districts like Ranchi, Ramgarh, Simdega, Lohardaga, Khunti,

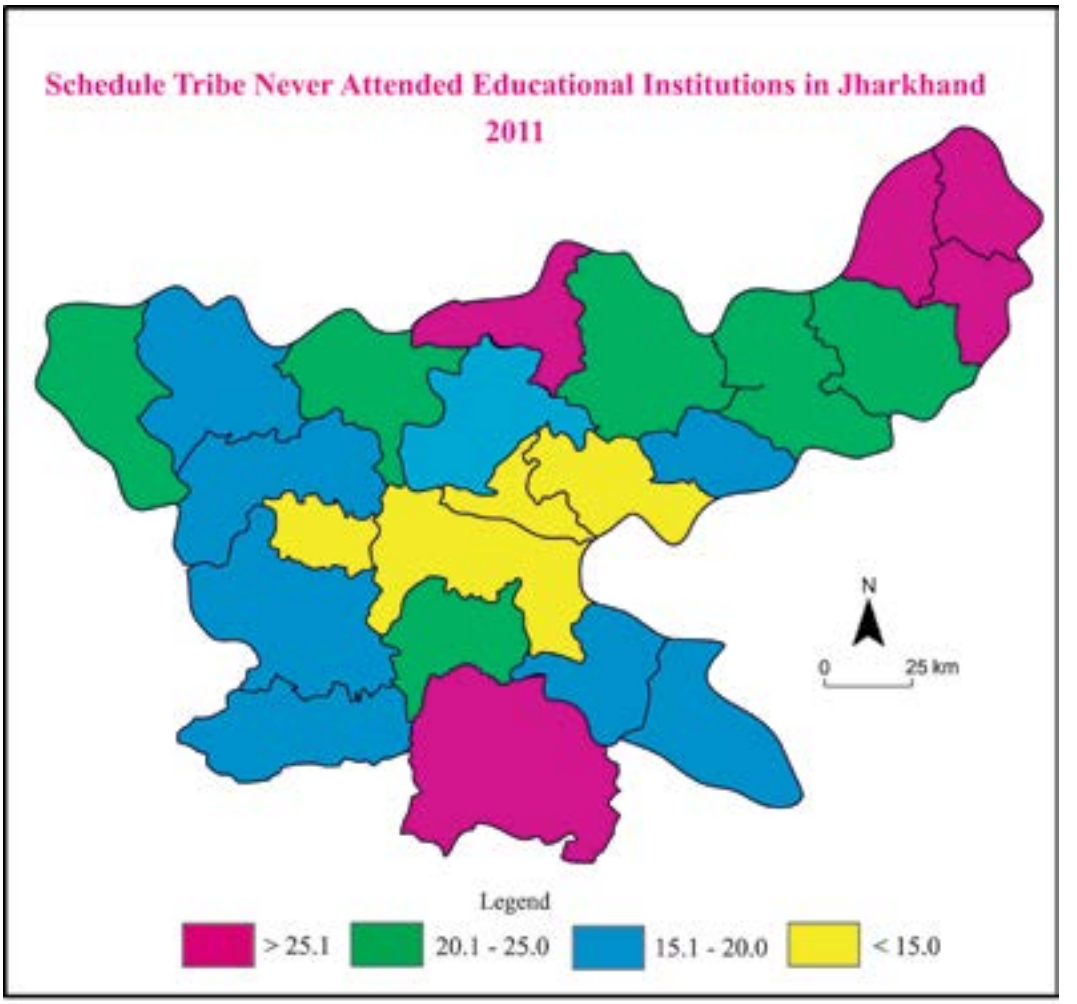

Schedule Tribe Never Attended Educational Institutions in Jharkhand
2011
N
0
25 km
Legend
> 25.1
20.1 - 25.0
15.1 - 20.0
< 15.0

Fig. 1

Table-2: Scheduled Tribes and Educational Institutions in Jharkhand

(Age 6-15 years)						
State/ Districts	Population Attending Educational Institutions (%)			Population Never Attended Educational Institutions (%)		
	Person	Male	Female	Person	Male	Female
Jharkhand	74.76	76.21	73.27	20.43	18.66	22.28
Garhwa	70.89	72.46	69.27	24.05	21.96	26.20
Chatra	71.92	74.09	69.61	22.16	19.95	24.51
Kodarma	53.15	59.23	45.51	41.91	34.76	50.90
Giridih	71.39	75.20	67.46	24.17	20.14	28.32
Deoghar	71.63	75.17	67.94	23.53	19.62	27.60
Godda	64.76	67.39	61.93	30.46	27.37	33.79
Sahibganj	66.34	68.78	63.74	30.14	27.48	32.98
Pakur	64.20	65.80	62.50	31.48	29.50	33.58
Dhanbad	77.98	80.35	75.54	17.45	14.87	20.10
Bokaro	81.50	83.40	79.59	15.00	12.77	17.25
Lohardaga	83.22	83.86	82.56	13.52	12.51	14.56
Purbi Singhbhum	79.02	80.18	77.78	15.70	14.31	17.19
Palamu	78.21	80.06	76.29	19.02	16.97	21.14
Latehar	76.21	77.65	74.75	19.73	17.94	21.56
Hazaribagh	78.38	80.15	76.62	17.26	15.50	19.01
Ramgarh	83.32	83.23	83.41	12.93	12.40	13.46
Dumka	73.68	74.62	72.71	21.08	19.79	22.42
Jamtara	69.81	71.70	67.80	23.10	20.92	25.41
Ranchi	83.73	84.07	83.39	12.14	11.48	12.80
Khunti	74.34	75.98	72.64	20.06	18.18	22.01
Gumla	79.61	80.29	78.91	16.59	15.57	17.63
Simdega	73.91	73.82	74.01	19.75	19.58	19.92
Paschimi Singhbhum	64.49	66.85	62.04	28.81	25.97	31.76
Saraikela-Kharsawan	78.26	80.20	76.22	17.22	15.04	19.51

Source: Census of India, 2011

and Purbi Singhbhum has never attended school and rest of the districts lies in between 20- 30 percent of tribal population who never enrolled in school. We can see the regional wise differences in the districts of Jharkhand who has been attended the school. The students' learning process was complicated by the teacher's unfamiliarity with the tribal dialect. A few of the difficulties faced by first-generation learners include fear of teachers, difficulty understanding subjects like Mathematics, Hindi, and English, and a nonfunctional parent teacher association that hampered learning and increased dropout rates (Ottaplackal, J. J., & Anbu, K. 2022:26). Appropriate early childhood education in tribal communities will undoubtedly contribute to fostering a love of learning at an early age and lowering the school dropout rate (Asha, C. M. 2020:1396). Most of the tribes live in steep terrain, forested areas, and remote areas. The tribal children live in remote areas, which makes it difficult for them to receive an education (Majumder, A. 2018:102). Additionally, among the social groups, the majority of SC/ST children attend government schools, which lowers the number of children who do not attend school. Girls outnumbered boys in the group of kids who were not attending school because "education was not considered necessary (Sankar, D. 2008:5). Positive attitude towards education and tribes living standard are strongly corelated, that is families with stronger economic background tend to have a higher proportion of literate member to families with weaker backgrounds. (Gupta, S., & Nanda, P. 2008:65). Tribal girls are prevented from attending and remaining in school by widespread gender-specific discrimination and stereotyping in Indian society (Sucharita, V. 2023:11). The majority of schools in tribal areas lack even the most basic facilities. Tribal areas typically have poorly maintained school buildings. Many tribal schools lack even blackboards and proper teaching and learning procedures (Jai Prabhakar, S. C. 2018:73).

After analyzing Pearson coefficient correlation by using data from the Census of India 2011, and UDIES 2011, Here several variables have taken like literacy of a family, socio-economic condition of a family, poverty, level of urbanization are the factors which effect the educational attainment of a children. we conclude that a family's socioeconomic status and level of education of parents effect the educational attainment of children. The correlation coefficient (r) value of tribal population never attended (6-15 age) and household using river as a source of drinking water is .499 which shows moderate positive association between both the variables. The P value is <0.05 (0.013) which means the relationship is statistically significant. So, we can say that increases in the dependence on river water also increases the population of never attended educational institutions.

Similarly, household using firewood and cow dung as a source of cooking showing (r) value of .415 showing moderate positive and P value is <0.05 (.044) which shows a significant relation. When we taking Electricity as a source of lighting in a household, it showing a negative relation with population never attended educational institution. The P value of <0.05 (.011) showing a significant relation. Lighting with electricity reduces the number of never-attended educational institutions. The social and economic aspects of any community have a big impact on education. (Lagravinese, Liberati, & Resce, 2019:18). Appendix 3 shows the strong negative relation of literacy with population never attended educational institutions. The (r) value of literacy is (-.850) with p value of <0.01 (0.000) showing a significant relation. It is evident that high literacy rates are correlated with high school enrolment rates and the population having low level of education are associated with a high proportion of the population that has never attended an educational institution. When compared to ST female literacy, there is also a clear negative correlation with the population that has never attended school with (r) value of -.584 and P value <0.01 (0.003) significant at 0.01 level. Poverty is again a significant factor in affecting education of a child. The correlation matrix shows a moderate positive correlation of poverty with (r) value of .405 with person never attended educational institutions. It is significant at 0.05 level with P value of 0.050. The percentage of population who have never attended an educational institution rises along with the level of poverty. Higher the level of poverty also increases the number of children who has never attended the educational institutions. Taking urbanization into consideration, which is strongly negative corelated with population never attended educational institutions with (r) value of -4.30 which is significant at 0.05 level with p value of 0.036. It demonstrates that the proportion of tribal people who have never attended an educational institution is lower in urbanized areas. The One of the most economically disadvantaged and marginalized groups in India is represented by the ST (Sahu 2014:1). The It is likely that the socioeconomic status of the family influences the decisions made by parents regarding whether or not to send their children to preschool (Ghosh, S. 2019:148).

Conclusion

This paper shows a descriptive analysis of the Indian states and the districts of Jharkhand that have never attended educational institutions of age group (6-15). Although the literacy rate among tribal population is increasing, it is doing so at a slower pace than it is among non-tribal people. According to census 2011, 18% of

the tribal population in India, comprising 46.4 % of male and 53.2 % of female, are not enrolled in school. In Jharkhand, 20.4 percent of tribal population (6-15 age group) 46.4% of male and 53.6 % of female have never attended school. The data indicates a percentage of females are high as compared to male counterpart who have never been sent to school. More than 20% of the tribal population (6-15 age group) in the states like Rajasthan, Rajasthan, Madhya Pradesh, Bihar, Uttar Pradesh, and Jharkhand, have not enrolled in the schools. However, in the southern Indian states, like Kerala, Karnataka, Andhra pradesh, Tamil Nadu the percentage of never enrolled tribal students is low as compared to north Indian states. The ignorance and neglect of parents regarding their children's education is a serious problem as well. Poverty is a major barrier to educational access because it keeps underprivileged households from funding their children's education with money for supplies like books, school supplies, uniforms, meals, and transportation. Another challenge in providing elementary education to tribes is their geographic location. Undoubtedly, a number of factors can have a significant impact on the educational attainment of children of Scheduled Tribes (ST) in Jharkhand and many other regions. These factors include poverty, socioeconomic status, literacy, and school facilities. Consequently, Tribal education is very important because it is essential to the growth and well-being of indigenous communities worldwide and also tribal education must be taken into consideration as a way to support the population's growth and integration into society at large.

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POPULATION DENSITY AND URBANIZATION EFFECTS ON AGRICULTURAL LANDUSE IN LUCKNOW DISTRICT

Vivek Kumar and Dr. S.P. Asthana

Abstract

This research paper is a comprehensive exploration of the intricate interplay between population density, urbanization trends, and their profound repercussions on agricultural land use patterns within Lucknow District, Uttar Pradesh. Against the backdrop of Lucknow's rich historical, cultural, and economic heritage, the study investigates the transformative impacts of rapid urbanization on the allocation and utilization of agricultural land. The findings, spanning the decade from 2001 to 2011, reveal notable changes in various land use categories, including a substantial decrease in forest land, cultivable wasteland, and current fallows. The increase in areas other than agricultural land use underscores diverse transformations beyond traditional agricultural activities. The research emphasizes the need for sustainable land management practices, considering the challenges posed by urban expansion to traditional farming practices. The conclusions drawn from this study provide valuable insights for policymakers, land managers, and urban planners, offering a nuanced understanding of the challenges and opportunities at the intersection of urban development and agriculture. The research aspires to contribute to the academic discourse on evolving land use dynamics, offering practical implications for sustainable land management and informed decision-making processes, specifically tailored to the unique context of Lucknow District.

Introduction

The research endeavours to conduct a comprehensive examination of the intricate interrelationships among population density, urbanization trends, and their profound impacts on agricultural land use patterns within Lucknow District, Uttar Pradesh. As urbanization undergoes unprecedented growth, it exerts significant pressure on the allocation and utilization of agricultural land, posing challenges to traditional farming practices. Lucknow District, with its rich historical, cultural, and economic heritage, provides a compelling backdrop for this study.

The rapid urbanization witnessed in recent years has transformed the landscape, necessitating a closer examination of how these changes influence the agricultural sector. The research aims to unravel the nuanced dynamics of this interaction, exploring how increasing population density and urban expansion reshape the agricultural land use mosaic. Through a meticulous geographical analysis, the study seeks to identify the specific effects of urbanization on the distribution, quality, and productivity of agricultural lands in the district. This investigation becomes particularly crucial given Lucknow's significance as a major urban center within the state of Uttar Pradesh. The findings of this research are anticipated to provide valuable insights for policymakers, land managers, and urban planners, fostering a deeper understanding of the challenges and opportunities that arise at the intersection of urban development and agricultural sustainability. In essence, the study aspires to contribute to the academic discourse on the evolving dynamics of land use in the face of urbanization, offering practical implications for sustainable land management and informed decision-making processes tailored to the unique context of Lucknow District.

Study Region

Lucknow district is a district located in the state of Uttar Pradesh in northern India. The city of Lucknow is the district headquarters and the district is part of Lucknow Division. It also is the capital of Uttar Pradesh. Lucknow is Bounded on the east by Barabanki district, on the west by Unnao and Hardoi districts, on the south by Raebareli district and in the north by Sitapur district. It is geographically located between latitude 26° 30' North and longitude 80° 30' East. Lucknow district covers an area of 2,528 square kilometers, centrally located in both the central Ganges plain as well as Uttar Pradesh as a whole. The climate of Lucknow district is predominantly subtropical in nature, and it experiences the effects of the South Asian monsoon. Lucknow district is divided into 4 tehsils: Lucknow, Malihabad, Mohanlalganj, and Bakshi Ka Talab. These tehsils are then divided into 8 community development blocks. According to the 2011 census Lucknow district has a population of 4,589,838. This gives it a ranking of 31st in India (out of a total of 640). The district has a population density of 1,815 inhabitants per square kilometre (4,700/sq. mi). Its population growth rate over the decade 2001-2011 was 25.79%. Lucknow has a sex ratio of 906 females for every 1000 males, and a literacy rate of 79.33%. 66.21% of the population lived in urban areas. According to the 2001 census Lucknow district had a population of 3,681,461.

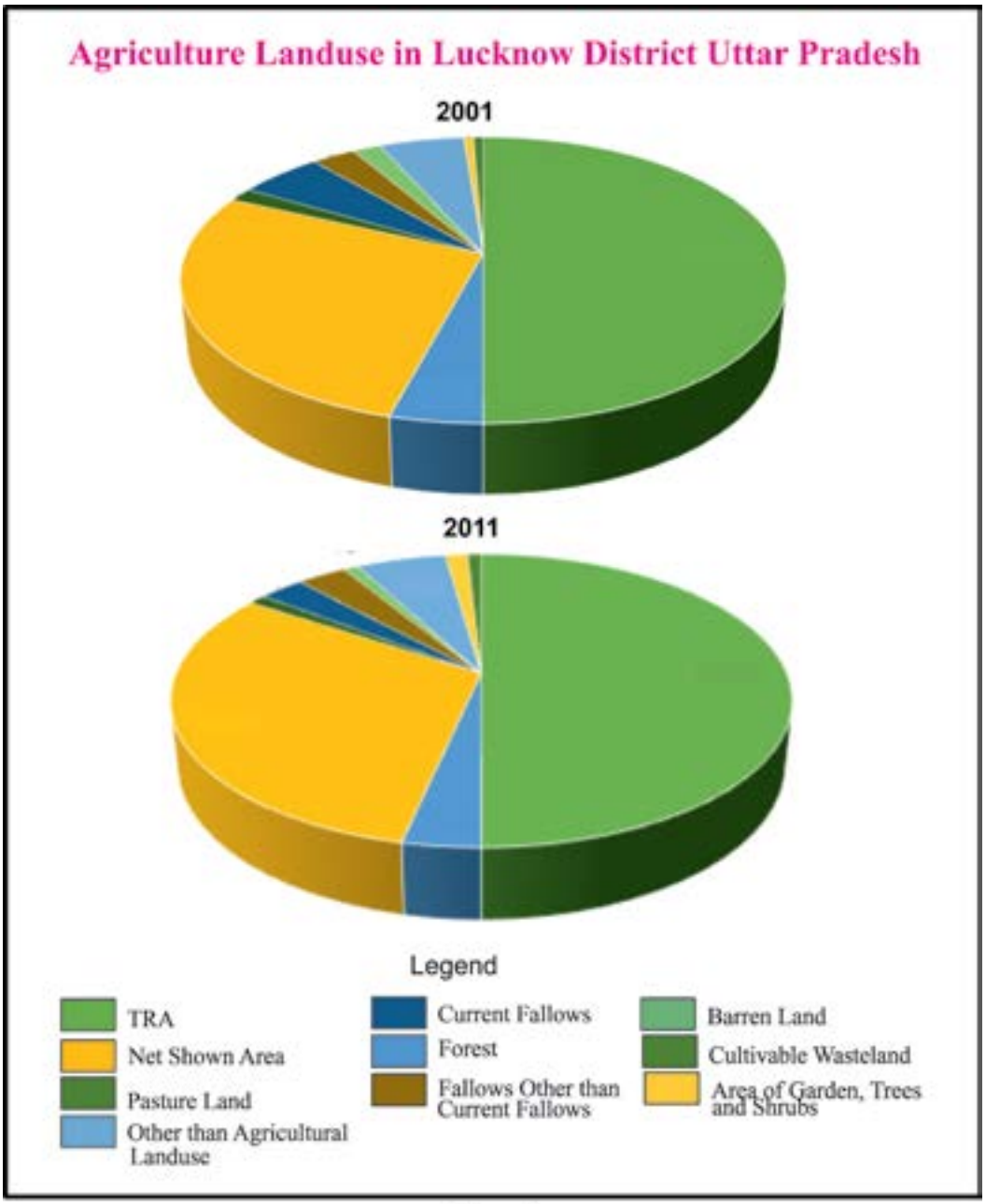

Agriculture Landuse in Lucknow District Uttar Pradesh
2001
2011
Legend
TRA
Net Shown Area
Pasture Land
Other than Agricultural Landuse
Current Fallows
Forest
Fallows Other than Current Fallows
Barren Land
Cultivable Wasteland
Area of Garden, Trees and Shrubs

Fig. 1

Objectives

(1) Examine the specific effects of urbanization on agricultural land use, including changes in landscape, land conversion, and potential loss of arable land.
(2) Analyze the dynamics of land conversion and its consequences for the overall agricultural landscape.
(3) Identify challenges and opportunities arising from the interplay between population density, urbanization, and agricultural land use.
(4) Highlight the need for sustainable land use practices in the face of a growing population in Lucknow District.

Database and Methodology

This research paper is based solely on secondary data. The approach involves a systematic and structured process for collecting, analyzing, and interpreting existing information. Secondary data from reliable sources such as government reports, statistical databases, academic journals, and research publications has been used for collection of data. Demographic data, urbanization statistics, and agricultural land use information has been collected. A comparative analysis of urban and rural areas within Lucknow District to discern differences in agricultural land use patterns has been done. By relying on secondary data, this research methodology aims to provide a comprehensive understanding of the complex relationships between population density, urbanization, and agricultural land use in Lucknow District.

Result and Discussion

Urbanization and Population Density in Lucknow District

In 2001 Lucknow District had a total population of 3,681,461, the population density was 1453 persons / sq. km. The urbanized population was 63.3%. In 2011, the total population of Lucknow District increased to 4,589,838 and the population density increased to 1815 persons / sq. km. The urbanization was 66.21%. The decadal population growth rate between 2001 to 2011 was 25.79%. (Fig. 1) The uptick in urbanization from 63.3% to 66.21% underscores the transformative impact of urban expansion on the district's landscape. This demographic shift is crucial in the context of the research paper, as heightened urbanization tends to exert substantial pressure on agricultural land. As the population grows and urban areas expand, agricultural land faces challenges such as conversion, potential loss of arable land, and changes in land use patterns (Table-1, 2 and 3).

Table-1: Blockwise Agricultural Landuse in 2001

Blocks	TRA	Forest	Net sown area	Cultivable Waste Land	Current Fallows	Fallows other than current fallows	Barren Land	Other than agricultural landuse	Pasture Land	Areas of Garden, Trees & Shrubs
Maliha bad	23056	1410	15917	729	1049	1439	452	1739	271	50
Mall	24503	685	13659	586	1927	2333	342	4241	304	426
Bakshi Ka Talab	38209	2808	23133	934	3982	2241	610	3794	432	275
Kakori	22159	812	14269	826	495	1702	1431	2224	235	165
Chinhat	19831	882	8605	919	4913	1684	270	2359	87	112
Sarojini Nagar	36871	2082	22614	682	3842	925	2576	3625	146	379
Gosain Ganj	34876	1271	20072	990	6345	996	1662	2291	489	760
Mohan Lal Ganj	38209	5946	20068	1034	2941	1789	1425	2973	1137	896
Total	251853	20967	139772	7734	26737	14164	8963	27278	3104	3134

Source: Up Statistical Bulletin, Lucknow (2001) Note: Area is in hectares

Table-2: Blockwise Agricultural Landuse in 2011

Blocks	TRA	Forest	Net sown area	Cultivable Waste Land	Current Fallows	Fallows other than current fallows	Barren Land	Other than agricultural landuse	Pasture Land	Areas of Garden, Trees & Shrubs
Maliha bad	22231	889	15575	474	965	1674	364	1934	257	99
Mall	23736	60	18002	568	759	1018	590	2360	326	53
Bakshi Ka Talab	34882	1307	22018	626	2618	2542	600	4302	467	402
Kakori	20652	240	13806	450	1691	1482	657	1955	224	147
Chinhat	12700	3	5328	665	1646	1260	492	3143	72	91

Contd...

Sarojini Nagar	30432	1172	17781	791	3640	2164	1353	3214	206	111
Gosain Ganj	27043	386	16610	741	2295	2262	814	3143	435	357
Mohan Lal Ganj	37766	2584	23359	776	2124	2336	679	4219	1048	641
Total	251596	12000	135737	5501	16224	15358	6775	55014	3051	1936

Source: Up Statistical Bulletin, Lucknow (2011)

Table-3: Changes in Landuse for 10 Years

Landuse Category	2001	2011	Change (in %)
TRA	251853	251596	-0.10
Forest	20967	12000	-42.76
Net Sown Area	139772	135737	-2.88
Cultivable Wasteland	7734	5501	-28.87
Current Fallows	26737	16224	-39.32
Fallows Other than Current Fallows	14164	15358	8.4
Barren Land	8963	6775	-24.41
Other than Agricultural Landuse	27278	55014	101.67
Pasture Land	3104	3051	-1.70
Area of Garden, Trees and Shrubs	3132	1936	-38.22

Source: Calculated by Authors Note: Area is in hectares

TRA

The total agricultural land in Lucknow District showed a marginal decrease from 251,853 hectares in 2001 to 251,596 hectares in 2011, reflecting a slight decline of 0.10% over the decade.

Forest

Forests in cities play a crucial role in enhancing air quality by absorbing pollutants, providing essential green spaces for recreation and mental well-being, and contributing to overall biodiversity (Fig. 1). They act as urban lungs, mitigating the impact of pollution and fostering a healthier, more sustainable urban environment. Additionally, urban forests contribute to temperature regulation and act as a natural habitat for diverse flora and fauna, promoting ecological balance within cityscapes. Forest land witnessed a substantial reduction from 20,967 hectares in 2001 to

12,000 hectares in 2011, indicating a significant decrease of 42.76%. This decline suggests potential urbanization effects, changes in land management, or alterations in forest policies.

Net Sown Area

Net sown area refers to the total cultivated land excluding fallow land. It represents the portion of agricultural land actively used for sowing crops during a specific agricultural season. Calculated by deducting the fallow land from the total cultivated area, net sown area provides insights into the actual land under cultivation, essential for assessing agricultural productivity and planning resource allocation. Net sown area in the study area slightly decreased from 139,772 hectares in 2001 to 135,737 hectares in 2011, reflecting a decline of 2.88%. Possible influences include changes in agricultural practices, land use priorities, or urbanization effects.

Cultivable Wasteland

Cultivable wasteland refers to land with potential for cultivation that is currently unused or underutilized. It encompasses areas suitable for agriculture but left fallow or abandoned. Rehabilitating cultivable wasteland can significantly contribute to expanding agricultural productivity and addressing food security concerns by bringing additional arable land into cultivation. Cultivable wasteland in Lucknow experienced a notable decrease from 7,734 hectares in 2001 to 5,501 hectares in 2011, indicating a substantial decline of 28.87%. Possible causes include changes in agricultural methods, land reclamation, or urban development.

Current Fallows

Current fallows refer to agricultural land left uncultivated for one or more regular crop-growing seasons. These fallow periods are intentional and part of the crop rotation system to allow the land to regenerate fertility. By allowing fields to remain fallow temporarily, farmers can manage soil health, prevent depletion, and enhance overall agricultural sustainability. Current fallows decreased significantly from 26,737 hectares in 2001 to 16,224 hectares in 2011, reflecting a substantial decline of 39.32%. This suggests changes in agricultural practices, land utilization patterns, or increased cultivation efficiency.

Fallows Other Than Current Fallows

Other fallows, apart from current fallows, include: Fallow land left uncultivated for an extended period beyond the regular crop cycle, known as "fallow land other than current fallow, temporary fallows where land is intentionally left unused

for a shorter duration to manage crop rotation effectively and in some cases, fallow lands are left to regenerate naturally, aiding soil recovery and preventing degradation for improved long-term agricultural productivity. The category of fallows other than current fallows increased moderately from 14,164 hectares in 2001 to 15,358 hectares in 2011, in the study area, indicating growth of 8.4%. Possible interpretations include changes in fallow land management strategies or shifts in agricultural planning.

Barren Land

Barren land refers to areas that are unproductive and unsuitable for cultivation due to factors like extreme aridity, poor soil quality, or environmental degradation. These lands lack the necessary conditions to support plant growth and agricultural activities. Barren lands contribute to challenges such as desertification and are often targeted for conservation or reclamation efforts to mitigate environmental impacts. In the District, Barren land decreased from 8,963 hectares in 2001 to 6,775 hectares in 2011, indicating a decline of 24.41%. Potential factors contributing to this decrease include urbanization, land reclamation, or improved land management practices.

Other Than Agricultural Landuse

Other than agricultural land use in cities includes various categories such as residential, commercial, industrial, and institutional land uses. Residential areas cater to housing, while commercial zones are designated for businesses and trade. Industrial zones accommodate manufacturing activities, and institutional areas include spaces for schools, hospitals, and other public facilities, collectively contributing to the diverse urban landscape and functionality. Other than agricultural landuse saw a substantial increase from 27,278 hectares in 2001 to 55,014 hectares in 2011, indicating significant growth of 101.67%. This emphasizes the need for understanding diverse transformations, potentially beyond traditional agricultural activities.

Pasture Land

Pasture land is open land used for grazing livestock, providing a natural environment for animals to feed on grass and other vegetation. These areas support the husbandry of livestock like cattle, sheep, or goats, promoting sustainable agriculture and animal husbandry practices. Pasture lands play a crucial role in maintaining ecological balance, preventing soil erosion, and supporting the livelihoods of pastoral communities. Pasture land decreased slightly from 3,104 hectares in 2001 to 3,051 hectares in 2011, reflecting a decline of 1.70%.

Possible causes include changes in livestock management practices or alterations in land use priorities.

Area of Garden, Trees and Shrubs

The area of garden, trees, and shrubs refers to the collective space dedicated to cultivated ornamental plants, trees, and bushes. This encompasses landscaped areas within residential, commercial, or public spaces, contributing to aesthetic beauty, environmental benefits, and recreational value. The careful planning and maintenance of these green spaces enhance urban aesthetics, air quality, and overall well-being. The area of garden, trees & shrubs notably decreased from 3,132 hectares in 2001 to 1,936 hectares in 2011, indicating a substantial decline of 38.22%. Implications may include changes in landscaping preferences, urban development, or altered land use priorities.

Conclusion

This research paper has provided a comprehensive examination of the intricate interrelationships among population density, urbanization trends, and their profound impacts on agricultural land use patterns within Lucknow District, Uttar Pradesh. The study elucidates the evolving dynamics of land use in the face of unprecedented urbanization, particularly focusing on the changes witnessed over the decade from 2001 to 2011. The findings reveal significant transformations in various land use categories, emphasizing the intricate balance between urban expansion and agricultural sustainability. Notable trends include the decrease in forest land by 42.76%, reflecting potential impacts of urbanization and changes in forest policies. Additionally, the decline in cultivable wasteland by 28.87% suggests alterations in agricultural practices or land reclamation efforts. The substantial decrease in current fallows by 39.32% indicates shifts in agricultural practices and increased cultivation efficiency. Importantly, the considerable increase in areas other than agricultural land use by 101.67% underscores the diverse transformations occurring beyond traditional agricultural activities. The findings highlight the need for sustainable land management practices and informed decision-making processes tailored to the unique context of Lucknow District. As urbanization exerts pressure on agricultural land, the study emphasizes the importance of striking a balance to ensure the coexistence of urban development and agricultural sustainability. The research contributes valuable insights for policymakers, land managers, and urban planners, fostering a deeper understanding of the challenges and opportunities at the intersection of urban development and agriculture.

In essence, this research aspires to contribute to the academic discourse on the evolving dynamics of land use, offering practical implications for sustainable land management and decision-making processes in the context of rapid urbanization. The insights gained from this study can inform future policies and initiatives aimed at ensuring a harmonious coexistence between urban development and agricultural resilience in Lucknow District and similar regions facing similar challenges worldwide.

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GEOGRAPHICAL ANALYSIS

RESEARCH ARTICLE

A Perspective on Ecological View and Ecodevelopment Approach for Land Use Planning in The Drought Prone Areas: A Case Study of United Anantapur District, Andhra Pradesh

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Abstract

Land is a basic natural resource. It forms the basis for all the biological, human and economic activities. In the developing countries like India, where agriculture is the main source of economy and livelihood for more than two-thirds of the working population, proper utilisation of land resource is vital.

Introduction

In recent years, serious concern has been shown on ecological management and optimum utilization of land resources for the benefit of mankind. Hence the use of land resource is "central to all discussions of land problems and policies [(1)] . Land use at any region is a complex, diversified and dynamic concept. It is due to the operation of whole range of environmental factors but modified by socio-economic and historical elements. In dry areas, the use of land resources is virtually associated with climatic and edaphic conditions, besides the socio-economic needs of the mankind. Undoubtedly, the erratic behaviour of the monsoon, frequent occurrences of drought and prolonged dry spells have had a devastating and debilitating effect on land use pattern and as a result, the landscapes in dry areas gets continuously varied and modified. Since land itself is one of the important components of the ecosystems, a critical study on landscape ecology and its planning calls for greater attention to be paid to the drought prone areas to keep the ecological balance between the environment and the socio-economic needs of the region.

Ecological View of Landscape

In the sense of ecology, land carries ecosystems, but is itself also a part of these ecosystems. Although the use of land resource may be considered from abroad view of human welfare, its use is always a process of modifications of ecosystem. The idea that land use is a process of modification of ecosystem was well explored by Simmons [(2)] .

He suggested that land use ecology might form a central theme in biogeography. It is also mentioned that the ecosystem concept provides the necessary modern scientific framework to the study of land use. The form and function of land use is a human enterprise, while the development of landscape is the continuous efforts of man for his needs and sustenance under every possible combinations of terrain, climatic, edaphic and vegetative conditions. By all means, it suggested that any scientific and rational land use planning should see that the ecological balance was not disturbed and that proper equilibrium between the environment and the socio-economic needs of the area be maintained.

Ecological Problems of Land Use

In the process of land use management and optimisation, ecological problems are becoming a most serious concern. The ever increasing pressure of population and decreasing man-land ratio are posing challenging problems to the land-use planners. Structurally, a land-use system consists of three interacting spheres namely, ecological (environmental), economic and social. Each sphere has its own unique set of human-ascribed goals. Ecological problems are those, which appear in connection with human socio-economic needs, change the quality of the physical environment and indiscriminate use of natural resource base. Ecological problems appear in different types of physical environment and various socio-economic, technological and political conditions.

The negative ecological effects like degree of decertification, land degradation, soil erosion, soil salinisation, chemical contamination and water pollution are frequent in the dry areas but taking place in different intensities and degree of criticality. The other problems related to land use are under-utilisation, over-utilisation and mis- utilisation of land resources. So the question is what are the reasons for the appearance of negative ecological effects in different environmental and socio- economic conditions. Off all, undoubtedly, man's indiscriminate use of land resources has resulted in the creation of negative ecological effects. His failure to recognise the long term implications of deforestation, faculty methods of cultivation, overgrazing, massive application of fertilisers and pesticides, practice of single crop monocultures, imbalances in the input and output factors and large scale exploitation of land and soil resources throughout an entire ecosystem. Results in widespread degradation.

The practice of monoculture was accompanied subsequently by great losses of genetic varieties in the fields, involving high risks of large hectarages being destroyed by single drought or pest. To cultivation of the same crop continuously and their synthetic fertilisation year after year has resulted in the disruption of the soil balance. With diminishing organic matter in the soil, its ability to retain moisture is also reduced and as a consequence, the soil becomes sterile and dry. To circumvent some of these problems a critical examination of landscape ecology is essential for a more rational approach to land use planning and conservation of resources.

Eco-development and Ecological Planning of Land Use

Generally speaking, ecological planning is a fundamental tool for landscape and regional planning, such that many landscape ecological studies are now done as integral parts of landscape and regional planning projects[3] . It offers an effective means of helping mankind to adapt to the dynamic changing environment of which he is but one integral part. Mc Harg[4] has defined ecological planning as "an instrument for revealing regions as interacting and dynamic natural systems having intrinsic opportunities and constraints for all human uses.

The goals of such planning are derived from the region and its people as proffered by locations where all or most advantageous (safe, healthy and beautiful) factors exist with none or few detrimental factors for any and all anticipated future uses. What constitutes 'detrimental' or 'advantageous' is derived from the use itself and the value system of the initiating person or group. The concept of eco-development forms the main strategy of 'Habitat Ecology'. It helps in explaining the form of planned growth which is concerned with the development of local available land resources within the constraints of local environment with a view to optimise the local capacities of the biosphere to support the welfare of life. The eco-development approach is very close to ecological and environmental planning to balance and harmonise the various enterprises of land use which man for his own benefit has superimposed on physical environment.

The eco-development approach related to land use rests on (i) rational utilisation, (ii) development of mankind pertaining to their well-being rather than in economic sense, and (iii) advancing a true symbiosis between man and environment. To activate and regulate the harmony between landuse development and environment both the demand and supply side of the equation must be acted upon. In the eco-development and ecological planning sense, any land use planning should not be considered merely from the agricultural point of view and bringing more land under the plough making it viable for cultivation, but should include rational utilisation of land resource, conservation of land from erosion, development of nutrients and soil cover through multiple vegetative systems, improving the potential capacity of land, application of modern scientific technology and lastly the preclusion of over exploitation of land.

Study Region

Anantapur district is one of the chronically drought-prone areas in the country. It is located in the rain-shadow region of

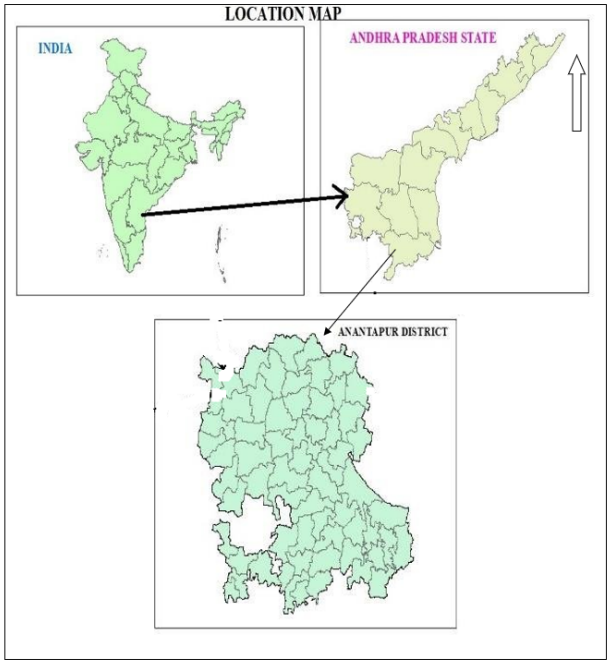


Fig. 1. Location map

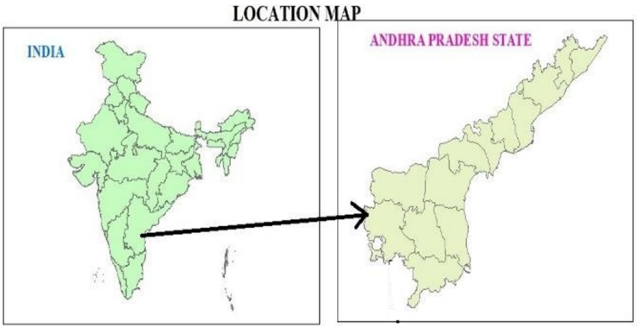


Fig. 2. Location map

the Western Ghats in Andhra Pradesh. It is the largest district in terms of area in the State. The population spread is very sparse with a density of population of 166 persons per Sq.Km. Agriculture is the predominant occupation of the people. The average annual rainfall of the district is 544 mm. with the lowest number of rainy days of 35 in the State. The district has been experiencing a drought once in every two years which is really serious and detrimental to stable agriculture.

Methodology

The spatial distributional pattern and changes in important land use types namely, forest land, fallow land and crop-land are examined and delineated with the help of both quantitative and cartographic techniques. The quantum of change is determined through percentages, regression trend and growth rates The impact of rainfall on land use types is measured with correlation testing.

Forest Land Use

Forests form distinct ecosystems. In fact, Anantapur district is very poor in forest cover with only 10.3% of the total geographical area of the district. The nature and character of forests in the district does not indicate any dense growth of tree population with different variety of plants. The forests of the district may be described as dry mixed deciduous and thorny open scrub types.

The distribution of forest-cover in the district is not only very low in proportion but also most uneven. Relatively, higher concentrations (15.1-20% and >20%) of forest-cover are found in southern, south-eastern and north-eastern parts of the district. In these areas, the amount of rainfall is comparatively higher than the other parts of the district. The western part of the district is found with very thin forest cover with discontinuous thorny thickets and scrub woodlands whose vegetative growth is stunted due to poor edaphic and very low isohyetal conditions.

During the three decades under consideration (1960-90) total area under forest has not shown any substantial change but showed a small increase of 0.1 per cent or 2000 hectares. The regression analysis has also revealed that the trend of forest land is marginally positive with 2 per cent of the goodness of fit. The annual compound growth rate has also shown a negligible rate of increase of 0.003 per cent.

Planning for the Development of Forest Land

In drought-prone areas, maintenance of ecological balance is one of the most important considerations to build-up the humus contents in the soil, avert soil erosion, increase the moisture in the atmosphere, raise the ground water level and heap in ground water recharge and storage besides other economic purposes. However, the poor quantity of forest cover in the district is too short to fulfil the requirement of ecological balance and is seriously jeopardizing the ecosystem of the region it is necessary to take up massive efforts on war-footing to develop forest-cover in the district

The development of forest-cover in the district heavily depends upon the (i) plantation of drought resistant species in large parts of the reserve forest areas, which are devoid of any vegetative cover, (ii) there are number of tanks in the district which are silted and do not fill up with meagre rainfall The foreshore of these tanks can be planted with eucalyptus and subabul plantations., (ii) depending upon the suitability of site and topography, particularly in the slopy agricultural lands and cultivable wastelands and all along the road sides the species like tamarind, neem, gulmohar, eucalyptus, fruit and flowering plants can be planted extensively. Agave species

can be planted in 'estate concept' mainly to yield raw material for fibre extraction and to put otherwise unproductive areas to productive use and (iv) pasture development can be taken up on the barren hills, slopy soils, community lands and village poramboke lands. Having all the afforestation schemes, it is utmost necessary to convert this dry belt gradually into a green belt for balancing the ecosystem.

Fallow Land Use

Land under fallows accounted for 17 per cent of the geographical area of the district. which is indeed a high proportion. More than one fifth of the geographical area under fallows is found in 17 mandals mostly located in western and north-eastern parts of the district.

During thirty years period, the proportion of fallow land has increased by 5.6 per cent amounting to about 106 thousand hectares. The increase is found in many parts of the district. The regression analysis has also confirmed this trend of increase of fallow land but is accounted by 22 per cent of co-efficient of determination. It indicates that the increase in the area under fallows is not perpetual from year to year but highly fluctuating. The annual average rate of increase is 0.6 per cent.

It is suggested that an increasing trend of fallow land should be controlled and utilised at optimum level through scientific land use management systems. If possible all the fallow lands should be brought under dry farming cultivation with suitable drought resistant rain-fed crops like millets, pulses, fodder crops and agro-forestry A considerable change in the outlook of farmers is to be brought out from traditional practices to new methods of dry farming for optimum use of fallow lands with multi-tier vegetations in different ecological systems and the sound management of Sylvi-Agri-Pastoral Systems.

Agricultural Land Use

The district has vast agricultural land resource base but suffers from instability due to vagaries of monsoon. The net area sown in the district accounted for 49.9 per cent of the total geographical area which is significantly. Higher than the average proportion of net sown area in Andhra Pradesh State (41.3 per cent)

The quantum of change in the proportion of net area sown during 1960- 1990 showed a significant decline of 5.5 per cent amounting to 105 thousand hectares. The trend of net area sown in the district has been negative. The goodness of fit of the regression trend states that the present negative trend is to the tune of 11 per cent only. It means that the negative trend of the net area sown is not exactly perfect but it is highly fluctuating from year to year depending on the variation of rainfall On an average, the annual compound growth rate declined at 0.03 per cent.

Impact of Rainfall on Arable Land

In the drought-prone region, where rain-fed farming is predominant and irrigation development is very low, it is a common assumption that the increase or decrease in either cropped area or fallow land will be in close association with the success or failure of monsoons. In the present study, the correlation analysis has revealed that there has been a positive correlation between rainfall and net area sown in the district to the tune of 0.55 Co-efficient value and negative correlation between rainfall and fallow land to the tune of 0.62 co-efficient value. A high negative correlation of 0.85 is found between net area sown and fallow land. It shows that if there is an increase in rainfall, the land under cropping may increase or if there is decrease in rainfall, the land under fallows may increase. It indicates that these two land use types are inversely correlated and functionally related with each other.

Strategy for the Development of Suitable Cropping Pattern

The present cropping pattern dominated by groundnut, cannot be treated as inappropriate and it appears to be a more or less natural consequence of the poor natural resource endowments of the district. Now that it required all the more is the optimisation and strengthening of present cropping pattern without further spatial extension of mon-crop groundnut. In view of varying drought conditions and agricultural drought which differs from one crop to another crop in an area, an extending monoculture groundnut farming to wider area may not be advisable, as a wide-spread drought may adversely affect the agricultural economy of the district. In such circumstances, all rainfed crops which are of high value and low water consuming must be preferred. The risks from droughts could be reduced by popularising suitable inter-cropping methods. If there is failure of rain, at least one of the component crops will yield something and thereby minimise the risk of total loss. The non-traditional crops like sunflower, safflower and castor etc. should also be grown in the suitable soil and moisture conditions.

Soil Characteristics and Problems

The soil is a dynamic layer which immediately reacts to the pattern of its use or changes in the soil forming environment. The district has 82 per cent of red soils and 18 per cent of black soils. The phosphorus and organic matter 3 content is poor in 82 to 90 per cent of the soils. But more than 90 per cent of the soils are moderately rich in potash more than 95 per cent of the soils are neutral or weakly alkaline. Less than 5 per cent of the soils are having severe saline and or alkaline problems.

The results of studies made by different organisations reveal that the soil characteristics are being changed in a short span of time by such activities of man like (i) removal of vegetation cover, (ii) application of heavy irrigation, (iii)

change of cropping pattern and (iv) change of morphology. The conclusions are that (1) in the undulating piedment regions where dry farming is practiced there is an increase of rill and gully erosion, (2) there is steady increase in the salinity and alkalinity problems in the canal irrigated mandals like Rayadurg, Gooty. Tadipatri and Anantapur, (3) there is a decreasing tendency in the potassium content of the soils particularly in the paddy cultivated areas and (4) with the shift from millet oriented to groundnut oriented cropping pattern, the soils have shown sulphur and zinc deficiency. Iron deficiency is also predicted in the near future.

Soil Management

The soil management programme in a semi-arid region like Anantapur district should be comprehensive and integrated one. First and foremost adequate importance should be given to the extension programmes to create the awareness in the farming community about the dangers of the mismanagement of the soil ecosystem and to motivate them to follow proper soil management 2 guidelines. The soil forming environment could be improved by managing catchments at t micro-level Construction of check dams and watersheds on small catchments serves as a multi-purpose schemes in this direction Both agronomic and engineering measures of soil conservation should be implemented in a complementary manner to achieve better results. The alkalinity and salinity problems of the soils have to be solved with suitable measures like zypsum application and leaching of excessive salts with suitable dosage of irrigation respectively Proper care should also be taken to minimise water sepage from the irrigation canals which will lead to the problems of salinity and alkalinity.

Conclusion

It has been observed that man, rather than the nature is bringing considerable change in the quality of land in a short span of time. The short- sighted and unplanned commercial and subsistence gathering of resources from the nature's bounty have caused considerable damage to the land system Many of his activities though fetching short-term gains, are causing long-term and sometimes irreversible damages to the quality of landscape system in this dry region. In view of very low proportion of forest cover, high proportion of fallow land, instability in agriculture land followed by mono-cultures and poor nature of soil cover, the landscape ecosystem of this region is delicate and is being easily disturbed.) The maintenance of ecological balance is one of the most important 4 considerations and is to be looked into it very seriously. To achieve the required goals, "Sustainable Land Use Development" is the way of environmental feature. Jacobs [5] has referred to sustainable development as "the offspring of ecological planning". To understand both and carry them out, environmental education is essential at all levels and in all sectors of the population.

It is also often emphasised that the transformation of rural habitat is the fundamental lead for the eco-development of the region the integrated Rural Development (IRD) is to be concerned with ecological and environmental issues in addition to the integration of sectors and policies in space-time dimensions. The IRD concept is also to be conceived as strategic design of problem solving planning process for the effective involvement of local human and physical resources to improve the socio-economic and ecological situation of the rural habitat.

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GEOGRAPHICAL ANALYSIS

RESEARCH ARTICLE

The Female Child Deficit: Its Causes and I mpending Consequences in Indian Perspective

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Abstract

The female children are equally important apart from male children of any country. It donated as Sex composition of Child population (0-6 Years), which is basic demographic characteristics. The deficit in girl children will have many implications, the most fundamental being to define the limits of the society's reproductive potentials. Further, the existing sex composition of children is also the basic demographic determinants of births, deaths and marriages in future. Moreover, future migration rates, work force and all other population characteristics can be influenced by the ratio between the sexes of children at present. The present aims to examine deficit of girl children and its causes along with upcoming consequences in India based on secondary data collected from census apart from others and suggestions are given for advocacy as well as policy matters.

Keywords: Gils Child; Discrimination; Son Preference; Neglect of Girls; Sex Selective Abortion

Introduction

In a "normal world," the female population equals or slightly surpasses the number of males. Except in India, that is, where the situation is just the opposite, where the gender ratio- or the number of females to males- is known to be among the most imbalanced in the world. Child Sex Ratio is defined as "number of females per 1000 males in the ages of 0-6 years" in given period in an area. Although China has the most severe shortage of girls compared to boys of any country in the world today, in India, the 2011 census revealed disturbing news: the proportion of girls aged 0-6 years dropped from 927:1000 to 914:1000 since the previous census done 10 years earlier. The census also revealed that the phenomenon has reached high proportions in states which had no prior history or practice of female infanticide, or where forms of discrimination against girls were not strongly evident earlier. The reasons behind this mistreatment of girls crosses the spectrum of Indian regions, economic classes, and castes and are due to a complex mix of economic, social, and cultural factors. In India, the changes in education, employment, nutrition, work patterns, religion, and culture, as well as family concerns such as marriage, property, inheritance, and continuity are the causes for imbalance sex ratio.

Though the population growth rate in respect of males was lower at 17.1 per cent, when compared with 18.3 per cent for females-implying some correction in the overall sex ratio- the child sex ratio (for the age group from zero to six years) deteriorated over the decade, from 927 to 919 females for every 1000 males. This should set off alarm bells in the government, civil society groups and the law. This ratio is mainly man-made through selective sex determination with the aim of getting rid of the girl child, early death due to neglect and infanticide. As per census of India, 2011 the declining sex ratio in India is due to "neglect of the girl child resulting in their higher mortality at younger age, high maternal mortality, sex selective female abortions, female infanticide, change in sex ratio at birth"[1] . The deficit of Girl Children is an unique feature of India over the decades as compared to developed nations, which has been highlighted in respective census repots and also studies by many authors viz,[2–4] , but many were examined the trends and causes for deficit of girl children population by examine the child sex ratios, while some[5,6] and IDRC and Action Aid India, 2011 with some efforts made on its impending consequences.

Objective

The objectives of the present paper are to examine deficit of girl children in India, it causes and future repercussions extensively along with suggestions to overcome the issues.

Methodology

The present paper based on secondary data collected from census of India and other published documents. Here the Girl Children is considered as number of female children per 1000 male children in the age group of 0-6 years in given area in a period of time.

Results and Discussion

The sex ratio worked out for population of all ages is not indicative of any clear picture to know whether it is favourable to females or otherwise. The child sex ratio generally affected by two factors namely mortality differentials and extent of medical interferences, which influence overall sex ratio also. Hence, child sex ratio is always considered as the best indicator to understand the sex ratio at birth when the data on births by sex are not easily available. Differentials in child sex ratio explain changes girl child population over period of time in India.

Table 1 depicts that Over all Sex Ratio(Number of females per 1000 males) was 945 in 1951, comedown to 934 in 1981 and recorded as 943 in 2011, implying some improvement in the overall sex ratio in recent decade; while, the child sex ratio (0-6 years of ages) deteriorated over the decade, from 983 in 1951 to 927 in 2001, thus declined sharply with 56 points in five decades and it further declined to 914 in 2011, such least had never recorded after independence.

Table 2 shows that in 1961 census, the child sex ratio at the National was 976; whereas the rural child sex ratio stands at 957 and urban child sex ratio was 951. The corresponding figures in 2011 census are 914, 919 and 902 respectively. Further, the gap in rural-urban child sex ratio was 6 in 1961, rose to 17 in 2011. Thus, the child sex ratio had been drastically declined and gap had been widened. The main causes for low child sex ratio and further decline, gap in rural-urban in the country are: Neglect of girl child resulting in their higher mortality rates at younger ages, high maternal mortality, sex selective abortions and female infanticide.

Causes

The causes for deficit of girl children in India context are many fold viz socio-economic, cultural, religious and political, which are complex in nature, most being are discussed here.

The son-preference trend in India

Apart from higher morbidity levels, which cause mortality of girl children, preference for son has been main causes for decline of girl children. Son-preference has being equally strong among different income groups and irrespective of caste and sex ratios where earlier period showed that sex ratios were better among lower castes and among the poor. The norms that have been part of India's socio-economic fabric for centuries are that Sons are considered pivotal to family welfare, as they are the ones who earn money, continue family lineage, and provide a form of old age security for parents. A daughter, meanwhile, is considered to be a "double loss" as she not only leaves her family when she marries, becoming an "asset" to her new family, but she is also a source of marriage expenses, including the payment of dowry to the groom's family.

Family planning-for sons

Some new trends, such as the two-child family norm encouraged by the Indian government, and an emphasis on education also influence decisions. However, it has been that although small families are accepted in Himachal Pradesh, Punjab, and Haryana, family planning effectively means, "Planning for sons." Generally, people want educated daughters-in law, because it "…is oriented towards the future family of the couple-children will get proper guidance and instructions from an educated mother…marriage prospects rather than employment appear to drive education." However, parents expressed the hope that more education for girls would result in them obtaining white-collar, regular, and secure work pre-marriage-and a better choice of prospective husbands. In rural areas of India, there may be a compromise in the duration of schooling. It observed that "… girls are encouraged to complete as much education as they can- but-

Table 1. Trends in Child sex ratio in India, 1951-2011.

Sex Ratios	Census Years						
	1951	1961	1971	1981	1991	2001	2011
Over all Sex Ratio	945	941	930	934	927	933	943
Child Sex Ratio	983	976	964	962	945	927	914

Source: Census of India, 2011.

Table 2. Child sex ratio of India

Child Sex ratio by Residence	Census Year					
	1961	1971	1981	1991	2001	2011
Total	976	964	962	945	927	914
Rural	957	968	963	948	934	919
Urban	951	948	959	935	906	902
Rural-Urban Gap	6	20	4	13	28	17

Source: Census of India, 2011.

if a 'good match' is found; the girl is married off before she completes her studies."

Sex-selection practices

In India, members of the older generation referred to children as natures or a divine gift, and of the sin of getting rid of a child. Women of reproductive age may agree with this view, and may protest, but decisions of family member's plays crucial role regarding gender of children. Since the 1980s, technology widely available in India, such as amniocentesis and ultrasound, has permitted parents to predetermine the size and gender composition of children for their families through abortion. Although sex-selective abortion is illegal and banned in India, it has been widely practicing even rural areas of India. Some people are did not stop at one abortion, but had more than two times-because a girl had been conceived each time. "Abortion," is the method of family planning par excellence-to limit family size, to enable spacing between children, and also to regulate the sex composition of the family. Sex Selective Abortion is referred as "High-Tech Sexism" by AmartyaSen[7] a renowned economist, who studied missing females in India.

Neglect of girls

Neglect of girls, whether planned or inadvertent, also contributes to the lower child sex ratio. The degree of discrimination varied by location, there nonetheless was widespread evidence of lower levels of nutrition, health care, schooling, and emotional care, and high levels of under immunization in general. "With nutrition and health, who may or may not take the decision is uncertain, but the discrimination is evident". A firstborn daughter was not typically subjected to inferior treatment; she was treated like her brothers. But with each additional girl, the pressure to have a son increased and starts discrimination against girl children.

Dissatisfaction of Daughters

When a daughter grows up and marries, she essentially becomes chattel in her husband's parents' home and has very limited contact with her natal family. Even if she earns a good living, it will be of no help to her own parents in their old age. So for parents, investing in a daughter is truly, in the Hindi expression, planting a seed in the neighbor's garden. Sons, by contrast, provide a kind of social security. Changes in work, education, marriage age, and marriage costs also seem to add up to disaffection for daughters, to a greater extent than before. The factors causing this include: increased investment that has to be made in daughters in terms of education and marriage; the loss of their material and labour support; fears for their sexual safety and security; and worries about their future happiness in an appropriate marriage.

Impending consequences: In India, the deficit of Girl Children leads to many severe upcoming consequences by way of socio-economic, cultural, religious, demographic, and political aspects, but many may be less gravity and some could be very serious, which are briefly discussed hereunder.

No relevance of institution of marriage: Continuous declining in Child Sex Ratio has many potentially serious consequences, although there are no historical model by which to learn about the implications of a lack of women relative to men, one fairly obvious social consequences is that there are not enough women for men to marry and the institution of marriage would lost its relevance.

Raise in Child marriages: The scarcity of brides might lead to the child betrothal and early marriage (child marriage) to cope with the problem. Increasing numbers of child brides will further contribute to the poor status of women, as will be less likely to finish the school or develop skills before

marriage.

Chances of Disease Burden: Young brides and their children are also more likely to suffer from the increased morbidity and mortality associated with early child birth Thus there are serious socio-economic and health implications of declining child sex ratio.

Increase in dowry Amount : Another consequence of scarcity of female is the increase in dowry i.e. payment of exorbitant dowry, daughters are often sold to higher castes and even poor man often paid a bride price to obtain a wife. Among the Jats in particular and various other in general, the scarcity of women led to wide spread system of polyandry.

Non available of suitable spouse by age and sect: Present trend of gender imbalance continues, one of the serious repercussions would be a rude shock to the institution of marriage in the decades to come. It has severe consequences especially in North Indian states of Punjab and Haryana which are characterized by in ability of men in marriageable age to find suitable partner by age as well as caste.

Increase in age gap: Scarcity of females may cause to increase in age gap between bide and bridegrooms. The brides will have much lower ages than bridegrooms, it causes to many problems like adjustment, family life, companionship etc.

Buying brides from other regions : The Hindustan Times, July 12, 2003read as "in Hathin (Haryana), because of shortage of women men buying brides from other states like Assam, West Bengal and from far away villages of Bihar. The price put on such a girl is much less than what people pay for cattle, after marriage they are condemned to a life of slavery.

Cultural Problems: Men from the shortage of female by caste, group, area and region causes to get marry of other castes, sects, areas and regions, it may causes to cultural problems, because brides have to adjust with bridegrooms family cultural, deviation may causes troubles in coping up of family life.

Abduction and trafficking of girls: Shortage of brides would be leads to abduction and trafficking of girls that resulted in expansion of the sex industry with the magnitude of spreading Sexually Transmitted Diseases and deadly disease like HIV/AIDS would increase manifold. The Hindustan Times recently reported that young girls from Assam and West Bengal are kidnapped and sold into marriage in neighbouring Haryana [8] .

Raise of anti-social behaviour: In this distorted social scenario marked by growing anti-social behaviour, crimes against women like rape, molestation,eve teasing, child marriages; forced polyandry etc. is also expected to rise.

Pressure on Women: Parents who have a fervent preference for male offspring will impose pressure on women. Thus, women who had given birth to only daughters were desperate for sons and would keep having children until they had one or two male children. In a study done by the Centre for Social Research in Haryana, fear of violence is a cause for female foeticide. Also the women who produce daughters face much more domestic violence which makes them complicit in getting rid of the girl child [9] .

Risk of ostracism: A family with only daughters will also likely lose its land when the father dies: although women can legally inherit property, in some areas of India, they risk ostracism or even murder if they claim what is theirs.

Some men may remain unmarried : Some states now experience a shortage of brides because of the adverse sex ratios. It was notes that 20% or more men in some states, including Haryana and Punjab, may remain unmarried. There are already examples of brides being "imported" from poorer eastern states. Further, unmarried men may faces Psycho-social problems like lack of sexual pleasure, family life, loneliness etc.

Delay in Marriages: Trends to higher age at marriage, more so in urban settings, were also observed, possibly as a function of the emphasis on education. In urban areas, it observed that the average age at marriage is now 20 for boys and 17 to 18 for girls, where earlier both were married at 14 years of age. Perhaps the rise in marriage age may be due to greater difficulty in finding an eligible spouse, with factors such as education, earning capacity, and dowries raising the stakes for the ideal match.

Choice of mate selection by girls may decline: Ensuring a girl's chastity is considered a great parental responsibility and is one of the arguments for promoting early marriage. For better or worse, some of the usual social, cultural, and economic norms in Indian society's choice of mates may be swayed. In some regions inter-caste marriage, marriage with girls of tribal communities, and polyandry are now becoming more common.

Social tensions arise: There are also reports of bride buying and forced remarriage of widows. In the near future social tension could rise because of the challenge of finding female partners, and may lead to crimes against women. Others wonder if a shortage of women will lead to less violence against them, or a decrease in dowries. Thus, the increasing imbalance in sex ratios is a sign of continued inequality between the sexes. The scarcity of females, they add, is symptomatic of their low value.

Disappear of mothering roles: In India, females are playing crucial role in household chores, childbearing as well as child rearing activities with more patience. Further, females role as mother cannot be ignored that strengthens family system;welfare of family members; however, in future, these can be slowly disappear if girl children decline rapidly.

Decline in Female labour: Apart from household works, females are engaging in outdoor employments, especially in agrarian sector of rural economy, the contribution of females by supporting men has been quite significant. However, their contribution is often unrecorded and unacknowledged. In

this context, decline in child sex ration leads squeezed female labour force. Further, the economic consequences are grave for deficit of females that a huge proportion of the productive population is missing and also the lack of women impairs the ability of men to work.

Decline Population Growth: In the entire world, for smooth growth of population of any county, both men and women are equally important. If females continuously declining, it causes to deficit of women population thereby it affects the growth of population by lack of females for men reproductive activity. Thus, scarcity of females brings down societies reproductive potential by lowering net reproductive rate. Moreover, events such as new household formation will decline.

Conclusion

Now a days, in a patriarchal society like India, a daughter is generally unwelcome due to "Guarding her chastity", as well as expenditures by way of Dowry are a heavy burden on parents apart from worry on uncertainty of her life after marriage. A son on the other hand continues the family line, provide the parents with emotional and financial security and perform the last rite i.e. male child is important for moksha. These are major cause apart from other reasons for rapid decline in child sex ratio in recent decades. Though, in India the acts are passed (such as The Prenatal DiagnosticTechniques Acts, 1994, The dowry prohibition Act), however these Acts are not properly implemented. It may be therefore, concluded that effective enforcement of laws along with softening a son-centered culture and bringing changes in cultures that are deeply rooted by way of socio-economic, and religious concerns which are causes for discrimination of girl children. Moreover, balanced child sex ratios are essential to avoid upcoming evil consequences of deficit of girl children in India.

Solutions and Advocacy

The long-term and short-term measures can stem to supersede from the deficit of girl children in India. In the long term, it is suggested that ensuring equal entitlements such as property rights, equal access to nutrition, health, education, affection, guarantee on safety and addressing the problem of dowry and life after marriage. While, in the short term, incentives to educate girls, financial support for girls, educating healthcare professionals and enhancing incentives for more number of female children born are recommended. "Another option is depositing some amount of cash to families where there are one or two female children in a household and no male children for future expenses such as education, marriage and life security. Such innovations are being started now in small settings in different places of India."

The development and focus aid on women are the two aspects that can tackle the declining girl population in India. The development can surely the wealthier the home, the more educated the parents, the more plugged in to the modern economy, the more a family will invest in its girls. But these efforts should be joined by an awareness of the unintended consequences of development and by efforts, aimed at parents; to weaken the cultural preference for sons. The other is focusing aid on women. The idea is that a mother who has more money, knowledge and authority in the family will direct her resources toward all her children's health and education. She will fight for her girls. While increasing women's decision-making power would reduce discrimination against girls, "When women's power is increased, prejudices and cultural practices opposite to girl children can decline".

In Indian context, it will not be enough to counter son-preference. But, dislike to daughters has to be evenly provoked through policy measures that increase the economic worth and support of daughters through improved employment opportunities, recognizing women's health and emphasizes on education levels than the mothering roles.

Finally, understand the formal and informal social, cultural, economic, and political processes that motivate the bias against having female children are needed to frame social policies to overcome a long-standing cultural preference for male children and to reverse a potentially disastrous future imbalance in the male/female child ratio of India's population.

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RESEARCH ARTICLE

Pattern of Housing Characteristics in India and its States : An Analysis

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Abstract

Housing plays a crucial role in the lives of individuals within any society. House ownership has traditionally been highly valued, seen as essential for family stability and wealth creation. The quality of housing, including access to basic amenities like water, sanitation, electricity, and more, is a significant indicator of a country's socio-economic development. Housing with basic necessities is a fundamental factor in economic, social, and civic progress, with various housing-related activities directly contributing to broader development objectives. When individuals and families do not have adequate housing with better characteristics, their well-being is severely affected. Inadequate housing can lead to poor health outcomes, placing a strain on the healthcare system. This study utilizes a descriptive research design, analyzing secondary data from the National Family Health Surveys (N.F.H.S) 1 to 5, to explore housing characteristics patterns in India and its states.

Keywords: Electricity; Drinking Water; Toilet; Fuel for Cooking; Pucca House and Persons Per Room

Introduction

India is home to a staggering 300 million individuals who endure extreme poverty and grapple with the lack of basic necessities such as food, clothing, and shelter. These individuals face the harsh reality of living in homes that lack essential services like water, sanitation, electricity, healthcare, and education **(Millennium Development Report, 2014)**. The provision of basic amenities in housing is crucial not only for improving the socio-economic status and standard of living of households, but also for fostering sustainable development. The absence of basic amenities within households, highlights the exclusion of a significant portion of the population from essential social infrastructures. In light of this, Rabiul Ansary and Bhaswati Das[(1)] argue that the denial of basic amenities like clean fuel and electricity will hinder India's efforts in controlling pollution and addressing issues such as climate change. The National Family Health Survey (N.F.H.S) offers insights into the demographic and socio-economic characteristics of households, shedding light on key housing aspects of the population. Understanding household characteristics and housing conditions provides valuable context for comprehending the socio-economic, demographic, and health situation of the population.

The study of housing and its characteristics serves as a reliable means of expressing human responses to the physical and cultural environment of a region. It represents the cultural achievements of the past and the preservation of traditions through simple architectural features. The housing conditions of families directly reflect their socio-economic and cultural status.

In typical human settlement patterns, there is a noticeable disparity in the types of houses occupied by different families. Affluent upper caste families reside in elaborate houses equipped with excellent all facilities, showcasing their social, cultural, and economic status. On the other hand, lower caste families find shelter in small houses or huts with inadequate basic facilities. Housing Characteristics like drinking water, bathroom and toilet facilities are essential to maintain one's good health and productivity. It is often argued that good housing conditions are essential elements for enhancing household health, and that poor housing and environmental conditions can lead to many health problems, including infectious diseases (such as tuberculosis and malaria), stress and depression (Udofia, Yawson, Aduful, & Bwambale, 2014). Zihan Kan et al[2] study results indicate that communities with relatively poor housing conditions have impact of housing on mental health may be more direct; while, for communities with relatively good housing conditions, the effect of housing characteristics on mental health may be indirect. The quality of life of any households in a region (state) is largely determined by availability of safe drinking water, sanitation, drainage facility for waste water, type of fuel used for cooking purposes and availability of separate kitchen, congestion of the households[3]. Availability of basic amenities within households is also another proxy indicator to study multi-dimensional deprivations and social inclusion or exclusion of a population. In many villages of India, the practice of untouchability still forces people belonging to a particular caste to fetch water from long distances[4].

Review

Bhagat et al. (2018)[4] conducted a study that focused on housing characteristics in nine villages located in the Melghat areas of Maharashtra and these areas are known for their high levels of poverty and malnutrition. In a study by Ibrahim Yakubu et al.[5], the link between housing conditions, resident health, and poverty levels was explored in the Metropolitan area. The findings revealed that a majority of houses in this area lack essential in-house facilities. Wei Guo[6] found that housing type and size have a significant impact on the health of migrants, while housing instability has a greater effect on the health of urban locals. Maria Löfstedt[7] conducted a new case study that reviewed the relationship between physical housing characteristics, housing accessibility, and various aspects of health among older people living in the community. Coley et al.[8] conducted research that demonstrated how poor housing conditions negatively affect the development of children and adolescents. Dekker et al.[9] concluded that individual characteristics such as age, presence of children, and length of stay are more influential in explaining residential satisfaction than specific estate characteristics. In a study by Daan Schipper[10], it was found that various socio-demographic variables have a significant impact on subjective well-being in relation to housing characteristics, as well as certain economic activities. Esraa A. Attia[11] aimed to reveal the relationship between rural housing characteristics and social-economic variables for the heads of families residing in these areas. Rabiul Ansary and Bhaswati Das[1] concluded that households lacking good housing conditions and basic amenities, which are essential for healthy and productive manpower, tend to have lower assets.

Objective

The paper aims at examine the pattern of housing characteristics in India and its 30 states based on secondary data during the period of 1992–93 of N.F.H.S-1 to 2019-21 of N.F.H.S-5.

Methodology

The research paper utilizes a descriptive research design and relies on secondary data obtained from the National Family Health Survey (N.F.H.S) conducted over a span of 38 years, from 1 to 5. The housing characteristics examined include electricity, drinking water, toilet/latrine facility, solid fuel used for cooking, pucca house, and the mean number of persons per room used for sleep. The N.F.H.S-1, conducted in 1992-93, encompassed 88,562 households. In 1998-99, the NFHS-2 survey included a representative sample of 91,196 households. NFHS-3 collected information from a nationally representative sample of 109,041 households in 2005-06, while N.F.H.S-4 in 2015-16 selected 628,900 households. Lastly, the NFHS-5 survey of 2019-21 covered a total of 636,699 sample households.

Results and Discussion

Housing characteristics data can be used as an indicator to address statistically how many people from various states have been excluded from an adequate standard/quality of living. The pattern of households' dwelling characteristics has been captured by seeing the condition of residential houses, types of house structures, the number of rooms a household possesses and other basic amenities such as electricity, drinking water, toilet/latrine facility, and percent of solid fuel used for cooking and these basic household amenities are discussed briefly hereunder.

Electricity

Electricity plays a crucial role in the daily lives of humans and is a significant factor in the modern economy. It is utilized for various purposes such as lighting, heating, cooling, refrigeration, operating appliances, computers/electronics, machinery, and transportation systems. Yunqing Lu et al.[12] conducted a study on energy consumption and household characteristics by implementing a dynamic pricing experiment in communal housing within a smart community in Japan. Table 1 illustrates the distribution of households with electricity in India and its states.

Table 1 reveals those substantial variations in households with access to electricity during the period of N.F.H.S-1 to N.F.H.S-3. However, access to electricity drastically improved in India and its states in the period of N.F.H.S-4 and N.F.H.S-5. In most states, over 95 percent of sampled households have electricity and almost all households in India (97%) have electricity in N.F.H.S- 5 of 2019-20. It clearly indicates that sampled households had electricity for many purposes in their homes to lead better life.

Drinking water

The provision and availability of safe drinking water and sanitation plays a crucial role in enhancing the quality of life and promoting good health. It helps in reducing illnesses, water-borne diseases, and fatalities, leading to lower health expenses, increased savings, and enhanced human efficiency. In rural areas, women or girls are typically tasked with fetching water from various sources for household purposes. The accessibility of water was a key aspect of the Minimum Need Programme initiated between 1974 and 1979 to cater to all segments of society. Ensuring access to clean and safe drinking water is essential for overall health and well-being. In certain states like Manipur, Odisha, Meghalaya, Tripura, Jharkhand, and Madhya Pradesh, around 33 percent of households, and in states like Nagaland, West Bengal, Chhattisgarh, and Rajasthan, approximately 25 percent of households, obtain water from sources located away from their homes[3] . Drinking water serves various vital functions in the body, such as regulating body temperature, maintaining healthy skin, and aiding in digestion (Duselis, Amanda R et al., 2007 and Amend, Sarah R et al., 2016). The National Family Health Survey (N.F.H.S) recognizes improved sources of drinking water, "including piped water, public taps, standpipes, tube wells, boreholes, protected dug wells and springs, rainwater, and community reverse osmosis (RO) plants". These sources help safeguard against external contamination, ensuring that the water is safe for consumption.

Table 2 reveals that significant percent of households had increaseaccess to improved source of drinking water in India and its states during the study period. In N.F.H.S-1, only over 40.0 percent access to improved source of drinking water in states like Assam, Manipur, Meghalaya, Mizoram, Tripura and Kerala being with least 21.0 percent) wherein most of the households get drinking water from open well with the premises of house in general., over 80.0 percent and 90.0 percent of household have access in most of the states and in India in N.F.H.S-3 and N.F.H.S-4 respectively. However, in most of the states and in India, over 95.0 percent of households have access to improved source of drinking water in N.F.H.S-5. This clearly indicates that most of people are protected from water born diseases with having access to improved source of drinking water.

Toilet facilities

According to the World Health Organization, open defecation is considered the most dangerous sanitation practice. Nearly 10 percent of all communicable diseases are associated with unsafe water and inadequate sanitation. In 1986, the Government of India initiated the Central Rural Sanitation Programme (CRSP) to enhance sanitation coverage in rural areas, aiming to improve the health and quality of life of rural residents, especially women, by providing privacy and dignity. The Total Sanitation Campaign (TSC), a variant of CRSP, was introduced in 1999 with a community-driven and people-centric approach. Despite efforts to achieve the MDG Goal of 'Sanitation for All' by 2012, the TSC programs fell short. The 2011 Census revealed that almost half of Indian households (49.8 percent) practices open defecation, with 53 percent lacking toilet facilities in their premises. A study by[3] based on the 2011 Census indicated that central Indian states have higher rates of open defecation compared to the rest of the country. While a significant portion of the population lacks household toilets, a majority own mobile phones. Cultural norms, traditional beliefs, lack of awareness, and low education levels are cited as the main reasons for this unhygienic practice[1]. The National Family Health Survey (N.F.H.S) defines toilet facilities as "any non-shared toilet types, including flush/pour flush toilets connected to piped sewer systems, septic tanks, and pit latrines; ventilated improved pit (VIP)/biogas latrines; pit latrines with slabs; and twin pit/composting toilets".

Table 3 depicts drastic improvement in households with any toilet facility in India and its states duringof N.F.H.S-1 of1992-93 and N.F.H.S-5 of 2019-20. In N.F.H.S-1, less than 25.0 percent of household have access to toilet in states like Himachal Pradesh, Jammu & Kashmir, Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Odisha and Andhra Pradesh. About 30.0 percent households have no toilet facility in state like Himachal Pradesh, Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Odisha and Andhra Pradesh in N.F.H.S-2, while significant percent of households had access to toilet facility in majority of the states and in India during the period of N.F.H.S-3 and N.F.H.S-4. However, less than 25.0

Table 1. Percent of households with electricity in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3(2005-06)	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	95.5	97.7	99.3	98.8	99.9
2.	Haryana	85.0	89.1	91.5	98.8	99.5
3.	Himachal Pradesh	90.2	97.2	98.4	99.5	99.4
4.	Jammu & Kashmir	86.7	90.1	93.2	97.4	99.3
5.	Punjab	92.0	95.5	96.3	99.6	99.6
6.	Rajasthan	51.9	64.4	66.1	91.0	97.9
7.	Uttarakhand	-	-	80.0	92.5	99.4
8.	Chhattisgarh	-	-	71.4	95.6	98.5
9.	Madhya Pradesh	62.4	68.1	71.4	89.9	98.1
10.	Uttar Pradesh	31.9	36.6	42.8	70.9	89.8
11.	Bihar	16.6	18.2	27.7	58.6	95.6
12.	Jharkhand	-	-	40.2	95.6	98.5
13.	Odisha	27.8	33.8	45.4	85.5	96.3
14.	West Bengal	32.9	36.7	52.5	93.7	97.0
15.	Arunachal Pradesh	63.1	68.9	76.9	88.7	94.7
16.	Assam	20.4	26.4	38.1	78.2	92.7
17.	Manipur	62.1	75.3	67.0	92.4	97.8
18.	Meghalaya	42.6	41.2	70.4	91.4	92.0
19.	Mizoram	76.0	64.1	92.3	95.9	98.0
20.	Nagaland	76.9	56.3	82.9	96.9	98.6
21.	Sikkim	-	80.7	92.1	99.4	99.3
22.	Tripura	45.1	-	68.8	92.7	97.9
23.	Goa	91.7	93.5	96.4	99.8	100.0
24.	Gujarat	76.6	84.3	89.3	96.0	97.2
25.	Maharashtra	73.6	82.1	83.5	92.5	97.4
26.	Andhra Pradesh	62.2	74.4	88.4	98.8	99.1
27.	Karnataka	64.0	80.9	89.3	97.8	98.8
28.	Kerala	60.3	71.8	91.0	99.2	99.5
29.	Tamil Nadu	63.8	78.8	88.6	98.8	99.0
30.	Telangana	-	-	-	98.3	99.3
India		**50.9**	**60.1**	**67.9**	**88.2**	**96.5**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health and Family Welfare, New Delhi, National Family Health Survey-1 to 5.

percent of household had not having toilet facility in states like Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Odisha, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu in the period of N.F.H.S-5, it causes to practice open defecation. No access to sanitary toilet provisions led to no ensure of hygiene conditions. It reveals the extreme conditions that exist in these states there by riskiest sanitation practice may causes to water and air born diseases that leads ill health of people.

Use of solid fuel for cooking

Exposure to indoor smoke, whether from cooking with solid fuels or smoking tobacco, can have adverse health effects. The risk of exposure to cooking smoke is higher when cooking is done indoors rather than in a separate structure or outdoors. India faces a significant challenge in providing safer cooking fuel options. The United Nations' efforts to combat extreme poverty may not reach their full potential unless countries prioritize bringing electricity and modern, safe cooking technologies to the billions of energy-poor individuals worldwide[13]. Majority (71.5 percent) of

Table 2. Percent of households with improved source of drinking water in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3 (2005- 06	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	99.5	98.7	92.1	80.0	99.5
2.	Haryana	73.0	88.0	95.6	91.6	98.6
3.	Himachal Pradesh	57.6	77.4	88.4	94.6	96.4
4.	Jammu & Kashmir	57.3	70.6	80.8	89.2	92.3
5.	Punjab	98.6	98.9	99.5	99.1	98.8
6.	Rajasthan	57.3	69.8	81.8	85.5	96.4
7.	Uttarakhand	-	-	87.4	92.9	95.5
8.	Chhattisgarh	-	-	77.9	91.1	95.6
9.	Madhya Pradesh	55.8	63.5	74.2	84.7	88.9
10.	Uttar Pradesh	74.3	85.6	93.7	96.4	99.2
11.	Bihar	63.6	75.4	96.1	98.2	99.1
12.	Jharkhand	-	-	57.0	77.7	86.8
13.	Odisha	50.9	65.3	78.4	88.8	90.8
14.	West Bengal	84.9	89.3	93.7	94.6	97.5
15.	Arunachal Pradesh	75.8	80.7	85.0	87.5	94.2
16.	Assam	43.2	60.1	72.4	83.8	86.4
17.	Manipur	47.0	48.9	52.1	41.6	77.0
18.	Meghalaya	47.6	42.1	63.1	67.9	79.2
19.	Mizoram	40.1	63.2	85.0	91.4	95.7
20.	Nagaland	72.1	40.5	62.8	80.6	91.0
21.	Sikkim	-	84.6	77.6	97.6	94.0
22.	Tripura	44.1	-	76.1	87.3	88.5
23.	Goa	56.5	61.8	80.1	96.3	98.2
24.	Gujarat	75.1	84.5	89.8	90.9	97.5
25.	Maharashtra	78.5	81.9	92.7	91.5	93.8
26.	Andhra Pradesh	63.4	78.5	94.0	72.7	96.7
27.	Karnataka	75.6	87.0	86.2	89.3	95.6
28.	Kerala	21.0	19.9	69.1	94.3	94.9
29.	Tamil Nadu	74.6	85.0	93.5	90.6	98.6
30.	Telangana	-	-	-	77.9	98.7
India		**68.2**	**77.9**	**87.9**	**89.9**	**95.9**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health and Family Welfare, New Delhi, National Family Health Survey-1 to 5.

Table 3. Percent of households with toilet facility in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3 (2005-06)	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	84.1	94.4	92.4	96.0	98.7
2.	Haryana	26.9	39.0	52.4	89.8	96.6
3.	Himachal Pradesh	12.6	26.7	46.4	85.7	93.5
4.	Jammu & Kashmir	19.1	51.0	61.7	79.3	94.3
5.	Punjab	36.7	51.4	70.8	92.9	97.2
6.	Rajasthan	19.8	27.8	30.8	54.0	77.5
7.	Uttarakhand	-	-	56.8	82.9	93.6
8.	Chhattisgarh	-	-	18.7	41.3	84.7
9.	Madhya Pradesh	21.3	22.2	27.0	42.8	73.8
10.	Uttar Pradesh	22.9	26.5	33.1	45.8	77.1
11.	Bihar	16.5	16.8	25.2	33.5	61.6
12.	Jharkhand	-	-	22.6	30.0	66.4
13.	Odisha	12.2	13.5	19.3	35.0	66.1
14.	West Bengal	40.4	44.8	59.6	74.9	88.0
15.	Arunachal Pradesh	73.6	73.0	80.6	90.8	98.5
16.	Assam	49.6	63.0	76.4	88.9	95.8
17.	Manipur	83.1	92.0	95.6	98.7	99.5
18.	Meghalaya	54.3	52.0	71.3	92.4	95.8
19.	Mizoram	98.3	97.7	98.0	99.1	99.9
20.	Nagaland	79.3	74.3	85.6	98.3	99.6
21.	Sikkim	-	72.7	89.0	99.7	99.6
22.	Tripura	79.4	-	96.7	97.9	98.9
23.	Goa	48.0	58.9	76.0	89.1	96.3
24.	Gujarat	35.0	44.9	54.6	71.0	80.7
25.	Maharashtra	40.8	45.9	52.9	71.2	82.7
26.	Andhra Pradesh	24.4	27.3	42.4	61.3	83.7
27.	Karnataka	31.2	38.6	46.5	65.8	82.3
28.	Kerala	70.9	85.2	96.1	99.2	99.7
29.	Tamil Nadu	29.4	34.0	42.9	61.7	77.5
30.	Telangana	-	-	-	69.0	87.3
India		**30.3**	**35.9**	**44.6**	**61.1**	**80.6**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health And Family Welfare, New Delhi, National Family Health Survey-1 to 5.

households in India still rely on firewood, crop residue, cow dung cakes, or coal for cooking, which are common traditional fuels in rural areas[1]. It is estimated that up to 70 percent of households in developing nations use wood, dung, and crop residues for cooking (International Energy Agency, 2002). The National Family Health Survey considers solid fuels for cooking to include "coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crop waste, and dung cakes".

Table 4 reveals the substantial variations across in India and states in households with usedsolid fuel for cooking. Significant percent of households had used solid fuel for cooking during the period of N.F.H.S-1 and N.F.H.S-4 in India and many states. Even in N.F.H.S-5 period also, over 50.0 percent of households used solid fuel for cooking in India and its many states. Hence, burn of solid fuel for cooking causes to harmful air pollution that leads health impact on lungs related diseases especially among women and children.

Type of House

Houses owned by the wealthy are considered 'pucca', indicating that they are constructed using durable materials such as stone, brick, and cement. On the other hand, the houses

Table 4. Percent of households with solid fuel for cooking in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3 (2005-06)	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	4.4	3.6	9.3	3.6	0.8
2.	Haryana	55.6	66.9	69.1	47.4	40.1
3.	Himachal Pradesh	84.8	64.0	68.9	62.5	47.7
4.	Jammu & Kashmir	64.9	65.8	59.5	41.5	30.2
5.	Punjab	44.9	60.6	54.9	33.5	22.1
6.	Rajasthan	81.0	81.0	77.2	67.8	58.5
7.	Uttarakhand	-	-	61.7	48.1	40.5
8.	Chhattisgarh	-	-	86.7	76.7	66.4
9.	Madhya Pradesh	68.2	79.3	80.3	69.7	59.3
10.	Uttar Pradesh	68.3	82.8	81.7	66.7	50.3
11.	Bihar	51.1	85.9	89.7	81.9	62.0
12.	Jharkhand	-	-	89.1	80.6	67.8
13.	Odisha	68.7	86.8	88.6	79.6	64.9
14.	West Bengal	31.6	65.7	79.2	69.6	59.1
15.	Arunachal Pradesh	87.7	80.8	67.7	54.2	46.6
16.	Assam	87.8	87.1	75.8	74.2	56.4
17.	Manipur	80.5	69.2	64.7	57.6	29.6
18.	Meghalaya	82.0	83.5	72.2	74.7	63.4
19.	Mizoram	66.2	57.4	34.1	31.2	16.0
20.	Nagaland	97.4	86.1	76.0	66.6	56.5
21.	Sikkim	-	63.2	52.4	39.1	20.7
22.	Tripura	91.1	-	80.4	62.1	53.0
23.	Goa	51.3	41.4	33.3	13.7	2.8
24.	Gujarat	55.9	54.5	52.3	44.2	32.2
25.	Maharashtra	55.2	51.9	48.1	36.0	18.2
26.	Andhra Pradesh	77.0	74.1	66.3	37.1	15.6
27.	Karnataka	75.4	67.8	63.8	43.4	19.4
28.	Kerala	87.4	81.7	71.4	42.3	27.4
29.	Tamil Nadu	77.7	66.5	60.5	24.3	15.4
30.	Telangana	-	-	-	30.8	7.7
India		63.9	71.7	70.8	54.7	40.6

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health And Family Welfare, New Delhi, National Family Health Survey-1to5.

of the poor are categorized as 'Semi katcha' or 'katcha', as they are built using less durable materials like country tiles, stone rubbles, mud, and thatch, which are readily available locally. In rural areas of India, the design of houses is influenced by the availability of local building materials. The construction of houses in rural settings aims to fulfill the functional needs of the families residing in them. Approximately 12 percent of residential structures in India are temporary in nature. The eastern and central regions (West Bengal, Odisha, Bihar, Jharkhand, and Chhattisgarh) have a higher percentage of dilapidated houses used for residential purposes, while the southern and western states report the lowest percentage [1]. According to the National Family Health Survey (N.F.H.S), "pucca houses are those constructed using high-quality materials for the floor, roof, and exterior walls".

Table 5 reveals the substantial variations in households living in a pucca house in India and its states during the period of N.F.H.S-1 to N.F.H.S-5 and majority of households were not lived in pucca houses in many states. However, an improvement was observed in percent of households living in a pucca house in India and its states during the period of N.F.H.S-1 to N.F.H.S-5 due to construction of pucca for socio-

Table 5. Percent of households living in a pucca house in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3 (2005-06)	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	81.0	88.2	94.9	90.3	93.7
2.	Haryana	39.6	46.7	61.1	76.3	76.5
3.	Himachal Pradesh	22.7	28.7	52.7	70.2	76.1
4.	Jammu & Kashmir	32.5	36.1	50.3	70.9	75.2
5.	Punjab	52.6	52.1	68.9	80.8	78.3
6.	Rajasthan	38.1	41.4	50.1	64.2	54.4
7.	Uttarakhand	-	-	49.8	64.5	75.7
8.	Chhattisgarh	-	-	21.7	35.9	43.2
9.	Madhya Pradesh	13.8	19.2	26.2	35.7	45.2
10.	Uttar Pradesh	20.1	24.8	28.8	33.1	40.5
11.	Bihar	15.5	15.5	20.4	25.9	34.0
12.	Jharkhand	-	-	28.3	37.9	42.8
13.	Odisha	9.5	14.8	31.9	44.5	59.0
14.	West Bengal	22.5	32.8	39.5	46.5	52.5
15.	Arunachal Pradesh	2.2	14.2	20.8	23.9	24.5
16.	Assam	2.2	10.9	19.8	25.2	31.6
17.	Manipur	4.9	7.1	10.7	17.7	22.6
18.	Meghalaya	3.9	14.5	35.1	43.0	45.0
19.	Mizoram	6.0	16.2	22.9	54.7	50.5
20.	Nagaland	8.4	18.1	20.7	28.4	33.5
21.	Sikkim	-	50.6	51.0	71.6	75.7
22.	Tripura	3.1	-	12.1	26.6	33.0
23.	Goa	54.0	51.0	73.0	84.2	90.0
24.	Gujarat	33.2	45.2	67.3	77.1	77.2
25.	Maharashtra	30.6	28.3	59.0	72.9	76.8
26.	Andhra Pradesh	31.3	39.9	56.3	81.5	84.6
27.	Karnataka	16.5	41.2	55.1	62.9	63.7
28.	Kerala	19.9	79.8	85.1	89.0	83.4
29.	Tamil Nadu	22.7	27.6	69.9	78.9	87.9
30.	Telangana			-	75.0	79.2
India		**23.7**	**32.0**	**45.9**	**56.3**	**60.3**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health And Family Welfare, New Delhi, National Family Health Survey-1 to 5.

cultural and economically marginalized by the governments under housing schemes. But still in N.F.H.S-5 period, 30.0 percent in India and over half of sampled households were not living in a pucca house in the states like Madhya Pradesh, Uttar Pradesh, Bihar, Arunachal Pradesh, Assam, Manipur, Meghalaya and Tripura. This clearly indicates that significant percent of households not had living in a pucca house in India and its states due to poor socio-economic, cultural and geographical reasons though pucca house is being the one of basic need of human being to live comfortably.

Person per room

The measure of crowding known as ”persons per room” takes into account all the rooms in a private dwelling and the number of people living in the household. A higher value for ”persons per room” indicates a greater level of crowding. In India, approximately 3.9 percent of households do not have rooms specifically designated for residential purposes [1]. According to the Census 2011 data, there are 43,813 families living in shared rooms, with nearly 40,000 of them located in urban Delhi. This data clearly highlights a significant proportion of the lower middle class residing in shared rooms

Table 6. Percent of households with mean number of persons per room used for sleeping in India and its states

S. No	India/ State	NFHS-1 (1992‑93)2222	NFHS-2 (1998-99)	NFHS-3 (2005- 06)2222	NFHS-4 (2015-16)	NFHS-5 (2019-21)2222
		Total	Total	Total	Total	Total
1.	Delhi	2.6	2.2	3.1	2.9	2.8
2.	Haryana	2.9	2.4	3.3	2.7	2.7
3.	Himachal Pradesh	2.1	1.8	2.5	2.1	2.0
4.	Jammu & Kashmir	2.8	2.2	2.9	2.5	2.1
5.	Punjab	2.7	2.1	3.1	2.7	2.6
6.	Rajasthan	3.0	3.0	3.6	3.0	2.7
7.	Uttarakhand	-	-	3.0	2.7	2.5
8.	Chhattisgarh	-	-	3.0	2.8	2.4
9.	Madhya Pradesh	2.8	2.9	3.6	3.1	2.8
10.	Uttar Pradesh	3.0	3.1	3.8	3.4	3.0
11.	Bihar	2.8	2.9	3.3	3.3	3.0
12.	Jharkhand	-	-	3.2	2.7	2.4
13.	Odisha	2.4	2.4	3.1	2.8	2.5
14.	West Bengal	2.8	2.7	3.1	2.7	2.4
15.	Arunachal Pradesh	2.9	2.2	2.7	2.1	1.7
16.	Assam	2.4	2.1	2.7	2.3	2.1
17.	Manipur	2.1	2.1	2.6	2.4	2.3
18.	Meghalaya	2.1	2.0	2.9	2.3	2.3
19.	Mizoram	2.0	2.6	3.5	3.0	2.6
20.	Nagaland	1.9	1.6	2.6	2.1	1.6
21.	Sikkim	-	2.0	2.3	1.9	1.5
22.	Tripura	2.4	-	2.9	2.4	2.3
23.	Goa	1.8	1.6	2.7	2.4	2.2
24.	Gujarat	3.3	2.7	3.6	3.2	3.0
25.	Maharashtra	3.2	3.0	3.5	3.2	2.9
26.	Andhra Pradesh	2.8	2.9	3.2	2.9	2.7
27.	Karnataka	2.7	2.5	3.4	2.7	2.5
28.	Kerala	1.4	1.3	2.2	1.8	1.8
29.	Tamil Nadu	2.5	2.2	2.9	2.4	2.3
30.	Telangana	-	-	-	3.0	2.6
India		**2.8**	**2.7**	**3.3**	**2.9**	**2.7**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health And Family Welfare, New Delhi, National Family Health Survey-1 to 5.

within the city's population.

Table 6 reveals the significant variations across in India and its states in mean number of persons per room used for sleeping during N.F.H.S 1 of 1992-93 to N.F.H.S-5 of 2019-21. On an average 2.5 mean number of persons per room used for sleeping in India and in many states. However, over 2.5 mean number of persons per room used for sleeping in states like Delhi, Haryana, Himachal Pradesh, Punjab, Rajasthan, Madhya Pradesh, Mizoram, Maharashtra, AndhraPradesh, Kerala Andhra Pradesh, and highest being 3.0 mean number of persons in Uttar Pradesh, Bihar, Gujarat in N.F.H.S-5 period. In states with higher mean number of persons per room used for sleeping can be problems such as individual privacies, congested and health issues especially such as the period of Covid-19 etc.

Conclusion

Drastic improvement had observed in house hold electricity and improved source of drinking water during the period of N.F.H.S-1 to N.F.H.S-5. All most of sampled households' access to have electricity (97%) and over 95.0 percent of households have access to improved source of drinking water in India and its states in N.F.H.S-5. However, less than 25.0 percent of household had not having any toilet facility in states like Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Odisha, Gujarat, Maharashtra, Andhra Pradesh, Karnataka Tamil Nadu and Telangana in the period of N.F.H.S-5. Substantial variations have observed across in India and its states in households with use of solid fuel for cooking. Over 50.0 percent of households used solid fuel for cooking in India and its many states. This could lead to lungs and heart diseases. Over 2.5 mean number of persons per room used for sleeping in states like Delhi, Haryana, Himachal Pradesh, Punjab, Rajasthan, Madhya Pradesh, Mizoram, Maharashtra, Andhra Pradesh, Kerala, Andhra Pradesh, Telangana and highest being 3.0 mean persons per room used for sleeping observed in Uttar Pradesh, Bihar and Gujarat, can be cause to problems such as personal and health. Therefore, the N.G.Os and govern agencies should make better inclusive policies related sanitation/toilet, clean fuel for cooking and pucca house for poor/ marginalized sections that are the highest level of deprivation and contributing to poor health, high mortality and low quality of living.

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CROP REGIONS IN DISTRICT KURNOOL OF ANDHRA PRADESH

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ABSTRACT

Agricultural regionalization is a process of Delineating on area in to territorial units of complexes of uniformities on the basis of physical factors like climate, soils, vegetation, and availability of water, farm size and socio-economic parameter. It has a significant bearing on the development of agricultural and regional planning in developing countries. It is needed to understand Agricultural types, variations, challenges, forecast productivity, feature plans for agricultural developments, suggest optimal land utilization patterns, and make an inter-regional comparison in different aspects and so on. Agriculture is one of the leading occupations in India. It is back bone of Indian economy. In India nearly about 64 % of the total population and 90 % of rural population is engaged in agriculture. India being a country of Intensive subsistence farming activities are observed all-round the year in various intensities. Understating the importance of regionalization, specifically crop regions; an attempt is made in the present study, to demarcate the crop regions of Kurnool district for two time periods i.e., 2007-08 & 2018-19.

Keywords : *Primary crop region, Secondary crop region, Tertiary crop region Ranking Method, and Change of crop regions***.**

INTRODUCTION

Agriculture is an important occupation which is considered as a part and parcel

of human life and which runs through a definite process. It is carried under the control of natural environment. Agriculture is an important source of food. In spite of growing industrialization and urbanization in the world. In developing countries agriculture sector has been a major source of employed and income. Agriculture is a backbone of Indian economy. In India near about 64 % of the Total population and 90 % of rural population is engaged in agriculture. In spite of technological development, environmental factors play key role in the Development of agriculture in the region. Socio-economic factors also support for the growth of agriculture. This it is necessary to focus on the physical and Socio-economic Factors of the study region to understand the agricultural scenario of the region.

Agricultural regionalization is one of the oldest concepts in Agricultural classification and has a significant bearing on regional planning and development of agriculture in developing countries. It is regarded as a device for clustering both visible and non-visible Agricultural phenomena on the earth surface. Such device enables geographers to divide an area in to several regions in terms of diversity present in agricultural system. It gives us the relative position of crops on regional scale (Dayalan N.2018). The analysis of general land use, agricultural regionalization and cropping pattern helps to denote the intensity and status of farming in an area and also helps in the formulation of Agricultural plans which may go a long way in reducing the regional disparities and inequalities.

Systematic study of crop regions is of great significance for a comprehensive and clear understanding of the agricultural mosaic of an agro-climatic region and the planning and development of its agriculture, in recent years the concept of crop regions has engaged the attention of geographers and agricultural land use planners.

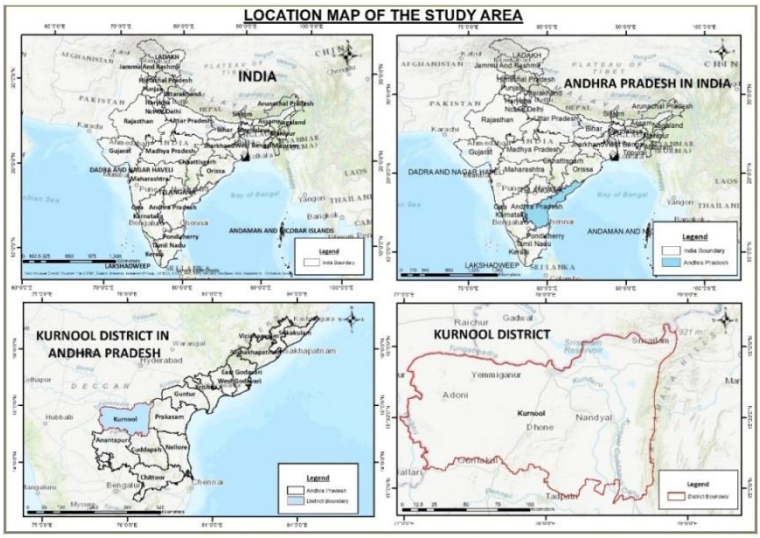
The first attempt of agricultural regionalization of Europe was made by *Jonsson* (1926) in his work Agricultural regions of Europe. Baker (1926), one of the Leading American Geographers, published Agricultural regions of North America, and Jones (1928) produced his book Agricultural regions of South America. Similarly, Taylor (1930) Delineated agricultural regions of Australia and Valkenberg (1931) divided Asia into Agricultural Regions. The first attempt to classify types of agricultural land use the world over, in terms of agricultural element – complexes, was in the form of the empirical system developed by Jones and Whittlesey (1932). A few of Russian authors who have put forwarded their views regarding Agricultural regionalization, Marshall (1787), Arsenev (1818), (Raktinika, 1959, 1971, 1973, 1975, 1979). Others have attempted to demarcate regions by aggregation of basic areal units based on agriculture with the help of quantitative taxonomic methods (Hartshorne and Dicken 1935, Nordgard 1974).

In India, geographers richly contributed to the studies of agricultural geography on various aspects including cropping intensity, crop combinations, crop concentration, crop diversification, agricultural efficiency, agricultural classification, agricultural regionalization, agricultural typology of which brought about lot of changes in the subject matter, approaches and methodology of agricultural geography. Deshpande (1942, 1964), Mukherjee (1942), Dayal (1950) etc. made regional studies in agricultural geography. Chatterjee (1952, 1956), Shafi (1960), Singh (1962), Bhatia (1967), Mishra (1969), Raifullah, Jasbir Singh (1972) etc. are among the notable agricultural geographers in India.

LOCATIONAL SETTING OF KURNOOL DISTRICT

Kurnool district is the south-western district of Andhra Pradesh and lies approximately between 14º54' to 16º18' North Latitudes and 76º58' 79º34' East Longitudes. The altitude of the district varies from 100 ft above the mean sea

level. This district is bounded on the north by Tungabhadra and Krishna River as well as Mahbubnagar district, on the south by Kadapa and Anantapur district, on the west by Bellary district of Karnataka state and on the east by Prakasam District. The district ranks 10 in population with 40, 53,463 people accounting for 4.63 % of the total population of the state as per 2011 Population census. While in area it occupies the 3rd place 17658 sq.km. which account for 6.41% of the total area of the state. The Nallamala and Earramalla are two important mountain ranges in the district running in parallel from North to south. Earramla divided the district into two well defined tracks from east to west in terms of soils. The Kurnool District is a combination of Red, Block and sandy soils. It has facility of Irrigation through canals (K. C. Canal, Tungabadra project low level canal and hundri neva sujalasravanthi project), tanks, wells, and river sources. The district has typically geographical aspects and climatic variation comparatively from other districts of Rayalaseema region of Andhra Pradesh. The district is well connected with road and rail transportation with national highways to farmer capital city of Andhra Pradesh.



OBJECTIVES

To identify and demarcate the crop regions such as primary, secondary and tertiary crop regions of Kurnool district for the years 2007-08 and 2018-19.

To study the changes in crop regions during 12 years period.

DATA AND METHODOLOGY

In the present study, secondary data pertaining to general cropping pattern for two time periods i.e., 2007-08 and 2018-19 have been collected from the Government records and reports from the Chief Planning Officer, Handbook of Statistics, Agricultural Department of Kurnool district taking 'Mandal' as Unit. Simple statistical techniques such as percentages and averages have been used to analyze the data. The spatial patterns of various crops that ranked from first to third in percentage of total cropped area is attempted here for the study of Primary, Secondary and Tertiary crop regions. The task of the first order crop regions (or) first ranking crop regions is accomplished by considering the crops which account for the maximum percentage of the total cropped area in each of the component areal units, no matter what percentage it occupies in the total cropped area. In the same way, the second-order crop regions and third-order crop regions have been demarcated on the basis of their percentage in order. To fulfill the set objectives, percentages of different crops that are growing in the district have been calculated and arranged in descending order, to demarcate the crop regions.

PRIMARY CROP REGIONS (2007-2008)

During the study period, out of 10 crops, only four crops namely Pulses (22 mandals), Ground nut (13 Mandals), Sunflower (10 mandals) and Paddy (8 Mandals) were registered as primary crops in different mandals with different concentration and one mandal srisailam which is in north eastern part of the district is 100 % covered with forest. Pulses occupied first place in the Maximum no of mandals and paddy crop in the minimum no of mandals in the district.

PULSES REGION

Pulses crop is dominant primary crop region in the study period occupying in

the district. It formed the largest region as primary crop. Pulses are one of the important food crops globally due to their higher protein content. Pulses are an important group of crops in India which is also responsible for yielding large financial gains by amounting to many exports. Pulses form an integral part of the Indian diet provides much needed protein to the carbohydrate –rich diet. India is largest producer of pulses in the world. In India the main regions with high productivity are Punjab, Haryana, western UP, West Bengal Delta region, Coastal A.P, Tamil Nadu, Kerala, Coastal and eastern Karnataka, and some parts of Maharashtra. In Kurnool it occupied about 269832 Hectares. In about 22 mandals of the district spread over in most of the south western, south-eastern, north-eastern part of the district. (Table 1 & Fig. 1).

GROUNDNUT REGION

Groundnut crop is the second –largest crop region in the study period occupying 13 mandals of the district. Groundnut is a leguminous plant that is widely cultivated in the tropics and subtropics. It is valued for its high oil edible seeds and as such, it is the fourth most important source of edible oil and a third most important source of vegetable protein and an important agricultural export commodity. In India, after Gujarat, Andhra Pradesh occupies 2nd place in groundnut production. In the actual area, it occupied about **236972** hectares. In About 13 Mandals of The district, Namely C.Belagal, Dhone, Bethamcherla, Veldurthy, Krishna Giri, Peapully, Kosigi, Pedda Kadubur, Yemmiganur, Pattikonda, Devanakonda, Tuggali, Gonegandla, mostly confined to the central, south and north western part of the district (Table 1 & Fig. 1).

SUNFLOWER REGION

Another important primary crop region in Kurnool District is sunflower spreading over 10 mandals. In the actual area, it occupied about *157104* hectares. The mandals where the sunflower region is dominant as the primary

crop region are Kallur, Kodumur, Atmakur, Kothapalle Gadivemula, Adoni, kowthalam, Nandavaram, mantralayam, Holagunda mandals, which are located in western, north, north eastern part of the district. (Table 1 & Fig. 1)

PADDY REGION

As primary crop region, paddy crop spreading over 8 Mandals, namely Velogode, Pamulapadu, Nandayala, Mahanandi, B. Atmakur, Rudra varam, sirvella, Gospadu which are distinctly seen in the eastern part of the district in Andhra Pradesh, it is mainly cultivated in the Krishna, Guntur, Kurnool, Nellore Prakasham, and twin Godavari district Kurnool sonamasoori rice is popularly fine rice variety being cultivated in Rayalaseema, especially in Kurnool due conductive atmosphere. (Table 1 & Fig. 1).

PRIMARY CROP REGIONS (2018-2019)

During the year 2018-19, 5 crops have been noticed under primary crop region in Kurnool District. They are cotton (17 Mandals), Pulses (15 Mandals), paddy (9 Mandals), millets (8mandals), Ground nut (4 mandals).

COTTON REGION

In 2018-19 cotton crop is dominant primary crop region. Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fiber) to cotton textile industry. Cotton in India provides direct livelihood to 6 million farmers and about 40 - 50 million people are employed in cotton trade and its processing. In India, there are ten major cotton growing states namely Punjab, Haryana, Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu.

Cotton region is newly formed primary crop region during the period 2018-19 replacing the sunflower, ground nut and pulses crops. The actual area it occupied in this district about 259498 hectares and spread over 17 mandals especially located in Western and northern part of the district. It is emerged as the largest crop region in the study is during 2018-19. (Table 1 & Fig. 1)

PULSES REGION

This is 2nd largest crop regions occupying the 15 mandals during the study period, confined mostly to the north, south, south eastern part of the district. (Table 1 & Fig. 1)

PADDY REGION

As a primary crop region, paddy crop is reported 9 mandals of the district, especially located in eastern part of the district. (Table 1 & Fig. 1)

MILLETS REGION

Eight mandals namely Pagidayala, Jupadubunglow, Atmakur, Pamulapadu, kothapalle, Gadivemula, Allagada, Chagalamari are reported as primary crop regions with millets in the Study period (Table 1 & Fig. 1).

GROUND NUT REGION

Ground nut as a primary crop region has been noticed in only four mandals namely Dhone, Krishna giri, Devanakonda, Tuggali located in central part of the district. (Table 1 & Fig. 1)

CHANGE IN PRIMARY CROP REGIONS (2007-08 & 2018-2019)

Noticeable changes have occurred in primary crop regions of the district during 12 years' period. Among the 4 primary crop regions which are registered in 2007-08, namely pulses, groundnut, sunflower, and paddy have been noticed.

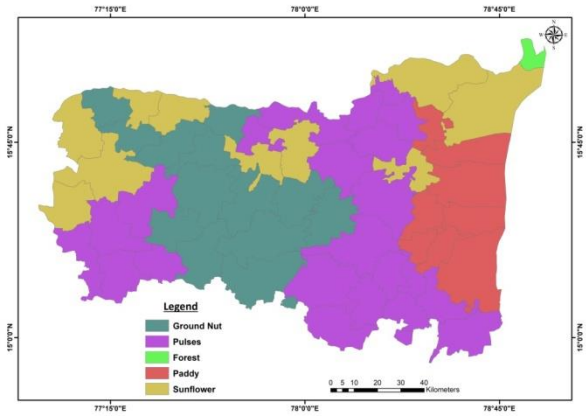
After 12 years' period, new crops Cotton and millets were registered. The other changes are, increase in the number of mandals regarding paddy crop region (+ 1 mandals). A decrease in the number of mandals has been seen in the pulse's region (-7mandals) and ground nut region (-9 mandal) and sunflower crop remarkably decrease and not registered in 2018-19. New regions i.e., the Cotton and Millets regions have emerged with 17 and 8 mandals that previously belonged to the sunflower, groundnut and pulses region (Fig. 1 & Table 1).

Table – 1

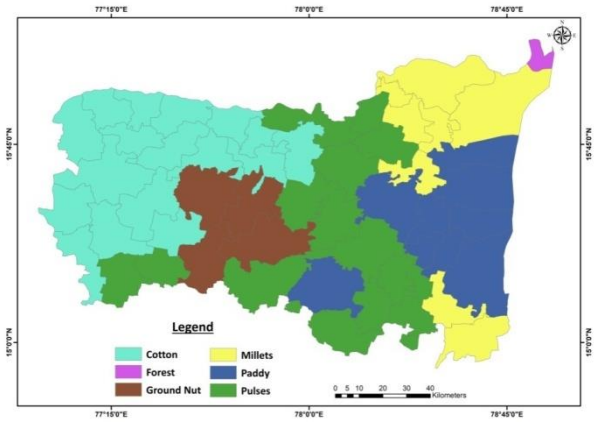
Primary crop regions in Kurnool District 2007-08 & 2018-19

S. No.	Crops in Primary Crop Region	No of Mandals in each Individual Crop Region		Decrease / Increase in the Number of Mandals during 12 Years Period
		2007-2008	2018-2019	
1	Pulses	22	15	-7
2	Ground Nut	13	4	-9
3	Sunflower	10	0	-10
4	Paddy	8	9	1
5	Cotton	-	17	17
6	Millets	-	8	8
7	**Total**	**53**	**53**	-

Fig. 1



Kurnool District Primary crop Regions 2007-2008



Kurnool District Primary crop Regions 2018-19

SECONDARY CROP REGIONS (2007-08)

Seven crops have been reported in secondary crop regions during the year 2007-08. The maximum number of mandals is in sunflower region found (15 mandals) fallowed by millets region (9 mandals), Pulses (8 mandals), Ground nut (8 mandals), Paddy (6 mandals), Fruits and vegetables (6 mandals) and cotton (1mandal). (Table-2 & Fig. 2)

SECONDARY CROP REGION (2018-19)

During 2018-19, about seven crops gained ground under secondary crop regions. Among these seven crops, Pulses region dominated with 22 mandals fallowed by millets region (10 mandals), cotton (8 mandals), Ground nut (6 mandals), Paddy (4mandals), Fruits and vegetables (2 mandals) and Condiments and spices (1 mandal). Sunflower has lost its place in the secondary crop regions during the study period. Condiments and spices came up as a new crop in the secondary crop region (Table 2 & Fig. 2).

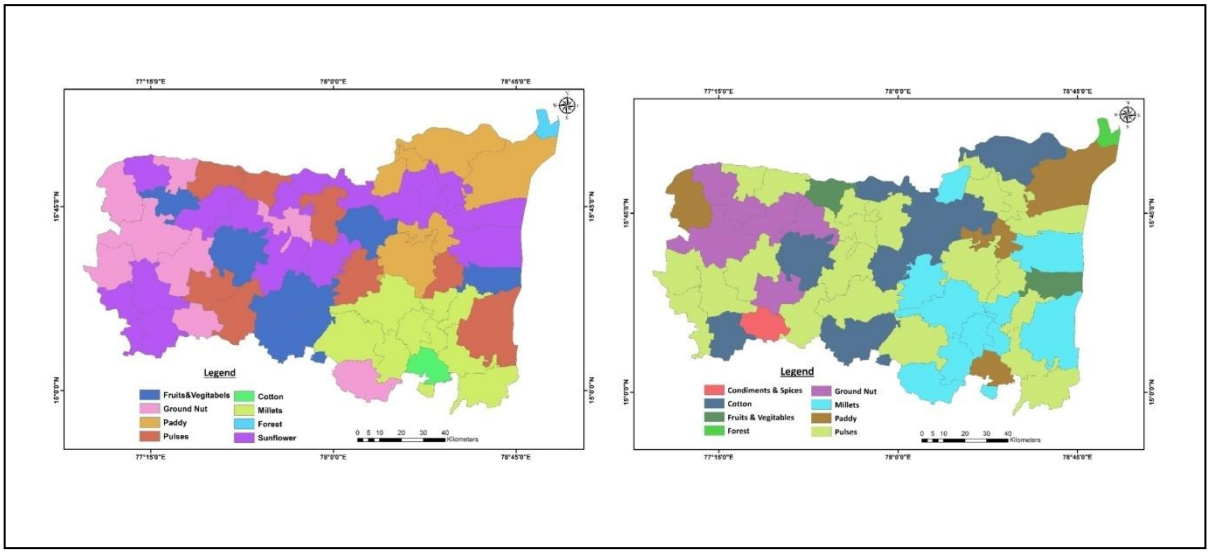
CHANGES IN THE SECONDARY CROP REGION (2007-08 TO 2018-19)

Table -2

Secondary crop regions in Kurnool District 2007-08 & 2018-19

S. No.	Crops in Primary Crop Region	No of Mandals in each Individual Crop Region		Decrease / Increase in the Number of Mandals during 12 Years Period
		2007-2008	2018-2019	
1	Pulses	8	22	14
2	Ground Nut	8	6	-2
3	Sunflower	15	-	-15
4	Paddy	6	4	-2
5	Cotton	1	8	7
6	Millets	9	10	1
7	Fruits & Vegetables	6	2	-4
8	Condiments & Spices	-	1	1
	Total	53	53	-

Fig. 2



Kurnool District secondary crop regions 2007-08

Kurnool District secondary crop regions 2018-19

During 2007-08, seven crops have been recorded under secondary crop regions and the year 2018-19 also seven crops formed secondary crop regions. An increase in the areal spread has been observed in pulses (14 mandals), cotton (7 mandals), Millets (1 mandal) and condiments and spices (1 mandal). Decrease in the number of mandals has been found in fruits and vegetables (4 mandals), Ground nut (2 mandals) and paddy (2 mandals). Sunflower has lost its place in the secondary crop regions. Condiments and spices crop region is the new secondary crop region reported in 2018-19.

TERTIARY CROP REGIONS (2007-08)

In 2007-08, as many as 8 crops have emerged as the third ranking crops in the district, among which pulses (11 mandals) fallowed by sunflower (10 mandals), paddy (10 mandals), millets (9 mandals), Ground nut (7 mandals), Fruits and vegetables (3 mandals), condiments and spices (2 mandals) and cotton (1 mandal). (Table 3 & Fig. 3).

TERTIARY CROP REGIONS (2018-19)

During the year 2018-19, 9 crops have been noticed under tertiary crop regions with varied intensity. Paddy crop region is emerged as the largest tertiary crop region with 15 mandals fallowed by Millets (14 mandals), pulses (7 mandals), cotton (5 mandals) fruits and vegetables (4mandals), Ground nut (3 mandals), condiments and spices (3mandals), onions (1 mandal) and castor (1 mandals). sunflower has lost its place in the secondary crop regions. Onions and castor crop regions are the new secondary crop regions reported in 2018-19. (Table 3 & Fig. 3)

Table - 3

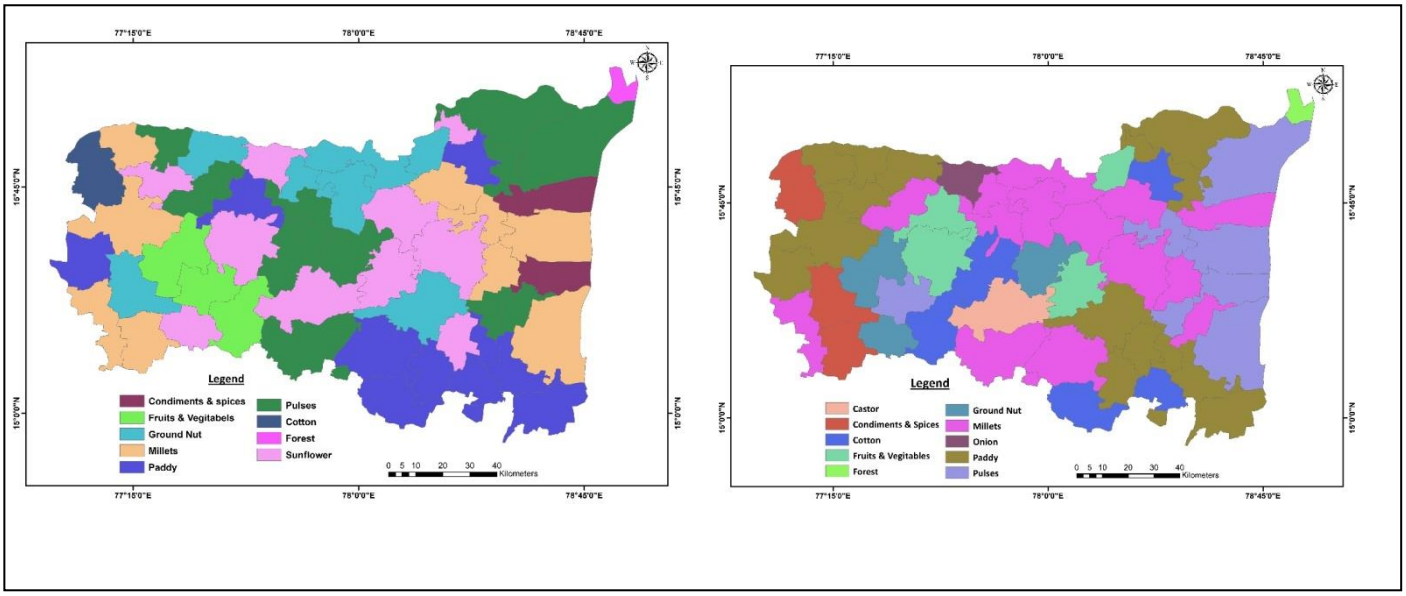
Tertiary crop regions in Kurnool District 2007-08 & 2018-19

S. No.	Crops In Primary Crop Region	No Of Mandals In Each Individual Crop Region		Decrease /Increase In The Number Of Mandals During 12 Years Period
		2007-2008	**2018-2019**	
1	Pulses	11	7	-4
2	Ground Nut	7	3	-4
3	Sunflower	10	-	-10
4	Paddy	10	15	5
5	Cotton	1	5	4
6	Millets	9	14	5
7	Fruits &Vegitables	3	4	1
8	Condiments &Spices	2	3	1
9	Onions	-	1	1
10	Castor	-	1	1
		53	53	-

Totally about 10 crops have been reported in the study period under tertiary crop regions. They are pulses, Groundnut, sunflower, paddy, cotton, Millets, fruits and vegetables, condiments and spices, Onions and castor. A decrease in the number of mandals each tertiary region during the 12 years is observed in pulses (-4 mandals) and Ground nut (-4 mandals). Increase in the number of mandals under each tertiary crop region during the 12 years of study period is noticed paddy (5mandals), millets (5 mandals) cotton (4 mandals), Fruits and

vegetables (1 mandals) and condiments and spices (1 mandals). Onions and castor crop regions are the new secondary crop regions reported in 2018-19. Sunflower tertiary crop region is absent during the 2018-19.

Fig. 3



Kurnool district Tertiary crop regions 2007-08

Kurnool district Tertiary crop regions 2018-19

CONCLUSION

During the agricultural year 2007-08, Kurnool District in India exhibited four primary crop regions, which included Pulses, Groundnut, Sunflower, and Paddy. However, in the subsequent agricultural year of 2018-19, there was a significant decline in the Sunflower crop region, and it was no longer registered in the district's agricultural landscape. In addition to the existing primary crop regions, Cotton and Millet crop regions emerged previously encompassed within the regions of Sunflower, Groundnut, and Pulses. Regarding the secondary crop regions, the year 2007-08 saw a total of seven crop regions. Unfortunately, in 2018-19, Sunflower lost its place among the secondary crop

regions, and a new crop region, namely Condiments and Spices, emerged, resulting in a total of seven secondary crop Regions.

In both years, 2007-08 and 2018-19, the district reported eight different crop regions at the tertiary level. However, in 2018-19, the Sunflower tertiary crop region was absent, and instead, Castor and Onion regions emerged, replacing one of the tertiary crop regions from 2007-08, namely sunflower. The agricultural landscape of Kurnool District underwent notable changes between 2007-08 and 2018-19. Sunflower experienced a significant decrease and was no longer present in both secondary and tertiary crop regions. Meanwhile, new crop regions like Cotton, Millet, Condiments, and Spices emerged, showcasing the dynamic nature of agriculture in the region over the year.

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IDENTIFYING THE TRUE COST OF NITRATE CONTAMINATION IN THE MID-GANGETIC PLAIN, BIHAR (INDIA): WHO'S PAYING FOR THOSE COSTS AND WHO'S RECEIVING THE BENEFITS

Narender Singh

Abstract

The Mid-Gangetic Plain (MGP) covers an area of 99,058 km^2 & is a lifeline for millions of people who rely heavily on groundwater. Although this is a region rich in rivers, more than 80% of the irrigation needs of the Bihar plains are met by groundwater, mainly due to easy access, unpredictability and poor irrigation networks. This has led to a rapid decline in water quality and quantity in shallow aquifers. This research aims to understand how nitrate contamination in the groundwater of the MGB has developed over time & comprehend the specific impacts on the rural communities of India particularly those facing socio-economic challenges. Given that a substantial 80% of India's populace resides in these rural regions, understanding & addressing these implications is of paramount importance. The weighted average water quality index (WAWQI) shows that 20.2% of groundwater is unfit for drinking. Surface water irrigation in the 19th century, the introduction of nitrogen-intensive crops (i.e. wheat, rice & sugarcane etc.) & pesticide at higher rate in the 20th century, urban development and groundwater irrigation intensified agricultural activity in the Indo-Gangetic Plain. Furthermore, the districts of South Bihar, compared to North Bihar, naturally receive a disproportionate amount of irrigation water from the Ganga and its tributaries. Additionally, during the non-monsoon season (November to June with little rainfall), groundwater is most often used for irrigation, especially for growing wheat & during the monsoon season (July to October with abundant rainfall), the demand for rice is met by the combination of monsoon rains and groundwater that transfers excess nitrate to shallow aquifers through vertical connections. This can cause secondary reactions in aquifer minerals, leading to the mobilization of toxic pollutants, thereby affecting human health. Other sources of groundwater contamination include unrestricted discharge of partially or untreated sewage and industrial wastewater into surface waters, which eventually percolate underground and contaminate surface aquifers.

Introduction

Nitrate contamination is an escalating concern in India, endangering groundwater safety and public health. Groundwater serves as the primary drinking water source for 85 % of India's rural population and fulfills 60 % of its agricultural water demands. The Ganga alluvial plain hosts a significant population, around 10% of the global populace, with agriculture serving as the primary livelihood in the Mid-Gangetic Plain. (World Bank, 2011) Due to over-exploitation of groundwater for irrigation and instability over time, groundwater levels are currently decreasing, especially in southern Bihar districts (i.e. Buxar, Bhojpur, Rohtas, Kaimur, Aurangabad, Gaya, Arwal, Nawada, Jamui, Banka, Sheikhpura and Lakhisarai). Furthermore, the main factor influencing changes in groundwater storage in the Mid-Gangetic Plain is pumping rather than differences in rainfall. Similar alluvial aquifer systems worldwide have faced water table declines due to unchecked groundwater extraction (Konikow, Kendy et al., 2005; Gautam et al., 2020). Furthermore, the swift pace of urbanization and industrialization poses a major threat, deteriorating both the quantity and quality of groundwater (Nijesh et al., 2021; Pant et al., 2021).

High levels of groundwater nitrate primarily stem from extensive nitrogen fertilizer usage, yet other contributing factors include intrinsic elements like geology, hydrogeology, hydro-geochemistry, biogeochemical processes, as well as external human-driven influences such as land use. These aspects collectively affect the leaching and distribution of nitrate in groundwater. In the last 30 years, northern India has experienced declining water tables due to shifting rainfall patterns and extensive groundwater extraction. While this issue receives considerable attention, the deterioration of groundwater quality from significant pollutants like nitrate, arsenic, heavy metals and organic contaminants is equally concerning, albeit less highlighted. (MacDonald et al., 2016). To solve this problem, the Indian government has proposed to increase the efficiency of groundwater use for irrigation by 20% (MOWR, 2014). A recent study supports this suggestion, showing that different watering methods (sprinkler, drip, and alternating wet/dry systems) can increase efficiency by 23 to 49% without reduces productivity (Bouman et al., 2001) but currently, the impact of this proposed improvement on water levels in the area has not yet been quantitatively assessed. Therefore, consistent and methodical monitoring of groundwater quality is crucial to track contamination factors and develop sustainable aquifer management strategies. (Bonsor et al., 2017). Hence, it's crucial to pay particular attention to shallow groundwater extensively used for household needs.

Objectives

(1) To determine the groundwater quality in the Mid-Gangetic Plain and assessing its adequacy for municipal water supply requirements using the WAWQI (Water Quality Index); and

(2) Moreover, to examine the true costs associated with nitrate pollution in the research region in order to determine which organizations bear these costs and who benefits from this circumstance.

Study Region

The current research area is 99,058 square kilometers, including the latitudes of 24°00′N to 28°40′N and the longitudes of 78°40′E to 86°10′E. It is located in India's Middle Ganga Basin includes 29 districts in the state of Uttar Pradesh. This area is located in an active tectonic zone in the Ganga Plain. The majority of the sediments in this basin are from the Himalayas, which are periodically subject to tectonic movements and climate changes. (Shukla, Raju et al. 2008). Over 30% of India's groundwater supplies are unsuitable for human consumption (Cronin, Prakash et al. 2014). It could be a difficult and nerve-wracking effort to provide drinking water to approximately 700 million rural Indians who live in 15 different ecological regions. Additionally, water-related chronic diseases impact the economy and cost the country approximately 180 million working days annually. (Water Aid, 2007). According to the Agency for Toxic Substances and Disease Registry (ATSDR) of 2011, the toxicity ranking nitrate is 220 but this groundwater contamination challenge impact socioeconomically deprived rural inhabitants in India, where about 80% of the population resides. The concentrations of nitrate in drinking water, primarily induced by agricultural activities, exceeded the Bureau of Indian Standards (BIS) of 45mg/L in 11 states of India. The first reported case of high concentrations of nitrate was in the southern district Rohtas of Bihar. (Ray, et al., 2000) Later, groundwater nitrate contamination greater than the BIS standard was reported in a total of 266 and 503 blocks (out of 534) in 9 districts (out of 38) respectively. (Mishra, Shaw et al. 2009). In the consecutive years numerous habitations were found contaminated with nitrate levels greater than the World Health Organization (WHO) standard of 50mg/L. Elevated levels of nitrate in the soil and in the food chain, and health risks associated with the consumption of nitrate through water and foods were also reported in the state. (Singh, Ghosh et al. 2014)

Database and Methodology

Groundwater samples were collected from across the Gangetic plain during the post-monsoon period of 2015 by the Central Ground Water Board (CGWB). They mainly collected samples from hand pumps that draw water from the aquifer. Various factors influencing the chemical composition of water have been extensively studied worldwide using statistical techniques such as hydro chemical scatter plots, simple linear regression, analytical multivariate trilinear regression, multivariate statistical analysis (MSA), remote sensing and geospatial methods. Multivariate statistical analysis (MSA) was used for sedimentary rock aquifers in Canada to understand hydrogeochemical evolution (Cloutier et al. 2008), similar method for assessing aquifer connectivity and sediment flux in Australia (King et al. 2014). In the Ganga basin, researchers have successfully studied the geochemical processes in aquifer evolution and hydro geochemistry using MSA, various graphs and correlation matrices (Pant et al., 2021; Kumar et al., 2021). Geospatial techniques are valuable for spatial visualization and temporary and have been used worldwide to identify potential groundwater areas, understand seasonal variations in contaminants in different hydro geological environments and more. (Nitesh et al., 2021) Maps created with Adobe Photoshop 7.0 taking into account the ATSDR (2011) toxicity level of the contaminant, based on district-level groundwater pollution data for nitrate, fluoride and any other contaminant which we obtained from the official website of Ministry of Drinking Water and Sanitation, Government of India.

Results and Discussion

In Bihar, out of 532 community blocks, roughly 13% of the blocks had nitrate contamination; no district had 100% nitrate contamination. Of the districts in the state, only 4 had nitrate contamination levels of ≥50%, while eleven were completely free of nitrate pollution. A total of 180 community blocks (out of 532) had only one contaminant, according to several groundwater contamination analyses. That is, nitrate contamination affected 8 neighborhood blocks across 6 districts. There were 13 blocks containing iron and nitrate in 8 districts; 5 blocks containing nitrate and arsenic in 4 districts; and 1 block containing fecal coliform and nitrate in just one district (**Fig. 1**). Thus, it determined that four districts are at the extreme end of the pollution prevention scale, and nine districts are at the high priority level, requiring rapid attention to water management. Most of the districts that border the Ganges River are classified as either high priority areas or extreme areas. Groundwater mitigation strategies and interventions should be given top attention in the

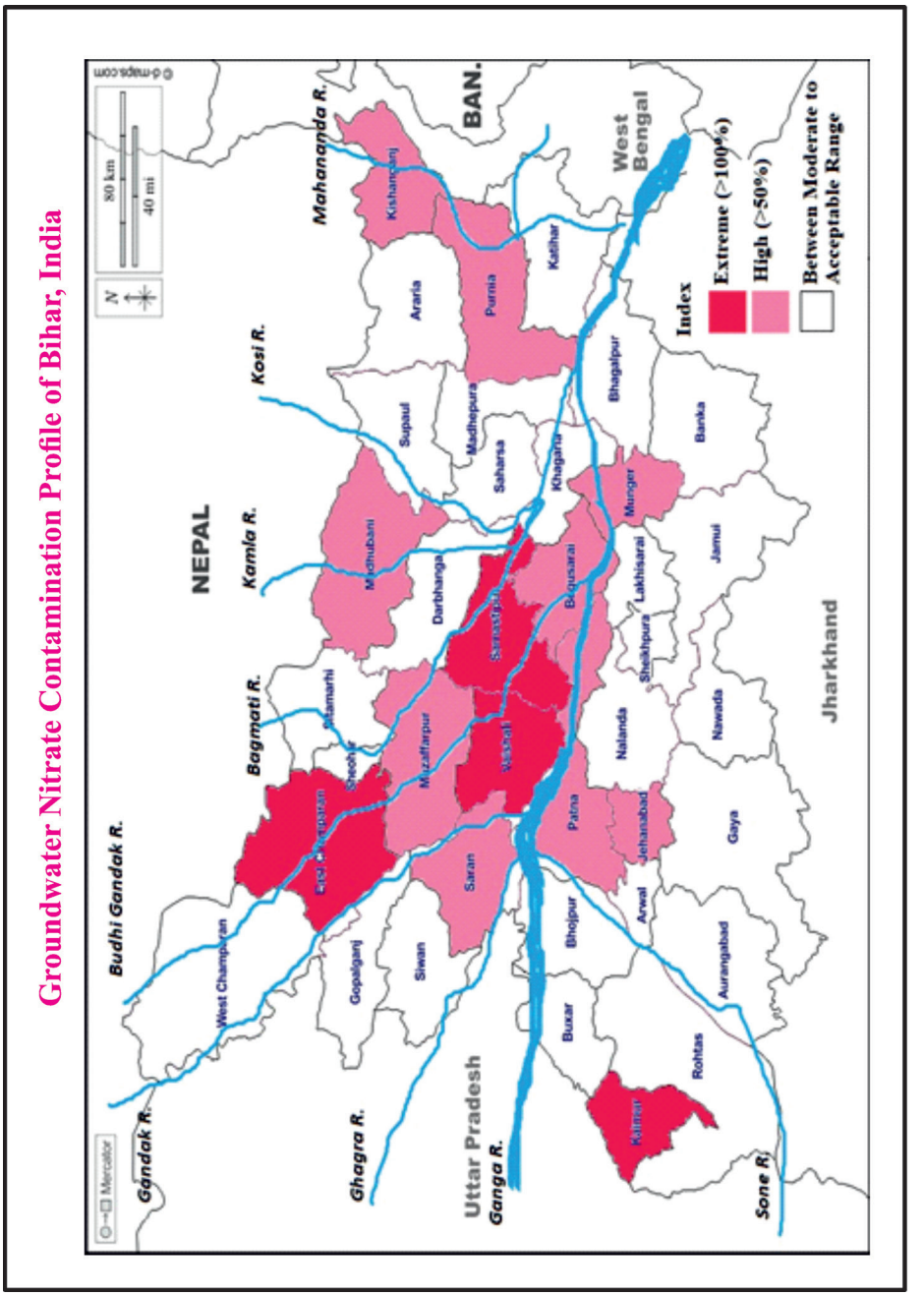

Groundwater Nitrate Contamination Profile of Bihar, India
NEPAL
BAN.
Uttar Pradesh
Jharkhand
West Bengal
Budhi Gandak R.
Gandak R.
Bagmati R.
Kamla R.
Kosi R.
Mahananda R.
Ghagra R.
Ganga R.
Sone R.
Index
Extreme (>100%)
High (>50%)
Between Moderate to Acceptable Range
Mercator
N
80 km
40 mi
© d-maps.com
West Champaran
Gopalganj
Siwan
Saran
Buxar
Bhojpur
Rohtas
Kaimur
Aurangabad
Arwal
Jehanabad
Gaya
Patna
Nalanda
Nawada
Sheikhpura
Lakhisarai
Jamui
Banka
Bhagalpur
Munger
Begusarai
Khagaria
Saharsa
Madhepura
Supaul
Araria
Purnia
Kishanganj
Katihar
Darbhanga
Madhubani
Sitamarhi
Sheohar
Muzaffarpur
Vaishali
Samastipur
Darbhanga

Fig. 1

districts of E. Champaran, Samastipur, Vaishali, and Kaimur. The current study examined the following research gaps and insights in light of the findings:

(1) Lack of guidelines for the minimum number of drinking water sources (sampling density) in a community and inaccurate data on the pollutants that are specific to a community's water quality.

(2) The inability to prioritize mitigation plans due to a lack of instruments for decision-making resulted in the failure of water management programs.

(3) The monitoring of water quality and mitigation strategies is increased when sampling density criteria, or the minimum number of samples to be evaluated per square mile, are not followed.

(4) Many water filters were created and tested on a national and regional level in the areas affected by multiple contamination; however, the majority of the time the filters failed.

Magic Limit of Nitrate in Drinking Water

What is the safe limit for nitrate contamination to protect public health? The simple answer is that we do not know and can agree with people, who say that the 10 ppm may not be the right number, and that's a completely different discussion as what is the allowable level of nitrate in our water supply, and should we be looking at just the isolation of nitrate alone or should web looking at nitrate in with other compounds such as uranium, fluoride, arsenic or others around?. Another important thing for people to understand that to go based on that 10-ppm number because that's what's legal. It's important to kind of layout where that number comes from (Blue baby syndrome based) decade's worth of health studies and showing the difference between what is legal and what is safe? So presumably that is a good place to start not trying to debate what the magic number is or what should be legal? We do know there is a growing awareness that nitrate contamination is probably associated with a number of public health conditions at levels much lower than the BIS (Bureau of Indian Standards) ISI 201245mg/LNO3-. Conditions are, namely, Colorectal cancer [from0.87 mg/LNO3-N], Abortion [from5.5 mg/L], Premature babies &/or short-term gestation [from5.5 mg/L], Thyroid cancers [from2.5 mg/L], ladder cancer and Spinal bifida, brain tumors and spinal cord defects of babies. (**Fig.** 2)

The Indian Government was and still been failing to put public health before GDP. This is underscored by a "risk analysis" commissioned by CGWB who are

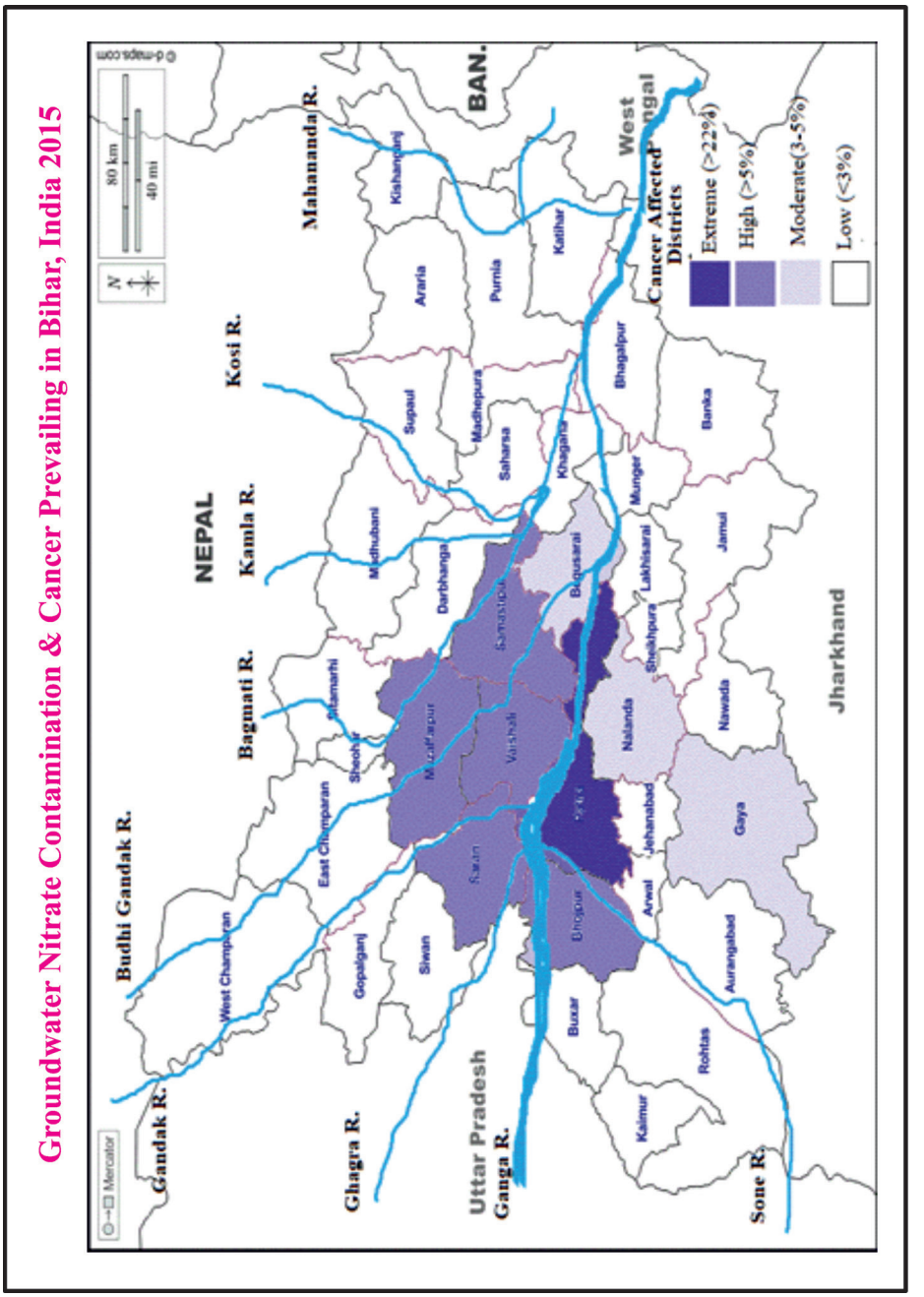

Groundwater Nitrate Contamination & Cancer Prevailing in Bihar, India 2015
Mercator
N
80 km
40 mi
© d-maps.com
NEPAL
BAN.
Budhi Gandak R.
Gandak R.
Bagmati R.
Kamla R.
Kosi R.
Mahananda R.
Ghagra R.
Uttar Pradesh
Ganga R.
Sone R.
West Bengal
Jharkhand
West Champaran
East Champaran
Gopalganj
Siwan
Saran
Buxar
Bhojpur
Rohtas
Kaimur
Sitamarhi
Sheohar
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Jehanabad
Aurangabad
Gaya
Nalanda
Nawada
Sheikhpura
Lakhisarai
Begusarai
Samastipur
Darbhanga
Madhubani
Supaul
Madhepura
Saharsa
Khagaria
Munger
Jamui
Banka
Bhagalpur
Araria
Purnia
Katihar
Kishanganj
Cancer Affected Districts
Extreme (>22%)
High (>5%)
Moderate(3-5%)
Low (<3%)

Fig. 2

in an illusion that high levels of nitrate contamination in drinking water does not pose a risk to human health so long as yours green. (Anti-oxidants in the diet should provide adequate protection). In the absence of not too many Indian research studies, it is useful to look to first world countries prepared to spend money on much needed research.

Who is Receiving the Benefits for Nitrate Contamination?

The question of who benefits from purifying the water quickly becomes a delicate question when you consider who benefits from using the nitrates that need to be purified. Obviously, it's the producers/farming community in the area, but it's not just the producers, it's the whole chain that makes money from this grain, whether it's cooperatives, selling seeds or selling chemical ointments. This causes the money chain to spread rapidly. In India, the amount of money paid out by the medical system for nitrogen-related cancers or other water contamination-related health concerns is in the millions of INR, as are the health care costs. Who else stands to gain if we successfully address these issues? The quality healthcare that we provide to the rural population is not just for Bihar, but anything that is designed in this state can be applied to other Indian states as well, where we need to take care of the rural population. You can move to another state. Since the main activity is agriculture, we have developed a system to address these issues. How to effectively care for this population could benefit us and, frankly, other places around the world (**Fig.** 2).

Who is Paying Costs for Nitrate Contamination?

In terms of health impacts, obviously the person who is dealing with the disease, the toxicities that comes with the therapy for it. It also then impacts the rest of their life because even though the person who survived the disease, 75% of them will go on to have long term impacts of the care that they received that will require medical attention for the rest of their life. According to a 2015 research report by Gahlot & Kumar, patient registration data comes from Mahavir Cancer Sansthan Hospital in Patna (Bihar) India, shows that the annual registered new patients from all cancers were 20,746 and 50% of the patients belong to 6 districts (Bhojpur, Saran, Muzaffapur, Samastipur, Vaishali & Patna) which fall in Gangetic belt. The study found that 95% of patients were of low socio-economic status and 54% of patients had never attended school. Furthermore, groundwater contamination, poverty, and disease literacy were identified as key important factors for the high incidence of cervical cancer. Who else pays that cost? The family in many different

ways, first of all, obviously the horror of dealing with a child/person who has cancer or others health issues, but in that bill logistics terms, we know that there are many, many costs that are passed on to the family. Whether that is the idea of can they stay employed because it takes so much time off to care for their child both in land outside of the hospital, travel costs that can be impacted more on rural areas for people have to travel such a great distance. So if we say that water quality is having a hand in diseases like cancer or birth defects, the cost is going on to the family Source: MCS (Mahavir Cancer Sansthan), Registration Data 2015, Patna (Bihar). Besides that; when it comes to discussing contamination or setting regulations or policies, or even just changing the practices. The discussion always comes down to cost benefit, and it's much easier to come up with figures for additional treatment at a water treatment plan to or cost too businesses or farms for prevention measures, but feel like downstream cost of the health impacts, which is always missed out, because it is harder to quantify it spreads across many individuals instead of just impacting one entity with financial records even and those impacts are harder to relate directly back to the water contamination. So try and bridge that gap between what we know academically from research about health risks, and then what we can do to advance policy discussions and paint those fuller fair pictures of the costs overall, because it's not just treatment plant or cost to businesses, cost of farms, there is also health impacts and all of those other peripheral impacts really needs to be taken into account.

Conclusion

India's food security is largely dependent on its groundwater system in the Indo-Gangetic Basin (India), hence the current over exploitation of this groundwater resource is a serious worry. The presence of higher groundwater nitrate concentrations in predominantly agricultural parts of alluvial IGB basin aquifers, is of grave concern to the region's vast groundwater-dependent population. The groundwater in most parts of Bihar is getting increasingly contaminated with either nitrate or other forms of dangerous pollutants, as demonstrated by early inquiry and data analysis. This is not a legacy issue, but a worsening situation. The majority of the districts bordering the Ganges and its tributaries are classified as either extreme or high priority zones. Because the exposed communities are socio-economically deprived, water filters capable of filtering numerous contaminants should be produced and delivered at a discounted rate to the affected communities. Furthermore, we must emphasis the importance of long-term monitoring research, including modelling approaches, to aid in the development of more detailed quantification of groundwater nitrate

problems and appropriate groundwater management policies, not only in Bihar but across India. We all benefit if we can increase their (farmers') efficiency, reduce their input costs, and keep nitrogen out of the water. This escalating pollution trend requires immediate and drastic solutions to prevent further degradation of natural water bodies, particularly in developing countries like India, where water shortages exacerbate the issue. Urgent actions are essential to avert the complete deterioration of these vital water resources.

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IMPACT OF TROPICAL CYCLONE DISASTER ON LIVESTOCK RESOURCES OF ODISHA

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Abstract

Odisha located on the eastern coast of India is being frequently affected by cyclonic storms. Life and property are generally affected by storms and floods. The economy of the coastal Odisha is agrarian, people grow crops, keep livestock to utilize crop residues as fodder, utilize natural fertilizer in agriculture, and augment family income. Economically and socially weaker sections of the society exclusively depend on livestock for their livelihood. Most of the people in the coastal Odisha live in traditional temporary houses made up of locally available construction materials not resilient to cyclonic storms and floods. They keep the domesticated animals mostly milching animals, drought animals, goat, sheep, pig and poultry birds in temporary houses. As part of the disaster management policy adopted by the state govt. evacuation of population could minimize human casualty, but no such policy adopted for a long time for livestock, which results injury and death of large number of livestock and poultry birds. Realizing the importance of livestock for the rural economy in the disaster-prone area, state govt. has initiated measures for evacuation of livestock and their care during disaster. In spite of this recent measure still large number of livestock and poultry birds are killed due to the impact of cyclonic disasters. The only solution is the construction of permanent livestock sheds in the coastal villages, awareness generation among the livestock farmers, post disaster care and insurance of the livestock.

Introduction

Disasters affect animals and human beings with more impact on animals. Animals are more vulnerable to disasters than human beings. In the developing countries the impact of disasters on animals is higher and more long lasting than in developed countries (Heath et al 1999).In developing countries livestock employs more people than developed countries (Schwabe 1984). In India, 70% of all livestock

are owned by 67% small and marginal farmers, who depend on animal husbandry for their livelihood. The contribution of animal husbandry to the GDP of India has grown up significantly over the years. Disasters that affect animals can, therefore, reduce an important source of employment, revenue and wealth particularly affecting small, marginal farmers and landless livestock keepers who often solely depend on livestock for their livelihood. In spite of serious implications of natural disasters on livestock and livestock owners, disaster management of livestock has yet to receive attention in India as also many other developing countries of the world (Sen and Chander 2003).The Livestock sector plays a central role in nature resource based livelihood of the vast majority of population and often considered as the poor people's ATM. Apart from providing a subsidiary income, rearing of livestock is a source of nutrition in the form of milk, egg and meat. They are kept as a unit of production and provide an important source of revenue, employment and wealth. This sector is facing problem due to the natural disasters like cyclone and flood. Lack of well-developed disaster management plans results in a severe loss of human life, animal life and property, which could be saved if necessary, mechanisms were evolved. The preparedness, response and rehabilitation mechanisms were primarily focused on human beings, whereas, inadequate attention to livestock management led to heavy losses and delayed recovery from livestock related damages. Whenever any region, country or a place is struck by any natural calamity be it cyclone, flood, earthquake, volcanoes etc. the livestock is first to be affected, the reason being the government's relief and rehabilitation measures are focused primarily on population and therefore the sector gets least importance.

Study Region

Odisha is located on the east coast of India with a coast line of 480 km along the Bay of Bengal. The state has an area of 15,5707 sqkm. and consists of 30 districts. Physiographically the state has been divided in to (i)-the northern plateau, (ii)-the central river basin, (iii)-the eastern hills, and (iv)-the coastal plain. The climate is tropical monsoon. The coastal plain of Odisha is agriculturally developed with high population density. The coastal districts are economically developed in comparison to other parts of the state. The state is vulnerable to multiple disasters. Due to its subtropical coastal location, the state is prone to tropical cyclones, floods, tidal surges and tsunamis. The state accounts for 4.05 % population of livestock in the country. According to 2012 livestock census, total livestock was 207.33 lakh Cattle and buffaloes-59.56%, goat and sheep-38.56%, pigs-1.35%.

Objectives

(1) To study the impact of cyclonic disasters on the livestock resources.

(2) To analyze various measures taken by the govt. and the community to reduce the loss and injury of the livestock.

(3) To analyze the livestock affected and loss in the districts.

(4) Suggestion for various measures to be taken to reduce the impact of cyclonic disasters on livestock resources.

Database and Methodology

Data were collected from memorandum on Cyclones from the Special Relief Commissioner, Govt. of Odisha. Disaster management plan of livestock, Animal Resource Development Sector, Govt. of Odisha, Economic survey of Odisha, review of literature, electronic and print media. Data has been analyzed at district level and presented as graphs to understand the trend of cyclonic disasters affecting livestock and loss. Also analyzed the spatial vulnerability of livestock by composite index.

Impact of Cyclone Disaster on livestock Resources of Odisha

Super Cyclone, 1999

The Super Cyclone of 1999 was the most destructive Cyclonic storm of the century. The most severe Super Cyclonic Storm hit the coast of Odisha near Paradeep on 29th October 1999. It affected severely 12 coastal and adjoining districts with wind speed of 270-300kmph and tidal surge of 5-7 m. height. The disaster management policy of the government was rescue and relief operation. The Cyclone prediction was not accurate in its intensity, wind speed, direction and timing. Warning was received three days before the Super Cyclone. People did not take the warning seriously, thus Resulted heavy human and livestock casualty. Lack of adequate cyclone/flood shelters and the shelters constructed by the red cross society was in damaged condition and few in numbers. Numbers measures were taken for evacuation of livestock to safer places before Super Cyclone. The livestock farmers received the warning through various sources well before (24 h to 12 h) the onset of the Super cyclone but, majority of them could not shift their animals to safe places. Non availability of sufficient safe shelters was the most important problem of shifting livestock, non availability of shifting arrangement, delay in decision making and ambiguity of warning. As a result, the majority of the livestock farmers

only untethered their animals before leaving home to save their own lives. They did not put much value to the warning due to their own judgment about the possible impact of the cyclone since they underestimated the impact. The warning messages could not provide information on the possible magnitude of the damage that the cyclone may cause and that might be the reason, why many of them did not think of an early evacuation. Livestock farmers had to suffer a lot for carcass disposal. Since most of the study area remained flooded by the sea water for about a week or more the farmers could not bury or burn the animal bodies. Later, Non-Governmental Organization (NGO) and Amy personnel took the responsibility but it was after 10 to 15 days of the Super Cyclone. The Veterinary personnel were not involved in the carcass disposal as they had no skills and experience. Marginal and small farmers suffered the most due to loss of livestock in the cyclone since they owned large number of livestock. The loss of farmers could have been reduced significantly had insured their animals. The Super cyclone. brought about major decline in the numbers of cattle, buffalo, sheep and ducks, while goat, pig and poultry only made up the loss quickly but also made impressive gains in their numbers by the year 2001(Kurup 2003).It was also reported that the affected areas were the major producer of milk, meat and eggs (Bhanja etal1999) and severe scarcity of milk and milk products were noticed in the coastal districts of Odisha even after 2 years of the Super cyclone(Das 2002).Government paid compensation of Rs.2420.48 lakh for loss of animals and birds, supply of chicks for immediate recovery programme Rs.322.50lakh,establishment of poultry units for the poor families Rs.938.00 lakh, community fodder cultivation Rs.190.00lakh,growing of perennial trees for fodder Rs.186.00lakh and development of fodder nurseries Rs.13.89lakh.Govt spent Rs.4070.871lakh for livestock due to Super Cyclone impact.

Phailin

The very severe cyclonic storm (VSCS) Phailin hit the southern coast of Odisha at Gopalpur on 12th October 2013 with wind speed of 205-220kmph and tidal surge of 3-3.5 m. height ravaged 14 coastal and adjoining districts of the state. On getting the information from the IMD on 8th October, the state govt. intimated to all the collectors, the print and electronic media. On the 10 of October 2013, the IMD reported that the deep depression had intensified in to a Very Severe Cyclonic Storm named as Phailin, indicating the threat to Odisha coast along with the track and intensity of the system. Accordingly, the collectors of the 14 coastal and adjoining cyclone prone districts were alerted through mailman and telephone. As part of the preparedness measures steps were taken for cattle health and supply of cattle feed

for the affected cattle population. Steps were taken to shift 31,062 livestock to safer places.283 veterinary teams were deployed, 89840 livestock treated, 230400 cattle vaccinated, 849.25 MT of cattle feed distributed among 29248 livestock in 1284 cattle camps. They were directed to take all precautionary/preparatory measures to meet the cyclone threat. Total livestock affected were 4689838 with 3250810 Large livestock and 1439028 small livestock. Poultry bird affected were 2368865. Maximum 1995500 livestock and poultry affected in Ganjam district. Total 4502 livestock lost and maximum 3704 livestock lost in Ganjam district.99159 cow sheds were damaged with maximum 65371 damaged in Ganjam district. As per the relief code provision for the replacement of the animals killed due to Phailin subject to ceiling of 1 large milch animal @Rs.16400 or 4 small milch animal @ Rs.1650 or 1 large drought animal @ Rs.15000 or 2 small drought animals @ Rs.10000 per household. For the reparation of the damaged cowshed @Rs1200 paid. Government spent is Rs.3277.15lakh for the livestock affected by Phailin (**Table-**1and 2, **Fig. 1** and 2).

Hudhud

The Very Severe Cyclonic Storm Hudhud crossed close to the Visakhapatnam coast of Andhra Pradesh on 12 the October 2014 with wind speed of 80-100 kmph. and passed through southern Odisha. IMD, Pune disseminated alert of the affected districts of Odisha from 9thOctober on wards. The state govt. circulated the IMD forecast to the Collectors of 16 coastal and adjoining districts likely to be affected, with instructions to remain in full preparedness to meet any eventuality. Collectors of 8 southern districts were cautioned about the flash flood and instructions were issued to start evacuation of livestock and domesticated animals to safer places before the occurrence of the disaster. Advance arrangements were made for the cattle health care and supply of cattle feed in the affected districts. As preventive measure 22 297 animals were shifted to safer place,106 veterinary doctors and 680 para- veterinary teams were deployed,3140 livestock treated,26950 cattle vaccinated and 159 MT of cattle feed distributed. Large areas were inundated in Kendra pada and Puri districts due to storm surge.15 districts affected due to the disaster. Due to its impact 39350 livestock and poultry affected. 670 livestock killed in 4 districts, Gajapati, Koraput, Malkangiri and Rayagada. Maximum 614 livestock killed in Koraput district.670 big animals,198 small animals and 472 poultry birds killed. About 57 cattle sheds damaged. As part of the compensation and related expenditure, the state govt. spent Rs.5.35lakh for the disposal of caracasses, Rs.41.78 lakh for the replacement of livestock, Rs.30.41 lakh for the distribution of

fodder and Rs.85,500 for the reparation of cattle shed. Government spent Rs.78.67 lakh. For the livestock affected by Hudhud.

Titli

The Very Severe Cyclonic Storm Titli crossed the coast near Palasa of Andhra Pradesh, south west of Gopalpur with wind speed of 140-150 kmph. and tidal surge of 1meter on 11th October 2018. The Indian Meteorological Department (IMD) reported on 7th October 2018 about formation of a low-pressure area over south east of Bay of Bengal and adjoining North Adaman Sea. It was predicted that the depression very likely to move towards Odisha during the next 72 hours. After getting the information from the IMD, the state govt. started closely monitoring the situation and intimated all the Collectors, print and electronic media. In the preparedness measures, all Collectors of likely affected districts were instructed for the evacuation of livestock and domestic animals to safer places and to ensure that no cattle should be left tied in kutcha (temporary)house. All cyclone bulletins and warnings shared by the IMD disseminated through DD, AIR, other electronic media for information of the public. 711 MT cattle feed supplied,208462 animal vaccinated,129637 animal treated,158 veterinary team deployed,1798 veterinary camp opened and 48858 carcasses disposed. Livestock were affected in six districts, Cuttack, Gajapati, Ganjam, Puri, Kandhamal and Rayagad. Total 481068 livestock affected with large animal 299795 and small animal 181273.Total poultry affected were 481068.Maximum number of 190349 livestock affected in Ganjam and Gajapati districts of south Odisha. Government spent Rs.623.58lakh.for livestock affected by Titli.

Fani

Extremely Severe Cyclonic Storm Fani crossed the Odisha Coast between Satapada and Puri on 3rd May 2019 with wind speed of 175-185kmph. and tidal surge of 1.5-meter height. On 28th April, IMD Indicated that cyclonic storm Fani moved northwards and would very likely to intensify in to a very severe cyclonic storm. There was also forecast and warnings for Odisha that light to heavy rainfall likely to occur at one or two places in southern Odisha on 2nd May and heavy rainfall from 3rd May over coastal Odisha. Though there was no warning issued by IMD for the Odisha coast, the state government started closely monitoring the situation. On 30th April IMD reported that the Very Severe Cyclonic Storm Fani very likely to cross Odisha coast between Gopalpur and Chandbali to the south of Puri on 3rd May afternoon. Massive preparedness measures were undertaken by

the government soon after receipt of warning from IMD. The districts were alerted based on the probable cyclone track and impact area.14 coastal and adjoining districts were affected due to the impact of Fani. Severely affected districts are Puri, Khurdah, Ganjam, Kendrapara, Cuttack and Jajpur. The cattle population shifted to safer places and cattle feed /fodder arrangement was made. Instructions were issued to field veterinarians to aware dairy farmers and small animal owners to take immediate measures by shifting their animals to safe places to avoid livestock loss.635 animal shelters in school premises and multipurpose cyclone shelters were identified. Over 40,000 large animals like cow, buffalo, bullock etc. were shifted to such shelters.300MT cattle feed stored to meet the requirement. About 80,000 livestock farmers of such districts were made aware about safeguarding of animals and severity of the cyclone through sending of mobile voice messages under mobile advisory programme. Steps were taken for health care services and carcass disposal. Total livestock affected were 3439282,large animal affected were 2443329 and small animal affected were 996053.Poultry bird affected were 5371373.Maximum livestock and poultry affected in Puri, Cuttack and Khurdah districts. Total 6281 livestock lost, maximum loss in Khurdah, Puri and Cuttack districts.119694 cowshed damaged. 2006.5 MT of cattle feed were supplied and steps were taken for the supply of two thousand quintals of green fodder to the severely affected districts. Mobile veterinary units and 115 rapid response teams were used for conducting veterinary camps,4105 animal health camps organized and 5.08 lakh animals treated. Compensation given for the loss of livestock for the replacement of drought/milch animals Rs.950.92lakh,provision of fodder and cattle health care Rs.2432.85 lakh, disposal of carcass RS.437.56 lakh and reparation of cowshed Rs. 2513.574 lakh. Govt. spent Rs6334. 904.lakh for livestock affected by Cyclone Fani.

Bulbul

Very Severe Cyclonic Storm Bulbul crossed Sunderban delta on 9th November 2019 with wind speed of 110-120 kmph. and tidal surge of 0.5-1.0 m. height. On 5th November IMD informed that the depression would very likely to intensify in to a deep depression and cyclonic storm. It would very likely to move towards Odisha-West Bengal coast. Soon after receiving the meteorological warning, the state govt. started closely monitoring the situation. As per the special bulletin of IMD on 7th November the cyclonic storm Bulbul very likely to intensify in to severe cyclonic storm and move towards West Bengal–Bangladesh Coast. Soon after receipt of warning from IMD, the state govt. took all required preparedness

measures to combat the possible situation. It affected 6 coastal and adjoining districts of north Odisha. Due to its impact 31238 livestock affected with 27344 large animal and 3894 small animal. 6125 poultry affected. Only two districts, Bhadrak and Kendrapara livestock were affected and maximum affected in Kendrapara district. Total 19 livestock killed, 1464 cowshed damaged and maximum damage in Kendrapara district. 312 animal health camps at every affected GPs organized. Compensation given for replacement of milch/drought animal of Rs.4.00 lakh, animal health camps Rs15.60 lakh, reparation of cowshed Rs30.74 lank. Govt. spent Rs.50.34lakh for livestock affected.

Amphan

The Extremely Severe Cyclonic Storm Amphan crossed West Bengal coast of Sundarbans on 20th May 2020 with wind speed of 155-165kmph. and tidal surge of 4-5 m height. On 16th May, the IMD informed that the low pressure area would very likely to intensify in to severe cyclonic storm likely to move towards West Bengal Coast during 18th to 19th May 2020. The coastal Odisha would likely to experience light to heavy rainfall from 18th to 20th May.IMD informed that It was associated with high wind speed and heavy rainfall. As part of the preparedness measure, the government alerted the collectors of the 12 coastal and adjoining districts to effectively handle the disaster. Awareness campaign on protection of animal resources from possible cyclone situation was launched in electronic as well as print media. People were advised to shelter the cattle and domestic animals at safe places. They were advised to evacuate their cattle to the ground floor of the Multipurpose Cyclone Selter/Multipurpose Flood Shelter (MCS/MFS) and other suitable buildings in case of necessity. It affected 10 coastal and adjoining districts. Total 1903 livestock affected with 1249 large animal and 654 small animals. 18875 poultry affected. Livestock affected in 6 districts with maximum in Jajpur district.38 livestock killed with maximum in Keonjhar district.393 cowshed damaged. As part of the compensation Rs.8.20 lakh spent for replacement of drought and milch animal and reparation of cow shed Rs.8. 25 lakhs. Government spend Rs.16.45 lakh for livestock affected by Amphan.

Yaas

Very Severe Cyclonic Storm Yaas crossed north Odisha coast south of Balasore with wind speed of 130-140 kmph. and tidal surge of 2-3m.height on 26th May 2021.Indian Meteorological department (IMD) reported on 20th may 2021 that a low pressure area would very likely to form over north Andaman sea and adjacent

east central Bay of Bengal around 22nd May 2021.it would very likely to intensify in to a cyclonic storm and reach Odisha-West Bengal coasts around 26th May morning. Soon after receiving the meteorological warning, the state government started closely monitoring the situation. As part of the preparedness measure IMD weather bulletin and cyclone warnings were disseminated to Collectors, departments and other stake holders at regular intervals. The livestock and domesticated animals of vulnerable area were shifted to safer places. No cattle let tied in kutcha house. People were advised to shelter the cattle and domestic animals at safe places. They were advised to evacuate their cattle to the ground floor of the MCS/MFS and other suitable buildings in case of necessity. Required vaccines, essential medicines were prepositioned at veterinary hospitals/dispensary and 1500 MT of cattle feed was kept ready by OMFED. Due to its impact 11 districts were affected. Total 1358578 livestock affected with 1022361 large animals and 336217 small animals. 1115810 poultry affected. 72 livestock killed.3024 cowshed damaged with maximum damage in Bhadrak District.75 mobile veterinary teams deployed, 37 animal health camps organized, 1617 animals treated and 5100 animals vaccinated. Compensation paid for replacement of milch/ drought animals Rs.16.684 lakh and cattle feed Rs.148.760 lakhs. Government spent Rs.165.444 lakh for livestock affected by Yaas.

Livestock Affected and Loss in Districts

On the basis of the recent past cyclonic disasters affected Odisha from 1999 to 2021, total livestock and poultry affected in the state was 191,64, 505.Livestock affected was 100,01,907 and poultry affected 91,62, 598. Large animal affected were 70,44,888 and small animal 29,57,119. Maximum livestock 46,89,838 affected by Phailin followed by Fani and Yaas. Least affected by Amphan 1903.Maximum poultry 53,71,373 affected by Fani followed by Phailin (Table.1 &**Fig. 1** & 3). The most vulnerable district is Puri with maximum 3618558 livestock affected and lowest vulnerable district is Dhenkanal with 3011 livestock affected. On the basis of the composite index, very high vulnerable districts are Cuttack, Ganjam and Puri, high vulnerable are Bhadrak, Jagatsinghpur, Jajpur, Nayagarh and Kendrapara, medium vulnerable are Balasore, Mayurabhanj Khurdah, Keonjhar and Gajapati low vulnerable are Dhenkanal, Kandhamal and Rayagada. The vulnerability depends on the number of livestock farmers, intensity and track of the cyclone over the state. The vulnerability of the livestock is gradually declining as the people are more aware, construction of more permanent cowsheds and alternate shelters for the livestock during cyclones (**Table-**1 and **Fig. 1** and **Table-**2)

Livestock loss

Loss of livestock and poultry are due to the impact of very high wind speed coupled with flood and damage of temporary structures. Total livestock lost was 456110 with maximum livestock lost due to Super Cyclone 1999 was 621377. Lowest number of livestock lost was 19 by Bulbul. After Super Cyclone of 1999, loss of livestock drastically reduced to maximum 6281 by Fani in 2019.After Super Cyclone loss of livestock reduced to only 16388 from 2013 to 2021 by six cyclonic storms. Maximum livestock lost 110742 in Jagatsinghpur district, the landfall point of Super cyclone and minimum 10 in Rayagada district of southern Odisha. The composite index shows very high loss of livestock in Cuttack, Jagatsinghpur and Kendrapara districts, High loss of livestock in Balasore, Bhadrak, Jajpur, Dhenkanal, Puri and Khurdha districts.

Table-1: Livestock Affected by Cyclone Disasters in Odisha

Sl. No.	Districts	Cyclone						Total
		Phailin	Titli	Fani	Bulbul	Amphan	Yaas	
1	Balasore	446320	0	62268	0	1015	558855	1068458
2	Bhadrak	283835	0	6233	1417	14	1167787	1459286
3	Cuttack	1150000	519	1673790	0	3730	2	2828041
4	Dhenkanal	3011	0	0	0	0	0	3011
5	Gajapati	50000	530361	0	0	0	0	580361
6	Ganjam	1995500	190349	173709	0	0	0	2359558
7	Jagatsinghpur	589617	0	859282	0	886	0	1449785
8	Jajpur	892995	0	901816	0	17002	104336	1916149
9	Kendrapara	55982	0	550200	35946	34	622396	1264558
10	Keonjhar	79519	0	5803	0	0	8069	93391
11	Khurdha	3347	0	1126976	0	0	0	1130323
12	Mayurabhanj	206474	0	1324	0	0	12944	220742
13	Nayagarh	671342	0	466767	0	0	0	1138109
14	Puri	630761	5222	2982575	0	0	0	3618558
15	Kandhamal	0	17893	0	0	0	0	17893
16	Rayagada	0	16282	0	0	0	0	16282
	Total	7058703	760626	8810755	37,363	22681	2474396	19164505

Source: SRC, Bhubaneswar

Table-2: Livestock Lost by Cyclone Disasters in Odisha

Sl. No.	Districts	Cyclone							Total
		Super Cyclone	Phailin	Hudhud	Fani	Bulbul	Amphan	Yaas	
1	Balasore	38778	0	0	17	0	5	13	38813
2	Bhadrak	9766	10	0	28	8	7	24	9843
3	Cuttack	62114	46	0	1100	0	0	0	63260
4	Dhenkanal	11027	0	0	15	0	0	0	11042
5	Gajapati	0	40	17	0	0	0	0	57
6	Ganjam	0	3704	0	58	0	0	0	3762
7	Jagatsinghpur	110682	18	0	34	0	8	0	110742
8	Jajpur	19082	2	0	26	0	1	6	19117
9	Kendrapara	77453	7	0	70	11	0	21	77562
10	Keonjhar	8606	37	0	0	0	17	5	8665
11	Khurdha	53704	35	0	1214	0	0	0	54953
12	Mayurabhanj	555	23	0	1	0	0	3	579
13	Nayagarh	0	85	0	13	0	0	0	98
14	Puri	52764	495	0	3705	0	0	0	56964
15	Kandhamal	0	0	2	0	0	0	0	2
16	Koraput	0	0	614	0	0	0	0	614
17	Malkangiri	0	0	27	0	0	0	0	27
18	Rayagada	0	0	10	0	0	0	0	10
	Total	444531	4502	670	6281	19	38	72	456110

Source: SRC, Bhubaneswar

Management of the impact of cyclone disaster on livestock population

The new disaster management plan incorporates provision for evacuation of livestock and provision of fodder, drinking water and medicine. As preventive measures mobile veterinary team deployed, animal health camps organized, affected animals treated and vaccinated. In Super Cyclone of 1999, the number of livestock evacuated is still very low in comparison to the number of livestock in highly vulnerable areas. Evacuated livestock were kept in flood/cyclone shelters and school premises identified by the district administration for the purpose. People are also asked to take the animals to safer places and don't tide them in cowshed. Developed cyclone prediction, early warning and awareness of the people could able to reduce the loss of livestock. Large number of large and small livestock are affected

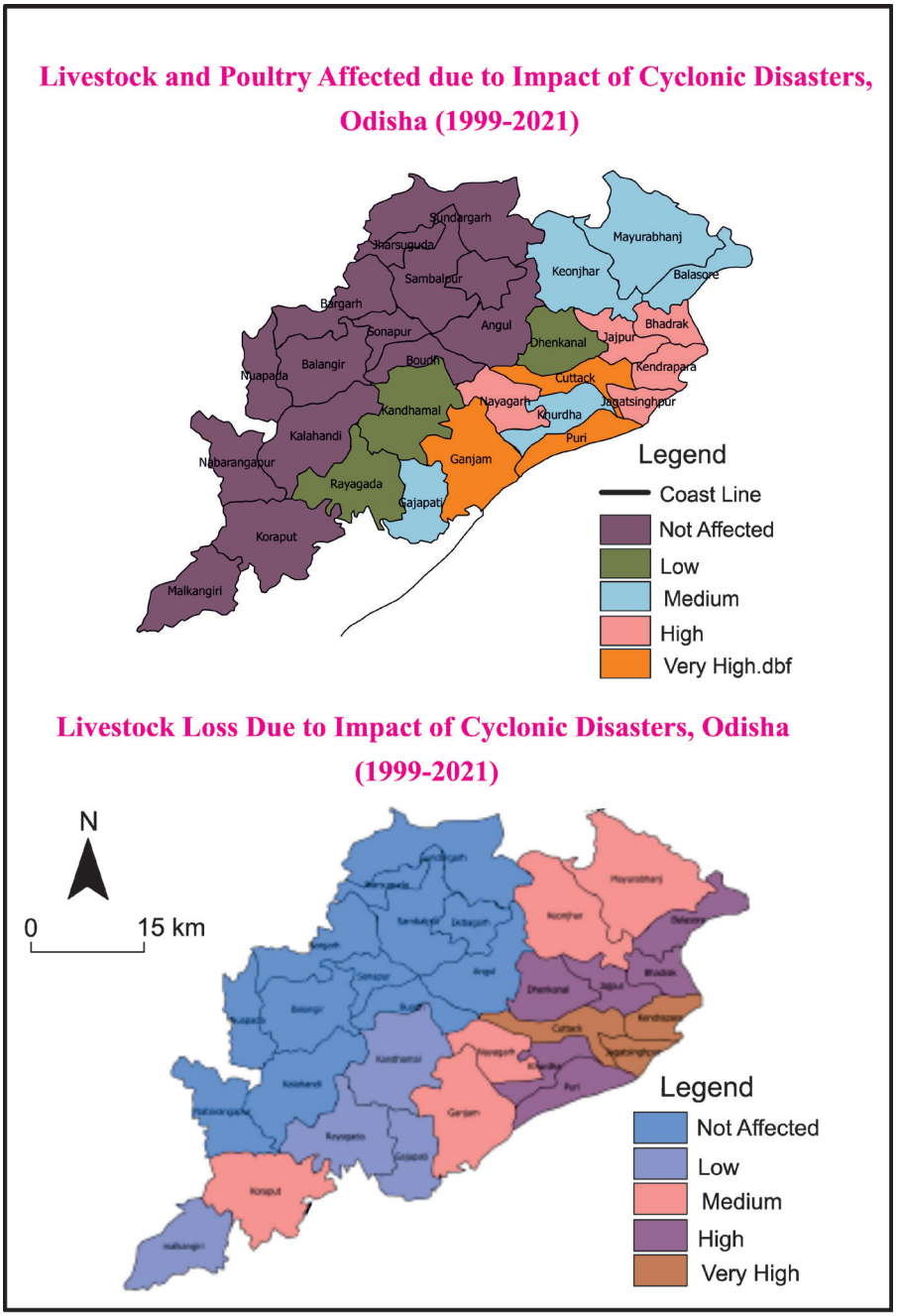

Livestock and Poultry Affected due to Impact of Cyclonic Disasters, Odisha (1999-2021)
Sundargarh
Jharsuguda
Sambalpur
Bargarh
Mayurabhanj
Keonjhar
Balasore
Bhadrak
Jajpur
Dhenkanal
Angul
Sonapur
Boudh
Balangir
Nuapada
Kendrapara
Cuttack
Nayagarh
Jagatsinghpur
Khurdha
Puri
Kandhamal
Kalahandi
Nabarangapur
Ganjam
Rayagada
Gajapati
Koraput
Malkangiri
Legend
Coast Line
Not Affected
Low
Medium
High
Very High.dbf
Livestock Loss Due to Impact of Cyclonic Disasters, Odisha (1999-2021)
N
0
15 km
Legend
Not Affected
Low
Medium
High
Very High

Fig. 1

due to the temporary cowsheds damage by wind and flood water. Loss of livestock is gradually decreasing where as number of livestock affected are increasing. Death of poultry bird is always high due to high wind speed; adequate protection needs to be taken. Post cyclone storm care of the livestock taken including immunization and fodder supply. Community based organizations lacked the necessary trained manpower, resources and know-how to cope with the challenges. In the aftermath of the cyclone, feed and fodder were scarce and consequently many animals starved and the productivity of animals decreased. The various steps to be taken prior, during and after disaster in relation to livestock management includes: Prevention: a) construction of shelter for animals in cyclone and flood prone areas and in case of shifting animals to safer places preference should be given to bullocks, milk cows, breeding bulls as their loss can cause immense damage to economy. b) Untethering the animals when shelter is not available c) Efforts should be made to collect feed, fodder, medicine etc and they should be kept at safer places d) Proper training should be given to farmers for evacuating their animals. Relief: a) Proper care should be taken to protect the animals against prey, poisonous snakes and reptiles b) proper arrangement for quick movement of veterinary personals to reach animals for treatment, vaccination and deworming. Rehabilitation: a) Livestock owners should be provided with compensation in case of livestock loss or diseased condition b) Working bullocks and milch animals should be provided from other unaffected regions that are surplus in these animals c) Reconstruction of veterinary and A.I centers that are damaged due to floods d) A permanent feed security system should be set up in flood prone areas) Livestock owners must insure their livestock. The scarcity of feed and fodder after any disaster poses a serious and indirect threat to the livestock. The use of urea treated straw as a feeding option that has the potential of meeting up the challenge to some extent. The straw feeding during the disasters can reduce the burden on the already scarce feed resources without compromising the production performance and also suggested use of Urea Molasses Mineral Block (UMMB) as a viable feeding option during disasters. Further, by products of sugarcane like bagasse, molasses, sugarcane tops etc., should be fed to animals during scarcity period. They also reported that urea when used for treatment of bagasse enhances its nutritional quality and steam treatment can also be used to increase its digestibility.

Conclusion

Exposure to cyclonic disasters and their consequences play a significant role to the socio-economy of the coastal Odisha. Livestock support the livelihood of

majority of the people of this region. Livestock are the easy victim of the cyclonic disasters as people keep them in highly vulnerable temporary cowshed. Protection of livestock resources should be given top priority for livelihood support of the poor people of the coastal villages. The number of livestock loss has been reduced due to preventive measures taken by the government but adverse impact on livestock is increasing. After disaster fodder problem becomes critical as dodder damaged by flooding water. Steps must be taken for availability of cheap fodder for the livestock. The number of poultry loss is increasing as the birds are sensitive to high wind speed. Number of livestock affected due to temporary cow sheds are increasing though the loss is reducing. Inadequate shelters for the livestock increase vulnerability. Steps must be taken to reduce death of livestock by construction of permanent cowshed. Compensation given for the loss of livestock and poultry ceiling must be removed by fully compensation by alternate agency. All livestock owners must insure their livestock for their benefit. Livestock farmers severely affected by loss of livestock should be provided alternate livelihood support.

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SPATIO-TEMPORAL VARIATIONS OF AGRICULTURAL LABOR WAGES IN INDIA

Professor Upma Chaturvedi and Abhinav Singh Yadav

Abstract

The paper analyzed variations in agricultural labors' real wage in 19 states of India from 2005-06 to 2020-21using statistical methods. For a comprehensive study and analysis of the changes in agricultural labour wages across the country, the paper attempted three statistical methods viz comparative analysis of agricultural wages' means across the time period; measuring fluctuations in the change in wages via coefficient of variance; and compound annual growth rate of agricultural wages. Mean real wages of Indian states across the years shows that, Southern and North Western states have higher wages as compared to states in Great Northern Plains, North East India and Central Uplands. Some states have deviated from general trend of increase in wages with the increase in economic growth and development. This decline in wages occurred both in states observing high and low agricultural wages. This anomaly emerged as a national concern because of its spatial diversity across the country and raising frequency in recent years. Fluctuations in the real wages of agricultural labor of different states across the years have no relation with actual real agricultural labor wages of the state. Both states with high and low wage rates experienced high as well as low fluctuations also. Growth rate of agricultural labor wages showed an inverse relationship with the past's real wage rates, that is, states which had high wage rates in past have showed relatively slower growth as compared to those states that had low wage rates. Agricultural labor real wages' increment requires special attention by the policy makers and administrator as it plays major role in boosting rural economy by raising demand of goods and services that too by masses, increasing production process conferring more diverse employment opportunities to disguised unemployed individuals, adding family income and improving standard of living by boosting education and health.

Introduction

A person is treated as an agricultural labor, if he/she follows one or more of the following agricultural occupations in the capacity of a labor on hire, whether paid in cash or kind or partly in cash and partly in kind: farming including cultivation, growing and harvesting of any agricultural commodity; production, cultivation, growing and harvesting of any horticultural commodity; dairy farming; raising of livestock, bee-keeping or poultry farming; and any practice performed on a farm as incidental to or in conjunction with the farm operations (including any forestry or timbering operations and the preparation for market and delivery to storage or to market or to carriage for transportation of farm products). Most deprived section of rural India is landless families who either migrate toward cities or work as agricultural labor. Agricultural workers constitute the most neglected class in Indian rural structure. Agricultural laborer's households constitute the historically deprived social groups, displaced handicraftsmen and dispossessed peasantry. Since, they possess no skill or training, they have no alternative employment opportunities either. Agricultural labors are socially and economically poorest section of the society. They are the poorest of the poor in rural India. The reason for their poverty is their easy exploitation because they remain largely unorganized, therefore their level of income, standard of living and the rate of wages have remained abnormally low. Demand of agricultural labor has declined due to improved farming methods and mechanization of middle and rich farmer's fields, decline in demand and abundance of supply pulled down the wages of the laborers making them economically further more weak. Agriculture laborer wages are function of demand supply of labor, irrigation and cropping intensity of region, fixed minimum wages, price of farm output in the market determining the paying ability of the employer, cost of living etc. Therefore, agriculture laborer wages are different in different states.

Study Region

The study is based over 19 states of the country including Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, and West Bengal. Data of CPI-AL base year 1986-87 is in continuity and gives data of parent and child state data on the name of the parent state to sustain continuity in the data, For example, Chhattisgarh from Madhya Pradesh, Jharkhand from Bihar, Uttarakhand from Uttar Pradesh, and Telangana from Andhra Pradesh. Therefore, these states are not studied separately rather they are clubbed with the parent states.

Objectives

The objective the paper is to analyze spatio-temporal variation of agriculture labor real wages across different states of India, finding out fluctuations in trend of increase in agricultural wages and evaluating growth rate of increase in agricultural wages in India.

Database and Methodology

Secondary data of nominal wages of agricultural laborers of different states used in the paper is extracted from Labor Bureau Shimla, Ministry of Labor and Employment, Government of India for 2005-06 to 2020-21. Consumer Price Index Agricultural Labor data for the same time period is taken from Handbook of Statistics on Indian States, RBI and Labor Bureau Shimla. State Indices:

$$I_n = \frac{\sum P_n Q_0}{\sum P_0 Q_0}$$

Whereas: I_n= Index Numbers

P_n= Price of current period

P_o = Price of base

Q_o = Quantity of base year

All-India Index: The all-India index is worked out as a weighted average of the indices of 20 States, weights being the estimated consumption expenditure of all rural and agricultural labor households in each State as a proportion of corresponding expenditure for all-India. All-India group indices are also compiled by using the State weights in the particular group, derived as a proportion of corresponding expenditure at all-India level. Base year of CPI is adjusted to 2014-15 for whole data set using following formula:

$$\frac{x}{CPI(214-15)} \times 100$$

x = CPI (2005-06 to 2020-21)

In the study real wages are used instead of nominal wages which is calculated using following formula:

$$Rw = \frac{Nw}{CPI} \times 100$$

Whereas: Rw = Real wage

Nw = Nominal Wage

CPI = Consumer price Index (Agricultural laborers)

Coefficient of Variance is used to measure the fluctuations in the wages of different states. Following formula is used in the study to find out growth rate of agricultural wages along with compound annual growth rate:

$$GR = \frac{PRw \quad CRw}{PRw} \times 100$$

Whereas: GR = Growth Rate

PRw = Previous Year Wages (average of 2005-06 to 2007-08)

CRw = Current Year Wages (average of 2018-19 to 2020-21)

Result and Discussion

Spatio-temporal Variation in Agricultural L labourer Real Wages

Average of 16 years (2005-06 to 2020-21) real agricultural labor real wages in India shows that 8 out of 19 states (Kerala, Jammu and Kashmir, Haryana, Himachal Pradesh, Punjab, Tamil Nadu, Tripura and Rajasthan) showed higher wages than national average with exceptionally high wages in Kerala followed by Jammu and Kashmir while the minimum wages are being paid in Madhya Pradesh followed by Maharashtra, Odisha, and Gujarat. Kerala labors are paid high wages due to high demand and low supply of labors. Kerala labors tends to migrate to foreign countries for grasping better opportunities in the form of high wages, better and safe working conditions facilitated by premigration established linkages. Cost of living in Kerala is also high therefore labor wage is highest among all states. Demand of labors in Jammu and Kashmir is not fulfilled as migrants avoid to migrate there because of volatile law and order conditions along with harsh climate and topography. Thus, leaving only local labors in the market for work that too for shorter period of time allowed by climate for cultivation. Himachal Pradesh is known for out migration. Many villages in Himachal Pradesh had turned into ghost villages because of migration by nearly all families out of their village. This trend of migration by youth causes lack of labors in the state. Demand of labors had increased due to rise in horticulture, evolution of modern technology to practice farming at mountains, and improved marketing facility in the form of better roads, and enhanced communication facility. High demand and low supply of labor made

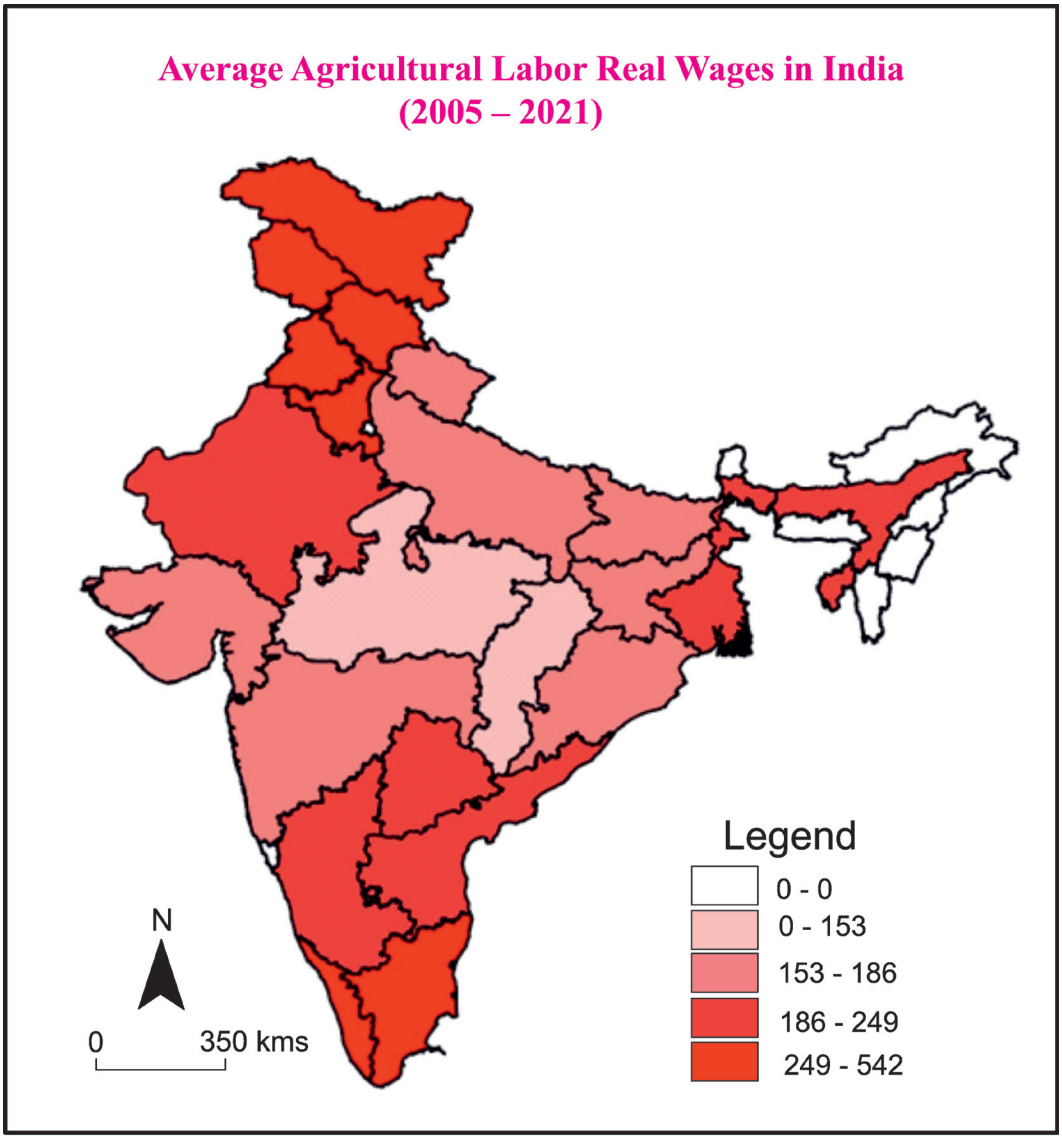

Average Agricultural Labor Real Wages in India
(2005 – 2021)
Legend
0 - 0
0 - 153
153 - 186
186 - 249
249 - 542
N
0
350 kms

Fig. 1

the agricultural wages of Himachal Pradesh high. Haryana and Punjab are hub of highly intensive agriculture which needs capital, technology and labors in large quantity. States themselves are not capable to fulfilled labor demand therefore in-migration of agricultural labors from low wages states like Uttar Pradesh and Bihar is observed in Punjab and Haryana. Only significantly high wages could attract labors to work far from their local area, thus they are offered higher wages. Along with agriculture, Haryana and Punjab have good level of industrialization which creates parallel demand of semi-skilled and non-skilled labors benefiting labors in the form of high wages at both places. Haryana is bordered with national capital which offers huge employment opportunities in tertiary sector, offering opportunities of wages in agriculture sector. Madhya Pradesh and Odisha have high tribal population that migrate and to labors to shift towards tertiary sector. This again push towards increment work as agricultural labor at a very low cost. Their bargaining power is low and their migration also results into adequate supply of labor in the market. Per capita income of farmers is also very low in these states and farmers practicing commercial agriculture are very less, thus these state experience low wage rates. Odisha is one the major rice producing states of India with limited mechanization of agriculture thus leaving large scope for labors to get engaged. Despite state's large share of rice production very meagre amount is cultivated for commercial purpose and mostly done for domestic or self-consumption which don not allow farmer to hire labor on high wages. Family members themselves cultivate in spite of hiring labor. Maharashtra and Gujarat are also among those states that receive maximum number of in-migrants thus they ensure supply in the market. Maharashtra is the state with very high farmers in distress making the state topper in farmer's suicide. The farmers of the state use minimum inputs for the agricultural production. Labor being a factor of production is avoided by the farmers up to possible limits. Uttar Pradesh and Bihar have huge human resource having low per capita income with suitable geographical conditions for cultivation and irrigation source in the form of rivers, canals and underground water. Bihar lags behind in development of other sectors of economy viz secondary and tertiary, which leaves little room for workers to find employment elsewhere, thus there is excessive supply of labors in the market with demand at fewer location causing fall of their wages. Due to high population in both of the states, agricultural land suffered from fragmentation in large scale, making the land unsuitable for commercial crop and fit only for subsistence agriculture which do not support high agricultural labor wages (**Fig. 1**)

Generally, it has been observed that with the economic growth, wages of employees of every sector (including agriculture) increase, but this is not universally applicable. For example, in Gujarat agricultural real wages had declined in 2017-21 period as compared to 2005-09. In many other states also during same time frame, agricultural real wages have seen decline instead of rise. For example, in Himachal Pradesh, Kerala and West Bengal wages declined in 2009-13 from 2005-09. Andhra Pradesh, Punjab and Tripura have seen higher wages in 2009-13 period as compared to 2013-17. Mean data shows that 7 states have witnessed decline in real wages in 2017- 21 as compared to 2013-17 viz Assam, Haryana, Jammu and Kashmir, Meghalaya, Punjab, Rajasthan and Tamil Nadu. Further analysis used 2017-18 as watershed and taking average of 3 year before and after that time period to find out the recent trend of the change in wages of agricultural labor in the country. Out of 19 states, 11 shows that a declining trend of real agricultural wages. They include Assam, Gujarat, Haryana, Jammu and Kashmir, Kerala, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan and Tamil Nadu. Although pan India data shows increase in real agricultural wages but that is very minute. State irrespective of the actual wages showed declining trend for example, Kerala, the highest paying state and Gujarat second lowest agricultural wages both showed decline in wages. Most significant decline is showed by Tamil Nadu (5.21%), Meghalaya (11.48%), Jammu and Kashmir (5.06%) and Rajasthan (-6.31%). All the states are located at four corners of the country which indicates that the decline in wages in not a regional issue rather a matter of national concern. Making 2014-15 as the divide line for comparison of previous and current agricultural wage we found that most of the states have improved their agricultural wages except for Gujarat and Tripura. Looking at the comparison of before and after 2014-15 collectively with the average of 2015-16 to 2017-18 and 2018-19 to 2020-21 reveals that the initially wages in most of the states were growing but decline of wages witnessed is a problem originated in very recent times that is after 2017.

Fluctuations in Real Agricultural Wages

Fluctuations in wages means abnormal rise and fall of wages. Fluctuation of wages are unsuitable for agricultural labors' sustained growth in a planned way. High fluctuations in wages demotivates labor to continue with the profession and seeks to engage in another alternative work for stable income. Fluctuation of wages may be caused by natural disaster, interference by administration in wage related issue, MSP hike in any specific crop etc. Coefficient of variance used to find the

fluctuations showed that maximum fluctuation of wages is in Odisha, Maharashtra, Tamil Nadu, and Himachal Pradesh whereas Jammu and Kashmir, Kerala, Gujarat, and Meghalaya are states with minimum fluctuation that is have high stability in wages of agricultural labors. Fluctuations in agricultural wages are independent of the level of wages in the states. States with high wages, shows both high fluctuations and low fluctuations in wages, for example Kerala and Jammu and Kashmir, are low fluctuating states whereas Himachal Pradesh is high fluctuating state. Similarly states with low wage rates also lies in both high and low fluctuating category. For example, Gujarat is low fluctuating state and Odisha is highest wage fluctuating state whereas both have low agricultural wage rates.

Growth Rate of Agricultural Wages in India.

Growth rate of agricultural wages is calculated between 2005-06 and 2020-21 using three years average (2005-06 to 2007-08) as previous data and three years recent data for current entry. Highest growth rate is observed by Odisha followed by Tamil Nadu, Bihar, and Uttar Pradesh whereas lowest is observed by Gujarat followed by Meghalaya, Tripura, and Jammu and Kashmir. These four states have showed negative growth rate, that is the wages in the 2005-06 were more than the 2020-21. This is because of sudden decline in agricultural wages due to economic impact of COVID-19. Despite fall in wages in current year due to COVID-19, 15 showed positive growth rate, indicating the overall growth in the wages. Compound annual growth rate for analysis of successive hike in wages over the years showed that Tripura and Gujarat experienced negative growth rate and very small positive growth rate is experienced by Meghalaya and Jammu and Kashmir. Highest growth rate is experienced by Himachal Pradesh, Odisha, Rajasthan and Bihar. A general trend observed in the growth rate is that states with high wage rate shows slow or negative growth rate for example Jammu and Kashmir and Kerala whereas the states with low wage rate shows high growth rate like Odisha, Bihar and Uttar Pradesh. Coefficient of correlation between compound annual growth rate of agricultural labor real wages and average agricultural real wages of states is negative which again indicates that states having high real wages showed lesser growth whereas as states having low wages rates experienced higher growth rate. This is because development of connectivity, transport and communication technology allowing free and unrestricted movement of labors loaded with required information and knowledge. This eventually is leading towards creating an equilibrium of wages across the country by filling the demand and supply gap.

Conclusion

Agricultural labors are among the most deprived section (economically, socially, politically) of rural society having meagre resources to sustain a meaningful, dignified life. Major and sometimes the only source of their income is the wages they derive by working in fields of others and other related allied activities. Decline in their wage or relatively slow growth as compared to inflation would have harsh impact on their development. Decline in agricultural laborer's wages would lead to reduction in purchasing power and demand of products and services thus slowdown in production process that would again hit the consumption as reduced production would cause increased unemployment, decline in capacity to spend for education, health, skill development. Agricultural labor wages depend upon demand and supply of labors thus in order to increase their wages their supply need to be cut short by engaging them in other sector of economy like decentralized micro, small, medium manufacturing enterprises, food processing industry, providing them with skill training for making them ready for semi-skilled jobs and increasing their demand by promoting farming practices that are more convention, integrated, labor intensive, and natural farming. Community farming or cooperative supported animal husbandry could support their household income and reduce vulnerability. Efforts are needed at central and state policy making level, by demotivating farm mechanization especially at those states that are labor surplus by introduction of seeds and techniques that engulfs more labor and support farmers financially to incur the increased cost of production thus tackling the problem of unemployment, reducing wages of agricultural labors and excessive rural to urban migration in one go.

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INCLUSIVE GROWTH: ROLE OF MIGRATION

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Abstract

Migration has an intimate association with the development and inclusive growth. While development causes migration the converse is also true. No doubt migration depri ves the society of origin of its young energetic creative manpower, but the remittances sent by them give rise to not only a number of developmental activities but also creates opportunities for all the section of the society in one way or the other. Remittances are most important to development though this depend on a variety of factors as the propensity to remit differs from person to person. Nevertheless, remittances helped in generating employment through the investments made by the migrant households thus helped the migrants and non-migrants equally. Remittances also helped in improving the standard of living of people through enhancing their consumption levels, thus having a multiplier effect on the economy. As the policymakers have shifted the focus away from the quantity of growth to the quality of growth, this paper is an attempt to highlight the key issues regarding the inclusive growth and how migration can impact inclusive growth. Therefore, the main objective of the present research is to know the role of migration in helping for an inclusive growth. To properly understand the relationship between remittance, migration and inclusive growth we need to look beyond household income effects and consider wider social impacts. In the present study the discussion is based on migration and inflow and use of remittances leading to poverty alleviation, migration and inequality, migration and changes in social institutions, and migration and change in role of women.

Introduction

Increasing migration flows in recent decades have been an important element of economic integration at both the global and regional levels, notably in Asia. The main drivers of migration in Asia, as elsewhere, are the wage gap between origin and destination countries, which remains wide, and the lack of employment

opportunities in origin countries, especially less-educated workers. These factors explain much of intra-regional migration by the low-educated (ADBI, 2013). In recent years, many policymakers have shifted their focus away from a narrow concern with GDP growth towards a broader target of 'inclusive growth.' This concept is understood to encompass both a lasting reduction in absolute poverty and a more equitable distribution of the gains from growth (UN, 2010). Since 2011, the Asian Development Bank Institute (ADBI), together with the Organisation for Economic Co-operation and Development (OECD), have organized an annual Roundtable on Labor Migration in Asia as part of its thematic priority in capacity building to promote regional integration and international cooperation and inclusive growth. The main theme of the second Roundtable, held in January 2012, was Managing Migration to Support Inclusive and Sustainable Growth. (ADBI, 2013). During the Roundtable, participating country-of-origin governments expressed the view that outmigration by educated citizens was largely positive. Governments raising this topic expressed confidence that it provides greater returns to education, and these countries hope to benefit from higher per capita remittance levels, the inclusive growth approach takes a longer term perspective. The emphasis on improving the productive capacity of individuals and creating conducive environment for employment, rather than on income redistribution as a means of increasing incomes for excluded groups. Due to this longer term perspective, there is an explicit focus on structural transformation and internal migration in the inclusive growth analytics framework. In developing countries a significant part of growth is generated through reallocation of labor from low productivity to high-productivity sectors.

Objectives

This paper is an attempt to highlight the key issues regarding the inclusive growth and how migration can impact inclusive growth. Therefore the main objective of the present research work is to know how migration weather internal or international work as a key for an inclusive growth.

Database and Methodology

In order to achieve the objectives of the present study, secondary data/ information have been used. The approach adopted for the research work is a systematic literature review strategy. Secondary data was collected from books, reports, journals, research articles having a direct bearing on the subject.

How Migration can help in Impacting an Inclusive Growth

Migration particularly rural to urban migration is one of the most conspicuous processes of the present day. The process can be comprehended in terms of the cause and consequences of migration in relation to the communities of the origin and destination of the migrants. The community structure generates situations which compel the people to make a move on the one hand and, on the other, the process of migration brings about changes in the community structure itself. Migration is a two way process, as it is a cause of development and as well as a consequence of development. The consequences of migration are numerous. These however are difficult to analyze as it involves a number of units and depends also on various factors at the place of origin and place of destination. The rapid growth of cities in the developing world is the major impact of migration. In the 20th century, rural-urban migration was viewed favorably in the economic development literature (Todaro, 1977). Internal migration was thought to be a natural process in which surplus labor was gradually withdrawn from the rural sector to provide needed manpower for urban industrial growth. The process was deemed socially beneficial since human resources were being shifted to locations where their social marginal products were not only positive but also rapidly growing as a result of capital accumulation and technological process. During the growth process, migration has a role to play in bringing about structural changes in the economy.

The consequences of migration are numerous. These however, are difficult to analyze because of the involvement of a number of units such as individuals, families, communities, regions and countries as well as intermediating variables like the socio-economic, political, environmental and cultural background and prevailing conditions at the place of origin and place of destination. Further, quite often, migration has more indirect than direct effects at the places of origin and destination and that too of variable temporal dimensions (U.N., 1984). Impacts of migration depend on the contexts, such as seasonality of movement, educational level of migrants, the length of time spent away, assets and social structures and institutions allowing women and others to pursue activities previously reserved for men and household heads (de Haan, 2000). Therefore to properly understand the relationship between remittance, migration and inclusive growth we need to look beyond household income effects and consider wider social impacts. Migrants impact both the place of origin and destination. And as the links between migration and growth is quite complex as the different aspects of it interacts,

making the quantitative assessments problematic. Therefore, it can observe from the following discussions that how migration impacts economy and society as well leading to an inclusive growth:

Migration and Poverty Reduction

The relationship between migration and poverty is a complex one. Migration can help to reduce poverty and poverty itself is also a cause of migration. But both are deeply interlinked. Researchers on migration have long grappled with the question of whether migration increases or reduces poverty. A consensus has not been achieved partly because of paucity of information and partly because of the tremendous variation across contexts and ethnic groups. The poverty reduction impact depends on a variety of factors like the availability of surplus labour with in the household and village and whether migration increases labour scarcity. Due to a tightening of domestic labor market (both agriculture and non-agriculture); however, that the wage increased in a higher rate in the agricultural sector shows an increase in employment opportunities and alternative particularly for low-income groups. An increase in wage rates can be a pivotal element for rural growth dynamics (Brown et al, 2013; Housen et al, 2012).

A research in Kenya showed even though poor households have less access to opportunities, income from migration may form a more important part of their income than that of the better-off (Knowles and Anker, 1981). Although most international remittances do not flow directly to the poorest people, remittances often make upon important share of the income of the poor people and poor communities as poor people might be affected indirectly through the economy wide effects of remittances expenditure on wages, prices and employment in migrant sending countries (Taylor et. al.1996). Taking the example of Nepal it has been observed that despite the political upheavals, there is a dramatic fall in poverty level and maintaining a stable level of growth over the past two decades, averaging around 4% annually. This sustained growth and reduction in poverty rate is a contribution of outmigration and remittances and this recent growth is termed as an inclusive growth (Maskay and Adhikari, 2013). Teto (2001) estimated that 1.7 million (out of 30 million) Moroccans would fall back into absolute poverty without international remittances and the proportion living below the poverty line would increase from 19 to 23.2 per cent. Another analysis of Egyptian and Ghanian survey data equally indicates that migration enables poor people to move out of poverty. Afsar (2003) also argues that migration has reduced poverty directly and indirectly in Bangladesh as remittances have expanded the area under cultivation and rural labour markets

by making land available for tenancy. Morina, D., Gashi, P. and Morina K., 2015 had observed in their study on Kosovo, that migration is a selective process that affects the growth potential and the welfare of non-migrants as well.

Anh's (2003) conclusions based on data from China, Vietnam, Phillipines and Bangladesh identifies migration as a driver of growth and important route out of poverty with significant positive impacts on people's livelihood and wellbeing. Research by the World Bank and other institutions points to a positive correlation between migration and poverty reduction. A study of 74 low and middle income developing countries reveal that on average a10 per cent increase in the number of international migration in a country's population can lead to a 1.2 per cent decline in poverty (Page and Adams,2004). Therefore, it seems to be of little doubt that migration can reduce poverty and stimulate economic growth (Deshingkar and Gramm, 2004). Migration may have direct and indirect effects on poverty. It can directly reduce poverty by reducing the number of people that a poor household must support. If the potential migrant was not working before leaving, this effect is particularly beneficial. Migration helps stabilize the household income and prevent the household from plunging further into poverty. Migration and migrant can have indirect effects on poverty in the migrant's home community. Migrants leave the local labour force making local labour force more scarce and pressuring the wages upwards, while remittances adds liquidity to local market, potentially stimulating economic activity (de Brauw, 2007).

Migration and Inequality

A commonly held view is that migration increases inequality. The effects of rural out migration on economic welfare in sending areas depends critically on how emigration effects the local capital-labour ratio among non-migrants, that is, on the distributional effects of migration. Moreover, an important concern of the literature on migration is that the poorest are rarely found the major beneficiaries of remittances, at least directly. This is due to the inability to finance expansive moves such as those overseas or those requiring some degree of education. Thus, the impact of migration and remittances on income distribution and in source regions remains a matter of interest in the literature but also of some dispute. The effects of remittances on income distribution and other aspects of wealth is primarily a function of migration selectivity. If migrants mainly originate from relatively wealthy households, migration is more likely to imply greater inequality in the community of origin, while the reverse seems likely if migrants come from relatively poor households, as in the case of Indian rural to urban migration, it has been emphasized

that better off migrants are "pulled" towards better job prospects while the poor are "pushed". "Push" and "pull" migration are twin children of inequality in the same sort of village; but they are also sources of new inequality (Lipton, 1980). It is more correct to say that the impact of migration on income inequality on migrant sending communities vary for different types of migration and for different periods in a community's migration history (see for instance, Stark et.al, 1988). Through the development of social networks between migrants and people staying behind which diminish the risk and costs of migration (Bauer and Zimmermann, 1988), and the flow back of international (Kornar, 1992) less wealthy households initially tend to gain increasingly easy access to international migration. As a consequence of this diffusion process, the initially negative effect of remittances on income inequality might, therefore, be dampened or even reversed in the long term. One might conclude that migration has contributed to increasing household income inequality within a certain community or region however, when comparing this migrant sending region as a whole with other more wealth and centrally located region in the same country (or between countries), one may find that inequality between the region has actually decreased as a consequence of developmental effects of migration (Taylor et. al, 1996). Inequality clearly influences and is in turn, influenced by migration (Waddington, 2003). The search for a better and more secure livelihood drives many migratory movements, and according to Nyberg-Sorensen et. al. (2003), is most common where survival is at stake. Not only does inequality influences who can migrate where, when and how, but it may also be a primary cause of migration. For example, Salemink (2002) shows how internal migration in Vietnam relates to a lack of land rights is customary law for certain excluded social groups. Gaps and access to water and land resource are also documented as causing migration in South Africa (Rwelamira et.al, 2000), Cameroon (Schrider and Knerr, 2000), West Bengal (Ragaly, 2003) and tribal Western India (Mosse et. al, 2002). Here, however the concern is more with how migration influences inequality. Although inequality increasing effects, have been found in various studies at the regional (Adams, 1989) and national (Mishra, 2007) levels, this mechanism is not inevitable.

Migration and changes in Social Institutions

Several historical and empirical studies of immigration have recognized and confirmed that the concentration of particular nationality and ethnic groups in certain cities facilitated the migration of the same groups to these cities (Levy and Wadycki, 1973). Networks play an important role in migration. Kinship ties, friendship and shared community origins are hypothesized to increase migration flows because

they reduce the psychic and risk costs of immigration. These networks connection constitute a valuable social capital that migrants can drop on to gain access to foreign employment and better wages and working conditions (Boyd, 1989).

Massy (1989) has made a case for networks under the assumptions of a risk-diversification model. According to this model families allocate member labour within the constraint of their own needs and aspirations in a cost-efficient and risk minimizing way. Moreover, modernization and development create social and economic dislocations that intensify the unstable and unpredictable economic environment created by the usual risks of drought, crop failure and natural disasters, for rural as well as urban areas. In the absence of other ways to ensure against such risks, diversifications of family members location minimize overall family income risk (Massey, 1989). Networks promote the independence migratory flows for two reasons. First, once network connections reach some threshold level, they amount to an autonomous social structure that supports immigration. This support arises from the reduced social and economic and emotional costs of immigration that network permit. That is, network supported migrants have important help in arranging transportation, finding housing and jobs in their place of destination and in effecting a satisfactory personal and emotional adjustment to what is often a difficult situation of cultural marginality.

These benefits make migration easier, thus encouraging people to migrate who would otherwise have stayed at home unless migrants are uprooted. Education appears to be a major factor in who benefits from and is able to undertake migration with in a community, even if this is only in relative terms (Skeledon, 1997). As stated by the Tilak (2007) also "education is the most critical ele¬ment in empowering people with skills and knowledge and giv¬ing them access to productive employment in the future". Therefore, education is an important sphere of wellbeing that can be affected by migration and a livelihood outcome in its own right. Through migration, individuals may be educated or skilled (i.e. it may be a motive to migrate itself) assuring migration is an accumulated strategy thus future generation may benefit through investment in their education (Waddington, 2003). Expenditure in areas such as education, health, food, medicines and investment in housing as well as community projects for education, health and recreational facilities can enhance people's wellbeing and ability to lead the lives they have reason to value. De Haan (2000) reviews literature from parts of India. Zimbabwe and Kenya finding on balance. That migrants are more educated as education can assist the development of critical consciousness and expose individuals to different values and norms.

Where women are educated they are able to participate in transnational migration and entrepreneurship, sending remittances that help to sustain social networks and participating in migrant organization (Nyberg-Sorenson, 2002).

Work in different parts of India by Parry (2003), De Neve (2003) and de Haan (2003) documents how networks are important even, crucial assets to enable migration. This may be through kinship or other kinds of social affiliation and identities such as caste solidarity. In the former, dependency patronage and other kinds of support (e.g. business partnership) can lead to upward mobility. For the later, the village community can be a good source of information and help with alternatives. In west Bengal, Rogaly (2003) reports how migrants establish long term relations with individual employers, which are crucial for survival. De Haan (2003) reports that caste identity plays a role in the personal networks that mediate migration of migrants to Calcutta. Migration can reinforce the structures, ideologies and support networks for development works and also influence positively institutions such as family, school, social norms and traditions and religious organizations by bringing in new progressive ideas into the development of social institutions and also migrants invest in strengthening these local institutions (Haque, 2006).

Women Migration and Empowerment

The most striking example of the social changes in Nepal resulting from out migration has been the empowerment of women in the rural areas. As men have moved abroad to work, women left behind in Nepal have gained increasing autonomy and discretion over household budgets. In a nationally representative survey of married women, more than half of currently married women who earn cash said that they themselves mainly decide on how their cash earnings are used; two in five indicated that the decision is made jointly with their husbands and only 5% said that the decision is made mainly by their husbands. Similarly, the proportion of surveyed married women who earned cash for their work and who solely decided on the use of their cash earnings has increased from 31% in 2006 to 53% in 2011. It is now recognized that gender equality and female empowerment are central to improvements in standards of living and wellbeing (World Development Report, 2011). Further, the empowerment of women in the rural economy has led to drastic changes such as increasing access to information, offering new choices, and providing demonstration effects. Thus, an unforeseen consequence of foreign labor employment to Nepalese labor is that it has spurred societal changes, namely the empowerment of women in rural areas. It has been argued that female migrants show a deeper commitment than male migrants to providing more economic support to

households that are left behind (Osaki, 1999; Carling, 2005; Boyd, 1989). Several studies indicate that until recently migration was dominated by single men (De Haan, 2000), but things are now changing and feminization of migration is now occurring. In India, regional differences in women's mobility have been noted by Singh (1984 cited in De haan,2000), where migration among women in South India is higher than their northern sisters who live in a cultural milieu that is similar to West Asian and North African Arab countries. Bremen (1996) observed that migrant women in Gujarat, India carrying out equivalent tasks to migrant men earned lower wages. It is sometimes assumed that the migration of men encourages the emancipation of women who stay behind since behind since in their husband's absence, women's responsibilities, autonomy and power would increase (see, for instance, Fadloullah et. al, 2001), while remittances enable these women to assert this newly acquired independence. The pattern in China is still largely male-dominated as a number of studies have established (Zhao, 2001, 2003) both due to cultural reasons restricting female mobility and the nature of the demand for manual workers in urban areas. But more women are migrating to labour intensive industries in areas such as Guangdong. Regional comparisons show that women's migration is very high in South America and South East Asia (Guest, 2003). For example, a study of the cities of Ho Noi and Ho Chi Minh estimates that 40-45 per cent migrants are female (Grace, 2002).

There is micro evidence from several countries in South East Asia that the levels of female migration have increased over recent decades. The employment of women is greatest in the five major export-oriented, labour intensive industries, which are electrical machinary, electronics and computer parts; textiles and readymade garments; frozen and canned foods; precious stones and jewellery and footwears (Clawn,2002). The majority of female rural-urban migrants in East and South East Asia are young and unmarried and the concentration of this group in urban areas is partially in the mega cities (Guest, 2003). This form of migration has increased and become more socially acceptable in South Asia (Siddiqui, 2003). In some areas cultural barriers are breaking down because of the huge opportunities offered by migratory work. Migration thus offers many prospects for helping women to exit from poverty (Deshingkar and Grimm, 2004). It is now recognized that, international migration is positively associated with the status of a women and the opportunities for women to go abroad for employment draws from changes of role of women in areas such as household's decision making, division of labour, gender roles and community perception. Gammage (2004) found that, through migration

and remittances, Haitian women have been able to change the political landscape of Haiti and have challenged traditional gender roles. The so called, "autonomous female migration", has increased because of a greater demand for female labour in certain services and industries and not just as accompanying spouses.

The feminization of migration is one of the principal recent changes of population movement. Today women account for about half of the migrant population (Haque, 2006). Both Courbage (1996) and Fargues (2006) hypothesized that besides factors such as older age of marriage, increased female labour participation and improved education migration from North America to European countries has contributed to the diffusion and adoption of European marriage patterns and small family norms and so has played an accelerating role in the demographic transition. Blue (2004) found that females were positively associated with remittances behaviour among Cuban emigrants. The changes in the family and social norms brought by the female migrants are insignificant and potentially beneficial for the society (Haque, 2006).

Conclusion

Inclusive growth is regarded as the new mantra of development. This paper looks at the approach to the building up of a relationship between inclusive growth and migration and how migration is impacting it. Though many have argued that migration deprives poor countries of its valuable human resources, but studies also have proved that migrants are a potential source of development to their origin as they bring with them the new skills, advanced technology and also potential sources of finance in the form of remittances sent by them. Therefore, it can be concluded that migration does not always lead to brain drain but also to brain gain. Therefore, migration weather internal or international promotes the welfare of the economies and help in bringing an inclusive growth and development directly or indirectly, through the helps provided by the migrants to the area of destination or origin, such as construction of houses and cattle sheds, purchase of land and livestock economy, introduction of new farm technology, education etc. To continue the process of economic growth and social transformation to which remittances are contributing, the economies should foster an economic environment conducive to the productive use of remittances. Therefore, migration weather internal or international promotes the welfare of the economies and help in bringing an inclusive growth and developmental process directly or indirectly. To continue the process of economic growth and social transformation to which remittances are contributing, the economies should foster an economic environment conducive to the productive use of remittances. In particular it should maintain a reasonable level

of economic stability through building consensus among the political parties on minimum common economic agenda for development and growth.

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PROSPECTS AND CHALLENGES OF SUSTAINABLE TOURISM IN ANDAMAN AND NICOBAR ISLANDS

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Abstract

The paper discussed the status, prospects, and challenges of sustainable tourism in Andaman and Nicobar Islands. It has been found that there is huge potentiality of sustainable tourism in the islands. Unexplored geographical features, diversified biodiversity, rich cultural heritage, rich tribal culture, evergreen forests, wild life sanctuaries, and river tributes, are prominent factors for the potential growth of the tourism sector. Travellers can enjoy the village life of the local tribes. The islands have plenty of marine wildlife, and amphibian. Cellular Jail National Memorial, Chatham Saw Mil, Samudrika Naval Museum, Anthropological Museum, Corbyn's Cove, Sound and Light Show are the popular places. But, there are also challenges before the tourism industry. Therefore, government should implement policies for mitigating such challenges.

Introduction

The term tourism was introduced in the 19th century and it is associated with the term "sustainable tourism". Tourism industry is important for any country, because it surge growth and demand of products/services of industries in the country. Tourism has the cultural, and economic phenomenon, where people move from one place to another for multiple purposes. It is the short period or temporally movement from the native place. Duration of the visit may be just one night, or up to one year. It always includes the domestic tourism, inbound tourism, and outbound tourism. Tourism industry is considered as a bigger industry in terms of employment and foreign earnings. It improving the communications among the peoples and solving various social disputes. It has many benefits, such as introduction of new technologies, boost in economic activities, infrastructure development, increase global connectivity, source of foreign exchange earnings, improve nations brand image, improvement of living standards, cultural growth etc. Sustainable tourism involved in development of both the present and future generation. It means movement of people outside own houses and visit various

places without harming the natural environment. Sustainable ecotourism benefits both the visitors and the local peoples. It is useful for swelling conservation and economic growth. Travellers can witness the beauty of the natural environment and also learn about the culture of the ethnic peoples. Ecotourism is natural based activities that increases the interest of people about certain places. Such activities will be economically, ecologically, and socially sustainable and helpful for the wellbeing and conservation of the areas. Local people will be benefited through such tourism without affecting their culture and customs.

Objectives

The main objective of this study is to investigate the prospects of sustainable tourism in Andaman and Nicobar Islands, and to study the challenges before the tourism sector.

Study Region

Andaman and Nicobar Islands is a union territory of India. It contains two island groups, Nicobar Islands, and Andaman Islands. The total land area of the islands is nearly 8,249 km^2. There are 572 islands. Port Blair is the capital of the union territory. It is situated 1,255 km from Kolkata, 1,200 km from Visakhapatnam, and 1,190 km from Chennai. Hindi, and English are the official languages of the islands. (**Fig.** 1)

Database and Methodology

(1) Design and approach: The present study is based on the secondary data. The data has been collected from reports of Andaman and Nicobar Tourism, and India Tourism Statistics. Various journals and books have also been referred in the present study.

(2) Method of analysis: To reveal the growth of tourism industry of Andaman and Nicobar Islands in general and the sustainable perspectives of the industry in particular, different methods of qualitative analysis comprising of tabulation and text analysis were performed.

(3) Hypothesis: Data analyses have been done on the following hypotheses:

H0: There are no impact of corona pandemic on the Tourism Industry in Andaman and Nicobar Islands.

H1: There are impact of corona pandemic on the Tourism Industry in Andaman and Nicobar Islands.

Results and Discussion

Tourism industry in Andaman and Nicobar Islands are increasing due to the beautiful beaches, and adventure sports like sea-walking, and snorkelling. Its tropical rain forest is rich with a diversity of animal life. Kalpong River, Alexandra River, Galathea River, and Dagmar River are the popular rivers. Kalpong river situated in Andaman District, are originated from Saddle Peak. The remaining three rivers situated in Great Nicobar. Hydroelectric dam is constructed on the Kalpong River. The top tourist visited places are Port Blair, Havelock Island, Neil Island, Ross Island, Diglipur, Long Island, Cinque Island, Mayabunder, and Little Andaman. Port Blair is the capital and headquarter of Andaman and Nicobar Islands. It is the gateway for the others incredible islands. Veer Savarkar International Airport is the only airport in the islands. It is well connected with the mainland by air from Visakhapatnam, Chennai, and Kolkata. Cellular Jail National Memorial, Chatham Saw Mil, Samudrika Naval Museum, Anthropological Museum, Corbyn's Cove, Sound and Light Show are the popular places of the city. Cellular Jail is a British colonial prison. Today it is a national memorial monument. Wandoor Beach is situated 25 km south-west of Port Blair. It is located near the Mahatma Gandhi Marine National Park. There are plenty of marine wildlife, and amphibian. Saltwater crocodiles are often found on the coasts. Wandoor is also recognized for its Mangroov forest, lagoons, and backwater. Travellers can enjoy the village life of the local people. Agriculture crops (coconut, and paddy) and fishing are the main sources of income of villagers. Travellers can see the rural life of the diversified tribes. It will enhance the rural tourism in the islands.

Table-1 discussed the populations and areas in Andaman and Nicobar Islands. It has been found that south Andaman district have the largest number of population, followed by the North. and Middle Andaman districts. It is the largest district followed by the South Andaman district. Mahatma Gandhi Marine National Park was established in 24th May 1983 under the Wildlife Protection Act of 1972 for the protection of nesting sea turtles, and corals. Twin Islands and Labyrinth Islands are the two major island groups in the park. Majority of the coral reefs are fringing reefs. There are nearly some 20 islands and rocks in the park. Many islands are covered with thick mangrove vegetation, sheet rocks, uprooted trees, and sand covered beaches. There is scope of ecotourism in Red Skin and Jolly Buoy islands. Havelock island is a popular eco-tourism spot. Water sports like as scuba diving, banana boat ride, and sea walking are popular among the tourist.

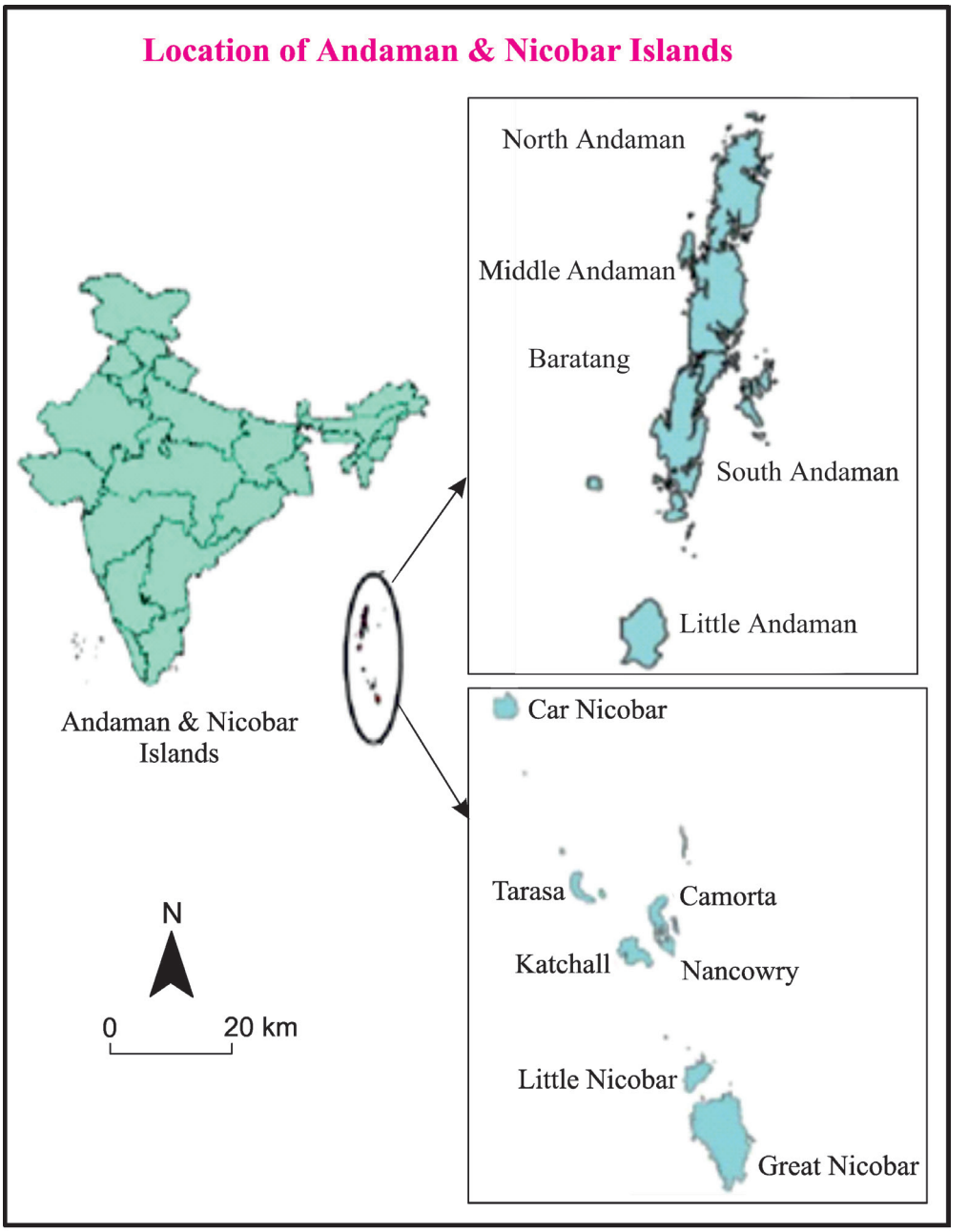

Location of Andaman & Nicobar Islands
North Andaman
Middle Andaman
Baratang
South Andaman
Little Andaman
Andaman & Nicobar Islands
Car Nicobar
Tarasa
Camorta
Katchall
Nancowry
Little Nicobar
Great Nicobar
N
0
20 km

Fig. 1

Elephant beach, Kala Patthar beach, and Radhanagar beach are the popular beaches. Tourist can also enjoy the mangrove safari, fishing, trekking, scuba diving etc. Neil Island is situated 40 Km. away from Port Blair. Sitapur beach, Laxmanpur beach, and Bharatpur beach are popular beaches of Neil Island. Travellers can witnessing the unexplored coral reefs. Ross Island is an uninhabited island. The ruins and a small museum of Indian Navy is the main attraction of the island. Ross Island is located three km. east from central Port Blair. There are many lighthouse towers. Peacocks and spotted deer are easily available in the island. Palm and coconut trees are the native trees of the island. Travellers can see the amazing landscapes and sunset views in the evening. (**Table-**1 and 2)

Table-1: The Populations and Areas in Andaman and Nicobar Islands

District	Capital	Population (2001)	Population (2011)	Area (km.)
South Andaman	Port Blair	208,471	238,142	2,640
N. and M. Andaman	Mayabunder	105,613	105,597	3,536
Nicobar	Car Nicobar	42,068	36,842	1,765
Totals		356,152	380,581	7,950

Source: Office of Registrar General & Census Commissioner of India.

Table-2: Historical Population Growth in Andaman and Nicobar Islands

Year	Population	Growth	Year	Population	Growth
1901	24,649	-	1961	63,548	+105.2%
1911	26,459	+7.3%	1971	115,133	+81.2%
1921	27,086	+2.4%	1981	188,741	+63.9%
1931	29,463	+8.8%	1991	280,661	+48.7%
1941	33,768	+14.6%	2001	356,152	+26.9%
1951	30,971	−8.3%	2011	380,581	+6.9%

Source: Census of India.

Table-2 discussed the historical population growth in Andaman and Nicobar Islands. It has been found that except 1041-1951 period, in other periods population was increased. Viper Island lies four kilometres west of Port Blair. It is popular among the tourist because for its mesmeric picnic spots, and having historical

importance. Nali, Mud Spitting Volcano, and Kalipur beach are the popular places of the island. Saddle Peak National Park, Orange gardens, paddy fields, Saddle Peak, and expansive greenery and marine life are other tourist attractions. Trekking, scuba diving, and snorkeling are the common activities. Long island has the beautiful eco-huts headed by Blue Planet. Merk Bay, and Lalaji Bay are the popular sports. Clinque Island is a human inhabited island. Tourist can enjoy the wildlife, greenery, and marine life of the island. The Mahatma Gandhi Marine National Park, salt water crocodile, starfish, sea weeds, varieties of coral reefs, fishes, shells, turtles, and sprawling marine life are the major tourist attractions. Mayabunder situated in middle Andamans. It is cultural hub of 71 villages where majority of people are immigrated from Pakistan and Bangladesh. Karmatang beach, and Karmatang Beach have the turtle nesting spots. Little Andaman is paradise for the natural lovers. Travellers can involve in coral watching, fishing, diving, snorkeling, surfing etc. Beautiful beaches, Red Oil Palm Plantation, evergreen rain forests, and waterfalls adds additional satisfactions to the tourist. (**Table-**3)

Table-3: Year-wise Arrivals of Tourist in Andaman and Nicobar Islands.

Years	Tourist Visits			Percentage Share		Rank	
	Domestic	Foreign	Total	Domestic	Foreign	Domestic	Foreign
2008	123914	12512	136426	0.00	0.10	31	23
2009	142042	13684	155726	0.00	0.10	31	23
2010	180781	14615	195396	0.00	0.10	31	25
2011	202221	15814	218035	0.02	0.08	31	25
2012	238699	17538	256237	0.02	0.08	31	25
2013	243703	14742	258445	0.02	0.07	30	25
2014	285146	17235	302381	0.02	0.08	31	27
2015	296684	14674	311358	0.02	0.06	32	27
2016	384552	15466	400018	0.02	0.06	31	26
2017	471919	15313	487232	0.03	0.06	30	27
2018	498279	15242	513521	0.03	0.05	31	28
2019	505398	16206	521604	0.02	0.05	31	29
2020	191207	5412	196619	0.03	0.08	28	25
2021	126238	1687	127925	0.02	0.16	32	21

Source: India Tourism Statistics.

The above **Table-**3 discussed the arrivals of tourist in Andaman and Nicobar Islands. It has been found that number of tourist are increasing continuously since 2010, but declined in 2020, due to the corona pandemic. Domestic tourist arrival was more than 50 thousand in 2019, but it was dropped to only 126238 in 2021. On the other hand, foreign tourist arrivals were 16206 in 2019, and it was just 1687 in 2021. Lockdowns, and travelling restriction due to the corona pandemic is main factors behind the sudden drop of the tourist arrivals. Therefore, the null hypothesis is rejected and alternative hypothesis is accepted, i.e. there is impact of corona pandemic on the Tourism Industry in Andaman and Nicobar Islands. There are three districts in Andaman and Nicobar Islands. They are Nicobar, South Andaman, and North and Middle Andaman. Malacca is the capital of Nicobar district. It is situated in Car Nicobar tehsil. Car Nicobar is located in the northernmost of Nicobar Islands. It is popular for the silvery beach. It is flat island with clusters of coconut palms, and areca nut. It is a small island (only 126.9 km^2). There are 21 villages. It has tropical monsoon climate. Bird watching is popular among the tourist. Green imperial pigeons, Andaman boobooks, White-headed starlings, Andaman cuckoo-doves, Andaman wood pigeons, and Nicobar serpent-eagles are the prominent birds. Car Nicobar is 260 kilometers, far away from Port Blair.

Ship service is available between the two towns, and travellers can collect ticket from the office of the Director, Shipping services, Port Blair. Indian Air Force operating the charter services between Car Nicobar Air Force Base, and Port Blair's Veer Savarkar International Airport, Campbell Bay. Regular service of Pawan Hans helicopter is also available. Mount Thullier is the highest point of Nicobar Island. It is 642 meter above the sea level. Dak Tayal, Dak Aniang, Amrit Kaur, Jubilee, and Galathea are the popular rivers of the island originated from Mount Thullier. Among the rivers, Galathea River is the longest river. Indian passport holders can travel the island, but the foreign passport holder's needs Landing Permits from the Office of the Deputy Commissioner, Andaman District. Indira Point is the most southern point of Great Nicobar Island. Great Nicobar Island is declared as World Network of Biosphere Reserves by the UNESCO. The island is comprising three distinct groups- Northern Group, Central Group, and Southern Group. Nicobarese, Shompen, and Mainland Indians are the ethnic tribes. Galathea National Park, and Campbell Bay National Park of Great Nicobar are protected areas. The island has the tropical climate. Mayabunder is the headquarter of North -Middle Andaman district. It is connected with Port Blair by the Andaman Trunk Road. It is the major highway. This highway connected Diglipur and Port Blair, via Mayabunder,

Nimbudera, Billy Ground, Rangat, Kadamtala, Baratang, and Ferrargunj. The distance between the two places are 242 km. Ferry service also available between them. It is a waystation for several tourist attractions, like as Karamatang Beach (13 km), beach at Aves Island (30 minutes by boat), and mangrove lined tidal creeks. Majority of the population of union territory lives in this district. Port Blair is the headquarter of South Andaman district. It is also the capital of Union territory. It is connected with the main land of the country by sea, and air. Other towns are Garacharma, Prothrapur, and Bambooflat. Bambooflat is located nearly 13 Kilometers from Port Blair. (**Table-**4)

Table-4: District-wise Popular Tourist Places in Andaman and Nicobar Islands.

District	Popular Tourist Places
South Andaman	Jolly Bouy, Swaraj Dweep (Radha Nagar Beach), Netaji Subhash Chandra Bose Island, Chatham Island, Cinque Island, Corbyn's Cove Beach, Cellular Jail, Mount Harriet, Gandhi Park, and Shaheed Dweep.
North- Middle Andaman	Lamiya Bay Beach, Karmatang Beach, Ramnagar Beach, Mud Volcano at Shyam nagar, Kalpong Hydro Electricity, Limestone Caves in Diglipur, Twin Islands - Ross & Smith Islands, Saddle Peak, Kalipur Beach and Turtle Nesting Ground.
Nicobar	Little Nicobar, Great Nicobar, and Car Nicobar.

Source: Official website of the districts.

Table-4 exhibits the popular tourist places in districts of Andaman and Nicobar Islands. It has been found that tourist places are scattered in the districts. Lamiya bay beach is situated in the foothill of Saddle Peak. It is near the Kalipur beach. Karmatang beach is perfect place for the snorkelling and scuba diving. Travellers can observe the olive ridley turtles, hawksbill turtles, green ocean turtles, and leatherback turtle. Ramnagar beach located 35 kilometers from Diglipu. It is more suitable for suitable for swimming. turtle nest is easily available. The beach has the eco-friendly beach facilities, like as seating arrangements, and eco-huts. Mud Volcano located near Hathilevel. The chain of Mud volcanoes can observe in the green jungle of Shyamnagar. Seating facilities along with information boards are available for the tourists. Kalpong dam is constructed on the across Kalpong river at Nabagram. It is only dam in the Union Territory. Turtle Nesting takes place at

Ramanagar beach and Kalipur beach are popular among the tourist. It is the home to thousands of turtles during their nesting period. Alfred caves is located near the Ramnagar beach. Ross & Smith islands are popular among the tourists. There is a marine sanctuary. It is enclosed by tropical forests. It is the perfect place of trekking and trail hiking. Diglipur is popular for eco-friendly tourists. It is a beautiful place having the orange garden paddy field, forest, and marine life. Andaman and Nicobar Islands are enriched in culture & heritage. Folklore is narrated and folk songs are the part of the festivals. There are many indigenous peoples in the islands. Andamanese are a listed as scheduled tribe as per India's constitution. Traditionally they lived a hunter-gatherer lifestyle, Great Andamanese and Jarawas are the major tribes. Jarawasve lives in Middle and South Andaman Islands. According 2011 Indian census, their population is 380. They are hesitated interaction with outsiders. Tourism department of the Andaman and Nicobar administration issued warning for attempting photographing them, or contact with Jarawas. They are protected under the under the Protection of Aboriginal Tribes Regulation, 1956. Onge is the another tribe. They live in Little Andaman. Their belief system is a form of animism. They are still maintaining their cultural and biological identity. Their population is declining due to their food habits brought about by their contact with the outside world. Therefore, there are huge potentiality of sustainable tourism in the islands. Unexplored geographical features, diversified biodiversity, rich cultural heritage, rich tribal culture, evergreen forests, wild life sanctuaries, and river tributes, are prominent factor for the potential growth of the tourism sector. But, there are also challenges before the tourism industry. Lack of media coverage, ethnic conflicts, lack of alternatives means of transport, boundary issues, poor connectivity, and abysmal infrastructure are the major challenges before the sector.

Conclusion

There is enormous potentiality of sustainable tourism in Andaman and Nicobar Islands. Port Blair is the capital, and the largest city. It is well connected with mainland by air and sea. Cellular Jail National Memorial, Chatham Saw Mil, Anthropological Museum, Corbyn's Cove, Sound and Light Show are the popular places of the city. The top tourist visited places in the islands are Port Blair, Havelock Island, Neil Island, Ross Island, Diglipur, Long Island, Cinque island, Mayabunder, and Little Andaman. Havelock island is a popular eco-tourism spot. Water sports like as scuba diving, banana boat ride, and sea walking are popular among the tourist. Elephant beach, Kala Patthar beach, and Radhanagar beach are the popular beaches. Diglipur is popular among the tourist because for its mesmeric picnic

spots, and historical importance. It is a beautiful place having the orange garden paddy field, forest, and marine life. Travellers can observe the olive ridley turtles, hawksbill turtles, green ocean turtles, and leatherback turtle. Great Nicobar Island is declared as World Network of Biosphere Reserves by the UNESCO. Andaman and Nicobar Islands are enriched in culture & heritage. There are many indigenous peoples in the islands. So, there are huge potentiality of sustainable tourism in the Union-Territory. But certain factors, like as ethnic conflicts, poor connectivity, lack of media coverage, lack of alternatives means of transport, boundary issues, and abysmal infrastructure are the major challenges before the sector.

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HISTOGENESIS AND GROWTH OF PATNA METROPOLITAN CITY

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Abstract

"Every place is a history of a life" (Tuan, 1977). Studying the histogenesis and growth of a historical city is not merely an exercise in understanding the past but it is an exploration of the transformative power of human civilization in crafting the urban environment as well. Examination of historical evolution of a city "illuminates the hidden relationships between power and space, revealing a deeply rooted interplay of social and spatial transformations" (Soja, 2010). This research paper delves into the histogenesis and growth of Patna settlement, a city of profound historical significance in India. Through an in-depth examination of historical records, maps and demographic data, this study traces the city's growth, from its ancient origin as Patliputra to its current status as a bustling metropolitan area. The research scrutinizes spatial expansion, population dynamics and key socio-political events that have shaped Patna's trajectory over millennia. The study reveals the pivotal role of strategic location along the Ganga river (Prasad, 2008), successive dynasties (Thapar, 2013) and colonial influence (Rai, 2010) in shaping the Patna's urban landscape. The analysis further delves into post-independence challenges, including economic decline and administrative restructuring, particularly following the separation of Jharkhand from Bihar in 2000. Despite these challenges, Patna's resilience is evident in its population growth which has multiplied tenfold since the early 20th century. This study projects a population of over 4 million by 2051, underlining the city's continued vitality and potential for further expansion. This comprehensive historical account contributes to a better understanding of the city's urban development processes and provides a foundation for urban planning and development in the future.

Introduction

To ensure a better future, it is vital to learn from the past. In order to comprehend the processes and patterns of urban development, it is essential to study the origin, evolution, and growth of cities. An examination of the histogenesis of a city is

necessary to properly comprehend the process of urbanization. The origin of ancient cities is often linked to myths, legends and divine interventions. The discipline of urban geography is concerned with the precise study of a city's location, site and situation in a temporal context. Recent advancements in underground exploration surveying technology have provided a gateway to search for 'city seeds' (Bosker, 2022). The development of cities is intricately tied to the progress of humanity and civilization. While traces of human civilization have been found worldwide, the civilization of the Indian sub-continent has an antecedence of urban nature. The Harappan civilization provides evidence of urban infrastructure such as proper drains, planned housing, lanes, and roads. Furthermore, several cities in mainland India are assumed to have divine origins dating back thousands of years, including Varanasi, Mathura, and Dwarika. Patna city has a history dating back to the 6th century BCE or even earlier. Apart from the Kumhrar excavation, there is no significant evidence of infrastructural traces to date. Historical and religious texts have always made appropriate mentions of Patna's expansion up to the pre-historical Mahabharat period. The travel accounts of foreigners during the ancient period also mention Patna under different names such as Pataliputra, Palibotra (Greek), and so on. The city has been given many names during the rule of different dynasties in the ancient history of the Indian sub-continent. As with other ancient cities, Patna's origin has evinced conflicting claims.

Study Region

Patna, the capital of Bihar, holds a prominent place in the historical and geographical landscape of India. This city, located in the west-central region of the Bihar state, lies in the midst of the fertile Ganga plain. The city falls within the coordinates of latitude 25°30' to 25°40' North and longitude 85°0' to 85°15' East. The city is surrounded on three sides by the Ganga, Sone, and Punpun rivers, and it boasts a unique convergence of four rivers with the Gandak river to the north. The Ganga's southern embankment forms the city's northern boundary, while the Punpun river flows approximately 5 kilometres to the south and the Son river more than 10 kilometres to the west. The city's elevation, averaging 55 meters above mean sea level, encounters lower areas to the southeast that are susceptible to prolonged waterlogging after floods. Most of the metropolitan area is part of the older floodplain, with the western region along the Ganga's embankment classified as an active floodplain. The city's population grew substantially between 1991 and 2011 with a significant "floating" population commuting daily. As of the 2011 census, Patna is home to a population of 2,046,652. The city extends for

about 24 kilometres from east to west, with an average width of 2.5 kilometres and encompasses an area of approximately 142 square kilometres.

Objective

The main objective of this study is to reveal the origin and evolution of the city including its evaluation of its spatial and demographic growth.

Database and Methodology

The study is solely based on secondary sources of data as it delves in to histogenesis and growth of the city. Accessible literature, historical maps, Survey of India Topo-sheets, Census data and other related government reports have been used as secondary data. ArcMap 10.8 has been used to prepare different relevant thematic maps such as extent of urban growth and settlement of urban landscape. MS Excel has been used for data analysis, presentation and interpretation.

Origin

The ancient origins of Patna are steeped in legend, with a multitude of stories surrounding the city's name and foundation. Over the course of its long and illustrious history, Patna has gone by a variety of monikers, from Patligram - a small village named after the patli flower that still grows in the city to this day - to pushpapuri and kusumpura, both of which mean 'city of flowers' and evoke an image of a tranquil city surrounded by blooming gardens. Patliputra is perhaps mostly well-known of these names, a testament to the city's rich cultural and historical heritage as the site of the ancient kingdom of Magadha and the Mauryan empire's flourishing capital. By the time of Sher Shah Suri in the 16th century, Patliputra had evolved into Patna, a name that phonetically resembled the Sanskrit word for 'port', paatan. However, the city underwent another name change when it became known as Azimabad during the Mughal era, named after the Mughal prince Azim-uh-shan, who established a court here. With the fall of the Mughal empire, the people of the city returned to calling it Patna, a name that has endured to this day and is synonymous with images of grand empires, scientific advancement and a rich cultural legacy that remains an integral part of India's history.

Tales and Anecdotes

The narrative from an ancient Hindi manuscript, translated from the Sanskrit Brihatkatha, provides a captivating account of the foundation of Patna. It chronicles the journey of a Brahmin Bhumideva and his sons, Kusa and Bikusa,

along with their wives Pramati and Sumati, who sought their fortune overseas. The intervention of deities Mahadeva and Parvati, prophesizing the birth of a child named Putra with a unique ability to generate a thousand gold coins. Putra, in a gesture of love and identity, established and named Pataliputra after his wife and himself. Following his reign, son Kusuma ascended to the throne, and under his rule, the city was renamed Kusumapur. This narrative intertwines folklore, divine intervention, and urban genesis, offering a rich tapestry of Patna's origin.

Evolution

The city of Patna owes much of its prominence to its strategic location, situated as it is amidst the rivers Ganga, Son, Gandhak, and Punpun. This unique position didn't only ensure its political pre-eminence but also allowed the city to thrive as a hub for riverine trade. Over the centuries, Patna has served as the capital of various powerful dynasties, from the Shishunaga and Nanda to the Maurya, Shunga, Kushana, and Gupta. Each of these dynasties has contributed to the city's cultural and historical heritage, leaving an indelible imprint on its identity. The city has also attracted travellers who found Patna inspiring and wrote vividly about its vibrant personality and historical journey. Patna played a critical role in India's struggle for independence, further cementing its place in the annals of Indian history.

Ancient Period (5th Century BCE to 12th Century CE)

In the 5th century BCE, Ajatashatru of the Haryanka dynasty of Magadh, son of Bimbisara, emerged as a significant ruling figure in Indian history. He was a contemporary of the great souls namely Mahavir and Gautam Buddha. Despite a tumultuous ascent to power, in which he forcefully overtook the kingdom from his father and imprisoned him, Ajatashatru emerged as a successful conqueror. By capturing Vaishali, fortifying a village to form the city of Patliputra, and capturing Kashi and other smaller kingdoms, Ajatashatru secured his position as the ruler of the most powerful kingdom in North India. Between 491 and 961 BCE, Ajatashatru moved the capital of Magadha kingdom from Rajgriha to Patliputra, and his son Udayabhadra succeeded him, leading to the city's growth into the largest city in the region. Although Gautam Buddha visited Patliputra during the last years of his life and prophesied a successful future, he also predicted the city's ruin from Flood, Fire and Feud. In the 4th century BCE, Chandragupta captured Patliputra and established the Mauryan dynasty, which lasted from 321 to 185 BCE. With the rise of the Mauryan dynasty, Patliputra became the centre of power. The city was constructed using wooden structures during this time, with multi-story buildings

and palaces surrounded by ponds and parks. The drainage system was another notable feature of Patliputra. The streets' water route drained into a moat , which functioned as both a defence system and drainage system. In 303 BCE, Greek ambassador Megasthenes visited the royal court of Chandragupta and described Patliputra as an important and fortified city with wooden walls, crowned with 517 towers and 64 gates, all surrounded by a protective ditch. The main gate of the city was protected by a special armed contingent under the kiledar . Megasthenes noted that visitors had to show their identity to the gatekeeper while entering the city. He described Patliputra as a splendid city and compared it to the contemporary Persian sites (Waddell, 1903). In the 3rd century BCE, King Ashoka, the grandson of Chandragupta, extended the Mauryan empire as far as Madras and renovated the wooden capital into a stone construction in 273 BCE. During this time, education and learning received immense state support, leading to Patliputra becoming home to several eminent world-class scholars, including Aryabhata, Ashvaghosha, Chanakya or Kautilya and Vatsyayana. Patliputra was considered the largest city during 300-195 BCE.

Emperor Ashoka's reign marked a significant period of cultural, social, and religious transformation, with his emphasis on Buddhism and his rock and pillar edicts promoting social justice, religious harmony, and non-violence. In 232 BCE, the Mauryan dynasty came to an end with the death of king Ashoka, and the Shungas took control over the kingdom. India then reverted to a group of unfederated kingdoms with the Shungas controlling most of the core territories of Magadha. In the 2nd century BCE, Magadh entered a period of political decline. Although most of the powerful kingdoms were located in the south and west, the north remained culturally active, with Buddhism spreading throughout the region. During the 4th century CE, Patliputra regained prominence under the Gupta dynasty, especially during the reign of Chandragupta I (320-335). He revitalized Magadh by conquering the territory, setting up Patna as the capital and consolidating a kingdom in the eastern region of northern India. Chandragupta I revived some of the principles of king Ashoka's government. However, it was his grandson, Chandragupta II (376-415), who established a vast empire in the north and western Deccan. In the 5th century CE during the reign of Chandragupta II, the Chinese pilgrim Fa Hein visited Patliputra (Po-lien-fu) and recorded the flourishing state of Magadh, as well as the impressive architecture of the city, describing the walls, gates, palaces, and buildings as being constructed in a manner that could not have been accomplished by human hands (**Fig.** 1 and **Fig.** 2). The wooden outer wall that Megasthenes

previously mentioned was still standing in the early 5th century. Patliputra was also home to many stone buildings and a great palace erected by Chandragupta's grandson, Ashok, who had converted to Buddhism. Hiuen Tsang, who travelled through the silk route, visited Patliputra in 1637 CE and found it to be a deserted and crumbling land, as fire, flood, and internal dissension had all left their mark on the city, as predicted by the Buddha. Following the collapse of the Gupta Empire and continuous annexation by the Hunas, Patna experienced a period of uncertainty similar to the rest of India. The territory eventually came under the growing empire of Harshvardhana Samrat, who defeated the Hunsa and took control of the northwest region of India. However, during the 7th century CE, another Chinese pilgrim named Hiuen Tsang visited India and found Patliputra in ruins.

Medieval Period (13th Century to 17th Century)

In the 13th century, with the Turkish conquest of India and the establishment of the Delhi Sultanate, urbanization and cultural development began in Patna. The first Muslim invasion of Bihar occurred in the late 1190s under the rule of Bakhtiyar Khilji, which led to the expansion of Turkish rule in Bihar. From 1206 to 1526, Patna remained a secondary settlement that was subordinate to the town of Bihar. During the Mughal period, provincial administration reached its zenith. Patna re-emerged as a major centre of trade, but not as a capital city. One of its most remarkable periods was under the rule of Sher Shah Suri, who hailed from Sasaram and revived Patna in the mid-16th century. On his return from Bengal in 1541, Sher Shah arrived in Patna, and while standing on the bank of the river Ganga, he had a revelation that if a fort were built in that location, the water of the Ganges could not flow too far away from it, and Patna would become one of the great towns of the country. Sher Shah's words were put into action when he founded a fort in Patna, which enabled Patna to regain its identity as a hub of power and trade. However, the fort did not last, but the mosque built by him in 1545 survived, and it was built in Afghan architectural elegance with numerous tombs inside.

The earliest mosque in Patna dates back to 1489, built by one of the rulers of Bengal, Alauddin Hussani Shah. The locals call it Begu Hajjam's mosque in honour of a barber who repaired it in 1646. In 1574, the great Mughal emperor Akbar came to Patna to defeat Daud Khan, an Afghan chief. Akbar's secretary described Patna as a flourishing centre for paper, stone, and glass industries. He also mentioned the good quality of various strains of rice grown in Patna. In 1704, Patna was renamed Azimabad, after the grandson of Mughal emperor Aurangzeb, Azim, at the time when he was subedar of Patna (Boyk 2015). Other than the name, very little change

took place during that period. After the decline of the Mughal period, Patna was in the hands of the Nawabs of Bengal. At that time, the city was taken over by Jagirdars who claimed themselves as Nawabs. The Nawabs of Bengal imposed heavy taxes on people but allowed them to flourish commercially. During the 17th century, Patna became the hub of international trade. Much of the lost glory of Patna was revived during the medieval period, giving it a new identity as a medieval city in terms of function and structure under the Afghans and Mughals. The city almost emerged in the same area where it existed in ancient times.

British Period

Patna attracted the next generation of travellers, including Englishman Thomas Roe, who visited in the 17th century and spoke of the four rivers surrounding Patna, each of which served as a valuable waterway for trade. Ralph Fitch, a merchant, reached Patna in the 16th century via one of these riverine routes and observed a flourishing cotton and sugar trade, as well as the infamous opium business. Jean Baptiste Tavernier, a French traveller, visited in 1620 and described Patna as the largest town in Bengal and the most famous for trade, particularly for the exquisitely crafted coral and amber bracelets available in the city's market. By the 17th century, Patna had become a favourite port town for the Dutch, the British East India Company, and merchants from Central Asia, Armenia, and Portugal. In the 1620s, the British established a factory in Patna for the purpose of buying and storing cotton and silk, which soon became a bustling market for saltpetre (Hashmi, 2018). The French, Danes, Dutch, and Portuguese were all drawn to this attractive business, leading to the establishment of several European factories and godowns in Patna, which earned the reputation of being a lucrative location for merchants. In 1632, Peter Mundy declared Patna as the greatest mart in the eastern region. On October 6th, 1763, Nawab Mir Qasim was imprisoned and that led to killings of 45 members of the East India Company (Martin, 1838). Although they had been trading in Patna since 1620, when they established a factory for saltpetre, the British gained control of the city in 1765. After the Battle of Buxar, which took place 115 km west of Patna, the British East India Company was established in East India. Patna soon developed into a strategic centre for trade and regained its lost glory under British rule. Following the Delhi Darbar of 1911, the province of Awadh was divided, creating a separate province of Bihar, with Patna selected as its centre of power and capital city. No matter when, why, or for how long one visited, it was impossible to leave this city without a souvenir, be it a precious commodity from its market or an experience worth immortalizing in writing. After the partition of Bengal presidency

in 1912 (Ahmad, 1988), the city boundaries were extended westwards to include the administrative base and township of Bankipore, known as the New Capital Region. This era also saw the construction of two prominent landmarks, the Patna secretariate and the Patna High Court, designed by architect J.F. Munnings. Many buildings, reflecting either Indo-Saracenic influence or manifesting a Renaissance imprint, were completed by 1916-17. Pseudo-renaissance is expressed in the design of buildings like the General Post Office and the old secretariate. The British also built numerous educational institutions, including Patna College, Science College Patna, Bihar College of Engineering, and Prince Wales Medical College. Patna played a significant role in the Indian struggle for freedom, with notable contributions such as the Champaran Movement against Indigo plantation and the Quit India Movement of 1942.

Post-independence Period

Following India's independence, Patna's economic standing witnessed a sharp decline, particularly in the domain of trade and commerce. The region was predominantly ruled by Congress government from 1947 until the declaration of a state of emergency in 1975. The Bihar movement, led by students such as Jayaprakash Narayan, against the existing maladministration and corruption was initiated in 1974-75, and came to be known as the Sampoorna Kranti, or Total Revolution, and the JP movement. In the year 2000, Bihar faced a severe blow when Jharkhand, a state known for its abundant mineral deposits, was separated from Bihar. This led to a substantial loss in the revenue earned through mining and industrial activities. According to Bhattacharya (2000), while the state has been exploited and left destitute in the past, it could perhaps make up for the loss of mineral deposits by curbing the issue of rampant corruption within its governance structure. In effect, the Freight Equalisation Policy, which involved the transportation of mineral deposits to other states, has resulted in Bihar being underdeveloped. Despite a few challenges encountered during the post-independence, the economy of Patna remained relatively steady until the separation of Jharkhand from Bihar. The present scenario has led to an attempt at rejuvenation and the revitalisation of the region.

Growth

Throughout its history, Patna has experienced growth in various aspects despite its declining status. The earliest known map of the city dates back to 1776, a product of James Rennel for the British-controlled Bihar and Bengal province.

At the time, the city's settlement area was approximately 52 square kilometres. As of 1924, however, the administrative area had expanded by more than double, reaching a total of 142.46 square kilometres. Patna's population has grown more than tenfold since 1901. According to the Statistical Account of Bengal for Patna district in 1877, the city was situated between latitudes 24˚ 58' to 25˚ 42' north and longitudes 84˚ 44' to 86˚ 05' east. The district encompassed an area of 2101 square miles according to the Boundary Commission of 1875. The Census Report of 1872 indicated a population of 15,59,638 for the district (**Fig.** 2).

Spatial Growth

It is challenging task to track the absolute spatial growth of cities in developing nations due to a lack of adequate documentation. During the British period, Azimabad was the main town of Patna, as it was commonly called by the locals. The district of Patna was bounded by the Ganga river in the north, separating it from Tirhut and Saran; Shahabad district lay on the west, separated by the Son river; Monghyr (Munger) lay on the east, and Gaya lay on the south. The settlement and administrative area of Patna has been slowly but steadily expanding. According to toposheet data of Patna from 1924, the settlement covered an area of approximately 52 square kilometres. As per census records in 1961, the administrative area increased to 79.87 sq km (Table-1). The map of the province of Bihar and Bengal (**Fig.** 1) prepared by Major Rennel in 1776 indicates that Patna was an important riverine port city at that time (**Fig.** 3).

Due to this reason, the British colonizers gradually built their separate settlement to the west of the existing settlement. They strategically created military cantonment to protect their interests in trade and power. Britishers had always exploited the resources of Patna without considering the welfare of the city. Buchanan (1812), O'Malley (1907), and Forster (1924) had been critical of the city and its view from a distance was often termed as "mean," "disgusting," "disappointing," and other such derogatory terms. The series of maps for the years 1885, 1924, 1976, and 2009 show the spatial extent of Patna. The map of Patna from 1885 (**Fig.** 1) was prepared by Else Reclus and published in Nations and Nationalities of the World. Although Major Rennel's map does not align with the current system of latitudes and longitudes in modern map-making, it depicts the schematic settlements of Patna at that time. The native settlements mostly confined to the middle of eastern part of the city, between the southern bank of the Ganga in the north and the railway track in the south. Bankipur evolved as the settlement for Britishers, while Danapur cantonment can be seen in the north-western part of the city map.

He Survey of India has performed an outstanding task in mapping the Indian subcontinent's entire terrain in great detail since the British period. These topographical sheets have been invaluable for both military and civilian development purposes. In archives, three distinct toposheets of Patna have been discovered for the years 1924, 1976, and 2009. In 1924, the settlement area was primarily situated along the river Ganga (**Fig.** 2), and the railway line acted as an unofficial southern boundary of the city. Vegetation and water bodies were visibly present in the north-western and central regions, respectively. By 1976, the city had gradually expanded towards the south and south-west (**Fig.** 2), leading to the depletion of vegetation and water bodies during the mentioned period. The nalas of the central zone were severely impacted by the construction of government buildings in that area. The city rapidly expanded towards the west and north-west after 2001, as reflected in the settlement map of 2009 (**Fig.** 2). By this time, the spread of settlements had surpassed the official city limits, providing ample scope for urban sprawl.

Population Growth

Urban studies rely heavily on analysing population growth as a key determinant of the area's land use, infrastructure, and urban amenities. Patna has been a significant urban centre since the British era, as evident from **table-**1. In 1901, the population of the city was 1.8 lakh, which increased to over 2 million in the 2011 census and is expected to exceed 4 million by 2051. However, the rate of population growth has not been constant over time. The 1881 population enumeration recorded a population of 1,70,654, indicating a 7.4% increase of 1,58,900 in nine years. The increase was due to both natural growth and under-enumeration in 1872. In 1901, the population of Patna was 1,80,025. The city experienced stagnant or negative growth during 1911-1921 due to the Bengal famine. The census of 1911 was the last within the state of Bengal, while the 1921 census was the first as the capital city of Bihar and Odisha. Around 12.5 lakh people migrated from Bihar to Bengal in 1911, while around 1.65 lakh people immigrated (**Table-**1).

Post-1921, Patna's population growth fluctuated between 20-40%, indicating steady growth. However, it became a bumpy ride with rapid population growth from 1971-2001. **Table-**1 highlights that the Patna metropolitan city experienced tremendous growth rates in population during 1971-81 and 1991-2001 due to official expansion of the city boundary in adjoining areas. During 1971-81, the PRDA was formed, and three colonies were founded. The outgrowths and adjoining areas of Phulwarisharif, Digha-mainpura, and Danapur cantonment were included in this

Patna in 1776: (a) Clipping from Provinces of Bengal, Bihar and Co. by Major Rennel



Fig. 1

Patna in 1885: (b) Extracted from Universal Geography, Vol-VIII by Elisee

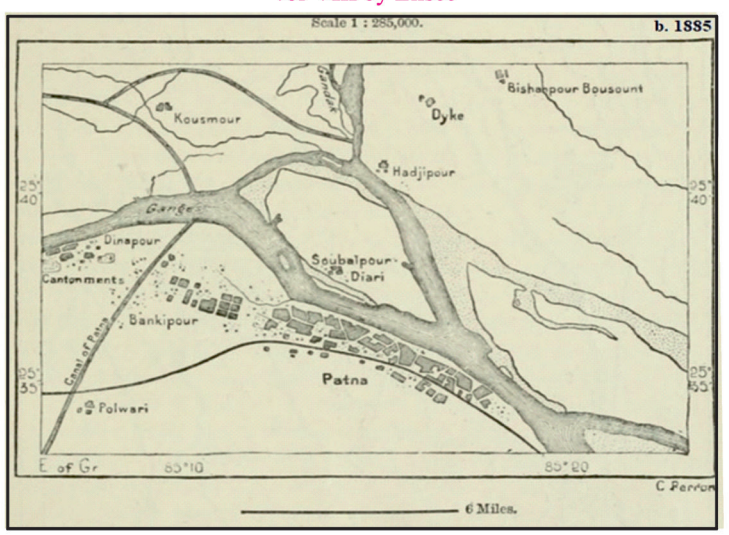


Fig. 2

Table-1: Population Growth in Patna (1901-2011)

Census Year	Persons	Growth Rate (%)	Area (sq km)	Population density (Person/sq km)
1901	1,80,025		-	
1911	1,76,688	-1.85	-	
1921	1,58,048	-10.55	-	
1931	2,01,540	27.52	-	
1941	2,45,267	21.70	-	
1951	3,41,911	39.40	-	
1961	4,35,360	27.33	79.87	5,451
1971	5,75,476	32.18	97.01	5,932
1981	9,53,064	65.61	112.24	8,491
1991	11,40,100	19.62	132.27	8,619
2001	16,97,976	48.93	135.19	12,560
2011	20,49,156	20.68	142.46	14,384

Source: Based on A-4 Table, Census of India, 2011

agglomeration. During 1981-91, new colonies in Patna gradually expanded in open space within the city limits, which were included in previous official boundary expansion. Prior to the 2001 census, the city boundary was further extended. This time, the expansion was from Didarganj to Sherpur and Bailey road to Saguna more and Danapur junction. Apartment culture was on a boom during 1991-2001. Post-2001, the city boundary has remained unchanged, but the status of towns/outgrowths has been modified, and administrative units have been freshly demarcated during the census of 2011. The adoption of the concept of urban agglomeration dates back to the 1971 census, when it replaced the "town group" category. In the interest of developing plans and changing policies, the Government of Bihar has designated the Patna urban agglomeration as the Patna metropolitan city. Despite this, it was not until 1991, when the population exceeded 1.1 million, that Patna attained the status of a metropolitan area. In the 2001 census, Badalpura was identified as an outgrowth, while Patliputra housing colony and Saidpura were classified as census towns in the 2011 census. Previously, both of these towns had been considered as outgrowths. The expected population of Patna in 2051 is estimated to be around 4.3 million. However, due to its relative power status identity and strategic location,

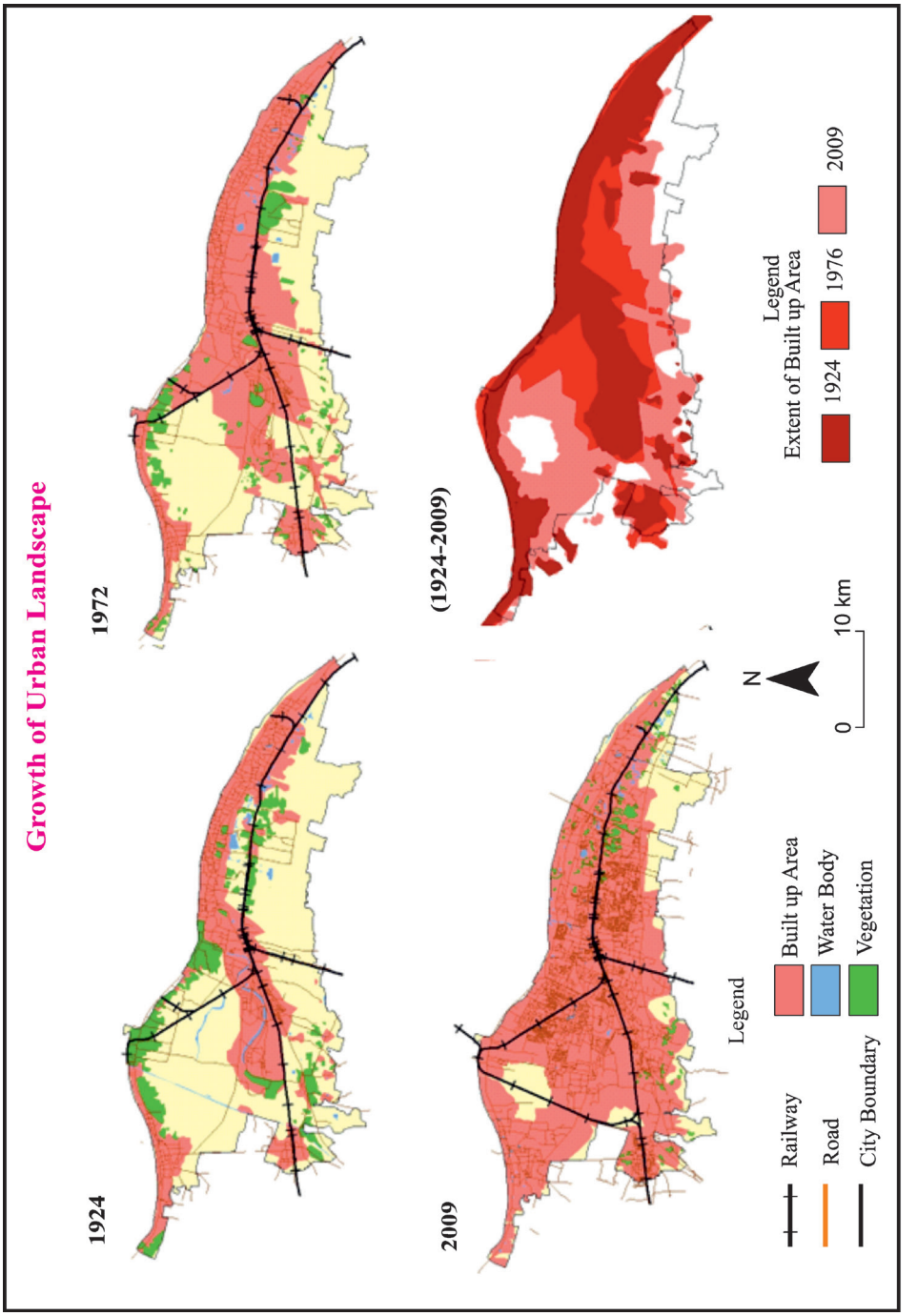

Growth of Urban Landscape
1924
1972
2009
(1924-2009)
Legend
Built up Area
Water Body
Vegetation
Railway
Road
City Boundary
N
0
10 km
Legend
Extent of Built up Area
1924
1976
2009

Fig. 2

the city may even exceed 5 million in the near future, largely due to the rapid influx of migrants. Survey results indicate that a significant number of Patna residents have migrated to the city over the past three decades.

Conclusion

The history and evolution of Patna, the capital of Bihar, is a captivating narrative that spans millennia, reflecting the city's deep-rooted cultural, historical, and geographical significance. Its origins are steeped in legend, with various names and tales that narrate its evolution from a small village named after the patli flower to the flourishing capital of the Mauryan Empire. This historical tapestry weaves folklore, divine intervention, and urban genesis into the fabric of Patna's identity. Megasthenes described the city as being located on the southern bank of the Ganges, at the confluence of the Son river which once joined the Ganges below present-day Patna. Memories of this junction still exist amongst the villagers to the southwest of Patna, where an old channel named the Mara Son flows. As time progressed, the city underwent significant changes, from the Mauryan period to the Shershah Suri era, ultimately becoming an essential strategic and trade centre for the British. The modern Patna has expanded exponentially since British times. Post-independence, the city faced economic challenges, and the separation of Jharkhand in 2000 led to a decline in revenue from mining and industrial activities. With the exponential growth in population and physical expansion of the city, the local administration is tasked with the challenge of providing basic urban amenities and maintaining the city's infrastructure. As the city continues to receive migrants from other areas, there is a shift in the land-use and land-cover patterns, resulting in urban sprawl beyond the city limits.

Between 1924 and 2022, the Patna metropolis has undergone a nearly threefold expansion, specifically from 51.46 to 142 square kilometres. Correspondingly, the demographic landscape has witnessed significant growth, with the city's population escalating substantially from 1.8 lakh in 1901 to 20.5 lakh in 2011. However, notwithstanding these pronounced spatial and demographic advancements, the city exhibits a deficiency in terms of fundamental industrialization. As Patna looks towards the future, it is poised for further growth and development, with its strategic location and historical significance continuing to shape its trajectory. The city's journey from ancient legends to a modern metropolis underscores its resilience, adaptability, and enduring importance in the cultural and historical landscape of India.

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BIOLOGIC EFFECTS OF INGESTION OF NITRATE IN DRINKING WATER AN OVERVIEW OF INDIA

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Abstract

Nitrate pollution in surface or subterranean water is a pervasive global issue, particularly prevalent in agrarian nations. Undoubtedly, regions most susceptible to climatic shifts face heightened vulnerability owing to their geographical disposition. Unfavorable topographic features and uncertainties in hydro-meteorological conditions amplify the extent of contamination. Given that nitrate pollution in our potable water sources is pandemic and the costs linked to purifying these water sources are exorbitant, exposure to elevated nitrate levels significantly contributes to deleterious health consequences that necessitate attention. This manuscript delves into the biological ramifications of surplus nitrate in our drinking water and the diverse array of human health concerns in India and various pivotal parts of the globe. In a bid to forestall methemoglobinemia, an acute toxic response to nitrite exposure impeding oxygen transport via the bloodstream, the US EPA (Environmental Protection Agency) has designated the maximum admissible nitrate level in drinking water at 10 mg nitrate-N/L. However, it's a common occurrence for surface and subterranean water in agricultural regions to surpass this standard periodically and/or over extended durations. While a definitive correlation between nitrate consumption and cancer remains elusive, some indications suggest a potential linkage. The magnitude of health risks posed by nitrate contamination in drinking water remains a subject of debate. Groundwater stands as a vital water source for both domestic and agricultural usage on a global scale. It serves as the primary domestic water source for 50% of the world's populace and nearly 90% of rural inhabitants. A substantial 75-80% of water used for agricultural irrigation originates from groundwater. Safeguarding groundwater against nitrate pollution presents a multifaceted managerial challenge necessitating effective policy alignment at federal, state, and local echelons, particularly due to the inherent complexity of groundwater purification. Moreover, these challenges are compounded by varying levels of awareness, socio-economic development, low literacy rates, high poverty, and the inclusion of cultural practices and rituals, all of which exacerbate the intricacies of the endeavor.

Introduction

Ensuring safe drinking water remains crucial for public health, a fundamental human entitlement. Regrettably, this right falls short of people's expectations. Water, an essential element, faces an impending challenge as research indicates an upward trajectory in nitrate levels. This concern extends beyond rural communities, impacting major urban centers reliant on bore water. The solubility and biodegradability of nitrates contribute significantly to their increased presence in water bodies. The consequential decline in both quality and quantity of water bodies persists due to the heavy reliance on synthetic fertilizers, sewage, industrial waste, and livestock manure. Guidelines from the US EPA's nutrient data policy reveal the distinct markers of nitrate presence. While nitrates occur naturally at very low levels (<1mg/L NO3-N), levels exceeding 1mg/L NO3-N are indicative of human activities. Concentrations surpassing 3mg/L NO3-N generally signal groundwater contamination. In India, the Bureau of Indian Standard (BIS) stipulates the Maximum Contaminant Level (MCL) for nitrate in public drinking water supplies at 45 mg/L as nitrate (NO3-), nearly akin to the WHO guideline of 50 mg/L as NO3- or 11.3 mg/L NO3-N (derived by multiplying NO3 mg/L by 0.2258).

Interestingly, this MCL, initially set in 1962 by the US EPA to prevent infant Methemoglobinemia, lacks considerations for other potential health impacts. A crucial issue with the current MCL for nitrate in drinking water is its obsolescence, particularly its lack of association with colorectal cancer, thyroid ailments, or neural tube defects. Consequently, a more lenient limit of less than 10mg/L NO3-N was established as a generalized threshold for nitrate contamination, offering a lax aspiration level within this range. This distinction between actual safety and mere cleanliness holds immense significance. It delineates a fine line between life and death, between improved health and the burden of costly medical bills for young families, and between mere survival and flourishing for entire communities. Nitrate, prevalent in various foods, peaks in green leafy vegetables like spinach and celery, as well as root vegetables such as beetroot. Daily intakes from food range from 30-130 mg/day as NO3- (7–29 mg/day NO3-N) (ICAR, 2020). Once consumed, most of the ingested nitrate travels through the body and is absorbed into the bloodstream via the small intestine. Approximately 25% of the nitrate in the blood is transformed into nitrite through a reduction process in saliva. While most nitrite is absorbed into the blood and converted into beneficial compounds, a fraction may form potentially harmful N-nitroso compounds.

Study Region

Indeed, nitrate pollution stands as one of the oldest and most financially burden some environmental issues, both regionally (India) and globally. Several contributing factors underline this reality: A notable surge in population, from 5.3 billion to 7.7 billion between 1990 and 2020, with projections foreseeing a rise to 9.7 billion by 2050 (UN, 2020). The onset of increased industrial activities since the mid-19th century has significantly amplified pollution and deterioration of water resources (Bond et al., 2018). Climate change exacerbates water stress globally, particularly in arid regions, through diminished rainfall, leading to severe droughts and erratic rainfall patterns during the rainy seasons (Lorite et al., 2018; WHO, 2012). In recent years, ensuring access to clean drinking water for communities has become increasingly challenging due to the emergence of new water quality issues. Groundwater sources, vital for global agri-businesses, industries, and drinking water needs, face mounting pressure amid growing scarcity concerns and fears of microbial contamination. Nitrate contamination, prevalent in agricultural and densely populated regions, notably affects the Indo-Gangetic Plain (IGP), recognized as one of the world's largest alluvial aquifer systems (MacDonald et al., 2016). Spanning approximately 52 million hectares, it supports a population of 500 million across Delhi, Haryana, Punjab, Bihar, Uttar Pradesh, and West Bengal according to the 2011 Census.

The northwestern segment, marked by intensive agricultural practices and widespread nitrogen-based fertilizer use, exhibits significant groundwater contamination hotspots. India grapples with 20 identified nitrate hotspot areas, each displaying varying average nitrate levels. Some regions indicate averages below 50 ppm, while others range between 59 and 215 mg/L, showcasing considerable data variability (Devaraj et al., 2020; Pant et al., 2020). Notably, values surpassing four times the WHO-recommended standard are reported in certain areas, such as Birbum in West Bengal (44 & 45), Solapur in Maharashtra (66 & 71), and Bareilly in Uttar Pradesh (31 & 51), with reported average values spanning from 7 to 47 mg/L. Even within these regions, over a quarter of samples exhibit nitrate concentrations exceeding 50 mg/L (Hossain & Patra, 2020; Mazhar & Ahmad, 2020; Mukate et al., 2019). The causes of pollution in the country are attributed to various factors, including inadequate maintenance of septic tanks, boreholes, sanitation, and fertilizer use, as highlighted by several authors (Barbieri et al., 2019; Devaraj et al., 2020; Roy et al., 2020).

Objectives

(1) This study aims to conduct a health risk assessment of nitrate in distributed drinking water in India and across significant global regions.

(2) Assessing what needs to be done to ensure an adequate drinking water supply throughout the country & what can be done in managing land & water to limit nitrate pollution.

Database and Methodology

The interest in studying groundwater health, particularly concerning nitrates, has seen a significant surge since the early 1980s. From an average of 100 articles per year globally in the 1970s and 1980s, the scientific community published 2742 articles in 2020 on this subject. In India, the Integrated Management Information System (IMIS) was established in 2009 alongside the National Rural Drinking Water Programme (NRDWP), creating a web-based platform for annual online monitoring of water supply projects and rural coverage. Sarkar et al. (2021) investigated the spatial variation of nitrate content in Indian groundwater using data from the NRDWP database. Various studies nationwide have sampled groundwater from wells, boreholes, and springs primarily used for irrigation or domestic purposes (Devaraj et al., 2020; Hossain and Patra, 2020; Mazhar and Ahmad, 2020; Mukate et al., 2019). However, several nitrate-contaminated areas, particularly within the Indo-Gangetic Plain, were not adequately covered in individual studies, posing a significant limitation. Larger-scale or national studies are necessary to comprehend the extent, spatial distribution, sources, and health impacts of groundwater nitrate contamination, mandating efficient local governance and management. Yet, a comprehensive detailed interpretation required for this remains lacking. Despite numerous articles published until December 2021 detailing groundwater quality parameters, a comprehensive understanding of nitrate pollution and its health impacts at the local level remains elusive. Conducting a comprehensive research and assessment of the health effects of groundwater nitrate contamination at the local level is a novel undertaking. This review delves into nitrate sources in groundwater, its health implications, and focuses on human health risk assessment. Such a study is pivotal in understanding the challenges India faces in achieving Sustainable Development Goals (SDGs) 6.3 outlined by the United Nations in 2015.

Result and Discussion

Methemoglobinemia

Methemoglobinemia, linked to elevated nitrate levels in drinking water used for infant formula preparation, was initially documented in 1945 (Comly H.H. et al., 1945). When ingested, bacteria in the mouth and the less acidic infant stomach convert nitrate to nitrite. Nitrite, in turn, binds with hemoglobin, forming methemoglobin, which disrupts the blood's capacity to carry oxygen. Methemoglobinemia is a severe condition, posing a life-threatening risk when methemoglobin levels exceed approximately >10 mg/L NO3-N. Risk factors for infant methemoglobinemia encompass formula prepared with water containing high nitrate levels, along with foods, medications, and enteric infections that exhibit high nitrate levels. non-existent in these areas.

Adverse reproductive outcomes: (spontaneous abortions)

There have been several studies examining spontaneous abortions, linking high maternal methemoglobin levels caused by elevated nitrate ingestion to miscarriages in laboratory animals and livestock. An intriguing 1996 Center for Disease Control (CDC) of Morbidity and Mortality Weekly Report (MMWR) report documented a cluster of spontaneous abortions among women using private wells in rural Indiana, where nitrate levels exceeded twice the Maximum Contaminant Level (MCL) of 20 mg/L NO3-N. When these women switched to low-nitrate water sources, they experienced healthy live births. While this wasn't a formal study, the evidence was compelling, suggesting the involvement of high-nitrate water in the miscarriages. Interestingly, a separate study in Massachusetts found no association between spontaneous abortion and lower nitrate levels below 5.5 mg/L NO3-N, indicating divergent findings in different settings Indeed, there's been documentation of a heightened incidence of infant methemoglobinemia in Eastern Europe, as noted previously (Ayebo A. et al., 1997). A 2002 WHO report on water and health highlighted significant cases in the region: 41 cases annually in Hungary, 2913 cases in Romania spanning 1985–1996, and 46 cases in Albania in 1996. Generally, nitrate levels surpassing >10 mg/L NO3-N were often linked to increased methemoglobin levels, though clinical methemoglobinemia wasn't consistently present (Fig-1). In India, methemoglobinemia is relatively uncommon, possibly owing to limited awareness or a scarcity of epidemiological studies on the disease. It's intriguing that in a country where agriculture is a predominant livelihood and where sanitation remains inadequate in numerous regions, reported instances of methemoglobinemia are rare (**Fig.** 1).

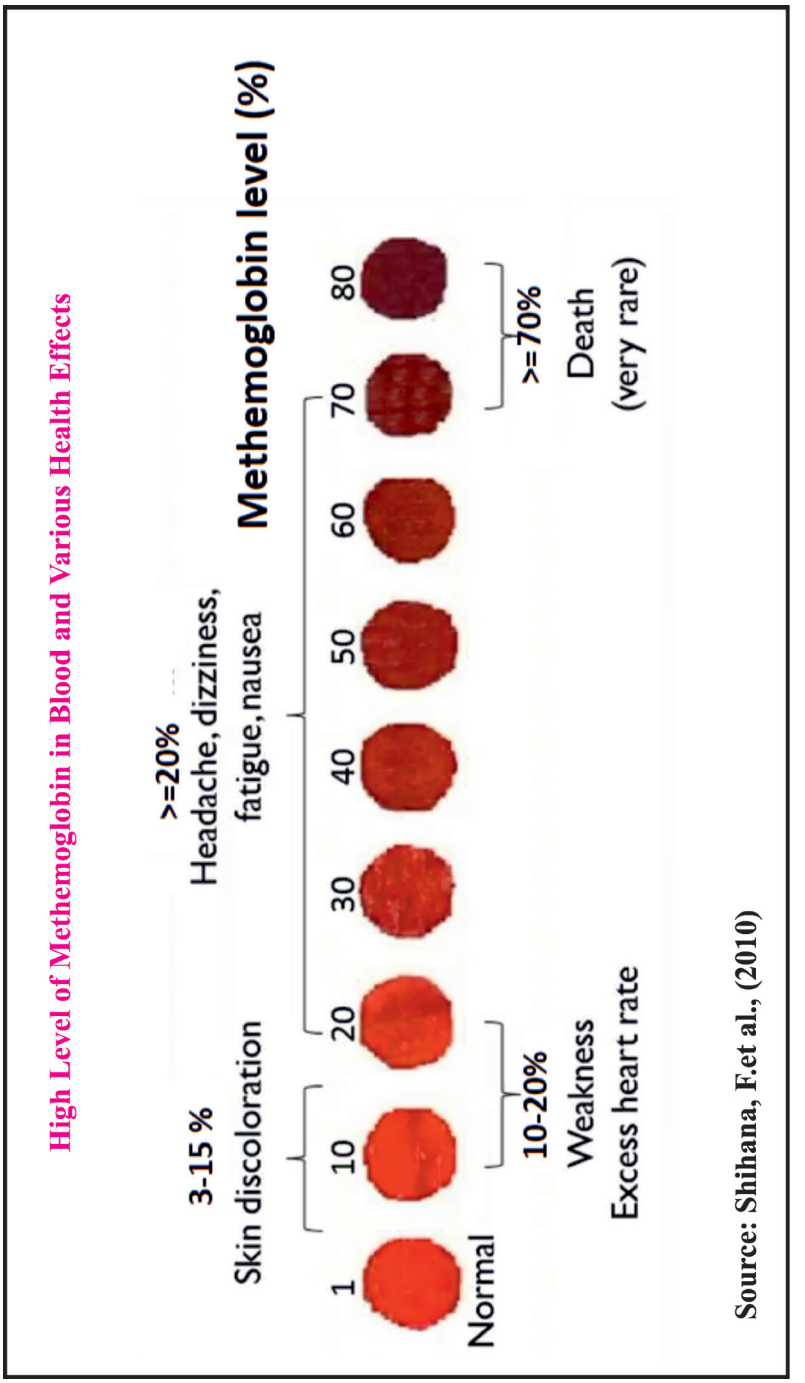

High Level of Methemoglobin in Blood and Various Health Effects
Methemoglobin level (%)
1
10
20
30
40
50
60
70
80
Normal
3-15 %
Skin discoloration
10-20%
Weakness
Excess heart rate
>=20%
Headache, dizziness,
fatigue, nausea
>=70%
Death
(very rare)
Source: Shihana, F.et al., (2010)

Fig. 1

Birth Defects and Cancers

According to a 1995 IARC report, over 300 nitroso compounds were tested in animals, with about 90% found to be carcinogenic. These compounds showed carcinogenicity across various animal species, including non-human primates, suggesting a likelihood of impact on humans. These nitroso compounds have the potential to induce tumors in multiple organs such as the lungs, digestive tract, urinary tract, and some reproductive organs. Exposure during pregnancy can lead to congenital malformations, particularly affecting the Central Nervous System, especially during the critical phase of organ development in the first trimester. Shifting focus to cancer, in 2006, an IARC working group assessed the evidence for the carcinogenicity of ingested nitrate and nitrite. Their conclusion stated that under conditions conducive to the formation of N-nitroso compounds or endogenous nitrosation, nitrate and nitrite were deemed probably carcinogenic to humans. The evaluation drew from compelling evidence obtained through animal studies, where carcinogenicity was consistently observed across all species tested in laboratory settings. Additionally, human mechanistic studies provided further support. These studies indicated that exposure to nitrosamine compounds increased with nitrate ingestion, either through drinking water or controlled intake experiments. It was demonstrated that nitrate ingestion led to heightened exposure to nitroso compounds, measured by their excretion in urine. This correlation between nitrate intake and increased presence of these compounds provided robust evidence supporting the evaluation's conclusions.

Case-control or Cohort Studies of Drinking Water Nitrate and Cancer Studies

(1) Colorectal:5 studies (4 Positives)
(2) Brain(Children/young adults):3 studies (3 Positives)
(3) Bladder:4 studies (2 Positives)
(4) Kidney: 2 studies (2 Positives)
(5) Non–Hodgkinlymphoma:3 studies (1 Positives)
(6) Pancreas: 2 studies (0 Positives)
(7) Brain (adults): 2 studies (0 Positives)

In terms of epidemiological studies, investigations into dietary nitrate consumption didn't yield any association with an increased risk of cancer. However, when it comes to drinking water, the evidence was deemed inadequate due to the limited number of studies available.

Presently, the strongest evidence from epidemiological research suggests a positive association between nitrate exposure and colorectal cancer, with four out of five studies demonstrating such a link. Similarly, concerning childhood brain tumors (including young adults in one study), all three available studies indicate a positive association, with two of these studies conducted or published within the past year. However, for other cancer sites, there's notably less evidence available.

Nitrate in Drinking Water and Hypothyroidism:

In terms of biological plausibility, the concern doesn't solely revolve around nitroso compounds, but also involves nitrate's potential to impede iodine uptake by the thyroid. Three studies showed positive associations between higher water nitrate ingestion and related health issues: A study conducted on school-age children in Slovakia revealed an increased prevalence of subclinical hypothyroidism in areas with high water nitrate levels (ranging from 51 to 274 mg/L NO3-) compared to areas with nitrate levels at or below 50 mg/L (11 mg/L NO3-N) in water supplies (Tajtakova M. et al., 2006). A cohort study of post-menopausal women in Iowa found that higher nitrate intake, both through diet and drinking water from Public Water Supplies, was linked to an increased prevalence of hypothyroidism (Ward M.H. et al., 2010). An Amish cohort study in Pennsylvania discovered that among women, but not men, higher water nitrate levels (>6 mg/L NO3-N) were associated with elevated thyroid stimulating hormone (TSH) levels and a greater prevalence of subclinical hypothyroidism (Aschebrook-Kilfoy B. et al., 2012).

The primary human-caused sources of nitrate contamination fall into five categories: septic tanks, sewage, agriculture, landfills, and industrial activities. Often, nitrate pollution occurs alongside contamination by fluorine, sulphates, potash, phosphates, and heavy metals like zinc, cadmium, or arsenic. This pollution is frequently concentrated in areas reliant on agriculture for income or where sanitation infrastructure is lacking. Beyond these sources, various catastrophic events in recent decades have altered nitrate levels in groundwater in affected regions. For instance: The groundwater near the Union Carbide factory in Bhopal has faced excessive nitrate, chloride, and heavy metal contamination. ("Water Contamination Crisis - Bhopal's Second Disaster - The Bhopal medical appeal", 2021) The Beirut explosion in 2020, caused by inadequate storage of 2750 tons of ammonium nitrate, released a substantial amount of pollutants into the environment. Following the Chernobyl accident, two regions in Belarus reported similar radiation levels, yet the incidence of pediatric thyroid cancer differed significantly due to variations in nitrate contamination in drinking water, measuring 40 vs. 185 ppm (Drozd et al., 2018).

This escalating pollution trend requires immediate and drastic solutions to prevent further degradation of natural water bodies, particularly in developing countries like India, where water shortages exacerbate the issue. Urgent actions are essential to avert the complete deterioration of these vital water resources.

Conclusion

This review examines the water quality of various groundwater bodies throughout the country in terms of nitrate concentrations, discusses various health issues for both this compound and other important pollutants. On the basis of which some general conclusions can be drawn.(1) The occurrence of nitrates in groundwater continues to increase and urgent measures are therefore required to prevent nitrates from breaking down into water particles. (2) Levels exceeding the WHO standard (50 ppm) exist in various parts throughout the country. (3) Nitrate pollution from agriculture, especially the use of fertilizers and pesticides, is common across the nation. (4) In India, large fluctuations in NO3- concentration are observed due to the strong influence of the rainy season and insufficient treatment of septic tanks. (5) In addition to pollution from fertilizers, wastewater discharged without proper treatment & industrial activities contribute significantly to the occurrence of nitrates in groundwater. (6) Apart from the various reasons summarized above, environmental pollution is mainly due to poor health conditions in many parts of India (e.g. the presence of untreated septic tanks). Currently, there are many surface water treatment facilities, but the number of groundwater treatment facilities is still very limited and further research is needed into different treatments for nitrate removal. Recent studies on cancer and birth defects have started identifying population subsets prone to internal nitrosation, but direct methods for identifying these individuals are necessary. New approaches in epidemiological research, such as detecting nitrate-reducing bacteria in the oral micro biome and studying genetic variations in nitroso compound metabolism, hold promise in identifying high-risk individuals. However, a lack of comprehensive studies on individual health impacts hampers definitive conclusions about the risks of consuming nitrates through drinking water. Further investigation is crucial, especially in refining exposure assessment for users of public water systems, understanding exposure levels among those using private wells, quantifying nitrate-reducing bacteria, and assessing various factors influencing nitrosation. Focusing on conditions like colorectal cancer, thyroid disease, and central nervous system birth disorders, consistently associated with nitrate ingestion from water, will significantly contribute to clarifying these concerns.

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A GEOGRAPHICAL ANALYSIS OF CROP CONCENTRATION IN PRAYAGRAJ DISTRICT

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Abstract

This study focuses on analyzing crop concentration in Prayagraj District, encompassing all 20 blocks. Secondary data from the year 2020-21 was utilized for this research. Crop concentration is crucial in understanding the suitability of specific areas for particular crops, particularly considering changes in agricultural land use and shifts in crop proportions. Crop concentration has been determined using the Bhatia's location quotient technique. This technique identifies changes in agricultural land use by examining shifts in the proportion of land allocated to various crops. The study calculated the amount of area involved in these changes, highlighting the crops with the most significant increases and decreases. The data obtained is used to create thematic maps, providing a spatial representation of crop concentration in the district. Crop concentration is categorized into four sections: High, Medium High, Medium and low. These categories help depict the intensity of land utilization and identify areas suitable for specific crops. One significant determinant of cropping patterns is irrigation, which generally has a positive influence on the intensity of cropping. The study observed substantial variations in land use and cropping patterns across the study area. Wheat and Rice emerged as the dominant crop throughout the district, in terms of total agricultural production. This research sheds light on the changing cropping patterns and land utilization in Prayagraj District, providing valuable insights into the suitability of different areas for various crops. The findings can inform agricultural planning and land-use policies in the region, helping optimize crop production and land utilization.

Introduction

Crop concentration, as defined by TS Chauhan in 1987, pertains to the spatial distribution of individual crops within a specific area. It serves as an indicator, revealing the variability in crop density within a given region at a particular moment in time.

The delineation of crop concentration assumes paramount importance in the realm of agricultural planning and development. The cropping pattern observed in any region is intricately woven with a tapestry of influences, including geo-climatic, socio-economic, historical, and political factors, as noted by M. Hussain in 1996. Moreover, technological factors have emerged as influential forces shaping these patterns. Terrain, topography, slope, soil composition, and the presence of irrigation facilities all contribute to the diversity of cropping patterns. The use of pesticides, fertilizers, and mechanization further compounds these complexities. Understanding the myriad factors that influence cropping patterns, from natural elements to human interventions, is fundamental for effective agricultural planning and development. The various geographers applied location quotient methods to work out the degree of Crop Concentration in a specific region. The geographers pioneer work of Chisholm (1962), Bhatia (1965), Jasbir Singh (1976) are the contributors to make the agricultural region with the help of quotient method. In this research work, Bhatia's method has been adopted to measure the index of Crop Concentration in Prayagraj District.

Study Region

Latitudinal and longitudinal extent of Prayagraj District is 24°47' N to 25°45'N and 81°31'E to 82°21'E in the south of Uttar Pradesh State at an elevation of 98 meter (322 Ft) and is situated at the confluence of Ganga and Yamuna. To its south and southeast is the Baghelkhand region, to its east is middle Ganges valley of North India, to its southwest is the Bundelkhand region, to its north and northeast is the Awadh region and to its west along with Kaushambi it forms the part of doab i.e. the lower doab region. Prayagraj has a humid subtropical climate. It experiences three seasons in a year. The summer lasts from April to June, monsoon begins in in early July and lasts till September, and the winter season lasts from December to February. The Ganga and Yamuna are the main rivers of the district. The plain area of the district is situated in between Ganga and Yamuna so these rivers play a very pivotal role in the agriculture of the district. The main staple crop of Prayagraj is wheat and rice. According to 2011 census, population of the study area is 5,954,391 of which male and female were 3,13,807 and 2,822,584 respectively. Population growth rate was 20.63% compared to 2001 census. The headquarter of the district is Allahabad City. The district is divided into blocks and tehsils. As of 2011 census there are 20 blocks in 8 tehsils. The total area of the district is 5,482 sq. km. The number of villages is 3003 according to Prayagraj statistical bulletin.

Objectives

(1) To analyze the crop concentration and its variation in Prayagraj District.

(2) To identify the areas of crop concentration in the basis of Bhatia's method.

Database and Methodology

The research work is based on the secondary data obtained from UP statistical Bulletin, Prayagraj (2020-21). Various thematic maps related to cropping patterns are prepared with the help of GIS. In order to determine block wise crop concentration Bhatia's method has been used.

Crop Concentration Index: = (a/b)/(A/B)

Whereas:

a= area of crop 'a' in the component areal unit

b= area of all the crops in the component areal unit

A= area of crop 'a' in the entire region

B= area of all crops in the entire region

Here, the higher index values represent a high level of crop concentration and low values show the low concentration of crop

Crop Concentration Pattern

Rice: It is a staple crop that serves as a primary food source for more than half of the world's population. Paddy is the second most important food grain in Prayagraj district it is cultivated in the kharif season. Moderate temperature and high rainfall is required for its cultivation. Rice cultivation supports the livelihoods of millions of farmers worldwide, it is a source of income and employment for rural communities. Rice is a major agricultural commodity in international trade, contributing significantly to the economies of exporting countries. In 2020- 21, total area under paddy cultivation was 155655 hectares. Paddy is cultivated in all the blocks of Prayagraj district. The blocks having medium high concentration of paddy are Jasra, Shankargarh, Meja, Manda, Holagarh, Mauaima, Soraon, Phulpur Pratappur and Dhanupur. Rest of the blocks have medium concentration of rice. Medium high concentration is in the northern and southern regions of the study area except Koraon and medium concentration is in the centre of the district.

Wheat: Wheat is the most important crop in Prayagraj. It is a Rabi crop it requires cool temperature and moderate rainfall, wheat is harvested in the summer

Table-1: Crop Concentration Index of Rabi Crops in Prayagraj District

Blocks	Crop Concentration Index 2020-21									
	Wheat	Barley	Red Lenti l	Split Chickpe as	Split Peas	Mustard	Flaxseed	Potato	Vegetables	Fodder
Kaudihar	0.91	1.11	0	1.2	0.96	2.52	0	2.03	1.60	3.45
Holagarh	0.86	0.25	0	0.07	1.03	0.14	0	3.92	2.23	1.25
Mauaima	0.83	0.19	0	0.11	1.03	0.48	0	4.02	2.50	1.24
Soraon	0.78	0.84	0	0.25	0.90	0.59	0	4.41	2.87	0.90
Baharia	0.98	0.50	0	0.08	0.96	0.33	0	1.75	1.91	1.26
Phulpur	1.06	0.34	0	0.07	1.15	0.14	0	0.85	1.38	0.80
Bahadurpur	0.89	2.76	0	2.77	1.37	0.56	0	0.69	2.13	0.87
Pratappur	1.03	0.84	0	0.19	1.53	0.66	0	0.76	1.69	2.10
Saidabad	0.98	1.28	0	0.93	1.24	0.30	0	1.23	1.53	0.98
Dhanupur	1.00	0.95	0	0.27	2.45	0.42	0	0.90	1.84	0.65
Handia	1.01	1.11	0	0.83	1.16	0.46	0	0.39	1.95	1.38
Jasra	1.16	0	0	0.49	0	0.62	0	0.05	0.11	0.10
Shankargah	1.00	0.61	5.07	1.89	0	0.38	1.46	0	0.09	0
Chaka	0.95	3.49	0.67	0.89	1.72	1.87	1.12	0.92	1.51	1.55
Karchhana	0.93	2.93	1.18	3.03	1.21	5.04	1.04	0.70	0.57	0.62
Kaundhiyara	1.07	1.46	0.17	1.06	1.48	0.54	2.69	0.50	0.17	0.69
Uruwa	1.04	2.44	0	1.63	0.95	1.12	0.77	0.60	0.30	0.84
Meja	1.10	0.66	2.01	0.58	1.05	0.63	0.71	0.10	0.05	0.12
Koraon	1.09	0.55	1.48	1.18	0.53	1.55	2.44	0.04	0.04	1.11
Manda	0.87	2.02	6.85	2.88	1.12	0.51	6.70	0.28	0.11	0

Source: Calculated and compiled by Authors.

when the grains have fully developed and turned golden brown, modern machinery such as combine harvesters is used for efficient harvesting. Wheat is a primary source of carbohydrates for a significant portion of the world's population. It is a staple food in many countries and is used to make a wide variety of products, including bread, pasta etc (**Table-**1). Wheat is a fundamental component of the world's food

supply. Reliable wheat harvests help stabilize food prices and ensure a consistent food supply enhancing global food security, therefore good concentration of wheat is very crucial for famer and other people. The total area under wheat cultivation in 2020-21 was 249902 hectares. Blocks having medium high concentration are Phulpur, Pratappur, Handia, Jasra, kaundhiyara, Meja and rest of the blocks have medium concentration. Medium high concentration is in the south and north east in Prayagraj District and medium concentration is in the northwest of the study area (Fig-1).

Barley: Barley holds significant importance due to its various uses and nutritional benefits, it is rich in dietary fiber, vitamins and minerals and has low glycemic index. Farmers often cultivate barley for both human consumption and livestock feed, enhancing agricultural productivity. In Prayagraj barley is grown in winter season. In Prayagraj total area under Barley is 2062 hectares (2020-21). In the district blocks having high concentration are Bahadurpur, Chaka Karchhana, Uruwa and Manda the block having medium high concentration are Kaudihar, Saidabad, Handia and blocks having medium concentration are Soraon, Pratappur, Dhanupur, Shankargarh, Meja and Koraon. Rest of the blocks have low concentration.

Vegetables: The vegetables grown in Rabi season are tomato, potato, onion, cauliflower spinach, radish green peas etc. The blocks having high concentration of these vegetables are Holagarh, Mauaima, Kaudihar, Baharia, Soraon, Pratappur, Saidabad, Dhanupur, Handia, Chaka and the block having medium high concentration of Rabi vegetables is Bahadurpur. Rest of the blocks have low concentration. The vegetables grown in Kharif season are bitter gourd, bottle gourd, brinjal, green beans, sponge gourd etc. Blocks having high concentration are Kandahar, Holograph, Bahrain, Manama, and Soprano. The blocks having Medium High concentration are Philpot, Pratappur, Bahadurpur, and Handia. Blocks having medium concentration are Dhanupur, Chaka. Rest of the blocks have low concentration.

Sorghum: Sorghum, also known as jowar in India, is a versatile cereal crop that holds significant importance in the country. Sorghum is drought- resistant, making it crucial crop in regions prone to water scarcity. It can withstand harsh weather conditions, ensuring food security in arid and semi-arid regions. This is a kharif crop, the blocks having high concentration are Shankargarh, Meja, Uruwa, Chaka, Karaon and Meja, the block having medium high concentration is Handia. Mauaima and soraon have zero concentration of Sorghum. Bahadurpur, Pratappur, Saidabad, Dhanupur, Jasra, Kaundhiyara and Manda have medium concentration, rest of the blocks of low concentration (**Table-**2).

Table-2: Crop Concentration Index of Kharif Crops in Prayagraj District

Blocks	Crop Concentration Index 2020-21									
	Rice	Sorghum	Pearl Millet	Maize	Urad	Pigeon Pea	Sugarcane	Sesame	Vegetables	Fodder
Kaudihar	0.90	0.49	1.51	0	2.04	0.86	0	0.08	2.18	1.40
Holagarh	1.23	0.03	0.19	1.14	0.08	0.07	0.07	0.22	2.55	0.88
Mauaima	1.25	0	0.11	0	0	0.02	1.74	0.33	2.58	0.88
Soraon	1.18	0	2.18	0	0.11	0.14	1.13	0.19	3.46	1.27
Baharia	0.94	0.10	1.76	0.88	0	0.30	0.56	1.11	1.56	0.94
Phulpur	1.18	0.11	0.44	0.88	0.13	0.14	1.05	1.45	1.27	1.10
Bahadurpur	0.60	0.79	2.97	0	0.41	1.15	0	1.87	1.47	1.84
Pratappur	1.12	0.88	0.48	3.62	1.07	0.30	2.39	2.07	1.31	1.10
Saidabad	0.89	0.67	1.58	1.56	0.85	0.85	0.98	2.09	0.95	1.36
Dhanupur	1.13	0.51	0.50	2.28	0.49	0.38	4.70	1.74	0.76	1.30
Handia	0.89	1.25	1.38	1.82	0.47	0.84	1.31	0.92	1.06	2.03
Jasra	1.02	0.83	0.84	0	3.30	1.07	0	1.00	0.23	0.40
Shankargah	1.08	1.55	0.46	0	5.65	0.79	0	0.39	0.29	0
Chaka	0.74	2.32	1.47	0	0.40	2.27	0	0.26	0.72	1.37
Karchhana	0.57	0.48	2.44	0	2.24	2.72	4.72	0.07	0.30	1.00
Kaundhiyara	1.16	0.70	0.26	0	0.63	0.73	0.90	2.68	0.30	0.49
Uruwa	0.56	1.75	3.11	0	0.93	1.36	0.34	1.22	0.28	0.89
Meja	1.07	1.54	0.65	0.46	1.07	0.77	0.21	1.83	0.19	0.37
Koraon	0.99	2.77	0.07	2.55	0.96	2.25	0.44	0.07	0.09	0.63
Manda	1.09	0.59	0.53	0.97	0.17	0.91	0.54	1.99	0.26	1.07

Source: Computed by Authors

Pearl Millet: Pearl millet is known as Bajra in India. Bajra is rich in protein, fiber, vitamins, and minerals, making it a valuable dietary staple, especially in regions with poor soil quality and limited access to other nutritious food. This is also a drought resistant crop, many small scale farmers rely on bajra cultivation for their subsistence, providing a source of income and sustenance for their families. This is grown in kharif season the blocks having high concentration are Soraon,

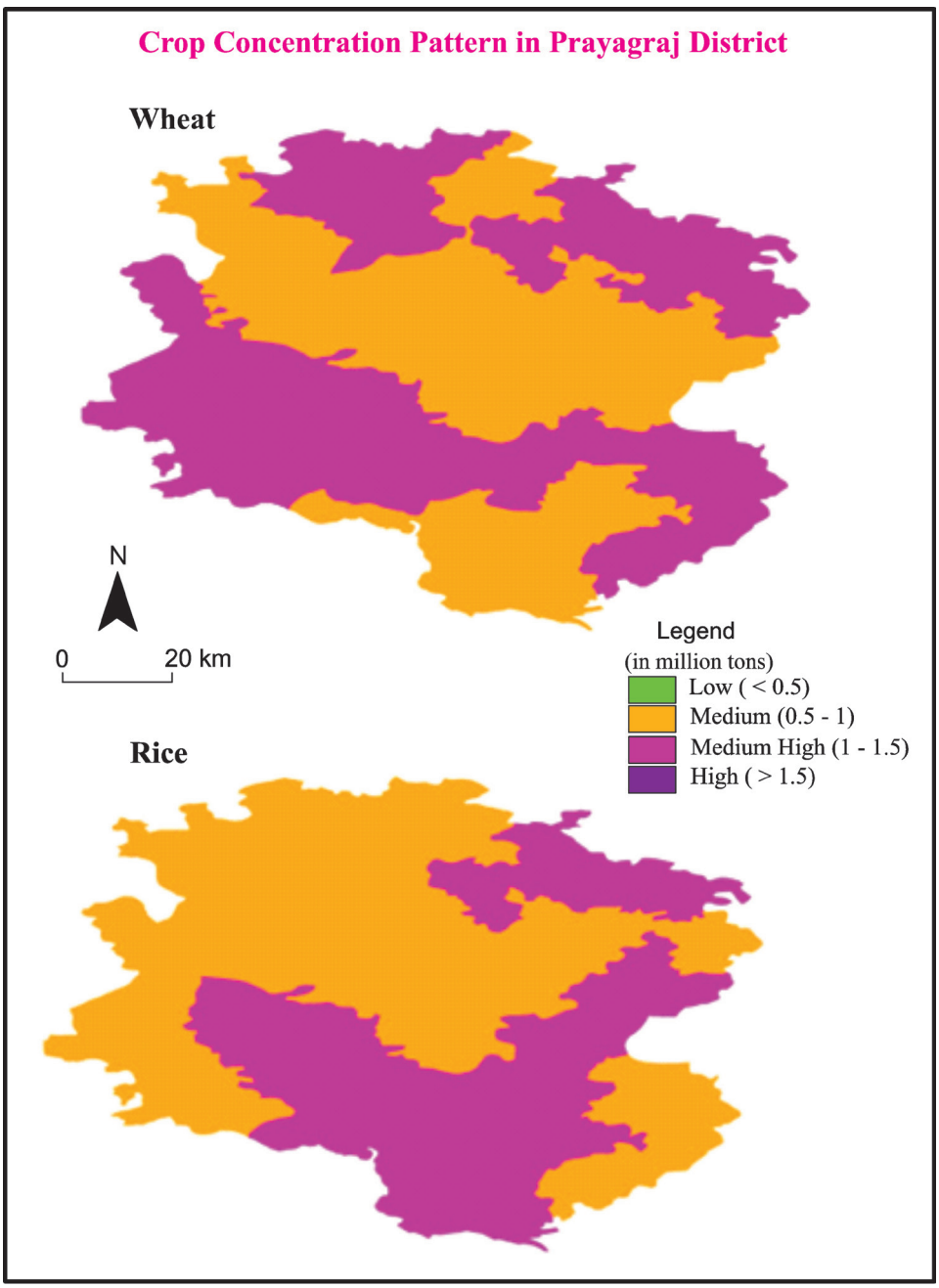

Crop Concentration Pattern in Prayagraj District
Wheat
N
0
20 km
Legend
(in million tons)
Low (< 0.5)
Medium (0.5 - 1)
Medium High (1 - 1.5)
High (> 1.5)
Rice

Fig. 1

Bahadurpur, Karchhana, Saidabad, Kaudihar, Baharia and Uruwa. The blocks having medium high concentration are Handia and Chaka. Meja has medium concentration of Pearl millet, rest of the blocks have low concentration.

Maize: Maize is a staple food for millions of people in India. It is consumed in various forms, such as corn on the cob, popcorn, and makki di roti. This is a droght resistant crop making it suitable for cultivation in regions with irregular rainfall patterns. Maize crop yields a high quantity of grains per hectare, contributing to agricultural productivity. It is grown by both small scale farmers and commercial agricultural enterprises. In Prayagraj, Maize is grown in kharif season, this is rainfed crop, Pratappur, Saidabad, Dhanupur, Handia and Koraon have high concentration of maize. Holagarh has medium high concentration. Baharia, Phoolpur and Manda have medium concentration.

Pulses: Pulses are a primary source of protein for millions of vegetarians in India. They are essential for fulfilling the protein requirements of a predominantly vegetarian population. The pulse industry creates employment opportunities in rural areas, including processing, trading, and transportation, contributing to the rural economy. Pulses cultivated in Prayagraj are Urad, Arhar, Masoor and Chana, the most important among them is Arhar or Pigeon Pea. Arhar dal requires a warm and tropical climate, moderate and well distributed rainfall, well-drained soil, abundant sunlight, and careful management of pests and diseases. The total area under arhar is 14639 hectares (2020-21). Chaka, Karchana and Koraon have high concentration. The blocks Jasra and Uruwa have medium high concentration. Kaudihar, Handia, Saidabad Shankargarh, Kaundhiyara, Meja and Manda have medium concentration. Rest of the blocks have low concentration. Out of 20, 7 blocks have medium concentration of Arhar in Prayagraj District.

Sugarcane: Sugarcane is the primary source of sugar production in India. Sugarcane cultivation and the sugar industry contribute significantly to the Indian economy. India is one of the largest producers of sugarcane and sugar in the world. Sugarcane farming provides employment to millions of farmers and labourers, especially in rural areas. Sugarcane is a long duration crop and requires 10 to 14 months to mature depending upon the geo- climatic conditions, it require 75 to 150 cm rainfall and in average 21 degree to 27° C temperature for better growth in 2020-21 total area under sugarcane cultivation was 666 hectares, the blocks Karchhana, Dhanupur, Pratappur and Mauaima have high concentration. Soraon, Phulpur, Handia have medium high concentration. There is no cultivation of sugarcane in Shankargarh, Chaka and Jasra. Baharia, Kaundhiyara and

Manda have medium concentration. Rest of the blocks have low concentration index of sugarcane in Prayagraj District.

Oilseeds: The most important oil seed in Prayagraj district is mustard. This is usually sown in the winter season from October to December, mustard prefers cool and dry weather during its growth period. Moderately drought resistant but requires adequate moisture during its early stages. The blocks having high crop concentration are Karchhana, Chaka and Koraon. The block having medium high concentration are Bahadurpur, Jasra and Meja. Rest of the blocks have low concentration of mustard crop. Other oilseeds grown in the district are Sesame and Flaxseeds. Sesame is cultivated in all the blocks of the district while flaxseed is cultivated only in 8 blocks of the district.

Fodder: The choice of fodder crop depends upon climate soil type and livestock requirements. For any region fodder plays a crucial role in supporting the livestock population. Fodder is crucial for dairy farming. Well-nourished dairy animals produce higher quantities of milk, supporting the dairy industry and ensuring a regular supply of milk and dairy products for consumers. In the district most of the fodder is grown in kharif season covering 2753 hectares (2020-21) of the total crop area. Two blocks have high concentration, they are Bahadurpur and Handia. The blocks having medium high concentration are Kaudihar, Soraon, Phulpur, Pratappur, Saidabad, Dhanupur, Shankargarh and Manda. The blocks Holagarh, Baharia, Karchhana, Uruwa and Koraon have medium concentration, rest of the blocks have low concentration. Crop concentration index of fodder in the blocks are mostly in medium high and medium range.

Conclusion

The variations in the concentration of Crop cultivation across the study region can be attributed to a complex interplay of factors, including geographical features, climate, water resources, socio-economic conditions and technological influences. These factors collectively contribute to the special distribution pattern of crops in the area. According to research analysis there is not much difference in crop concentration pattern of rice and wheat in the blocks of Prayagraj, this can be attributed to almost similar physical features across the district. High concentration of Barley can be seen in the centre of Prayagraj, only the 25% of the total production of Barley is irrigated. High and medium high concentration of vegetation of both Rabi season and Kharif season is in the Northern portion of the district. Medium high concentration of Sorghum is in the southern portion of the district,

it is a completely rainfed crop. High concentration of sugarcane is observed in east of the district and in Mauaima block which is in northern region of Prayagraj. High concentration of mustard is observed in the centre of the district in northwest and in southern block (Koraon). We can observe that crops like wheat and rice have almost even concentration and the other crops like barley, sorghum, pearl millet, maize, pulses, sugarcane and oilseeds have uneven distribution. This is because wheat and rice is the staple crop of Prayagraj which supports them financially and provides sustenance and other crops are cultivated by the choice of farmers where they have favorable conditions.

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SOCIO-ECONOMIC STATUS OF THE VANTANGIYA COMMUNITY: A CASE STUDY OF VANTANGIYA VILLAGES IN MITHAURA BLOCK OF MAHARAJGANJ DISTRICT

Ruchika Singh and Vaibhav Tripathi

Abstract

The Vantangiya community is a community based on economic activities, which the Britishers settled between the 1920s and 1930s to plant and protect Sal and Teak trees in the Terai areas of the states of Uttar Pradesh and Uttarakhand to meet their economic and infrastructural needs. Since the beginning, the people of this community have been living a displaced life; they were displaced from one place to another in an interval of about five years to plant and protect trees like bonded labours. More or less, this situation remained the same even after the country got independence. The Vantangiya community has been a victim of socio-economic deprivation for many years, and they have struggled a lot to get their rights. The current study examines the socio-economic status of the Vantangiya community in the Mithaura block of Maharajganj district. Socio-economic status of the different villages of the Vantangiya community was identified using the Socio-Economic Index which was constructed by the composition of various socio-economic factors like health, demographic characteristics, education, income-expenditure ratio, land ownership, etc. Variables of all these socio-economic factors and their values are pre-assumed and the value of Standard Socio-Economic Index (SEI) has been calculated on the basis of standard values of all these variables. Based on the value of the Standard Socio-Economic Index, a comparative analysis of the socio-economic status of the five villages of the Vantangiya community is analysed in this study.

Introduction

"Socio-economic development is a process of quantitative, qualitative and structural changes that are a result of actions of subjects taken within social(economic) practice. These changes influence life conditions in the following fields: material conditions (possibility to satisfy needs associated with consumption

of goods and services; it is related with the phenomena of economic growth), economic structure and entrepreneurship, access to public goods and services (that results in changes of education level, a way of taking care of someone's health etc.), relation within social system (integration between individuals, trust, security, social conflicts), environment condition and life satisfaction." Its goal is to maintain the region and its people's social and material well-being in order to achieve the optimal level of human development. Development, in the socio-economic context, refers to the improvement of people's standard of living through better employment, income, skills, and development opportunities. Thus, socio-economic development is the process by which a society develops both socially and economically. Health care facilities, sanitization, the availability of clean water, literacy, the income-to-expenditure ratio, and land ownership are some indicators used to measure it. A person's or group's socio-economic status is a combined economic and social measure of their position about others based on their health, education, and occupation. Socio-Economic status consistently and accurately predicts a wide range of outcomes throughout a person's life. A community is a social group that shares common things like area, traditions, beliefs, values, and identity. Communities may share a sense of place in a specific geographic area (like a country, hamlet, town, or neighbourhood) or virtual space through many communication platforms. According to the given definition of community, a community developed based on economic activities in the state of Uttar Pradesh and Uttarakhand of India in the first half of the 20th century is called the Vantangiya Community. Natural forests were extensively cleared for railway tracks some 100 years ago in this region when India was ruled by the British. Based on the Tangiya technique, a farming strategy used in the mountains of Myanmar, the British chose to create a forested area in its place. Many labourers were brought to the forest for this purpose from the villages of the Gorakhpur division. As a result, they were given the name "Vantangiyas"; "Van" signifies forest, and "Tangiya" comes from the words "tongya" where "tong" means mountain and "ya" belongs to the agricultural area. In Uttar Pradesh and Uttarakhand, the Tangiya system was implemented between 1920 and 1923. More than 5,000 Vantangiya families live in 23 forest villages in Gorakhpur and Maharajganj districts. Since the beginning, the people of this community have been living a displaced life; they were displaced from one place to another in an interval of about five years to plant and protect trees like bonded laborers. More or less, this situation remained the same even after the country got independence. The Vantangiya community has been a victim

of socio-economic deprivation for many years, and they have struggled a lot to get their rights. Due to the prohibition on their primary economic activities for the past several decades, they were forced to lead a displaced life, but for some years, through governmental and non-governmental efforts.

Study Region

Maharajganj district is situated north-eastern Tarai part of Uttar Pradesh in India. Its boundaries touch Nepal Estate in the north, Gorakhpur district in the south, Kushinagar district in the east, and Siddharth Nagar and Sant Kabir Nagar districts in the west. The total area of this district is 2952 square kilometers. Based on the census of 2011, the total population of this district is 26,85,292. Maharajganj was a tahsil of Gorakhpur and became a district on 2 October 1989. Maharajganj district consists of 12 Vikas khand blocks- Partawal, Paniwara, Pharenda, Dhani, Brijmanganj, Nautanwa, Lakshmipur, Mithaura, Nichlaul, Siswa Bazar, Ghughuli & Maharajganj Sadar. Vantangiya community lives in different blocks of the district in which Mithaura block takes prominent place where 5 Vantangiya villages are located: Baluahiya, Hathiahwa, 24 Nursery, 27 Nursery and 28 Nursery. The current study deals with the socio-economic status of these villages.

Objective

The main objective of the current study is to analyse the socio-economic status of the Vantangiya community in the Vantangiya villages of Mithaura block of Maharajganj district through the Socio-Economic Index (SEI).

Data Sources and Methodology

The current study is based on quantitative data analysis, and data are collected from primary as well as secondary data sources. This study used questionnaires, interview schedules, focused group discussions, and observation methods in primary sources, whereas in secondary sources, it considered data and documents related to village officials. This study analyzed 100 respondents and selected purposively 20 respondents from each Vantangiya village, Baluahiya, Hathiyhwa, Nursery 24, Nursery 27 and Nursery 28. After collecting the data, the socio-economic status of the Vantangiya community of Vantangiya villages in Mithaura block of Maharajganj district analyzed through the socio-economic index. For this, the current study used the method to calculate the socio-economic index as follows:

Socio-economic Index = {1/2 Social Index} + {1/2 Economic Index}

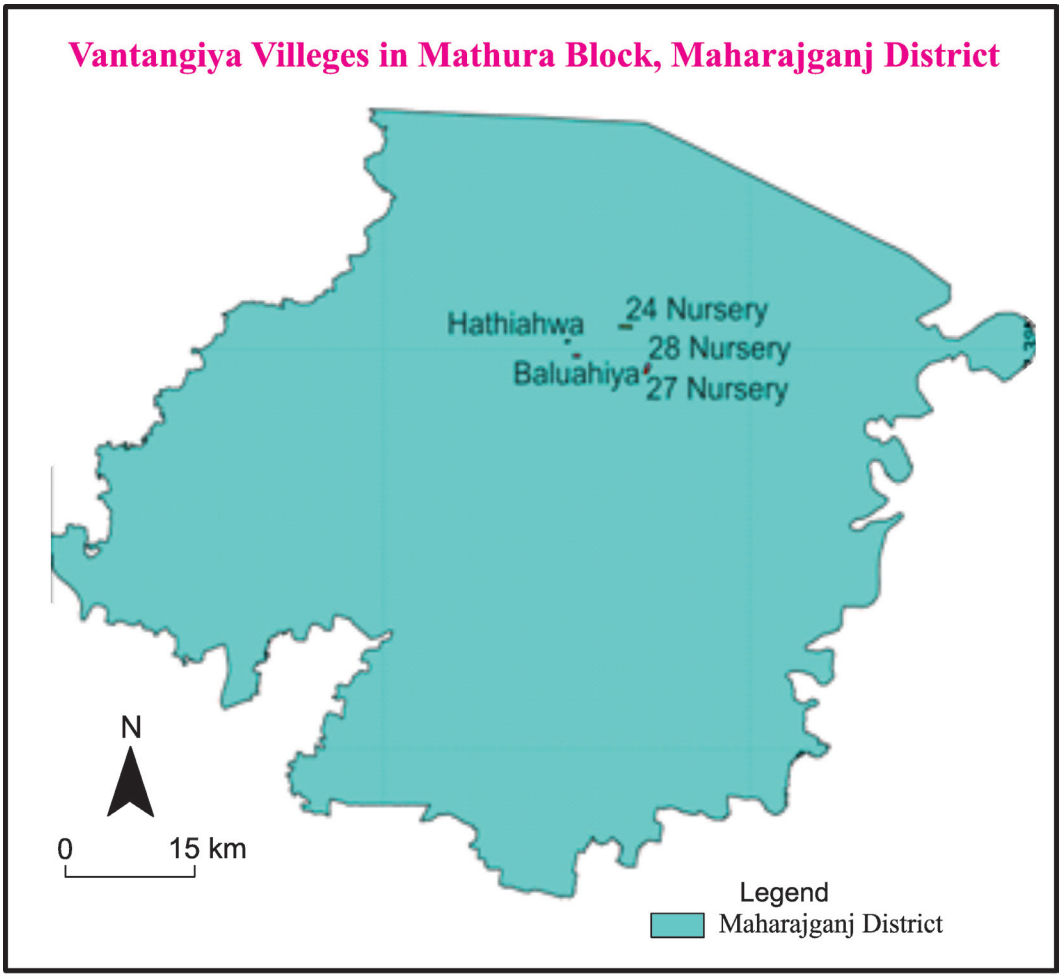

Vantangiya Villeges in Mathura Block, Maharajganj District
Hathiahwa
24 Nursery
28 Nursery
Baluahiya
27 Nursery
N
0
15 km
Legend
Maharajganj District

Fig. 1

Socie-Economic Index– The social index is measured by many indicators like health, demographic, and educational factors that impact a person's family or social position. The sum of the health, demographic, and educational indices is thus the social index.

Social Index = (1/3 Health Index) + (1/3 Demographic Index) + (1/3 Educational Index)

Health Index: Health is a major component of social index which affects society directly or indirectly. In this paper access of health and maternal facilities, standard toilet facilities, availability of safe drinking water and electric facilities are included as health indicators (**Table-**1).

Health Index = Actual Value – Minimum value/ Maximum Value – Minimum Value

Table-1: Health-related Variables and Value

Variables	Values
Access Health/ Maternal Care	No = 1, Yes = 2
Standard Toilet Facilities	No Facility/field = 1
Public Toilet = 2	
Pit/ Flush Toilet = 3	
Safe Drinking Water	No Facilitity = 1
Surface Water = 2	
Tube well/ Handpump = 3	
Basic Electric Facility	No = 1, Have = 2

Source: Computed by Authors

Demographic Index: Demography directly affects development of any society. People's marital status and family size are playing a key role to decide their level of socio-economic development (**Table-**2).

Demographic Index = Actual Value–Minimum value/Maximum Value–Minimum Value

Table-2: Demographic Variables and Code

Variables	Values
Age of Marriage	Less than 21(Male) 18 (Female) = 1, 21-25 (Male) 18-21 (Female) =2, Above 25(Male) 21 (Female) = 3
Size of Family	Above 5 members = 1 5 members = 2 4 members = 3 3 members = 4 Less than 3 members = 5

Source: Computed by Authors

Individual Educational Index = Actual Value/ Maximum Value

Education occupies a prominent role in the social index. An educated society achieves new dimensions of socio-economic development (**Table-**3).

Table-3: Educational Category and Code

Category	Code/Values
No Education/ Illiterate	1
Primary Incomplete/ Literate	3
Primary Complete	5
Junior High School	8
High School	10
Secondary	12
Graduation	15
Post Graduation	17
Ph.D/Other Advanced Study	18

Source: Computed by Authors

Economic Index: The aspects that affect a person's or family's financial situation, such as income, spending, involvement in community events, occupation, and land ownership, have an impact on the economic index (**Table-**4). With the use of the Socio-Economic Index (SEI) measuring formula, the following tables are constructed for the SEI of respondents of the different villages of Vantangiya community in Mithaura Block of Maharajganj district (**Table-**4 and 5).

Economic Index = Actual Value–Minimum Value/ Maximum Value–Minimum Value

Table-4: Economic Variables with their Category and Value Category

Variables	Values
Monthly Income (Expected)	Up to 10000=1
10000-20000 = 2	
Above 20000 = 3	
Expenditure Less than Income	Yes =2, No =1
Participation in Community Events	Yes =2, No =1
Occupation	No Job = 1
Day Labour/ Farmer/Housewife = 2	
Government/ Private Job = 3	
Land Ownership	
(Household)	Up to 1 Bigha = 1
1-3 Bigha = 2	
Above 3 Bigha = 3	

Source: Computed by Authors

Table-5: Socio-Economic Index for Baluahiya Village

Respondents	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	0.834	0.334	0.056	0.408	0.125	0.267
2	0.834	0.334	0.556	0.575	0.625	0.6
3	0.667	0.167	0.556	0.463	0.278	0.371
4	0.667	0	0.056	0.241	0.500	0.371
5	0.667	0	0.056	0.241	0.125	0.183

Contd...

6	0.834	0	0.056	0.297	0.750	0.524
7	0.834	0.167	0.444	0.482	0.625	0.554
8	0.667	0	0.056	0.241	0.250	0.245
9	0.5	0.5	0.056	0.352	0.167	0.260
10	0.5	0	0.278	0.259	0.250	0.255
11	0.5	0.5	0.056	0.352	0.375	0.364
12	0.834	0.334	0.056	0.408	0.5	0.454
13	0.834	0.667	0.056	0.519	0.25	0.384
14	0.834	0.5	0.056	0.463	0.5	0.482
15	0.834	0.334	0.444	0.537	0.375	0.456
16	0.834	0.334	0.667	0.612	0.5	0.556
17	0.834	0.834	0.444	0.704	0.5	0.602
18	0.667	0.5	0.056	0.408	0.375	0.392
19	0.834	0.167	0.167	0.389	0.75	0.569
20	0.834	0.167	0.278	0.426	0.375	0.400
Mean SEI = 0.414						

Source: Computed by Authors

Table-6: Socio-Economic Index for Hathiahwa Village

Respondent	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	0.834	0.167	0.167	0.389	0.625	0.482
2	0.834	0.667	0.834	0.778	0.5	0.639
3	0.667	0.167	0.056	0.297	0.5	0.398
4	0.834	0	0.056	0.297	0.375	0.336
5	0.667	0.167	0.056	0.297	0.25	0.274
6	0.667	0.167	0.278	0.371	0.25	0.311
7	0.834	0.167	0.056	0.352	0.75	0.551
8	0.834	0.667	0.667	0.723	0.625	0.674
9	0.834	0	0.056	0.297	0.5	0.398
10	0.667	0.167	0.056	0.297	0.5	0.274
11	0.667	0.5	0.056	0.408	0.375	0.396
12	0.834	0.5	0.056	0.463	0.5	0.482
13	0.834	0.834	0.125	0.598	0.5	0.549
14	0.667	0.167	0.056	0.297	0.5	0.297

Contd...

15	0.5	0.5	0.444	0.481	0.75	0.616
16	0.667	0.834	0.278	0.593	0.375	0.484
17	0.667	0.334	0.056	0.352	0.375	0.364
18	0.667	0.667	0.278	0.537	0.375	0.456
19	0.834	0	0.556	0.463	0.75	0.607
20	0.834	0.834	0.278	0.649	0.375	0.512
Mean SEI = 0.455						

Source: Computed by Authors

Table-7: Socio-Economic Index for 24-Nursery Village

Respondent	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	0.667	0	0.056	0.241	0.5	0.371
2	0.5	0	0.056	0.186	0.25	0.218
3	0.5	0.167	0.444	0.370	0.125	0.248
4	0.334	0.167	0.056	0.186	0.375	0.281
5	0.334	0.667	0.278	0.426	0.25	0.338
6	0.667	0.5	0.056	0.408	0.375	0.392
7	0.667	0.334	0.056	0.352	0.375	0.363
8	0.834	0,167	0.056	0.352	0.625	0.486
9	0.667	0	0.056	0.241	0.625	0.433
10	0.5	0.167	0.167	0.278	0.25	0.264
11	0.667	0.167	0.056	0.297	0.5	0.398
12	0.667	0.167	0.278	0.371	0.5	0.435
13	0.667	0.834	0.167	0.556	0.875	0.716
14	0.667	0.167	0.056	0.297	0.25	0.274
15	0.667	0.167	0.278	0.371	0.375	0.373
16	0.5	0.5	0.056	0.352	0.5	0.426
17	0.667	0.167	0.056	0.297	0.375	0.336
18	0.667	0.5	0.278	0.482	0.375	0.429
19	0.667	0.334	0.167	0.389	0.625	0.507
20	0.667	0.167	0.278	0.371	0.375	0.373
Mean SEI = 0.383						

Source: Computed by Authors

Table-8: Socio-Economic Index for 27-Nursery Village

Respondent	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	0.834	0.334	0.056	0.408	0.375	0.392
2	0.834	0	0.056	0.297	0.375	0.336
3	1	0.334	0.167	0.5	0.875	0.686
4	1	0.167	0.167	0.445	0.375	0.401
5	1	0.167	0.167	0.445	0.75	0.598
6	0.834	0.167	0.167	0.389	0.5	0.445
7	0.834	0.334	0.056	0.408	0.375	0.392
8	1	0.334	0.167	0.501	0.5	0.5
9	0.834	0.5	0.056	0.463	0.375	0.419
10	1	0.334	0.444	0.593	0.625	0.609
11	1	0.167	0.056	0.408	0.5	0.454
12	1	0	0.056	0.352	0.625	0.486
13	0.834	0.334	0.278	0.482	0.375	0.426
14	1	0.167	0.167	0.445	0.75	0.598
15	1	0.334	0.167	0.5	0.625	0.563
16	1	0	0.056	0.352	0.75	0.551
17	1	0.334	0.278	0.537	0.875	0.706
18	0.834	0.167	0.167	0.389	0.375	0.382
19	1	0.334	0.167	0.501	0.625	0.563
20	1	0.5	0.167	0.556	0.875	0.716
Mean SEI = 0.511						

Source: Computed by Authors

Table-9: Socio-Economic Index for 28-Nursery Village

Respondent	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	1	0.334	0.444	0.592	0.75	0.671
2	1	0.167	0.278	0.482	0.75	0.615
3	1	0.167	0.167	0.445	0.625	0.535
4	1	0.167	0.278	0.482	0.625	0.554
5	1	0.334	0.444	0.593	0.875	0.734

Contd...

6	0.834	0.167	0.056	0.352	0.375	0.364
7	1	0.167	0.167	0.445	0.75	0.598
8	1	0.334	0.167	0.5	0.625	0.563
9	1	0.667	0.444	0.704	0.667	0.686
10	1	0.5	0.056	0.519	0.5	0.505
11	1	0.167	0.056	0.408	0.375	0.392
12	1	0.334	0.167	0.5	0.75	0.625
13	1	0.334	0.056	0.463	0.875	0.670
14	1	0.167	0.056	0.408	0.625	0.517
15	0.834	0.334	0.056	0.408	0.25	0.329
16	1	0.334	0.167	0.5	0.625	0.563
17	1	0	0.167	0.389	0.625	0.501
18	1	0.167	0.056	0.408	0.5	0.454
19	1	0.167	0.167	0.445	0.5	0.413
20	1	0.334	0.167	0.5	0.25	0.375
Mean SEI = 0.533						

Source: Computed by Authors

Determining Standard Value for Socio-Economic Index

For analysis and comparison, there is a need for a standard value of the Socio-Economic Index (SEI). To do so, I have assumed a standard value for each variable. For example, the values for the "Age of Marriage" variable are 1,2 and 3 representing ages below 21(male) & 18(female), age between 21-25(male) and 18-21(female), and age above 25(male) & 21(female) respectively. Here the standard value for this variable is 2 or the age of marriage between 21-25(male) & 18-21(female). The list of variables and their standard value (**Table-**10) are tabulated below:

Table-10: Variables and Their Standard Value

Variables	Values	Standard Values
Access Health Care/Maternal Care	No = 1, Yes = 2	Yes = 2
Standard Toilet Facilities	No facility/field = 1 Public Toilet = 2 Pit/flush Toilet = 3	Pit/flush Toilet =3

Contd...

Safe Drinking Water	No facilities = 1 Surface water = 2 Tube well/Handpump = 3	Tube well/ Handpump = 3
Basic Electric Facilities	No=1, Yes=2	2
Age of Marriage	Less than 21 years(male) & 18 years(female) = 1 21-25 years(male) & 18-21 years(female) = 2 Above 25 years(male) & 21 years(female) = 3	21-25 years(male) & 18-21 years(female) = 2
Size of Family	Above 5 members = 1 5 members = 2 4 members = 3 3 members = 4 Less than 3 members = 5	4 Members = 3
No Education/Illiterate	1	Secondary = 12
Primary Incomplete /Literate	3	
Primary Complete	5	
Junior High School	8	
High School	10	
Secondary	12	
Graduation	15	
Post Graduation	17	
PhD/Other Advanced studies	18	
Monthly Income (Expected)	Up to 10000=1 10000-20000=2 Above 20000=3	10000-20000 = 2
Expenditure less than income	No =1, Yes = 2	Yes = 2
Participation in Community Events	No =1, Yes = 2	Yes = 2

Contd...

Occupation	No Job = 1 Day Labour/Farmer /Housewife = 2 Government/Private Job=3	Day Labour/ Farmer /Housewife = 2
Land Ownership (Household)	Up to 1 Bigha=1 1-3 Bigha=2 Above 3 Bigha=3	1-3 Bigha = 2

Source: Computed by Authors

By putting the standard values in the Socio-Economic Index (SEI) measuring formula,

I get the standard value for Socio-Economic index (SEI) = ½ (Social Index + Economic Index) = ½ (0.722 + 0.625)

Socio-Economic Index (SEI) = ½ (Social Index + Economic Index)

Standard Value for SEI = 0.674

Determining Mean Value for Socio-Economic Index (SEI) for different Vantangiya Villages of Mithaura block.

With the help of statistical techniques:

(1) Mean value of SEI for Baluahiya village = 0.414
(2) Mean value of SEI for Hathiahwa village = 0.455
(3) Mean value of SEI for 24-Nursery villages = 0.383
(4) Mean value of SEI for 27-Nursery villages = 0.511
(5) Mean value of SEI for 28-Nursery villages = 0.533
(6) Mean value of SEI for all these 5 villages = 0.459

Socio-economic Status of the Baluahiya Villages

The socio-economic status of the Baluahiya village covering the social and economic indicators is not better at all as none (0%) of the respondents reported standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and only 35% of respondents of this village whose SEI are 0.459 or above. It can easily be predicted that the

maximum of the respondents of the vantangiya community in Baluahiya village are not have better socio-economic status. The basic social and economic facilities and infrastructure are not available in this village.

Socio-economic status of the Hathiahwa Villages

The socio-economic status of the Hathiahwa village covering the social and economic indicators is not good as only 5% of the respondents have standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and 50% of respondents whose SEI are 0.459 or above. So the socio-economic status of the Hathiahwa village is not as good as required and the basic social and economic facilities and infrastructure are not available.

Socio-economic status of the 24-Nursery Villages

The socio-economic status of the 24-Nursery village covering the social and economic indicators is not good as only 5% of the respondents have standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and only 15% of respondents whose SEI are 0.459 or above. So the socio-economic status of the 24-Nursery village is not good and the difference between the mean SEI of this village and the individual SEI of the respondents shows the inequality in their socio-economic status.

Socio-economic status of the 27-Nursey Villages

The socio-economic status of the 27-Nursery village covering the social and economic indicators is good as 15% of the respondents have standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and 50% of respondents whose SEI are 0.459 or above. So the socio-economic status of the 27-Nursery village is comparatively good among vantangiya villages.

Socio-economic status of the 28-Nursery Villages

The socio-economic status of the 28-Nursery village covering the social and economic indicators is good as 10% of the respondents have standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and 55% of respondents whose SEI are 0.459 or above. So the socio-economic status of the 28-Nursery village is comparatively better among vantangiya villages. The homogeneity in the mean SEI of this village and the individual SEI of the respondents shows equality in their socio-economic status.

Comparison of socio-economic status among Vantangiya villages of Mithaura block

The mean SEI value is 0.459 for the 100 respondents from different villages of the Vantangiya community in the Mithaura block of Maharajganj district. The mean SEI value for respondents of Baluahiya (0.414), Hathiahwa (0.455), 24-Nursery (0.383), 27-Nursery (0.511), and 28-Nursery (0.533) villages is different and this difference in the SEI level indicates that 27-Nursery and 28-Nursery are maintaining better socio-economic status than the other three Vantangiya villages. Comparing with the standard value of SEI (0.674), none of the respondents in the Baluahiya village have standard socio-economic status; only 5% of the respondents in the Hathiahwa and 24-Nursery village have standard socio-economic status; and 15% and 10% of the 27-Nursery and 28-Nursery, respectively.

Conclusion

This comprehensive and comparative study discussed the socio-economic status of the five Vantangiya villages in the Mithaura block of Maharajganj district. A multidimensional socio-economic index is used to measure the socio-economic status of the Vantangiya community. The Socio-Economic index is the aggregate result of the social index and the economic index. The social index is also subdivided into the Health Index, Demographic Index and Educational Index. The study analyzed 100 respondents from different villages of the Vantangiya community and indicates that 27-Nursery and 28-Nursery villages are in better socio-economic condition than the other three. This study also indicates that there is a huge need for basic socio-economic and infrastructural facilities in these Vantangiya villages to uplift the socio-economic status of the people of the Vantangiya community.

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ASSESSMENT OF WILDLIFE HABITAT MANAGEMENT IN MUKUNDRA HILLS TIGER RESERVE, RAJASTHAN

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Abstract

Many researches have been done from time to time at local and global level in the context of climate change and biodiversity loss, many reports have been published. However, we all can feel these changes around us. We see the increasing environmental pollution around us and its impact on the life on land. This crisis has increased further due to changes in land use pattern in the last few years. With time, the area under forest cover and water bodies is decreasing while the area under man-made landscape is increasing. This destruction of natural habitat has led to greater decline in biodiversity. The 2022 global Living Planet Index shows an average 69% decrease in relative abundance of monitored wildlife populations between 1970 and 2018. Therefore, keeping in mind the need to conserve biodiversity, we should pay attention to the conservation of their natural habitats and saving top predators is essential for natural habitat conservation. Top predators, like tigers play an important role in maintaining the harmony of the planet's ecosystems. By preying on herbivores, tigers help to keep the balance between the prey animals and the forest vegetation which they feed upon. From the world's largest mangrove forests in the Sundarbans, to the snowy mountains in Northeast China and Russia, protecting wild tigers and their natural homes provides benefits for thousands of species and millions of people. (Why Tigers, n.d.) So we need to study their natural habitats, issues and solutions. This paper is based on common issues found in reserved forest areas. For example, it has been almost ten years since Mukundara Hills Tiger Reserve was declared a tiger reserve, but even today human settlements are present here. However, during the survey it was revealed that the residents themselves are not safe here. They also want to go out of these difficult situations and live a safe and healthy life. Apart from this, the context of water, food and safe habitat for wildlife has been discussed in this research paper also. Satellite images and field survey have been used for analysis. This forest area was also inhabited by

wild animals earlier and even at present there has been no significant change in this area. Most of the human settlements here are natural. Only a few road routes have been constructed. These can also be replaced by the Delhi-Mumbai Expressway in the future and made wildlife-friendly. Therefore, this area can be made a safe wildlife habitat. Moreover, the connectivity of Mukundra Hills Tiger Reserve with Bhainsroadgarh Wildlife Sanctuary in the south and Ramgarh Vishdhari Tiger Reserve and Ranthambore Tiger Reserve in the north makes it an excellent habitat for wildlife.

Introduction

In the Era of Machines and Development, many efforts are being made for environmental protection by the United Nations at the global level for the conservation of biodiversity. In this series, in the Conference on Sustainable Development held at Rio de Janerio in the year 2012, SDG goals were proposed by the United Nations. The purpose of which was to present goals globally to deal with the environmental, political and economic challenges faced by all countries of the world. In this series, in September 2015, United Nations Summit on Sustainable Development was organized in New York and the General Assembly adopted the 2030 Agenda for Sustainable Development with 17 SDGs. This research paper is based on one of them, on SDG 15: 'Life on land.' This goal includes study of our planet's ecosystem. As we know, without forest, there is no possibility of sustainable life on earth, but for the protection of forests, the presence of wildlife is also essential. Conservation of both forests and wildlife is essential for a balanced and secure life on earth, as stated as "The real wealth of the nation lies in the resources of the earth – soil, water, forests, minerals, and wildlife (Racgel Carson) If seen in the context of Rajasthan, the number of wild animals like bear, panther and tigers is increasing continuously, and for their protection it is necessary to study the available forest areas, which provide suitable living conditions for the wildlife. Moreover, seeking a favourable habitat for the cheetahs brought to the Kuno National Park in Madhya Pradesh, is also a need of the hour. To fulfill this objective, we need a place which has been preserving wildlife even in ancient times and which has not changed much even today, like Mukundra Hills Tiger Reserve. Although there are some challenges in front of Mukundra Hills Tiger Reserve even today, but their solution can be derived. In this research paper, we will discuss about those challenges and their solutions.

Study Region

Study area of this research work is Mukundra Hills Tiger Reserve, which has considerable diversity in topography, climate, vegetation, water resources etc. It is situated in the extension of Hadoti Plateau and Aravalli in the south-eastern Rajasthan, where Chambal, Bamani, Ahu, Kalisindh etc. rivers give life to land, make the forest flourish and create fertile plains.

Mukundra Hills Tiger Reserve (MHTR) was formed in 2013, which includes the area of Mukundra Hills National Park, Dara Sanctuary, Jawahar Sagar Sanctuary and National Chambal Gharial Sanctuary (from Garadia Mahadev to Jawahar Sagar Dam), which constitutes the core area of the Mukundra Hills Tiger Reserve in the Rajasthan. The tiger reserve is spread over an area of 759.99 square kilometers and is located in Ladpura, Sangod, Ramganjmandi tehsil of Kota district, Jhalarapatan tehsil of Jhalawar district, Talera tehsil of Bundi district and Rawatbhata tehsil of Chittorgarh district in Rajasthan. Jawahar Sagar Sanctuary is located between North Latitude 24°56' to 25°7.5' and East Longitude 75°26.50' to 75°41'. It is located 35 kilometers from Rawatbhata and 75 kilometers from Bundi. It is governed by the Government of Rajasthan Notification No. F 3(5) (13) Rev. 18/73 dated October 9, 1975 was declared as a sanctuary. The Mukundra Hills Tiger Reserve is named after the narrow central range with two continuous flat-topped and almost parallel hills, which is part of the Vindhya Range system, which extends from the Chambal River to Kalisindh and is about 80 kilometers in length and is 2 to 5 kilometers in width.

Objectives

(1) To analyze the problems faced in harmonizing the habitats of all living beings on the Earth as SDG 15.

(2) To study Mukundra Hills Tiger Reserve as suitable wildlife habitat for ever increasing tiger population in Rajasthan.

(3) To evaluate significance of Project Tiger in Rajasthan.

Database and Methodology

This research work is based on both primary and secondary data. The suitability of vegetation, water and habitat in the forest area has been studied with the help of satellite images and for its authentication, the area was surveyed. Satellite images of LANDSAT 8 have been used to analyze the forest area and health of vegetation. NDVI is calculated using Raster Calculator tool. In addition to this field survey was

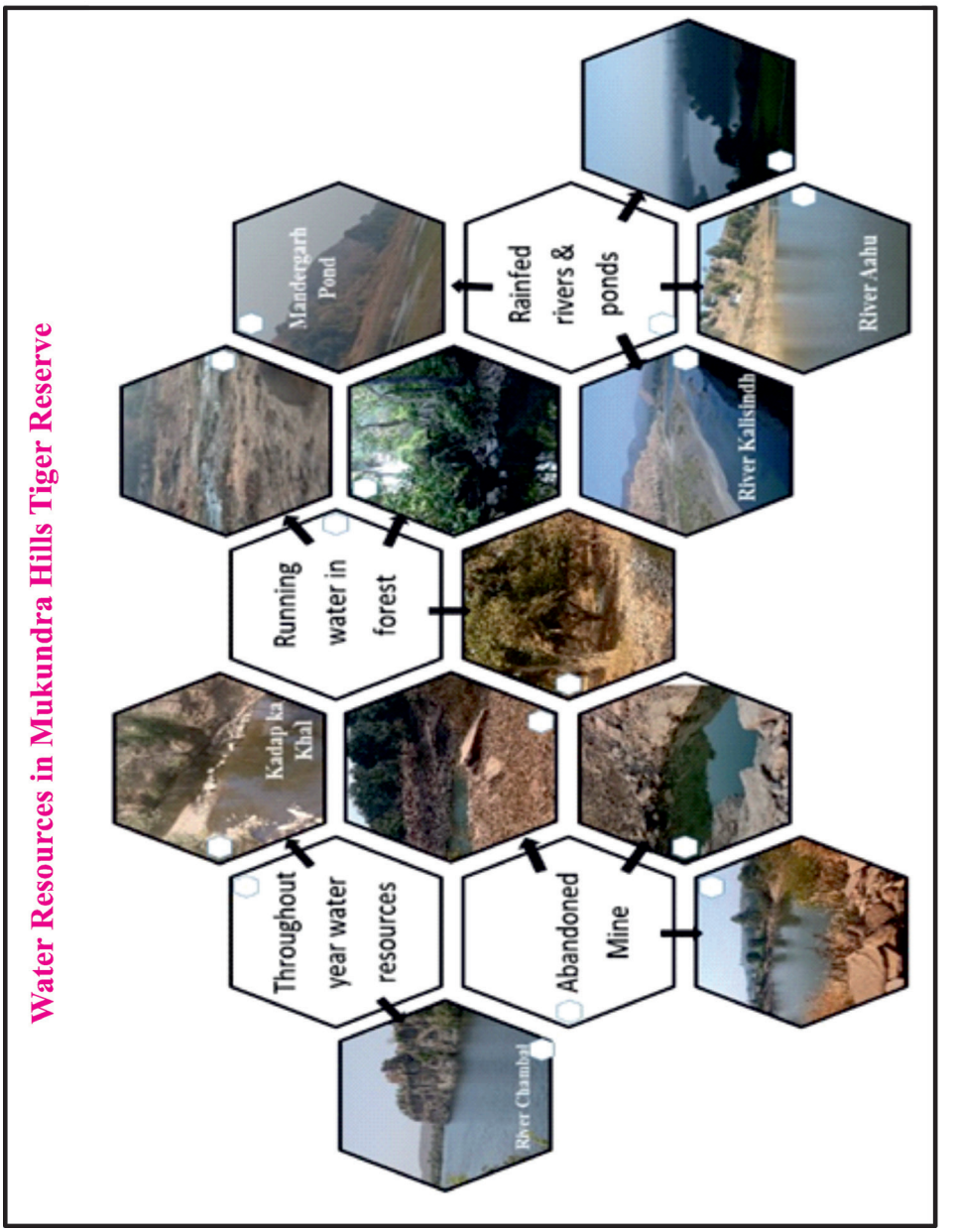

Water Resources in Mukundra Hills Tiger Reserve
Throughout year water resources
Running water in forest
Abandoned Mine
Rainfed rivers & ponds
Kadap ka Khal
Mandergarh Pond
River Chambal
River Kalisindh
River Aahu

Fig. 1

done through schedule to study the human impact and environmental condition of villages located in Mukundra Hills Tiger Reserve. During this survey, information was obtained from the residents about their lifestyle and their dependence on the forest. Apart from this, their impact on the forest was also analyzed. Some research papers and books related to forest management and biodiversity have been studied. Newspapers have been mainly used as secondary data to get information about positive and negative changes happening in Mukundra Hills Tiger Reserve from time to time. Maps were prepared with the help of open-source software. To create maps of the study area, shapefiles taken from forest department portal- 'rajforest' and 'Survey of India' portal were used.

Factors affecting wildlife habitat in Mukundra Hills Tiger Reserve

Water Resources

Mukundra Hills Tiger Reserve is located in the region of Rajasthan with more than 70 cm of rainfall. The only perennial river of Rajasthan, Chambal, and its tributaries, passes through the Mukundra Hills Tiger Reserve. They provide water to the Mukundra Hills Tiger Reserve for most of the year. The topography of Mukundra Hills Tiger Reserve also ensures the availability of water here. The Vindhyan range extends up to the Mukundra Hills Tiger Reserve, locally called Mukundra Hills, from which the rainwater seeps down and accumulates throughout the year in the foothills and lower areas of the valleys. Apart from this, the Forest Department is also conserving more than 100 natural and artificial water bodies in this region. (**Fig.** 1)

Food and Habitat

70 percent area of Mukundra Hills Tiger Reserve is covered with mixed deciduous forest. Dhok (Button), Khair (Black kutch), Churail (Indian elm), Amaltas (Golden shower), Sal, Gurjan, Palash (Bastard), Arjun, Tendu, Ber, Behda (Beleric Myrobalan), Mahua (Buttercup), Khejdi, Babool, Neem, Banyan, Peepal, Khechda, Khakara, Bamboo, Bilvapatra, Amla and many other species of deciduous forests found here. It provides favorable habitat and sufficient food to the wildlife (**Fig.** 2). Thorny autumn forests are found here, whose dry leaves provide food for herbivore animals chinkara, chital, sambar, nilgai, deer, and langurs even in autumn, which provide ample prey base like wolf, jackal, fox, mongoose, wild cat, civet, porcupine, wild boar, panther and tigers. Thus, there is enough food even for carnivorous animals. From the point of view of natural habitat, the total area

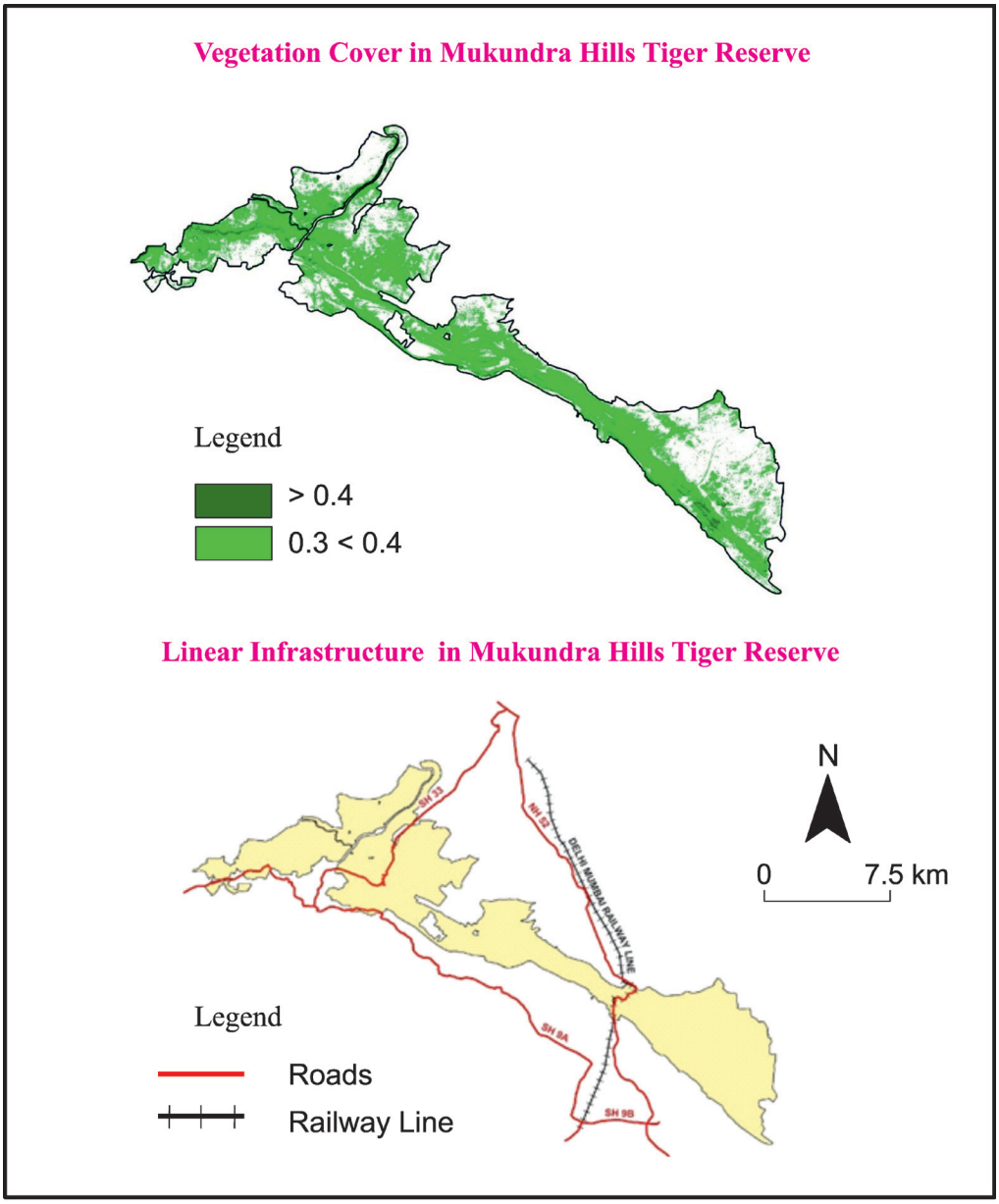

Vegetation Cover in Mukundra Hills Tiger Reserve
Legend
> 0.4
0.3 < 0.4
Linear Infrastructure in Mukundra Hills Tiger Reserve
N
0
7.5 km
DELHI MUMBAI RAILWAY LINE
SH 9A
SH 9B
Legend
Roads
Railway Line

Fig. 2

of Mukundra Hills Tiger Reserve is 759.99 square kilometers, out of which 417.17 square kilometers comes under the core area and the rest under the buffer area. Out of the core area, the area of 82 square kilometers is surrounded by wire fencing. The grassland is well developed within this wire fencing and sufficient prey base is also available in it. Apart from this, one enclosure of one hectare has been made in Selzar area of the tiger reserve and another enclosure of 28 hectares has been made in Sawan Bhado area. (Source: Dainik Bhaskar Newspaper, 05.05.2023) In addition to the above, Mukundra Hills Tiger Reserve has a glorious history as an abode of tigers, but now due to changing land use pattern some disparities have arisen in this area which need to be resolved.

Roads and Railways

National Highway 52 and Delhi-Mumbai railway line pass through Mukundra Hills Tiger Reserve for length of about 50 kilometers. The high speed of vehicles and blind turns of the roads have many times led to the death of wildlife. There are 30 villages located in the core and buffer area of Mukundra Hills Tiger Reserve, in which more than 1500 families reside. Although about 200 families have been relocated from here in the last 8 years, but still the residence and farms of the rest of the families are existing in the forest area. These forest dwellers go to the nearest cities only through the forest area to get the goods they need and for employment. It is dangerous for the life of both humans and wilds (**Fig.** 3).

Project Tiger in Rajasthan

The Tiger Project in Rajasthan started in 1973 when Ranthambore was declared as the first Tiger Reserve of Rajasthan in 1973-1974. In the next phase of the Tiger Project, Sariska was declared a Tiger Reserve in the year 1978-79. But even after three decades of the Tiger Project, there was a continuous decline in the number of tigers in Rajasthan. Tigers vanished from Sariska Tiger Reserve in the year 2005 and only 14 tigers were left in Ranthambore Tiger Reserve. But gradually the conditions started improving; the number of tiger reserves was increased, villages were relocated from Ranthambore and Sariska, mining and deforestation were banned and as a result, gradually the number of tigers started increasing in Rajasthan, which can be understood from the following table: At present, there are about 115 tigers present in Rajasthan. With the formation of Mukundra and Ramgarh Vishdhari Tiger Reserves, a natural wildlife corridor has been created for tigers in the south eastern part of Rajasthan. The number of tigers has grown


Vegetation Cover on Mukundra Hills Tiger Reserve
March 2022
Gagron
December 2022
Human presence in Mukundra Hills Tiger Reserve
Relocated
In processing
Rooppura
Keshavpura
Kothla Ghatti

Fig. 3

substantially in Rajasthan. Due to increasing population of Tigers, the tigers have started migrating to nearby forests of Madhya Pradesh and Rajasthan. This depicts the picture of success of the Tiger Project in Rajasthan.

Conclusions

In conclusion we can say that, Mukundra Hills Tiger Reserve has favourable natural conditions for the habitat of wildlife, but due to anthropogenic activities some anomalous conditions have arisen here. For example, on July 15, 2013, a tiger 'Broken Tail' had come from Ranthambore Tiger Reserve towards the Darrah forest area while roaming. But unfortunately, he was crushed to death by the Rajdhani Express on the Delhi-Mumbai rail route. After this, about 6 years later, in the year 2019, the T-98 tiger, leaving Ranthambhore Tiger Reserve and traveling about 150 kilometers, reached the Darrah region of Mukundra Hills Tiger Reserve via Kalisindh river.

This is the second case of moving from one tiger reserve to another through forest area. Therefore, there is a need to improve following conditions as much as possible and make them wildlife friendly. As (1) The villages should be relocated soon (2) The speed of vehicles should be regulated (3) Grasslands should be developed (4) There is uncertainty of rainfall in Rajasthan. Therefore, to deal with such situations, artificial water points should be developed and water availability should be ensured throughout the year using solar pumps as proposed in Ramgarh Vishdhari Tiger Reserve (5) Security walls should be built around the forest area so that wildlife stays away from rail and road routes and human settlements (6) Tiger reserves of south-eastern Rajasthan should be connected with each other by developing wildlife corridors. Although after the declaration of Mukundra Hills Tiger Reserve as such, many efforts are being made by forest department, and central and state government for the development of Mukundra Hills Tiger Reserve. In view of the protection of wildlife, mining work and deforestation has been banned in this area. Grasslands are being developed so that sufficient food is available for herbivorous animals and sufficient prey base can flourish in the forest. Now if there is any threat to wildlife it is from road and rail routes and human settlements. Forest Department. Apart from this, to ensure wildlife conservation in the area, measures have been taken in the Bharatmala Project, under which Delhi-Mumbai Expressway is being constructed. For wildlife conservation an eight-lane soundproof twin tunnel is being constructed. Along with this, the relocation of six villages settled in core area has also been done. (Shah, 2020)

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IMPACT OF ROADSIDE FRICTION ON ROAD CAPACITY IN ALIGARH CITY, INDIA

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Abstract

Indian cities are notorious for poor road capacity and the slow average mobility. Aligarh city has massive problem of traffic congestion and inadequate transportation infrastructure as the narrow lanes and roads crisscross the city. Absence of the well-designed junctions, footpaths and cycle tracks makes it difficult for pedestrians, cyclists and vehicles to commute safely. Moreover, the lack of traffic management has led to the usual traffic congestion and frequent road accidents. Inadequate parking space causes traffic jams due to road side unauthorized parking. One of the important reasons for this traffic chaos is that the city has one of the fastest growing populations due to the migration of people from rural areas as well as from other parts of the state and country, mainly for education and employment. It is the 77th most populous city in India. Due to Covid -19 lockdown restrictions much of the ridership in Aligarh city was curbed. Still, not much change was being observed in the side friction and traffic congestion. The busy roads of Aligarh city have emerged as the site of parallel economic structure for the migrants, poor and the marginalized section of the city. In this paper we have done a comparative study of two roads of the busy market areas of the Civil Lines zone of Aligarh city during the Lockdown, following all the protocols. The purpose of the study is to analyze the degree of influence the road side friction has upon the road capacity caused by the road side economy. The paper concludes that the side friction has considerable negative impact on the capacity of roads in Aligarh's market areas.

Introduction

Road transportation system has been playing a vital role in the socio-economic development of cities all over the world. Road traffic in India is marred by poor condition and below par performance. The main focus in the studies regarding speed-flow relationship of road traffic is on geometry, street type and urban environment

of roads. Recently many studies have concluded that in the cities of the developing world there are some activities going on or along the roadsides which influence the capacity of the road network which is known as the side friction (R. Amudapuram et.al, 2016). Road capacity is defined as the maximum sustainable flow rate at which vehicles can be expected to traverse a point or uniform section of a lane or roadway during a given time period under the prevailing roadway traffic and control conditions (IRC, 1990). The condition is getting worse in the cities of developing world where the increasing transport demand is causing the deterioration in the road capacity of the arterial and the local roads, and the inefficient performance of the traffic system (Salini.S et. al., 2014). As per the Indian scenario, the presence of the roadside markets and vendors is a common observation in every city. They attract people to stop by, which reduces the effective road width due to the roadside parking of the vehicles and other parking and un-parking maneuver. Due to lack of the meaningful employment for migrants and unskilled and semiskilled individuals, and the unavailability of the specified area for their informal fringe economic activities; vendors, rag pickers, mechanics etc. are also found to work along the roadside. The presence of road side markets, vendors, food stalls and the lack of pedestrian facilities compel people to walk on or along the road which disturbs the traffic flow. In consequence, traffic flow is considerably interrupted. It diminishes the performance of traffic operations and undermines the capacity and the functional integrity of the road. The road side frictions have negative effect on the road capacity as the width of road decreases and it becomes narrow. Side friction leads to decrease in the speed of vehicles, aids in the delays and becomes a cause of accidents. Literature review reveals that very little work has been done in 'Y' category cities in India like Aligarh till date to measure the impact of roadside friction upon the capacity of urban roads. This study intends to measure the influence of roadside frictions on the capacity of road in Aligarh city during the lockdown period in order to establish that even the regulated opening of the city creates unmanageable side friction reducing the capacity of roads below the base value. The study will be a precursor to the road traffic administration of Aligarh Smart city to find out the ways to regulate the unmanageable urbanization and the exponential motorization.

Study Region

Aligarh has been classified as class Y city (HRA, 2015) and one of the National Priority Cities and potential urban growth centers of India (Report of National Commission on Urbanization, GOI, 1988) located outside the National Capital

Region (in 150 km radius). It is the administrative headquarters of Aligarh district, and lies approximately 130 km south east of the capital, New Delhi. Aligarh Muslim University, the world famous seat of learning, is located here. Besides, it is a hub of a large number of small scales household and cottage industries, some of important large-scale food and agro-based industry, and the brass and lock industries. The decadal population growth rate of the city is 30.40 percent for 2001-11(**Table-**1).

Table-1: Geometric Parameters of the Roads under Study

Road Characteristics		Road	
		Marris Road	Dodhpur Road
Geometric condition	Road Types	Single Carriageway 2 Way	Single Carriageway 2 Way
	Carriageway Width	7 m	7.2 m
	Shoulder Width	2.7	1.1
	Road Alignment	Straight	Straight
	Footpath Width intermittent	2.6 m	2.5 m
	Road length	2.57 km	3.08 km
Environmental condition	Weather Condition	Day/Dry	Day/Dry
	Urban/Suburban	Urban	Urban
	Pavement Condition	Paved/Near to Smooth	Paved/Smooth
Traffic control condition	Nearby Major Intersections	Present	Present
	Traffic Signs	Present	Absent
	Pavement Markings	Present	Absent

Source: Based on Survey, 2021

The annual population growth of the city is reported as 3.16, 2.97, 2.89 and 2.81 percent for 4 consecutive years from 2017 to 2020 respectively. The estimated population of Aligarh city is 1,013,089 in 2021(UN- World Population / prospects). The population density of the city has increased from 14,500 persons per square km in 1971 to 24,573 persons per square km in 2011(excluding the University area). 10 percent of the urban population has spread beyond the city limits and in the towns which are also dependent on this city for their major needs.

The city is also having a high rate of motorization. The growth of road length network is not keeping pace with it.

Objectives

(1) To measure the vehicle composition and traffic flow rate of Marris and Dodhpur roads.

(2) To identify the major sources of side friction on these roads and to estimate the magnitude of side friction.

(3) To calculate the actual capacity of both roads.

(4) To estimate reduction in base capacity of both roads due to the side friction.

Database and Methodology

The present study is based on the primary sources of data generated through the comprehensive field survey, traffic counting (TC) survey, side friction (SF) survey, and geometric survey carried out during year 2021 in the month of April. The secondary data is collected from the Census of India (2011). For determining the influence of road side frictions on the capacity of road, two roads of Aligarh city are selected, with roadside friction activities. These are the Marris road and the Dodhpur Road which are undivided two lane two ways (2/2 UD). The survey was conducted for four hours from 8:00 am to 12:00 pm on these two roads. On each road a 50-meter length is specified for the surveys. In this study the evaluation of traffic flow, roadside friction (Pal and Roy, 2016) and capacity (Indonesian Highway Capacity Manual Urban Roads, 1993) is done according to the techniques mentioned in the sources shown in the parentheses. The traffic count survey was done manually by counting the number of each type of vehicle that had passed the fixed spot on the road in both the directions for every 5 minutes under four categories namely, two wheelers, animal drawn vehicles, three wheelers, cars and heavy vehicles. The vehicles in these categories are heterogeneous in nature. Therefore, for finding the total flow each vehicle type is converted into the homogenous category. Flow is calculated by converting the volume of vehicles per 5 minutes into the equivalent PCU (passenger car unit) as per IRC code. The peak hour factor (PHF) is calculated for finding the peak flow of an hour by the formula given by (HCM, 1965) as:

$$PHF = v \frac{60}{av} \Big/ 12xv \frac{5}{av}$$

Average volume during the peak 60 minute period v_av^60 is divided by twelve times to get the average volume during the peak 5 minute's period v_av^5. For the side friction survey a section of 50-meter length on both roads was delineated and width was measured with the help of a measuring tape. On these two sections of the both roads the survey was done to count the number of pedestrian /hour walking, vehicles parked or stopped on their way for a while /hour/width, number of vendors standing/hour/width, number of stray animals moving/hour/width, number of beggars present along the road/hour/width. Pedestrian is considered unit of friction. Impact of side friction included the physical dimension of the side friction as well its position on the carriage way. Area effect of an element of friction is considered as the ratio of projected area of a particular friction to pedestrian and expressed as area ratio (AR). Positional disturbance effect of an element is calculated as the ratio of distance of particular midpoint of strip from edge of carriageway on which friction element is positioned to midpoint of the edge strip named as distance ratio (DR). Weight factor for each element is determined by summing up area ratio and distance ratio. After assigning weight these frequencies are converted into a single unit of roadside friction index (RSVI). To plot the side friction frequency graph all categories of side friction frequencies are summed up and then average frequency per five minutes is calculated for the whole study duration. The geometric survey was done to measure the width of the carriageway, and its edge strips and the middle strip. These capacity parameters have helped in finding the capacity of two roads. Capacity is F calculated as follows.

$$C = C_0 \times FW \times FKS \times FSD \times FSF \times FCS$$

Whereas:

C_0 = Base Capacity

SF = Curb and shoulder adjustment factor

FW = Carriageway width adjustment factor

FSF= Curb and shoulder adjustment factor

FKS = A directional split adjustment factor

FCS = Side friction adjustment factor

FSD = City size adjustment factor

The actual capacity is determined by multiplying the base capacity with all the adjustment factors as mentioned above. The capacity is dependent upon the

geometry of road (the width of road, shoulder width, city size, and median width), side friction activities and the city size. So the values of different adjustment factors have been taken from (Indonesian Highway Capacity Manual Urban Road, 1993). Actual capacity of both roads is estimated by calculating percentage of base capacity reduction.

Results and Discussion

Composition of Vehicles of Roads, (2021)

Traffic Composition is shown in Fig 2 and it is clearly indicated, at Marris Road the vehicle composition is found to be as; two wheelers' 61 percent (bicycle 2.99%, motorcycle and scooter 58.543%), animal drawn vehicle 0.5 percent, car 20 percent, e-rickshaw 15 percent, bus 2 percent and others 2.07 percent. On Marris Road two wheelers and cars have the greatest contribution in traffic flow. However, at Dodhpur it is found that two wheelers constituted 62 percent (bicycle 3.08%, motorcycle and scooters 59.35%), car 14.24 percent, e-rickshaw 18.08 percent and others 5 percent (animal drawn vehicles, truck, van, tractor etc.) of the total traffic. Two wheelers and e rickshaws are the most ubiquitous vehicles here. (Fig 1)

Traffic Flow Analysis

The traffic flow is greater at Marris Road as compared to at Dodhpur road. At Marris Road peak hour volume is 2269.353 pcu/hour observed in between 9.40am-10.40am. Marris road's connectivity with the Center Point, a major marketing area of Aligarh city, Ramghat road and railway junction is the main cause of greater traffic flow. At Dodhpur road peak hour volume is found to be 1803.6 pcu/hour between 9.20 am-10.20 am and it is mainly due to the vendors and regular shops attracting the major share of the traffic flow.

Composition of Road Side Friction

Fig 2 and 3 show, at Marris Road main components of the roadside friction are roadside parking, vendors, food stalls, squatters etc. occupying the footpath and allowing less space for pedestrian's movement resulted into the movement of pedestrians on the road or along the road causing hindrance to the flow. There are three schools located along this road but because of COVID 19 their contribution in hindering the flow is negligible due to the online. In normal time these schools cause considerable road side frictions.

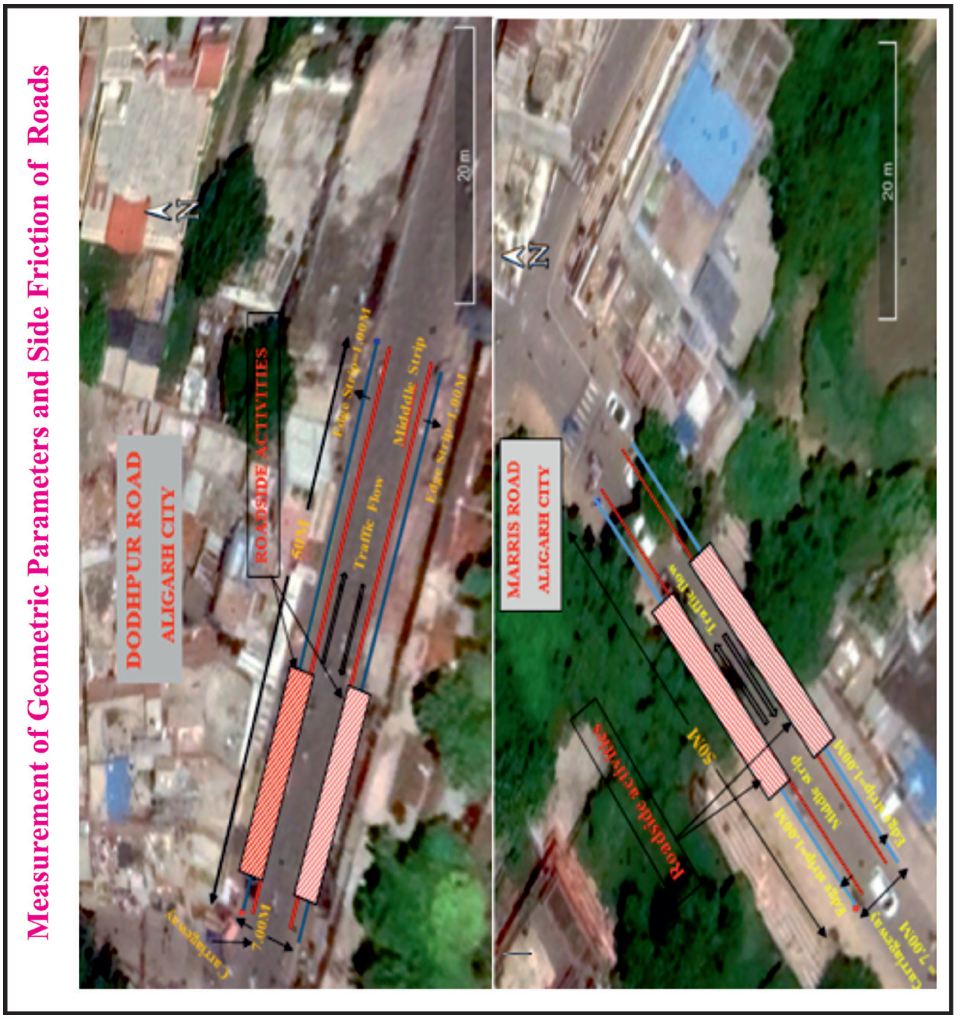

Measurement of Geometric Parameters and Side Friction of Roads
DODHPUR ROAD
ALIGARH CITY
ROADSIDE ACTIVITIES
50M
Traffic Flow
Middle Strip
20 m
N
MARRIS ROAD
ALIGARH CITY
Roadside activities
50M
Traffic Flow
Middle strip
20 m
N

Fig. 1

At Dodhpur road the roadside friction is mainly due to the presence of vendors compelling pedestrian movement along the road. The roadside parking has emerged as the second biggest factor causing the side friction on Dodhpur road as here no official legalized parking space is found. Squatter, begging and dumping also act as other sources of friction for the traffic flow on this road. Due to increasing rate of in migration and lack of suitable employment more people are turning up to the road side informal economy as vendors. Due to absence of the decent public transportation and traffic infrastructure, private ownership of vehicle is increasing but absence of proper parking facilities it is creating more road side frictions. Road side friction is greater at Dodhpur road as compared to at Marris Road. At Dodhpur road the peak hour for the roadside friction is between 9.45 am to 10.45 am. The frequency of roadside friction count is found as 110-116 per hour. Roadside vendors, Restaurants, and Market attracted the flow during this time. At Marris Road the frequency of roadside friction is found to increase and decrease alternately and being maximum between 10.35 am-11.35 am.

The frequency of friction is found to be 80-75 per hour as it is the time when restaurants, shops, banks, offices etc. located here and the vendors attract the flow causing road side parking and pedestrians' movement on the road. It is evident that the overall roadside friction during peak hour is less at Marris Road as compared to Dodhpur road. During the study it was found that the edge of the roads experienced more side friction as compared to the middle part of the road. Therefore, for the better results the sections of both roads under the study were divided into two portions, one meter edge strips on both sides of the carriage way and the remaining 5 meter and 5.2-meter middle strip for Marris and Dodhpur road respectively. **Table-**2, 3 and 4 shows a detailed analysis of the weighted factors assigned to the different types of side friction element found along the edge strips and the middle strips of Marris Road and Dodhpur road. di is distance of ith friction element from carriageway edge, A_i projected area of ith friction element, AR is area ratio, DR is distance ratio and PA is projected area. These calculated values are used to develop the road side friction index (RSFI) (**Fig.** 2 and 3). It is clearly indicated in **Table-**3 that RSFI is greater at Dodhpur road (3937) as compared to that of Marris Road (2564.4). Therefore, we can deduce that the encroachment of road by the road side friction activities is greater at Dodhpur road as compared to that of Marris Road.

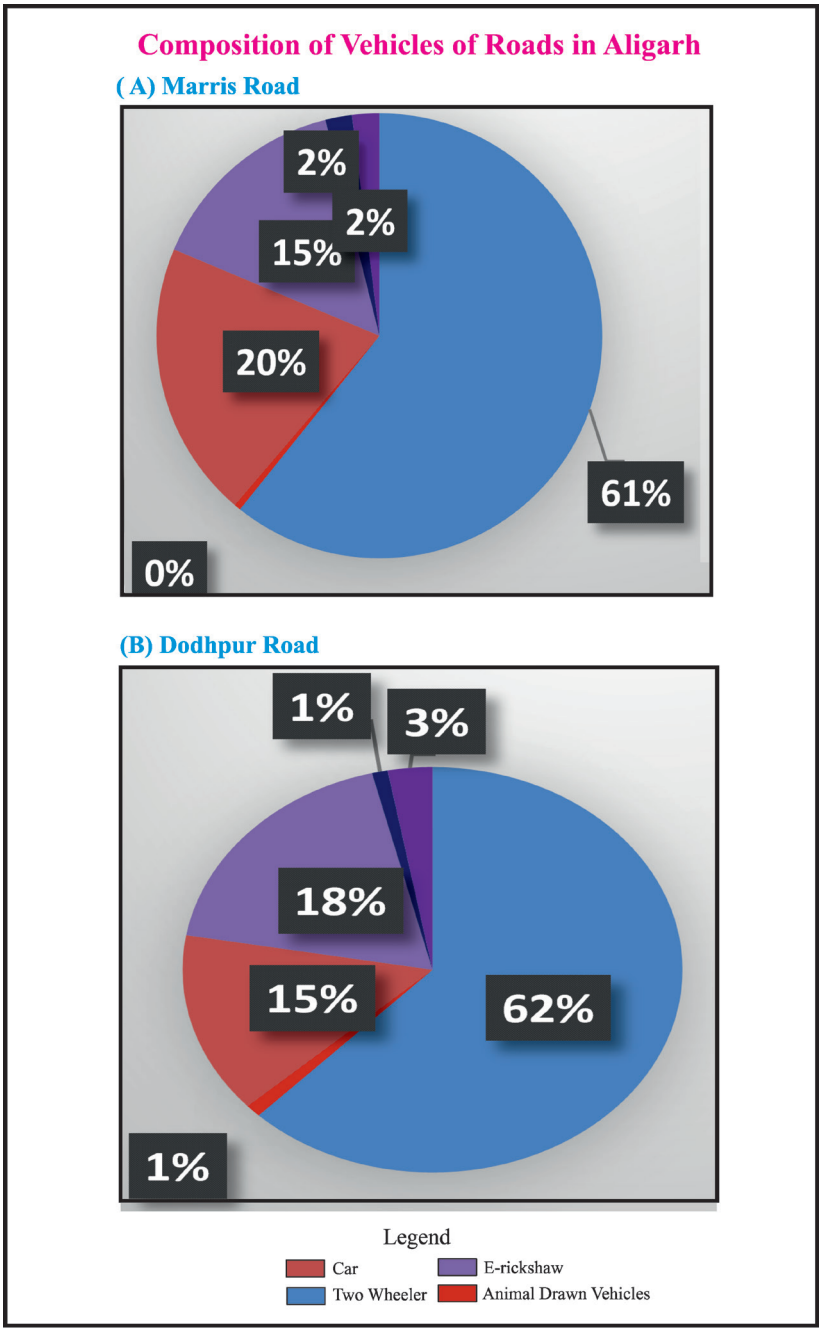

Composition of Vehicles of Roads in Aligarh
(A) Marris Road
2%
2%
15%
20%
61%
0%
(B) Dodhpur Road
1%
3%
18%
15%
62%
1%
Legend
Car
E-rickshaw
Two Wheeler
Animal Drawn Vehicles

Fig. 2

Roadside Friction Index

Table-2: Side Friction on Edge and Middle Strip of Marris and Dodhpur Roads

Friction Element Marris Road	PA (Projected Area)	Edge of Strip 1m			
		Distance of carriage width edge from strip midpoint (m)	AR (area ratio) Ai/Ap	DR (distance ratio) Di/Dp	AR + DR
Pedestrian	0.5	0.5	1	1	2
Roadside Parking	2	0.5	4	1	5
Vendor	1.2	0.5	2.4	1	3
Squatter	2	0.5	4	1	5
-	-	-	-	-	-
Middle strip = 5.00m					
Pedestrian	0.5	3.5	1	7	8
Roadside Parking	2	3.5	4	7	11
Vendor	1.2	3.5	2.4	7	9.4
Squatter	2	3.5	4	7	11
-	-	-	-	-	-
Friction element Dodhpur road					
Pedestrian	0.5	0.5	1	1	2
Roadside Parking	1.8	0.5	3.6	1	4.6
Vendor	1.5	0.5	3	1	4
Dumping	0.5	0.5	1	1	2
Begging	1	0.5	2	1	3
Middle strip = 5.20m					
Pedestrian	0.5	3.6	1	7.2	8.2
Roadside Parking	1.8	3.6	3.6	7.2	10.8
Vendor	1.5	3.6	3	7.2	10.2
Dumping	0.5	3.6	1	7.2	8.2
Begging	1	3.6	2	7.2	9.2

Source: Based on Survey (2021)

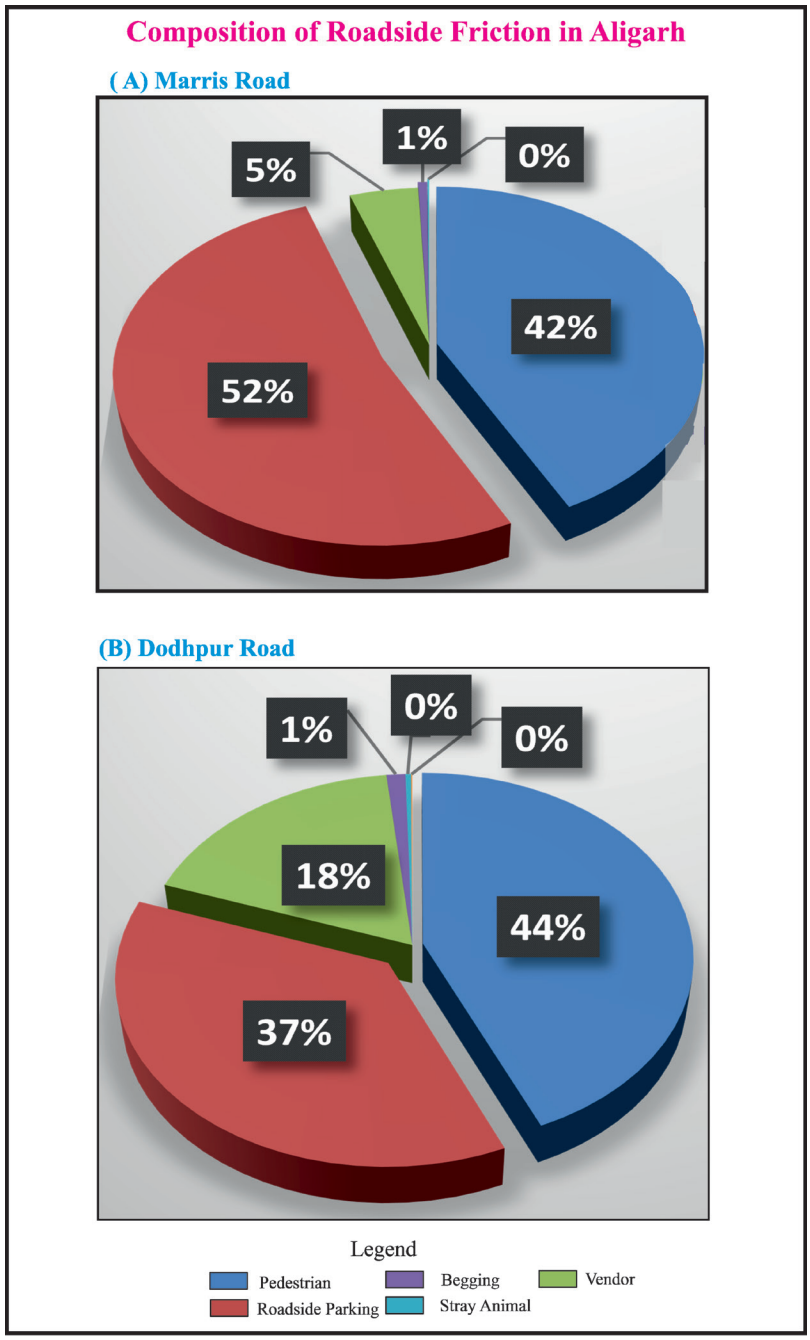

Composition of Roadside Friction in Aligarh
(A) Marris Road
1%
0%
5%
42%
52%
(B) Dodhpur Road
0%
1%
0%
18%
44%
37%
Legend
Pedestrian
Begging
Vendor
Roadside Parking
Stray Animal

Fig. 3

Table-3: Marris Road: Average Number of Friction Element

Time	Average number of Friction Element (Marris road)												Total
	Left edge strip				Middle Strip				Right edge strip				
	PD	RP	V	S	PD	RP	V	S	PD	RP	V	S	
Friction element	360	200	30	2	2	-	2	-	118	84	18		
Weightage factor	2	5	3	5	8	11	9.4	11	2	5	3	5	
RSFI	720	1000	90	10	16	-	18.8	-	236	420	54		2564.8

Source: Based on survey done by the researchers in 2021.

Table-4: Dodhpur Road: Average Number of Friction Element

Time	Average number of Friction Element (Dodhpur road)														Total
	Left edge strip					Middle Strip					Right edge strip				
	PD	RP	V	D	B	PD	RP	V	S	B	PD	RP	V	D	B	
Friction element	220	300	100	2	2	100	-	10	-	-	100	120	70	1	1	
Weightage factor	2	4	4	2	3	8.2	10.2	10.2	8.2	9.2	2	4	4	2	3	
RSFI	440	1200	400	4	6	820	-	102	-	-	200	480	280	2	3	3937

Source: Based on survey done by the researchers, 2021

Capacity Analysis

Adjustment Factors of Parameters of Capacity is given by (IHCM1993) and Actual Calculated capacity of Marris and Dodhpur Road (2021). It is clearly revealed that the actual capacity of Marris Road being 2680.05 pcu/ hour is greater than the actual capacity of Dodhpur road which is 2297.47pcu/hour. The base capacity at Marris Road is decreased from 2900pcu/hour to 2680.05 pcu/ hour and at Dodhpur road from 2900pcu/hour to 2297.24 pcu/hour due to high and very high levels of side friction respectively. **Table-**5 shows the reduction in capacity of both roads due to side friction. This finding is in conformity to other studies conducted in India and Indonesia (Sulistyono et.al. 2018). These studies highlight a reduction of capacity to the extent of 10-60 % due to different elements of side friction (**Table-**5).

Table-5: Capacity Reduction in Study Region

Location	RSFI	Base Capacity	Actual Capacity	% Reduction in Capacity due to side friction	% Reduction in Capacity including side curb
Marris Road	3679.2	2900	2680.05	10.76%	19.63%
Dodhpur Road	4960	2900	2297.47	20.78%	20.78%

Source: Based on Survey, 2021

Conclusion

The study reveals that the private vehicles have greater contribution in traffic flow (80%) on both the roads as compared to the public transport. The activities which cause main roadside friction (94%) at Marris Road is mainly by the roadside parking and the pedestrian movement making. The activities along Dodhpur road are mainly pedestrian movement roadside parking and vendors, comprising overall 99 percent of the total side friction activities. RSFI calculated to show the magnitude of roadside friction is found to be greater at Dodhpur road (4960) as compare to at Marris road (3679.2). The percentage reduction of the base capacity only due to side friction is greater at Dodhpur road as compared to at Marris Road, thus, it concludes that the roadside frictions have a greater impact on the capacity of road. The availability of the legalized parking area on both the roads, specified area for the hawkers and vendors, and footpath for pedestrian movement can drastically reduce the frequency of roadside friction. Installation of the intelligent traffic monitoring system, regulation on loading and unloading of the passengers by e-rickshaws, redesigning and readjustment of roads, construction of a roundabout at Dodhpur intersection are some of the actions which are required to be implemented on the priority basis.

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SPATIO-TEMPORAL DYNAMICS OF FLOOD SEVERITY USING MULTI-TEMPORAL SATELLITE DATA: A CASE STUDY OF KOSI FLOODS

Dr. Supriya and Dr. Shipra Soni

Abstract

Flood is a natural phenomenon and frequent disaster that occurs in the North Bihar Plain and causes damage to life and property almost every year. The main cause of floods in Bihar is usually known by people to be the shifting and slitting of rivers. The continuous silting has made the rivers shallow and losing their depth, so they are unable to face the forceful rain during the monsoons, which in turn results in breaking their banks and spreading water on the plains. Which is further reflected in the distinctive events like river course change and river capture in the flood plains of Bihar. Since floods increase each year, resulting in loss of life, property, and farm output, it is possible to use a generic approach as an estimate of flood damage. To mitigate flooding, spatial analysis is of paramount importance for the timescale and temporal characteristics of flood-affected areas. The Kosi River is one of the highly vulnerable to flood and is known for its frequent flooding, river course changes, and river-capturing events. The Kosi region faced a devastating flood on August 18, 2008, due to a breech at Kusaha village, which caused not even loss of property and lives but the change in the river course itself. Satellite imagining technology emerged as a powerful tool for the analysis of inundation areas and flood severity in the Kosi flood-prone basin during breech and flood. In order to better understand seasonal and yearly variations in the number of floods and to facilitate emergency response, this research provides an algorithm for mapping precipitation and flood inundation. Hence, the present study made an attempt to analyze the changes in rainfall and severity of flood using multi-spectral-temporal satellite data of the Kosi River basin for the 2008 Flood, Pre-flood (2007) and post-flood (2009) situations. The paper aims to describe thresholding and unsupervised classification methods to determine inundated areas, changes in persistent rainfall, and rising Kosi River water levels.

Introduction

Floods are the most widespread natural hazard that account for most damage and loss of life. They also can have serious secondary impacts on the economy and agriculture. Geographers have studied the complexity of such flood hazards for many years and have made significant contribution to their understanding. Flood is defined as any flow that exceeds the bank full capacity of a stream or channel and flows out of the floodplain, greater than bank full discharge. According to the World Meteorological Organization, a flood as a "(1) Rise, usually brief, in the water level in the stream to a peak from which the water recedes at a slower rate. (2) Relatively high flow as measured stage height or discharge. (3) Rising tide" (WMO, 1992). The magnitude of the floods and their probability of occurrence are strongly connected, although these relationships are regionally specific and depend on climatic conditions and characteristics of river catchment. On 18th August 2008, the eastern embankment of Kosi River was breached near Kusaha village, Nepal, about 12 km upstream of the barrage. At the time of breach, the river flow was below average, considering the same time-period in different years. The water inundated the adjoining villages of Kusha and Haripur (Nepal) immediately and reached Bhimnagar, Birpur (India) within a few hours. In Birpur, flood water rose alarmingly to a height of 5–6 ft within a short time after the breach. Subsequently, the flood water spread over a great extent covering Supaul, Saharsa, Madhepura, Araria and Purnea districts, causing severe damage to life and property.

In fact, after the 18th August breach, the Kosi River has altogether taken a new course, that of the 1930s, as reported by residents near Muraliganj. The Kosi River system is a monsoon-fed river system which has a long history of devastating floods in its lower catchment. After the 1954 floods in Nepal and Bihar, the flow of the Kosi River has been regulated by an embankment, constructed in 1963, on both sides of the river. The 2008 flood happened after breach of a levee on 18 August 2008 near Kusaha in Nepal, 12 km upstream on the eastern embankment of the river. The avulsion abandoned the current river course and the water followed an ancient channel midway through the alluvial fan. This led to inundation of a huge area, devastating the lives of millions of people (UNICEF Report 2008). Kosi River is considered as 'Sorrow of Bihar' since a long time due to its recurring and substantial flooding and repeated change in its course over the years. The change of river course has well documented in British rule. The river has changed its course in a westerly direction and it has laterally moved nearly 150 kilometers (Gole and Chitale, 1966; Wells and Dorr, 1987).

The movement of the river has not been gradual but of avulsive nature (sudden change in river course) originating from a nodal point (Wells and Dorr, 1987). The average avulsion frequency has been recorded as 24 years which is among the lowest in the world compared to 1400 years for the Mississippi river (Slingerland and Smith, 2004). Several paleochannels on the satellite image of the Kosi basin testify the migratory behavior of the river (**Fig. 1**). The river is typically braided in nature and has formed a very large alluvial fan due to a large sediment supply from the Himalaya and a generally aggregational regime. Further complications arise due to (a) very high rainfall in the catchment (1200- 2000 mm in most parts; Sinha and Friend, 1994), and (b) high seismicity in the hinterland causing landslides and large sediment production which eventually fill up the basin. The initial flood control schemes were introduced during late 19th century which included construction of marginal embankments, high dam at upstream section, river training in lower reaches and a series of barrages and canals. However, no consensus was reached and no definitive action could be taken until 1953. A very severe flood in 1953–54 and the subsequent social and political pressure led to the first serious attempts towards flood control the Kosi basin and the formulation of the 'Kosi project' in 1954. This project was primarily aimed at flood control and to provide irrigation for increasing agricultural productivity. The project started in 1959 and the river was diverted through the barrage in 1963. The embankments on both sides have been designed to protect nearly three thousand square kilometers of land in north Bihar and Nepal. Although the embankments have checked the lateral movements of the Kosi, the flooding problem continues in the Kosi basin and the objectives predicted in the Kosi project have been only partially met. Several large floods and frequent breaches in the embankments have continued to occur in the region. In addition, several adverse effects of the Kosi project have been noted viz. drainage congestion and water logging rise of river bed level, and reduction in crop productivity due to reduced silt flux on the floodplains (Ghani, 2001). In the view of above mention facts the present paper attempts to analyze the severity of 2008 Kosi flood and the spatio-temporal dynamics of flood severity of Kosi floods with pre (2007) and post (2009) flooding situation using multi temporal satellite data. It also examine the effectiveness of precipitation.

Study Region

The Himalayan terrain, the Kosi river is formed by the confluence of seven smaller streams, viz. Indravati, Sun Kosi, Tama Kosi, Likhu Kosi, Dudh Kosi, Arun Kosi and Tamar Kosi at different places in China, Tibet and Nepal,

before its entry into the Indian state of Bihar In India, the Kosi river merges with the mighty Ganges near Kursela village, Katihar District, Bihar. Kamla, Baghmati (Kareh) and Budhi Gandak are the major tributaries of Kosi in India, besides many minor tributaries like Bhutahi Balan. The mountain-fed Kosi River has a total basin area of nearly 84,739 sq.km of which only 11,842 sq.km lie within Indian Territory and spans a total length of 730 km from its source to the confluence with the Ganga at Baltara. (Gole and Chitale, 1966; Sinha and Friend, 1994). The Tibetan region of the Kosi basin comprises 22% of the total drainage area and is characterized by high elevation and flat plateau on the leeward side of the Himalaya with many glaciers and glacier lakes (Bajracharya et al., 2007). About 40% of the drainage area of the Kosi basin lies in the Nepal Himalaya and is characterized by alpine and mountainous areas.

The alluvial part of the Kosi basin in the Bihar plains in India comprises 38% of the total drainage area and comprises low elevation and flat plains with high population density (**Fig.** 1). The climate of this region is monsoon sub-tropical. The Kosi region or Kosi division is an administrative unit of Bihar comprising three districts i.e. Saharsa, Supaul and Madhepura. The present study is confined to assess the severity of deluge falling under this region. NASA's Shuttle Radar Topography Mission (SRTM) DEM (Digital Elevation Model) data shows that the topography of Kosi region ranges from 30 meters near the confluence in Ganga River to 89 meters near Kosi Barrage at Bihar – Nepal border.

Objectives

(1) To study interpolated precipitation map of three years i.e. 2007, 2008 and 2009 to understand the rainfall pattern of the study area.

(2) To assess side by side comparison of precipitation and flood intensity and to extract numerical values of the extent of flood in all three study years.

Database and Methodology

Climatic Research Unit (CRU) gridded Time Series data is used for preparing precipitation map. Flood inundation layer for each year was generated using ISRO's multi-temporal satellite datasets (2007 to 2009) comprising of either IRS WiFS (188 meters) / IRS P6 AWiFS (56 meters) / Radarsat ScanSAR Wide / Narrow (100 meters & 50 meters) acquired during the flood season of that particular calendar year are used. The Raster data of flood inundation was downloaded using compatible software and with the help of Kosi region vector data study area masked out.

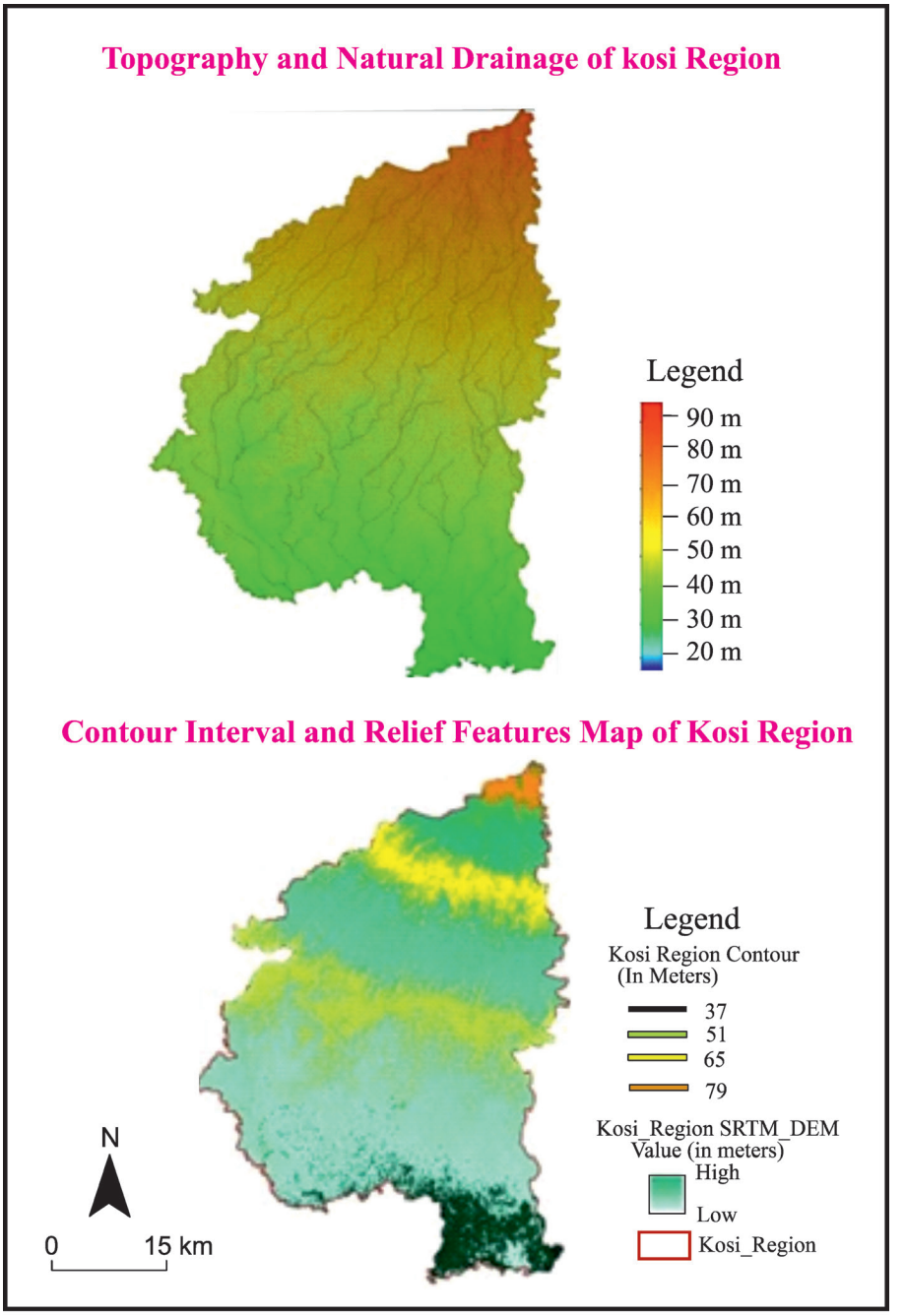

Topography and Natural Drainage of kosi Region
Legend
90 m
80 m
70 m
60 m
50 m
40 m
30 m
20 m
Contour Interval and Relief Features Map of Kosi Region
Legend
Kosi Region Contour
(In Meters)
37
51
65
79
Kosi_Region SRTM_DEM
Value (in meters)
High
Low
Kosi_Region
N
0
15 km

Fig. 1

The flood inundation layer for each year was delineated from satellite data by applying suitable classification technique. The precipitation map was prepared using the interpolation techniques in ArcMAP. Inverse Distance Weighted (IDW) was used to determine the temporal intensity of rainfall in Kosi region. Identification of flood prone area was done using the raster file in Global Mapper by using creating area feature using equal value tool in layer menu. The flood area vector layers were created and then smoothened using smoothing tool. The flood inundated area for each year was calculated and numerical values were noted in sq.km.

Results and Discussion

One of the main purposes of this study was to acquire interpolated precipitation map to understand spatio-temporal pattern of rainfall in Kosi region. The outcome of the rainfall pattern could be well understood (**Fig.** 1, 2 and 3 and **Table-**1, 2, 3 and 4.

Table-1: Changes in Rainfall in Kosi Basin

Rainfall (mm)	2007	2008	2009
Minimum	1220	1238	1114
Maximum	1664	1800	1547

Source: Computed by Authors

Table-2: Changes in Inundated Area of Kosi Region (2007)

Classified Area (2007)	Pixel Count	Area in sq. km	Area in percent
Uninundated area	5833621	5018.37	84.48050341
Inundated area	1071685	921.9	15.51949659
SUM of Area	6905306	5940.27	100

Source: Computed by Authors

Table-3: Changes in Inundated Area of Kosi Region (2008)

Classified Area (2008)	Pixel Count	Area in sq. km	Area in percent
Uninundated area	4868561	4188.17	70.50471
Inundated area	2036745	1752.1	29.49529
SUM of Area	6905306	5940.27	100

Source: Computed by Authors

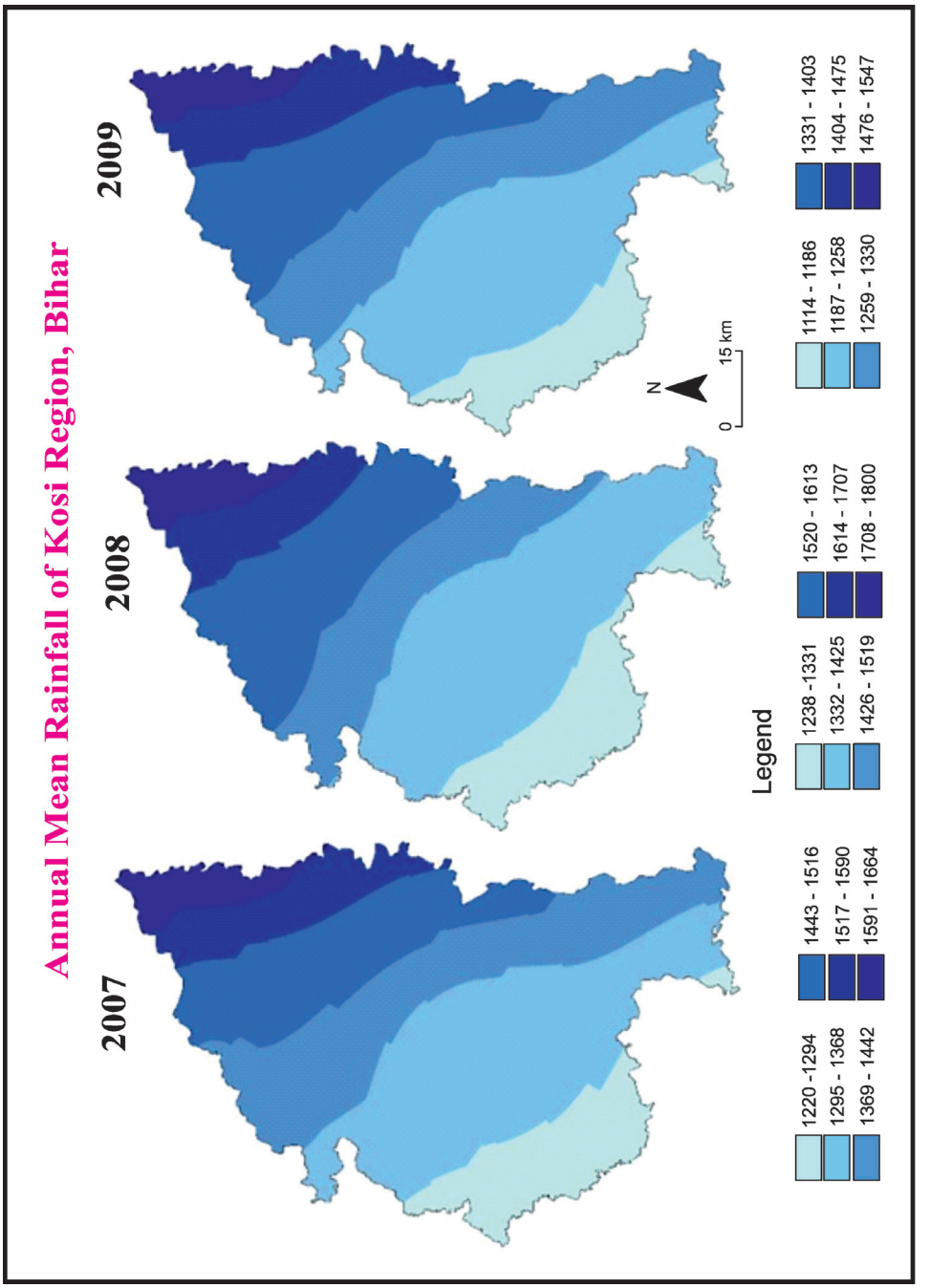

Annual Mean Rainfall of Kosi Region, Bihar
2007
2008
2009
N
0
15 km
Legend
1220 -1294
1295 - 1368
1369 - 1442
1443 - 1516
1517 - 1590
1591 - 1664
1238 -1331
1332 - 1425
1426 - 1519
1520 - 1613
1614 - 1707
1708 - 1800
1114 - 1186
1187 - 1258
1259 - 1330
1331 - 1403
1404 - 1475
1476 - 1547

Fig. 2

Table-4: Changes in Inundated Area of Kosi Region (2009)

Classified Area	Pixel Count	Area in sq. km	Area in percent
Uninundated area	6640423	5712.41	96.16414742
Inundated area	264883	227.86	3.835852579
SUM of Area	6905306	5940.27	100

Source: Computed by Authors

The flood inundation map for all three years was prepared using ISRO's Bhuvan raster data. These raster data contained ISRO's multi satellite sensors ranging from IRS series (WiFS, P6 AWiFS) to microwave satellite data from Radarsat satellites (ScanSAR Wide/ Narrow). The water levels observed at different gauge stations were closely monitored during floods and attempts were made to program the satellite data during peak/near peak positions. The next step was to create flood inundation layer using image processing classification algorithms, water layer was extracted from the satellite data and integrated with the pre-flood river and water bodies layer to derive flood inundation layer. Finally annual flood layer was created. The flood inundation layers generated for different flood waves in a calendar year were integrated to generate the maximum flood inundation extent observed in that year (Fig 1, 2 and 3). The second objective of this paper was to show the flood intensity and extract numerical values to know the extent of flood in study years (2007, 2008 and 2009). This can be analyzed in data obtained through raster data processing obtained from ISRO (**Table-**2, 3 and 4) while the manifestation of deluge could be observed in above processed maps. The processed data of 2007, a year before the famous 2008 flood shows the maximum extent of inundated area of Kosi region was nearly 922 sq kms which was approximately 15.6 percent of the total area under Kosi region. In 2008, the inundated area nearly doubled and in about 1752 sq kms. It accounts around thirty percent of the total Kosi region area. Finally in 2009 which was the post flood year, there was a drastic fall in flood inundation in Kosi region. The flood inundated area reduced to barely 228 sq kms which was less than four percent of total area of the Kosi region. It is also a major fact that 2009 was an El Niño year and it had lesser annual precipitation in comparison of both 2007 and 2008 as well.

Conclusion

In this paper, we have determined the variation of intensity in rainfall with the help of CRU grided time series data, and the spatio-temporal variation is represented

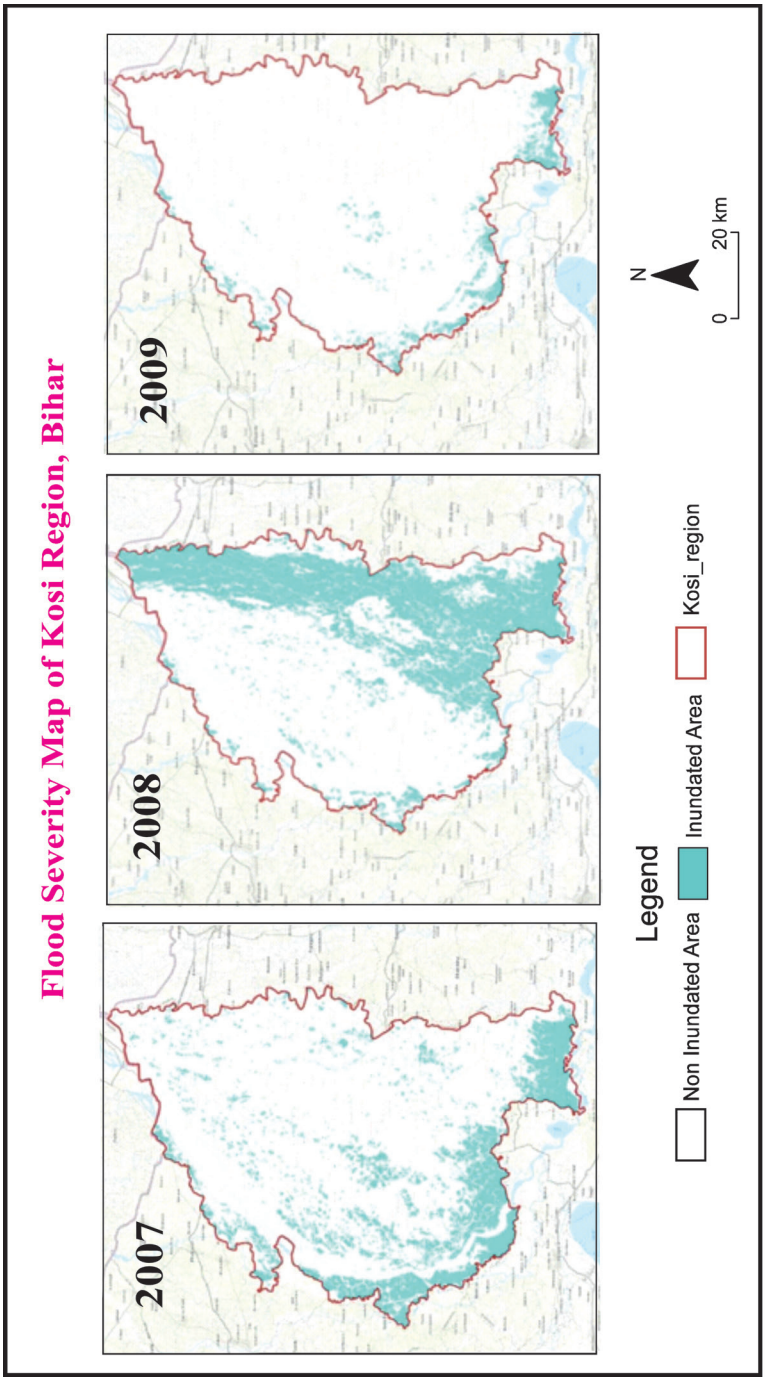

Flood Severity Map of Kosi Region, Bihar
2007
2008
2009
Legend
Non Inundated Area
Inundated Area
Kosi_region
N
0
20 km

Fig. 3

in the rainfall map prepared through ArcMap IDW tools. The result clearly reveals that in 2008, the upper plain of the Kosi River received a higher amount of average mean rainfall (1800mm) than in the post- and pre-flooding years. It was caused by the breach in the upper Kosi basin of Bihar, which helped raise the water level in the entire area and cause flooding. The study also reveals the changes in flood-prone areas with the help of the extraction of flood-inundated areas in Kosi River for the same time period through the analysis of multi-satellite data acquired from different sensors ranging from IRS series (WiFS, P6 AWiFS) to microwave satellite data and Radarsat satellites (Scan SAR Wide/Narrow) data and further converted in pixels to area in Global Mapper by using the Create Area feature. It reveals that approximately 30 percent of the total area was inundated due to floods in 2008; therefore, only 15.52 percent of the area in 2007 and 3.84 percent of the area in 2009 were submerged. It has clearly represented through the flood severity maps that in 2008, the eastward part of the study area was highly inundated, which was changed after 2008 flooding through the westward due to the main channel shifting towards the west and creating a very high flood hazard risk zone. Hence, the combined use of multi-temporal imagery and metrological data analysis achieves the objective of preparing flood severity maps for the study area. The spatio-temporal precipitation data, flood data, and processed maps can be used for the purposes of identification of annual precipitation effectiveness and rainfall pattern in Kosi region threshold area, identification of constantly flooded areas, regulate land use in the inundated areas and spotting safer flood relief shelters. In order to raise awareness among researchers and the scientific community, the possible importance of this research is to include these efforts as part of general flood management measures that do not include structural measures aimed at reducing short-term and longer-term damage. It is also a simple and cost-effective methodology for flood management and mitigation.

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GENDERED PERSPECTIVES OF MIGRATION TO GUJARAT: BEHIND THE NUMBERS

Dr. Harpreet Singh and Ms. Gauri Hanspal

Abstract

Migration is a complex phenomenon with profound implications for individuals and regions. This study explores migration to the state of Gujarat, India, shedding light on the gendered perspectives often overlooked in migration studies. Utilizing data from the Census of India 2011, the research analyzes the volume and patterns of in-migration, emphasizing the role of gender in shaping the demographic landscape of Gujarat. The introduction delineates the significance of migration, differentiating between internal and international migration based on administrative boundaries. It underscores the selectivity inherent in migration processes, driven by diverse factors such as age, marital status, education, gender, socio-economic status, and housing situation. Gujarat's status as a counter-magnet for individuals from economically constrained states is highlighted, with a focus on the megacity of Surat and other districts attracting migrants for varied opportunities. Maharashtra, Uttar Pradesh, and Rajasthan emerge as significant contributors to Gujarat's in-migrant population, playing pivotal roles in shaping migration dynamics. The study aims to uncover the nuanced narrative beneath migration statistics, emphasizing the often-overlooked role of gender. The spatial distribution of male and female in-migrants across different districts of Gujarat further reveals distinct patterns. Key findings highlight a notable gender imbalance in the in-migrant population, with higher female representation, particularly in rural areas. Maharashtra, Uttar Pradesh, and Rajasthan dominate in contributing in-migrants, emphasizing their pivotal roles. The study concludes by emphasizing the importance of considering gender-specific migration dynamics for informed policy interventions that address the diverse needs of both male and female migrants. This research contributes valuable insights for policymakers and scholars seeking a comprehensive understanding of migration dynamics, particularly the gendered perspectives, in the vibrant state of Gujarat.

Introduction

The movement of people within the boundaries of a country, is classified as internal migration whereas the process of movement of people away from national border, is called international migration(Rahul, 2022). The nature of migration process is selective. The selectivity is due to the differences between the individuals aspirations belonging to different groups. The most important differences are related to age, marital status, level of education, gender, socio-economic status, and housing situation. In case of migration selectivity is not only age based but also a gender based specific process(Khan et al., 2016). The role of gender, often relegated to the periphery in migration studies, is a crucial lens through which we can gain a deeper understanding of the social fabric woven by those who choose Gujarat as their destination. Gujarat, a crucible of cultural diversity and economic vibrancy, has become a magnet for individuals seeking opportunities, employment, and a new way of life. It has been reported in many studies that Gujarat is becoming the counter-magnet for the megacity like Mumbai, large number of migrants from the different states, like Rajasthan and Madhya Pradesh, Maharashtra, Chhattisgarh, Uttar Pradesh, Jharkhand, Bihar etc. where economic opportunities are rather limited (Shah and Dhak 2014) are attracted towards Gujarat. Also, the intra-state migration from less to more developed regions increased significantly as a result of increased connectivity and infrastructure within the state (Hirway et al., 2014). According to the census data on migration 2011, nearer to the half of the population of big cities composed of migrants including both the migrants from within the state and outside the state. Surat has the highest percentage of the internal migrants including both migrants from other states and from within the states. Ahmedabad is also one of the important city which attracts migrants. The major migrants sending states are Rajasthan, Uttar Pradesh and Maharashtra. The main reasons of migration that mentioned in the census are work employment and movement due to marriage (Half of the People in Gujarat's Big Cities Are Migrants | Ahmedabad News - Times of India, n.d.). Though there are large number of micro studies focusing on migration in Gujarat but less focus is on the gender-based migration study.

Objectives

The primary objective of this research is to unravel the often-overlooked gendered dimensions within the migration patterns to Gujarat. By delving into the dynamics of population movement, the study aims to shed light on how

gender influences and shapes the intricate narratives of migration. The study also intends to get information about the spatial analysis of migration across different districts in Gujarat.

Study Region

Gujarat is a state in India located on the western coast along the Arabian Sea. Gujarat is surrounded by the Indian states of Rajasthan to the north, Madhya Pradesh to the east, and Maharashtra to the southeast. It also shares international border with Pakistan in the northwest. Gujarat encircles the territory of Daman and Diu along with the Arabian Sea and shares a short portion of its southeast border with the Indian union territory of Dadra and Nagar Haveli. Gujarat has a 992-mile (1,596-kilometer) coastline. Gujarat is the ninth-most populous state, with a population of 60,439,692. The number of males is 31,491,260 and females is 28,948,432 according to the 2011 census data. The population density is 308 persons per square kilometre (800 persons/sq mi), lower than other Indian states. As per the census of 2011, the state has a sex ratio of 918 females for every 1000 males, one of the lowest (ranked 24) among the 29 states in India. In Gujarat, about three-fifths of the population lives in rural areas, however as urban areas have expanded, so the percentage of people living in rural areas has declined. The main concentration of population is in the eastern part of the state, in the plains surrounding the cities of Ahmadabad, Kheda, Vadodara, Surat, and Valsad; the region is both agriculturally productive and highly industrialized. There are also other population centres on the Kathiawar Peninsula, including on the southern shore between Mangrol and Mahuva, in the inland near Rajkot, and along the Gulf of Kachchh near Jamnagar. The population distribution rapidly declines towards the mountainous areas of eastern Gujarat and the northwest Kachchh district. The literacy rate of Gujarat is 79.31%. Gujarati is the official and primary language (Gujarat State Portal | All About Gujarat | Gujarat at a Glance, n.d.).

Database and Methodology

The present study is descriptive in nature. The study is based on the secondary sources of data. The census of India is the major source of information. The analysis of patterns of migration is based on the secondary source of data that is Census of India 2011. The data has been taken from the Migration Table (D series) of the census data and the place of last residence is taken into consideration for migration. Data based on the streams of migration like urban, rural and duration of migration have been carried out. The analysis and graphical representation of data has been done in excel.

Results and Discussions

Gender Disparity in the Volume of In-migrants to Gujarat

According to 2011 census, in total there are about 26.89 million migrants recorded in Gujarat as per their place of the last residence which forms nearly 45 percent of the total population of Gujarat. This all owing to the infrastructural and industrial development in Gujarat. Out of the total enumerated In-migrants i.e., 26,898,286 male in-migrants are 9,994,352 and female in-migrants are 16,903,934 females. In term of percentage males are 37 percent whereas females are 63 percent, suggesting a notable gender imbalance with a higher count of females. The In-migrants coming to rural and urban areas of Gujarat are 49 percent and 51 percent of the total In-migrants. Delving into the urban-rural breakdown, the total In-migrants enumerated in the rural area of Gujarat is 13,098,287, with 3,140,671 males and 9,957,616 females. In rural areas, the gender disparity leans towards females. In term of percentage the females are 76 percent of total migrants coming to rural areas. Conversely, the urban population of 13,799,999 exhibits a different pattern, with 6,853,681 males and 6,946,318 females. This indicates that urban areas attract a higher number of males. Males are dominated in all three basic industries like construction, textile and diamond industry the ratio of female workers is very less in these sectors (Hirway et al., 2014). These observations could be indicative of complex migration patterns, where males may be more inclined to migrate to urban centers for employment or other opportunities, leaving a higher proportion of females in rural settings.

The comprehensive analysis of in-migration patterns to the state of Gujarat delineates intriguing dynamics across various States and Union Territories (States/UTs). At the forefront, Maharashtra emerges as the primary contributor with 24.82% of the total in-migrant reported in the state of Gujarat, a substantial figure amounting to 971,975 individuals. Following closely by the state of Uttar Pradesh which contributes significantly with 23.73% in-migrants. The volume wise number is 929,411. According to a repot whenever a migrant from Uttar Pradesh visited their homes they bring their relative along with them to work in the textile industry the next important industry is diamond industry. Rajasthan, with 19.09%, constitutes another substantial share, which is 747,445 individuals enumerated in Gujarat. Migrants from the tribal areas of Rajasthan like Dungarpur and Banswara migrate to the state of Gujarat for work in constructional sites. Together, these three states form a significant portion, totaling 67.64% of the overall in-migrant population, indicating their pivotal roles as preferred origin place for those seeking

new opportunities, employment, and improved livelihoods. The main industries providing employment to migrants in Gujarat are construction industry, brick kiln industry, diamond cutting and polishing industry, textiles and power looms, and garments, engineering and electrical industries, domestic work, salt pan workers and other informal sectors(42 Lakh Migrants Have Made Gujarat Their Home | Ahmedabad News - Times of India, n.d.). Beyond these leading contributors, Bihar, Madhya Pradesh, Odisha, and West Bengal also play crucial roles in the intricate tapestry of in-migration, contributing to the overall diversity of population movement within the region. The other states are Bihar, Madhya Pradesh and Odisha. The odhiya workers are mainly engaged in the Surat power loom industries (Hirway et al., 2014). The complexity of these migration patterns underscores the interplay of diverse factors such as economic prospects, urbanization trends, and regional developmental disparities (**Fig.** 1 and **Table-**1).

Table-1: Gujarat: Percentage of In-migrants to Gujarat, 2011

State/UT's	Males	Females
Total In-Migrants	55.93	44.07
Maharashtra	46.34	53.66
Uttar Pradesh	64.61	35.39
Rajasthan	48.71	51.29
Bihar	70.28	29.72
Madhya Pradesh	49.37	50.63
Odisha	76.01	23.99
West Bengal	61.07	38.93
Jharkhand	77.33	22.67
Andhra Pradesh	50.91	49.09
Kerala	51.93	48.07
Remaining States/UT's	49.82	50.18

Source: Census of India, 2001

The analsis of in-migration patterns from States and Union Territories (States/UTs) reveals intriguing gender dynamics, showcasing variations in the male-to-female ratio among in-migrants. On an overall scale, in-migrants exhibit a slightly higher representation of males at 55.93%, compared to 44.07% females. Notably, Maharashtra demonstrates a gender distribution leaning toward females,

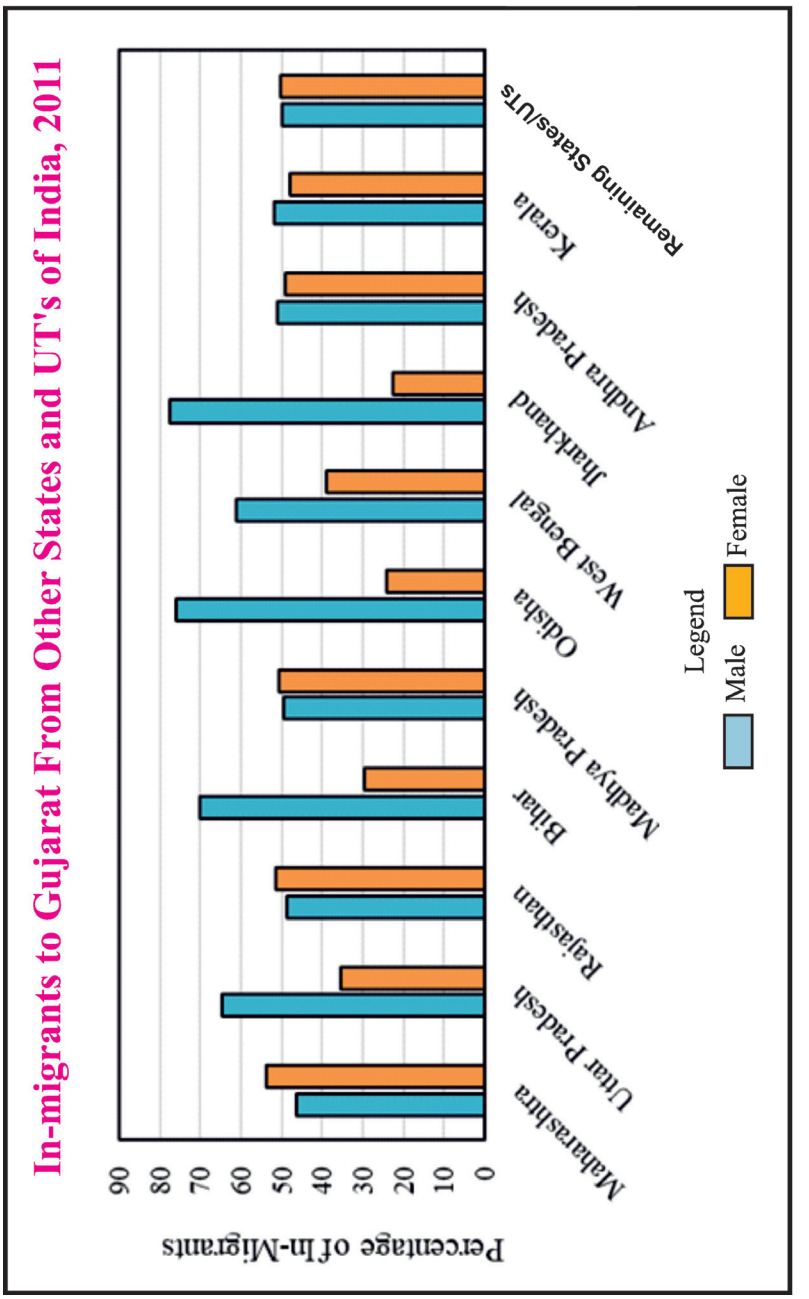

In-migrants to Gujarat From Other States and UT's of India, 2011
Percentage of In-Migrants
0
10
20
30
40
50
60
70
80
90
Maharashtra
Uttar Pradesh
Rajasthan
Bihar
Madhya Pradesh
Odisha
West Bengal
Jharkhand
Andhra Pradesh
Kerala
Remaining States/UTs
Legend
Male
Female

Fig. 1

with 53.66%, while Uttar Pradesh sees a higher male representation at 64.61%. Rajasthan maintains a relatively balanced ratio, with 51.29% females. Bihar presents a significant gender disparity, with 70.28% males dominating the in-migrant population. Madhya Pradesh shows a nearly equal distribution, with 50.63% females. Odisha exhibits a substantial male majority at 76.01%, contrasting sharply with Jharkhand, where females constitute 77.33% of the in-migrants. West Bengal displays a more balanced representation, with 38.93% females. Andhra Pradesh, Kerala, and the remaining States/UTs exhibit fairly equal gender distribution patterns, with minor variations. This nuanced analysis underscores the importance of considering gender-specific patterns in understanding in-migration dynamics, potentially influencing policy considerations related to healthcare, education, and social services catering to the diverse needs of both male and female in-migrants (**Table-**2).

The analysis of In-migration across all the districts of Gujarat provides insights into the gender distribution among in-migrants, revealing distinct patterns in various locales. From the **Table-**2, it is clearly seen that there is dominance of male in-migrants in case of more urbanized districts like Surat, Ahmedabad, and the main reason behind this is the availability of male oriented wok and employment. Surat, with a total of 10,60,934 in-migrants, exhibits a male-dominated influx with 63.99%, whereas females constitute 36.01% of the migrant population. In contrast, Ahmadabad sees a more balanced gender distribution, with 52.38% males and 47.62% females among the total 3,79,097 in-migrants. Vadodara displays a slight female majority at 51.73% among its 1,33,451 in-migrants. Valsad follows a similar trend, with 55.49% males and 44.51% females among its 1,33,422 in-migrants. "Golden Corridor" is the industrialized center of state formed by the districts of Valsad and Vadodara. These are the fastest growing cities in Gujarat, one can see the boom in constructional activities there, lot of construction happening in the real estate & major infrastructure projects are being undertaken by private as well as public sectors, the people migrated here to work in the constructional sites, these districts are also known for their textile and the diamond industry. The women workers didn't get jobs in the large and medium diamond polishing units. They tend to work in the low-profile jobs, in constructional works, cotton fields etc. In the less urbanized area we find the dominance of females the major reason behind this is the marriages (Hirway et al., 2014). Banas Kantha and Sabar Kantha, however, portray significant gender disparities, with a notably higher percentage of females at 76.39% and 75.9%, respectively. The highest gap between male and

Table-2: Gujarat: Spatial Pattern of In-migrants to Gujarat, 2011

Sr. No.	Districts	Total In-Migrants	Males In-Migrants (Percent)	Females In-Migrants (Percent)
1	Surat	10,60,934	63.99	36.01
2	Ahmadabad	3,79,097	52.38	47.62
3	Vadodara	1,33,451	48.27	51.73
4	Valsad	1,33,422	55.49	44.51
5	Kachchh	99,875	61.78	38.22
6	Rajkot	51,812	54.72	45.28
7	Navsari	46,899	53.39	46.61
8	Bharuch	49,637	57.13	42.87
9	Banas Kantha	16,782	23.61	76.39
10	Jamnagar	31,017	54.39	45.61
11	Sabar Kantha	13,696	24.1	75.9
12	Tapi	15,807	31.33	68.67
13	Gandhinagar	24,595	52.39	47.61
14	Bhavnagar	31,014	66.71	33.29
15	Dohad	6,000	15.68	84.32
16	Anand	17,416	48.46	51.54
17	Mahesana	15,237	49.23	50.77
18	Kheda	12,738	45.07	54.93
19	Junagadh	12,489	37.4	62.6
20	Panch Mahals	10,064	33.23	66.77
21	Narmada	5,489	45.92	54.08
22	Surendranagar	6,729	49.3	50.7
23	Amreli	6,595	41.84	58.16
24	Patan	4,258	21.23	78.77
25	The Dangs	1,649	48.61	51.39
26	Porbandar	3,510	41.76	58.24

Source: Census of India,2011

female migrants recorded in the districts of Dohad, Patan and Banas kantha. These all are the bordering districts and share close connection with the bordering states and linked by the social and cultural ties. Bharuch, Jamnagar, and Navsari maintain a more balanced gender distribution, reflecting the diverse patterns in migration. Bhavnagar, on the other hand, stands out with a substantial male majority at 66.71%. Districts like Dohad and Patan exhibit pronounced gender imbalances, with 84.32% and 78.77% females among their respective in-migrant populations.

Conclusion

In conclusion, the study illuminates the intricate dynamics of migration to Gujarat, with a specific focus on gendered perspectives. The state's economic vibrancy and cultural diversity have attracted a significant influx of migrants, both from within and outside its borders. The migration patterns highlight Gujarat as a counter-magnet for individuals from states with limited economic opportunities. Gender disparities in migration are evident, with a higher representation of females in the overall In-migrant population. Urban areas, particularly districts like Surat, witness a male-dominated influx due to the availability of male-oriented employment. Conversely, less urbanized districts, especially those bordering other states, exhibit a notable dominance of females, often driven by marriage-related migration. Maharashtra, Uttar Pradesh, and Rajasthan emerge as primary contributors to Gujarat's In-migrant population, collectively playing a pivotal role in shaping migration dynamics. Further research and targeted studies on gender-specific migration dynamics can provide deeper insights for more refined policy interventions in the future.

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BLOCK LEVEL DISPARITY OF HEALTH CARE FACILITY AND THE PERFORMANCE OF RURAL HEALTH CARE OF NORTH BENGAL, INDIA

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Abstract

Health is one of the determining factors that can expedite the process of social and economic development of the nation. The general health condition of the people of an area is indicative of the quality of the health care facilities available in that area. The present study strives to analyse different dimensions of health care facilities to find out the status of health care system of North Bengal, India and assess the performance of the rural health care units. To do so, Health Care Facility Index (HCFI) has been measured to appraise the overall health care condition of North Bengal. The analysis estimates the efficiency of the healthcare system at block level using data of census 2011, district statistical hand book 2014 and State Bureau of Health Intelligence, Govt. of WB 2016-2017. The English Bazar block of Malda district has shown the height HCFI and Goalpokhar-I of North Dinajpur shows the minimum level of HCFI. There is a substantial difference in performance between these two blocks, resulting from inadequate utilization of available health care resources. The study also identifies complementarities of private health care resources and the role of other factors, such as Health Care Institution Population Ratio (HCIPR), Bed Population Ratio (BPR), Doctor Population Ratio (DPR), Doctor Health Care Institution Ratio (DHCIR) and Bed Health Care Institution Ratio (BHCIR). The results suggest a need for better utilization of budgetary resources to increase health infrastructure and manpower to improve the quality of rural healthcare through training and better management of resources in order to overall performance of the rural healthcare systems in North Bengal.

Introduction

"Health is a condition of complete physical, mental, and social well-being, not only the absence of sickness or disability," (World Health Organization, 1948). This definition explains the significance of health, which is seen as a fundamental human right and a key indication of human growth. In recent years, there has been

renewed emphasis on efficiency in resource utilization in the healthcare sector. A number of studies have focused on the overall performance of the healthcare system and its impact on health outcomes (Murray & Frenk 1999; World Health Organization [WHO] 2000). Some notable studies, for instance, have concentrated on hospitals, nursing homes, Health Maintenance Organizations (HMOs) and district health authorities (Wang, (1999); Sankar & Kathuria 2004). India had made remarkable progress in the field of health. The first important initiative was made in 1943, by Health Survey and Development Committee Report and known as Bhore Committee (KPMG and ASSOCHAM, 2011). It was a detailed plan for healthcare in the country. The initiatives' list included the adoption of a National Health Policy in 1983, the 73rd and 74th Constitutional Amendments devolving power to local institutions in 1992, the National Nutrition Policy in 1993, the National Policy on Indian System of Medicine and Homeopathy and Drug Policy in 2002, introduction of a first health insurance schemes for poor people in 2003 and the inclusion of health in the Common Minimum Program of Government in 2004.

In order to improve the National Health System of India it is therefore necessary to evaluate and assess the health services in terms of quantity, quality, cost and sustainability (Capolongo et al. 2016b, 2015a). Moreover, most important aspects is the adjusting service delivery structures to meet the health needs of the population in terms of quantities and modalities of networked, affordable and sustainable evidence based services (Buffoli et al. 2015) and modernizing outdated structures. Currently India has 0.6 beds every 1,000 inhabitants. This scenario is worsened by the scarcity of architectures for health and support staff that leads to have 50% of beds in the public health sector and 30% in the private one not utilized totally. Nevertheless, the situation has, however, slightly improved by NRHM, founded by 85% the Union and the remaining 15% by the states, which aims to bring its action in rural areas strategic, engaging more than 800,000 workers paid according to the performances Capolongo S, B. M. (2015a). The public health is mainly guaranteed by primary levels, with differences between rural and urban areas; in urban areas there is a double level system: a Basic Health Post for few thousand inhabitants and a Health Centre Urban, or Urban Family Welfare Centre, for 100,000 people attached with a general hospital. Instead, in rural areas there is a triple level system: a Sub-Centre for 5,000 inhabitants manages by two professionals (a man and a woman); a Primary Health Care Centre for 30,000 people with medical and paramedical staffs; a Primary Hospital with 30 beds per 100,000 inhabitants and some basic specializations (WHO, India 2012). The last cases include primary care services, which mean that they are specialized, mainly, in vaccinations,

prevention of malnutrition, pregnancies, postnatal care and treatment of common diseases. The public health infrastructure in West Bengal area is wide covering even in the remotest villages. As HOPE Annual NGO Report reported, there are 9 Medical College Hospitals, 16 District Hospitals, 45 Sub divisional Hospitals, 346 Community Health Centers, 922 Primary Health Centers and 10.356 Sub-Centers across West Bengal (HOPE, 2014). More recent data, by Ministry of Health and Family Welfare, estimate that there is a rise in health Infrastructure: 13,186 Sub-Centers, 2,166 Primary Health Center and 541 Community Health Center. However, the level of welfare seems to be very poor in the entire region (Ministry of Health and Family Welfare, 2015). The healthcare system has a primary healthcare network, a secondary care system comprising district and sub□divisional hospitals and tertiary hospitals providing specialty and super specialty care. Each of the nineteen districts is coordinated by a Chief Medical Officer of Health (CMOH), together with Deputy and Assistant CMOHs, whose responsibility is to manage the primary health care and to ensure the effective implementation of the various medical, health and family welfare programs (Rebecchi, 2018).

The secondary level hospitals are managed by medically trained Superintendents, who directly report to the CMOH, all the useful information and take part into a hospital management committee. In addition, there is the Block Medical Officer, who is responsible for providing services, monitoring and supervising the primary health centres and health program implementation. The third level hospital is referred by two levels before; its specialist care needs to be identified and then patients can be directed to specialized departments. West Bengal Health Service provides the health care professionals for the state wide infrastructure, while Medical Education Service employs teachers at the training institutions (Office of the Registrar General and Census Commissioner, 2011). In general, the community based primary healthcare services have been formulated with the objective of bringing an overall improvement in the urban health scenario in West Bengal; 62 urban local bodies have completed training of honorary health workers. Ministry of Health and Family Welfare of the Government of West Bengal is responsible for healthcare administration in the region. The program budget for two years (2020-2021) was around ₹11,280 crore (US$1.4 billion, Ministry of Health &Family Welfare, West Bengal, 2022). The current study aims to examine the health-care facility system in the North Bengal districts of West Bengal on a block wise to see the disparity among the block in terms of health care facility and their performance.

Objectives

(1) To determine the block wise disparities in health care facilities in all Districts of North Bengal.

(2) To assess the block wise performance of Rural Health Care Facilities of North Bengal.

Study Region

North Bengal is a region located in the northern part of the Indian state of West Bengal. It is renowned for its breath-taking natural beauty, varied flora and wildlife, and extensive cultural history. The region is bounded by the lofty Eastern Himalayas in the north, and it shares its borders with countries like Nepal, Bhutan, and Bangladesh. The study area extends from approximately 24°40'20"N to 27°13'N latitude and 87°45'50"E to 89°53'E longitude. North Bengal consists of eight districts, namely Cooch Behar, Alipurduar, Jalpaiguri, Kalimpong, Darjeeling, Uttar Dinajpur, Dakshin Dinajpur, and Malda. It is characterized by a division into two distinct geographical zones. The northern part is classified as the Sub-Himalayan Zone, while the southern part is composed of sediment and debris brought by rivers descending from the slopes of the Himalayas. Consequently, except for the northern fringe, the entire region consists of plains. Numerous rivers, including the Teesta, Torsha, Jaldhaka, Raidak, Sankosh, Mahananda, Punarbhaba, Atrai, and Kulik, drain the study area. The climate in the study area is characterized by hot, humid conditions and heavy rainfall, although the northern hilly areas experience a cooler climate. The region is also home to diverse species of fauna and flora. This region is characterized by its diverse physical and socio-cultural aspects, displaying notable variations in economic and human development across the districts. It covers an area of 21,855 square kilometres, which accounts for 24.62% of the state's geographical area. According to the 2011 census total population of the region were 17291050, which were 18.83% of the state's total population, with a higher concentration of Scheduled Caste (SC) and Scheduled Tribe (ST) populations, as well as a significant influx of immigrants. The region has a total of 462 healthcare institutions with 13949 beds and 1628 registered doctor's facilities only, which is not sufficient to cater to the present population.

Materials and Methods

The present study is fully based on secondary database, gleaned from District level Census report, 2011, State Bureau of Health Intelligence,

Govt. of WB 2016-2017 and District Statistical Handbooks, 2014 of eight districts i.e., Alipurduar, Cooch Behar, Darjeeling, Jalpaiguri, Kalimpong, Malda, North and South Dinajpur of North Bengal. In order to compute the Health Care Facility Index, block level total population, numbers of health care institutions (both public and private), total number of beds and total number of doctors have been collected for total 69 blocks of North Bengal region. All the Hospitals including Rural Hospitals, Block Primary Health Centres (BPHC), Primary Health Centres (PHC), other clinical Departments of Govt. of West Bengal including State Govt. Undertakings, Local Bodies, and Govt. of India including Central Govt. undertaking, N.G.O. / Private Bodies (Nursing Homes) have been considered as Health Care Institutions (HCI). Total number of beds and total number of Doctors of each C. D. Blocks have been collected from District Statistical Handbooks of Eight Selected District, 2014 (Census, 2011; District Statistical Handbooks, 2014). The Health Care Facility Index (HCFI) is a combination of five selected dimensions. These dimensions have been calculated on the basis of above-mentioned data for each block it includes – Health Care Institution Population Ratio (HCIPR), Bed Population Ratio (BPR), Doctor Population Ratio (DPR), Doctor Health Care Institution Ratio (DHCIR) and Bed Health Care Institution Ratio (BHCIR). The HCIPR dimension/indicator is used to find out the number of health care institutions to serve one lakh population in the region. Bed Population Ratio or BPR is used to measure the number of beds available per 10000 populations in the study area. On the other hand, the Doctor Population Ratio or DPR helps to indicate the number of doctors per one lakh population in the region. The DHCIR dimension/indicator is used to find out the number of doctors per health care institution and the last dimension i.e., Bed Health Care Institution Ratio or BHCIR is used to measure the number of beds per health care institution in the study area. The following formulas have been incorporated to measure the above-mentioned dimensions/indicators for health care facility system-

$$HCIPR = \frac{Health\,Care\,Institution\,(HCI) \times 1,00,000}{Total\,Population} \tag{1}$$

$$BPR = \frac{Number\,of\,\,Beds\,in\,HCI \times 10,000}{Total\,Population} \tag{2}$$

$$DPR = \frac{Number\,of\,\,Doctors\,in\,HCI \times 1,00,000}{Total\,Population} \tag{3}$$

$$DHCIR = \frac{Number\ of\ Doctors\ in\ HCIs}{Number\ of\ HCIs} \quad (4)$$

$$BHCIR = \frac{Number\ of\ Beds\ in\ HCIs}{Number\ of\ HCIs} \quad (5)$$

After calculating the ratio of the five variables the values of each indicator are first normalized to an index value of 0 to 1, using Dimension Index formula. With the actual value for a given block, and the overall maximum and minimum, the dimension (indices) value for each metric is calculated as:

$$HFCI = \frac{A_i - m_i}{M_i - m_i}$$

Where,

d_i = Dimension index of ith dimension,

A_i = Actual Value of ith dimension,

M_i = Maximum value of ith dimension and

m_i = Minimum value of ith dimension.

Now, in order to measure the Health Care Facility Index for each block of North Bengal the composite index has been calculated using the five mentioned indicators. The formula used in the UNDP Goal Post technique uses minimum and maximum values that have been specified. However, in this technique, we have taken into account the observed minimum and maximum values for each dimension. According to Goel and Sharma (2017), the dimension's value (*di*) is between *0* and *1*. The success of the C.D. Blocks/Municipal Corporation is predicted to be higher in the i^{th} dimension by a high dimensional value (*di*). Considering all the five dimensions, i^{th} C. D. Block can be represented by a point (d_1, d_2, d_3) in three-dimensional Cartesian space like $0 \leq d_1, d_2, d_3 \leq 1$. In the three-dimensional Cartesian space, the point '*0*' would indicate the worst condition whereas '*1*' would indicate the ideal or perfect condition. HCFI is measured by the normalized inverse Euclidean distance of the point (d_1, d_2, d_3) from the best or perfect point.

$$HFCI = 1 - \sqrt{\frac{(1-d_1)^2 + (1-d_2)^2 + (1-d_3)^2 \ldots}{5}}$$

The value of HCFI ranges from '*0*' to '*1*'. The value '0' indicates the worst health care facilities system and '*1*' indicates the Perfect health care facilities. On the basis of the HCFI values, the C. D. Blocks of North Bengal region are classified into three categories. The range $0.5<HCFI\leq1$ indicates 'High' or 'Very Good' health care facility system; $0.2<HCFI\leq0.5$ indicates 'Moderate' health care facility system and $0<HCFI\leq0.2$ 'Low' or 'Poor' health quality facility system.

Result and Discussion

Health Care Institution Population Ratio (HCIPR): The population serviced by a single healthcare facility in the research area is determined using this dimension. In this dimension, Matigara C.D. Block of Darjeeling District is in the best position, while Goalpokhar-I of North Dinajpur District is in the worst. Bed Population Ratio (BPR): The bed population ratio is used to calculate how many beds are available for every 10,000 people. In North Bengal region, the greatest BPR is found in the Kurseong block of Darjeeling District, while the lowest BPR is observed in Goalpokhar-I of North Dinajpur District (**Table-**1).

Table-1: Health Care Facility Dimensions of North Bengal

Dimensions	Goalposts of the Dimensions			
	Maximum Value		Minimum Value	
Health Care Institution Population Ratio (HCIPR)	10.17	Matigara	0.61	Goalpokhar I
Bed Population Ratio (BPR)	40.50	Kurseong	1.23	Goalpokhar I
Doctor Population Ratio (DPR)	55.61	English Bazar	0.99	Itahar
Doctor Health Care Institution Ratio (DHCIR)	9.54	English Bazar	0.25	Rangli Rangliot
Bed Health Care Institution Ratio (BHCIR)	78.25	Darjeeling Pulbazar	8.00	Tufanganj II

Sources: (1) District Statistical Handbooks, 2014, Census, 2011;

(2) Computed by the Authors

Doctor Population Ratio: The number of doctors per lakh of people in the study region is indicated by this dimension. According to the Planning Commission of India's 2011 report, the doctor population ratio should be 1 doctor per 1000 people (**Fig.** 1). However, in North Bengal as a whole, none of the blocks can reach this crucial DPR threshold. The lowest DPR is found in Itahar block of

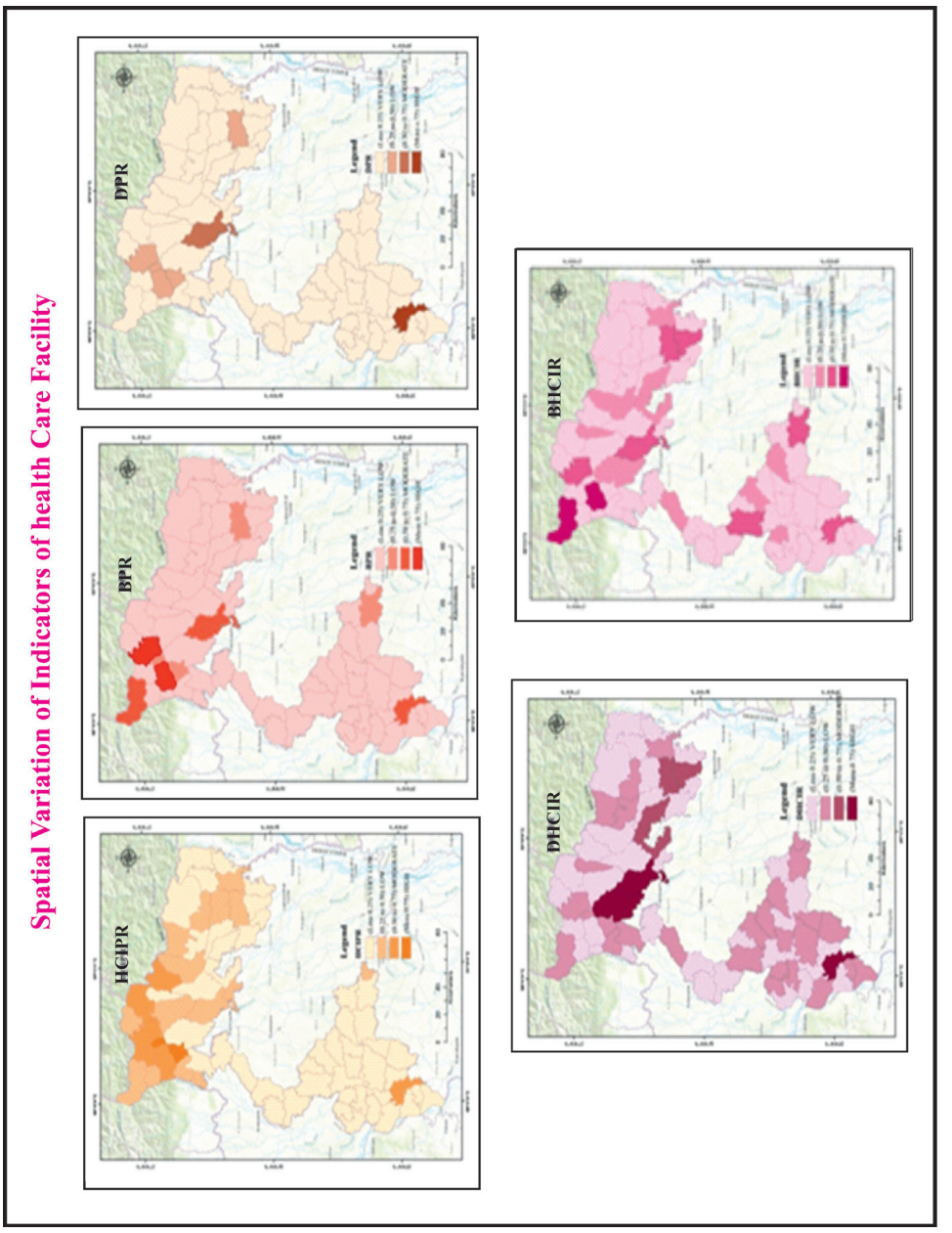

Spatial Variation of Indicators of health Care Facility
DPR
BPR
HGIPR
BHCIR
DHCIR

Fig. 1

North Dinajpur District, while the highest DPR is observed in English Bazar block of Maldah District (**Fig.** 1).

Doctor Health Care Institution Ratio: To determine the number of doctors per healthcare facility in the study area, this dimension is used. After analysing the dataset, it is observed that Rangli Rangliot block of Darjeeling District has the poorest DHICR conditions in the entire North Bengal, whereas English Bazar C.D. block of Maldah District has the maximum number of doctors per institution.

Bed Health Care Institution Ratio: In the study area, this dimension is used to calculate the average number of beds per healthcare facility. The more beds in a hospital means the better for the local people and shows the better healthcare facilities. Tufanganj II in Cooch Behar District has the minimum number of beds per institution whereas Pulbazar in Darjeeling District has the maximum number of beds per institution.

Health Care Institution Population Ratio: This indicates Health Care Institution Population Ratio which is one of the five main indicators of the Health Care Index. Based on the ratio of the HCIPR it is observed that Matigara block of Darjeeling district is in the top with index value 1 and Goalpokhar-I of North Dinajpur district has the lowest index value of 0. Based on the index values all the blocks have been categorized in four parts. Very low having the index value of 0 to 0.25, low 0.25 to 0.50, moderate 0.50 to 0.75 and last one is high more than 0.75 value. The map revels out of the total 68 blocks 46 blocks are comes under very low category which is 67.64 percent of the total block of the entire region all the blocks of Uttar Dinajpur and Dakshin Dinajpur. Low HCIPR has been recorded in 15 blocks out of 69 and it consists of 22.06 percent. Rest 7 blocks has been recorded as moderate HCIPR which comprise 10.29 percent of the total blocks and out of the 7 blocks 5 are from Darjeeling district which shows that Darjeeling district has the good health care institution as per their total population. High HCIPR is recorded in Matigara block which is again in the Darjeeling District. So, the map indicates that with in the north Bengal part out of the 8 district only Darjeeling district has the proper population and health care Institution ration, the main reason behind is that the biggest city of the north Bengal Siliguri. Siliguri has a quit large number of the private health care institution as the population is high of the city and the hinterland of the city also huge. There is few private super-speciality Hospital also functioning.

Bed Population Ratio: The bed population ratio is used to calculate how many beds are available for every 10,000 people. In North Bengal region, the greatest

BPR in the Kurseong Block of Darjeeling District, while the lowest BPR is observed in Goalpokhar-I block of the North Dinajpur District. The BPR ratio has been normalized based on the dimension index prescribed by UN in the HDI index. All the dimension index values of the BPR is categorized in four parts. Very low index value having less than 0.25, low (0.25 to 0.50), Moderate (0.50 to 0.75) and High more than 0.75 index value. The maps revels that out of the 68 blocks of North Bengal 61 come under very low BPR index which comprises 89.70 percent of the total blocks. Rest 10 percent are from the three different categories. Balurghat block of South Dinajpur, Cooch Behar- I block of Cooch Behar District and Matigara block of Darjeeling district shows low BPR index which comprises 4.41 percent of the total number of the blocks. Moderate BPR index has been found English Bazar block of Malda District, Jalpaiguri Sadar of Jalpaiguri District and Pulbazar block of Darjeeling district. All the six blocks are very close to their district town and some blocks surrounded the district town because of that the BPR index is much higher from the other blocks. Kalimpong Block of newly formed Kalimpong district and Kurseong block of Darjeeling district has the highest value in terms of the BPR index and both fall under the high BPR.

Doctor Population Ratio: The number of doctors per lakh of people in the study region is indicated by this dimension. According to the Planning Commission of India's 2011 report, the doctor population ratio should be 1 doctor per 1000 people. However, in North Bengal as a whole, none of the blocks can reach this crucial BPR threshold. The highest DPR in North Dinajpur District is in Itahar block, while the lowest DPR is in English Bazar in Malda District. From the map of DPR it is observed that 62 blocks out of 69 blocks of North Bengal is under very low (<0.25) category which is comprise 91.17 percent of the total blocks. Only four blocks fall under low (0.25-0.50) category. Jalpaiguri Sadar block of Jalpaiguri district comes under moderate DPR and English Bazar block of Malda district has the high DPR in the entire North Bengal which shows the actual condition of the health care facility.

Doctor Health Care Institution Ratio: To determine the number of doctors per healthcare facility in the study area, this dimension is used. After analysing the dataset, we have discovered that Rangli Rangliot in Darjeeling District has the poorest conditions in North Bengal, whereas English Bazar C.D. Block in Maldah District has the maximum number of doctors per institution. DHCIR ratio again used for the dimension reduction and the values of the dimension index has been categorized in four categories similar to the other dimension as very low, low, moderate and high with the same value rage of the index value to compare with the other indicators and

based on the dimension index value the map has 0 been prepared. Bed Health Care Institution Ratio (BHCIR): In the study area, this dimension is used to calculate the average number of beds per healthcare facility. The more beds a hospital has, the better off the local healthcare facilities are. Tufanganj II in Cooch Behar District has the lowest Bed per health care institution while Pulbazar in Darjeeling District has the highest beds per health care institution (**Fig.** 2).

The map revels that 35 blocks out of the 69 blocks of North Bengal have fall under the category of very low index (<0.25) which indicates 51.47 percent. 27 blocks out of the 68 blocks of the North Bengal are comes under the low (0.25-0.50) category as per the dimension index which comprise 39.70 percent and Moderate DHCIR is observed only in four blocks and all the four blocks are from Cooch Behar District. High (>0.75) DHCIR has been observed only in the rest 3 blocks out of the three 2 from Jalpaiguri District and one from Malda District. From the calculated ratio of the bed per health care also go through the process of the dimension reduction using the dimension index to compare with the other dimension of the health care facilities and the dimension index has been categorized in to the four category, very low (<0.25), low (0.25-0.50), moderate (0.5-0.75) and high (>0.75). Best on the dimension index value the map has been prepared. From the map it is observed that very low index has been found among 50 blocks out of the 69 blocks which comprises 73.53 percent of the blocks. Ten blocks out of 68 have fall under low BHCIR index which comprise 14.70 percent of the total blocks. Moderate BHCIR index is observed in the 8 blocks and only Pulbazar block of Darjeeling district has the highest number of beds per health care institution The above map (**Fig.** 2) indicates the healthcare facility of North Bengal. Similar to the other indices health care facility also categorised into four categories based on the index value which various from 0 to 1. Out of 69 blocks 52 blocks have shown the very low health care facility (less than 0.25) which is 75.36 percent of the total blocks of North Bengal. After calculating the district level health care as a whole it shows the worse condition in Malda and Uttar Dinajpur district are really in a very poor condition followed by the Dakshin Dinajpur and Darjeeling district has the better health care facility among the eight districts of North Bengal followed by Jalpaiguri and Cooch Behar. Low health care facility (0.25 to 0.50) has been observed among the 15 blocks out of 69 which comprises 21.73 percent of overall blocks. Out of the 15 blocks 5 blocks from Cooch Behar which is one third of the total, 3 block from Darjeeling, 2 each from Alipurduar and Dakshin Dinajpur. There is not a single block from Malda district in the low health care facility.

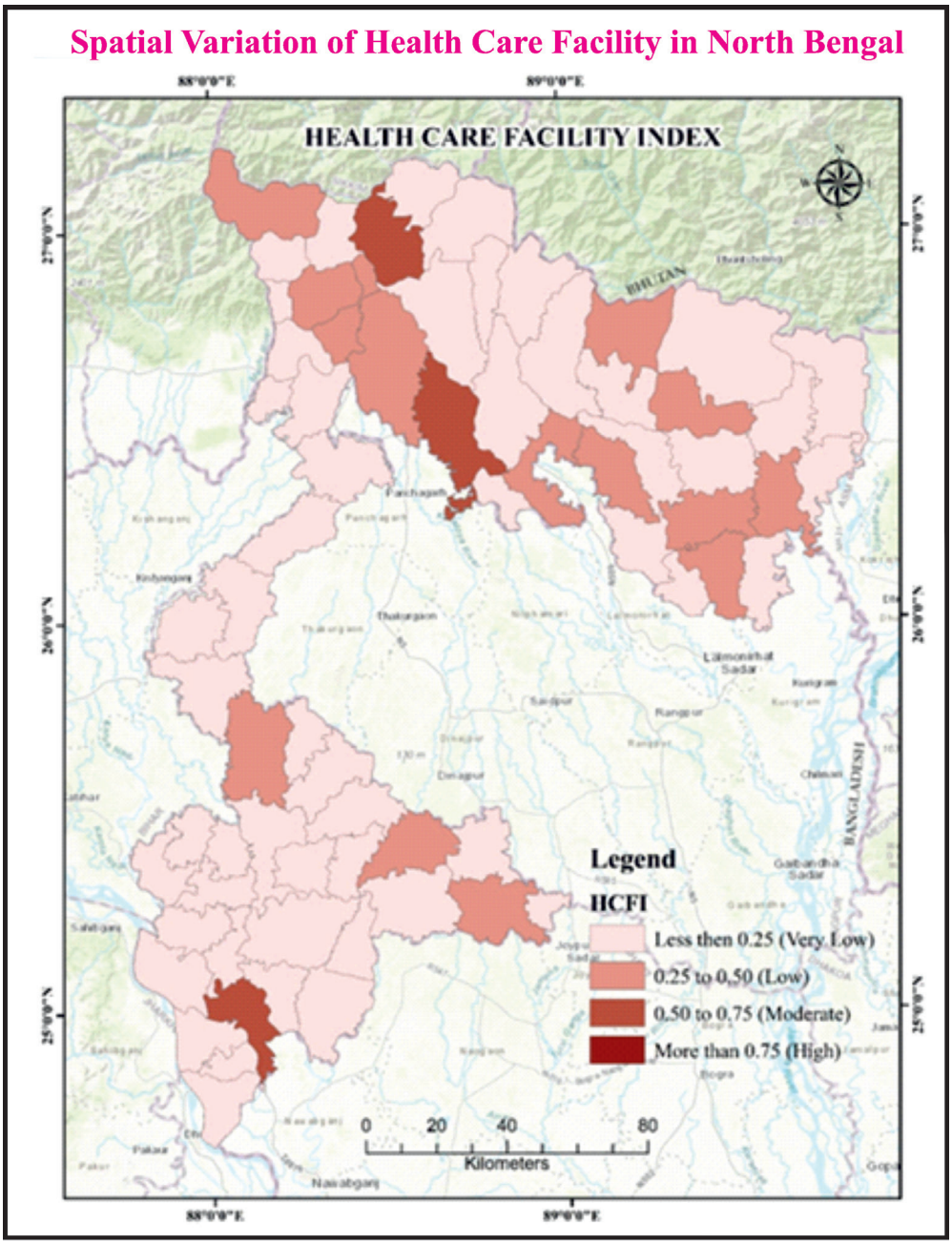

Spatial Variation of Health Care Facility in North Bengal
HEALTH CARE FACILITY INDEX
BHUTAN
BANGLADESH
Legend
HCFI
Less then 0.25 (Very Low)
0.25 to 0.50 (Low)
0.50 to 0.75 (Moderate)
More than 0.75 (High)
0 20 40 80
Kilometers

Fig. 2

Only 3 blocks out of the 69 blocks of North Bengal are fall under the moderate health care facilities (0.50 to 0.75) which comprises 4.34 percent. These three blocks are from three districts, Kalimpong I (0.54) block from Kalimpong district, Jalpaiguri Sadar Block (0.59) of Jalpaiguri district and English Bazar (0.65) of Malda District are under this category. There is no single block has found with high health care facility with more than 0.75 index value which show the real face of the health care facility of the region (**Table-**2).

Table-2: Dimension for the Performance of Rural Health Care Unit in North Bengal.

Dimensions	Goalposts of the Dimensions			
	Maximum Value		Minimum Value	
Bed Turn- Over Rate (BTR)	690.2	Kaliachak-III	13.9	Rangli Rangliot
Bed Occupancy Rate % (BOR)	460.5	Raiganj	6.1	Tapan
Average Length of Stay (ALS)	5.7	Falakata	0.2	Harirampur
% of Deliveries to Admission	47.2	Kaliachack-I	3.7	Alipurduar-II
Emergency Admission Rate %	139.4	Karandighi	0.1	Madarihat
% Of Imaging and Electro Medical Tests Total of IPD & OPD	5.6	Kurseong	0	In most of the block do not have the facility
% Of Laboratory Test to Total IPD & OPD	287	Madarihat	0	In most of the block do not have the facility
% Of Patient Referred Out to Total Discharge Patient	87.1	Falakata	6	Chanchal-II

Source: State Bureau of Health Intelligence, Govt. of WB 2016-2017

Performance of Rural Health Care Units

There are several ways for the assessment of the performance of the health care facilities but in the study simply few parameters have been taken into consideration which is given by the government in their report. For assessing the health care facility here Bed Turn over rate, Bed Occupancy Rate, Average length of stay in hospital, outpatient per day, percentage of deliveries to admission, percentage of emergency admission, percentage of imaging and electro medical test, percentage of laboratory test, and percentage of patient referred to the other hospital these

nine parameters has been taken into consideration. The information related to the performance of rural health care facilities have stated. Bed Turn Over rate (BTR) is maximum in Kaliachak-III (690.2) block of Malda District and Minimum in Rangli Rangliot Block (13.9) in Darjeeling District which indicates the number of patients treated per bed in the specific year (2016-2017) is maximum in Kaliachak-III as compare to the other block of North Bengal. The Bed Turnover Rate is a measure of productivity of Hospital beds. Out of the eight districts of North Bengal, Malda (318.65) is in the 1st rank in BTR followed by Jalpaiguri (168.66) and North Dinajpur (157.42) and lowest BTR is observed by the Kalimpong district (20.63) as Kalimpong is a newly formed district with low population and a smaller number of rural hospital and other health care facilities. Hospital Bed Occupancy Rate means the number of beds occupied for the treatment of the patient divided by the total number of beds over a specific year multiplied by 100. So, in terms of the BOR Rajganj block (460.5) of Jalpaiguri district is in the first rank followed by Nagrakata (445.5) of same district, Kaliachak-III (267.1) and Manikchak (243.1) of Malda district which indicates the patients pressure is very high in these blocks whereas Tapan (6.1), and Banshihari (8.9) block of South Dinajpur show the very low Bed Occupancy Rate as the health care facility is not good of these block so they prefer to go other hospital and the number of bed and hospital in this block also very few in number.

Average length of stay in hospital is another important parameter to assess the performance of health care facility. Average length of stay is mainly depended on the facility and care provided by the health care unit like number of beds, availability of doctors and admission facility and more over to deal with little complicated illness. Average length of stay is maximum in Falakata block (5.7) of Alipurduar district followed by Kalimpong-I and Gorubathan block of Kalimpong district and minimum length of stay in hospital has been observed in Harirampur block (0.2) of South Dinajpur. Percentage of the patient taken admission of delivery is one om the other important parameters of the study. It is observed that Kaliachak-I block of Malda district has the highest percentage of admission related to delivery (47.2%) followed by Chopra (43.9%), Raiganj (41.50%) block of North Dinajpur district (Appendix-3). Although the health care facility of these blocks are not good as these blocks fall under very low health care facility (**Fig.** 2) but due to population pressure the admission percentage is high. On the other hand, Kalimpong-II and Garubathan block has the lowest percentage of admission related to delivery. District wise Malda is in the height rank followed by North Dinajpur main reason behind it

as per the 2011 census birth rate and growth rate of population in high in these two districts of North Bengal. Similarly in terms of the emergency admission in health centre is maximum in these two districts. Karandighi block of North Dinajpur is high in terms of emergency admission in hospital followed by Harischandrapur-I and Raiganj block and minimum percentage of emergency admission has reported in Madarihat block (0.1%) followed by Cooch Behar-I block. Percentage of Imaging and Electro Medical tests are very low in all the blocks of North Bengal, in Alipurduar district only Falakata has reported 0.6% of imaging and eletro medical test and rest other blocks hospital do not have this kind of facilities. Similarly in Cooch Behar, North Dinajpur and South Dinajpur district reported one hospital each with this kind of facility. So the study shows that imaging and electro medical test is not much available in the rural hospital of north Bengal for this service people has to depend on the district of subdivisional hospital. Percentage of Laboratory test also shows the similar type of result but as compare to the imaging and electro medical tests laboratory test is quite higher. Percentage of laboratory test is maximum in Madarihat block of Alipurduar district as Madarihat block hospital is the only hospital in the entire block so the pressure is huge and on the other hand Cooch Behar-II block is nearer to the district hospital so most of the people goes to district hospital than the rural block hospital so it recorded the minimum laboratory test and there are so many blocks shows zero value which mean the imaging and laboratory test facility is not there in those blocks. Percentage of patient refer to the other hospital to discharge patient indicates that height refer percentage is found in Kalimpong district followed by Alipurduar district and lowest refer rate is observed in Malda district. Kalimpong -II and Garubathan has the maximum percentage of refer to the other hospital, the main reason to refer the patient is lack of medical facility in these blocks as per the health care facility map (map3) shows that both the block fall under the very poor category in terms of health care facility.

Conclusion

This paper has attempted to show the health facilities and challenges in North Bengal where the problem of providing effective health care services to the majority of its citizens has become an impossible task. Rural health services which form the backbone of public health system, is lacking in basic infrastructure, staff and essential medicines. The sufficient manpower is an important prerequisite for the efficient functioning of the Rural Health Infrastructure. Health indicators are very poor and the poor face financial ruin if visited by a serious health event. India is committed to the goal ‘health for all’ and in the last four decades, a wide network

of primary health centres and sub-centres has been created. Yet most of the states including West Bengal are far away from this goal. One of the fundamental metrics for assessing a society's well-being is the availability of health care. The health care system in North Bengal has been evaluated in this study by measuring several aspects of healthcare services. Each Block's Health Care Facility Index (HCFI) rating reflects the state of the healthcare facilities there as well as their location within the district. The average HCFI score for North Bengal is 0.19, which suggests that the majority of Districts have modest to subpar health care services. The HCFI of North Bengal, on the other hand, has a standard deviation value of 0.14, indicating that all Districts have moderately good health care services. Among all districts of North Bengal, the mean value is highest in Bed Health Care Institution Ratio, 23.38 whereas Health Care Institution Population Ratio and Doctor Health Care Institution Ratio is lowest like 2.81 and 2.87.

The number of beds in health care institutions per 10000 populations is not better numbered in all districts of North Bengal with 7.32/10000 population. The average Doctor Population Ratio is 8.03 in all Districts per one lakh population is not better in North Bengal. But at present, medical facility offered by Darjeeling is no match for its past glory. Since Darjeeling is the district headquarter Sadar or District Hospital is located here. However, the condition of these 308 bedded hospitals needs much improvement. Now hospital offers quality services to the resident of Darjeeling and their surroundings. As the regional headquarters of the Jalpaiguri district, the city of Jalpaiguri has a prominent position in North Bengal. The nearby population in the region often flocks to the city to get proper health care services. This position is amplified by the systemic industrial development of the district and rapid influx of people who needs proportionate medical care. Healthcare Facilities in Cooch Behar is quite effective with number of hospitals, path-labs, chemist shops and allied medical services. The citizens of the city enjoy well administered and well provided health services. Healthcare facilities in Cooch Behar are at par with other metro cities of West Bengal. But the problem of the health care facility in north Bengal is it mainly concentrated in the district town or particular in the blocks which are nearer to the main tow. The main problem is for the people who stayed in the blocks which is far from the district town so they could not access the medical facility due to their locational disadvantage for that parity should be there to improve the infrastructure for all the block hospital instant of concentrating a particular hospital or health centre. Although the government has taken initiation to improve the rural health care by

National Rural Health Mission which contribute a lot but it is not sufficient. Since the development of a region's health care facilities is intimately related to the wellness of that society, the government may seek for a strategy to raise the standard of those facilities from the ground up. Apart from economic condition, the social hierarchy or the system of social stratification existing in the society of West Bengal is likely to influence the health behaviour of individuals. Social stratification system determines the living conditions, privileges, obligations and cultural traditions surrounding the life of a person which in turn affect his perceptions regarding health, knowledge of health care and accessibility to health resources (SNM Kopparty, 1994). Who is responsible for this dilapidated health structure of North Bengal? This question echoes in the panorama of the broken health structure of the North Bengal.

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CROP REGIONS IN TUNGABHADRA RIVER BASIN IN KURNOOL DISTRICT, ANDHARA PRADESH

B. Appanna and Dr. Y. Sujatha

Abstract

The current study focuses on the regionalization of crops in the Tungabhadra River basin of Kurnool District. The basin is characterized by a rural population, and agriculture serves as the primary source of livelihood for the inhabitants due to the lack of an industrial base. Traditional and subsistence agricultural practices have been prevalent in the basin for a long time. The basin consists of 45% block cotton soil and 30% red soil. Primarily farmers are cultivating this area like commercial crops, particularly cotton and groundnut, along with food grains such as bengal gram, red gram, fruits, and vegetables. The choice of crops grown in the basin during an agricultural year is greatly influenced by physiographic, climatic, soil, and socio-economic conditions, as well as the people's are following traditional agricultural practices. As a result, specific crop regions have emerged in the basin. The study also examines the spatial variation at the mandal level in terms of temporal change, using data from two periods: 2009–10 and 2019–20. This paper aims to calculate and delineate crop regions based on a ranking method.

Introduction

The Tungabhadra River basin is located in the western part of the Kurnool district; it is characterized by its unique agricultural landscape. More than 75% of the region comprises Pedi plains, with 45% of the soil being cotton-rich block soils and 35 % of being red soils due to its geological connection to granite and gneisses. The primary mode of agriculture in this region is rain-fed, and agriculture stands as the predominant land use. Over 70% of the population relies on agriculture for their livelihoods. However, the agricultural system here is primarily based on traditional practices and operates at a subsistence level due to the limited availability of irrigation facilities and the prevalence of marginal and small landholdings. A significant portion of the working population is engaged in agricultural labor. In this particular context, the examination of crop regionalization assumes a crucial role in evaluating the arrangement and

distribution of crops across the basin. The concept of crop regionalization holds integral and significant within the realm of agricultural geography. Krishnakumari has expressed the view that the identification and demarcation of crop regions are immensely beneficial in the context of regional agricultural planning, particularly in optimizing crop cultivation. Agricultural regionalization holds a long-standing position in the field of agricultural classification and plays a crucial role in the planning and advancement of agriculture in developing nations. It serves as a tool to group together various agricultural phenomena, both apparent and hidden, across the Earth's surface. This tool allows geographers to partition an area into multiple regions based on the diversity found within the agricultural system. Moreover, it provides valuable insights into the spatial distribution of crops at a regional level (Dayalan, 2018). Therefore, a systematic investigation of agricultural regions based on crop associations is imperative for geographers as an initial step towards comprehensively understanding the Agricultural geography of the region. Ultimately, this aids in the planning and development of crops at a regional level. The objective of the present study is to identify the major crop regions in the Tungabhadra River basin of Kurnool district. The ranking method was employed to delineate the crop regions into primary (first rank), secondary (second rank), and tertiary (third rank) categories. The first three crops, regardless of their percentage of occupation were selected for the purpose of crop regionalization analysis. Given that the basin falls within a semi-arid climatic zone, effective planning is a great significance, and the present study sheds light on this aspect.

Study Region

The study area of the Tungabhadra River basin is in the north-western region of the Kurnool district in the state of Andhra Pradesh, India. It lies between North Latitude 15°15'00" to 16°'00" and East Longitude 77°0'0" to 78°15'00". The area falls within the Survey of India (SOI) Toposheet Nos. 57E/1 to 57E/16 and 57I/1 to 57I/5. The total area of the basin is 6,934 square kilometers. The basin consists of 30 mandals, with 21 mandals fully covered and the remaining 9 mandals partially covered. The basin receives an average annual rainfall of 670 mm and experiences temperatures ranging from 26°C to 46°C in the summer and 12°C to 31°C in the winter. The northwestern portion, which includes Adoni, Peddakadubur, Alur, Aspari, Chippagiri, Halaharvi, Holagunda, Pathikonda, Devanakonda, Krishnagiri, Veldurthy, Kodumur, and Kallur mandals, has a desolate appearance with vegetation mostly limited to small pockets of reserve forests. This portion of the basin covers an area of 41,712 hectares, which accounts for 4.46% of the total geographical area.

The terrain in this region slopes from south to north and is drained by the river Hundri, which joins the river Tungabhadra at Kurnool. The soils in the northwestern parts traversed by the river Hundri are black cotton, while the southeastern parts are predominantly pure red soils. Geologically, the basin is underlain by the crystalline rock of the Peninsular Gneissic Complex (PGC), which includes the granite gneisses and granite in the western and southern parts of the basin.

Objectives

(1) To identify and demarcate the crop regions, such as First, Second, and Third ranking crop regions, of the Tungabhadra River Basin for the years 2009–10 and 2018–19.

(2) To study the changes in crop regions during a 10-year period.

Data and Methodology

The current study has collected secondary data from the Chief Planning Officer (C.P.O.), Handbook of Statistics, Kurnool district, focusing on the general cropping pattern for two specific time periods: 2009–10 and 2019–20. The data has been collected at the 'Mandal' level, ensuring a comprehensive analysis. The data has been analyzed using basic statistical techniques such as percentages and averages. The objective of the study is to investigate the spatial patterns of crops that are ranked from first to third in terms of the percentage of the total cropped area, with a specific focus on First, second, and third crop regions. The first-order crop regions, which are those with the highest ranking, have been identified by considering the crops that contribute the highest percentage to the total cropped area in each of the component area units, regardless of their overall percentage. Similarly, second-order and third-order crop regions have been delineated based on their ranking in terms of percentage. In order to accomplish the objectives of the study, the percentages of different crops cultivated in the basin have been calculated and organized in descending order to define the crop regions.

Results and Discussions

First ranking crop regions or first order crop regions (2009-10)

Out of the 30 mandals, 11 mandals have groundnut as first-order crops, 10 mandals have bengal gram as first-order crop, 5 mandals have cotton as first-order crop, 2 mandals have red gram as first-order crop, 1 mandal has paddy as first-order crop, and one mandal has fruits and vegetables as first-order crops.

Groundnut and Bengal gram Region

Groundnut is the leading crop cultivated in the basin, with its cultivation spread across 11 mandals. The favorable environmental conditions in the basin have proven to be advantageous for the growth of groundnut, particularly on light mixed red and block soils. The distribution of groundnut cultivation is predominantly concentrated in the southern and central regions of the basin. It is the basin's second-largest crop cultivated as the first-ranking crop, next only to groundnut. Within the basin, it holds the top position in 10 mandals, namely Kurnool, Kallur, Orvakal, Kodumur, Gudur, Nanikotukur, Miduthur, Alur, Aspari, and Maddikera. The distribution of these mandals is predominantly concentrated in the northeastern and southwestern parts of the basin.

Cotton, Red gram Region

Cotton is the third most significant first-ranking crop cultivated in 5 mandals, namely Adoni, Kowthalam, Nandavaram, Mantralayam, and Holagunda. These mandals are primarily concentrated in the northwestern region of the basin. Red gram crop farming was limited to only 2 mandals, namely Bethamcherla and J. Bunglow.

Paddy and Fruits and vegetable Region

These are too tiny in their extent, as they comprise of 1 mandal each, i.e., paddy in Pagidayala mandal and fruits and vegetable crops in C. Belagal mandal.

First ranking crop regions or first order crop regions (2019-20)

In the year 2019–20, a total of 5 crops were observed in the primary crop regions, each with varying degrees of prominence. Among these regions, the cotton crop region stood out as the largest primary crop region, with 16 mandals. Followed by the Bengal gram region with 5 mandals, the red gram region with 4 mandals, the maize region with 3 mandals, and finally, the groundnut region with 2 mandals.

Groundnut, Bengal Gram and Cotton Region

As a first-ranking crop region, the groundnut crop is registered in two mandals, respectively, Krishnagiri and Tuggali mandals. Bengal Gram region is the 2nd largest first ranking crop region in Tungabhadra River basin during 2019–20, occupying five mandals located in a few mandals in the north-east and western mandals of the basin. The cotton crop is the dominant primary crop region among all other crops, and it was the first-ranking crop in 16 mandals.

It emerged as the largest crop region in the study area during 2019–20. Their concentration is high in the western, northern, and central mandals of the basin.

Red Gram and Maize Region

4 mandals, namely Dhone, Bethamcherla, Veldurty, and Peapully, are noticed as the first-ranking crop regions, with the red gram crop in the study area. The maize region is a newly formed primary crop region during the period 2019–20, replacing Bengalgram, paddy, and red gram crops. The region has been found in three mandals, such as Nandikotukur, Pagidayala, and J.Bunglow, which are located in the north-eastern part of the basin.

Changes in First Ranking Crop Regions (2009-10 to 2019-20)

Significant changes have occurred in the primary crop regions of the basin over a period of ten years. In the year 2009–10, six primary crop regions were registered, namely groundnut, bengal gram, cotton, red gram, paddy, and fruits and vegetables. Even after ten years, groundnut, Bengal gram, cotton, and red gram remained as primary crop regions. However, the crop regions of paddy and fruits and vegetables disappeared in 2019–20. A new crop region, maize, was recorded during this period. Other changes include an increase in the number of mandals (administrative divisions) in the cotton crop region (+11 mandals) and red gram (+2 mandals). On the other hand, there was a decrease in the number of mandals in the groundnut (-9 mandals), Bengal gram (-5 mandals), paddy (-1 mandal), and fruit and vegetable (-1 mandal) crop regions. Additionally, a new region for maize emerged, consisting of 3 mandals that were previously part of the Bengal gram, paddy, and red gram crop regions. (**Fig.** 1 and **Table-**1).

Second Ranking Crop Regions or Second Order Crop Regions (2009-10)

The second ranking of crops comprises a greater number of crops compared to the first ranking of crops. In the year 2009–10, a total of 10 crops were classified as second-ranking crops. Among these, Castor held the highest position with 8 mandals of the basin. These are located in the north-western and southern parts of the basin. Next in importance among the second ranking of crops is groundnut. It is extended to only 6 mandals, namely Kodumur, C. Belagal,Bethamcherla,Adoni, Aspari, and Maddikera. Bengal gram is the third-important second-ranking crop cultivated in 5 mandals. They are J. Bunglow,Kowthalam, Nanavaram, Holagunda, and Pattikonda. The sunflower crop is the fourth important crop grown in 3 mandals located in the north-central part of the basin. They are in Kallur, Gudur, and Gonegandla.

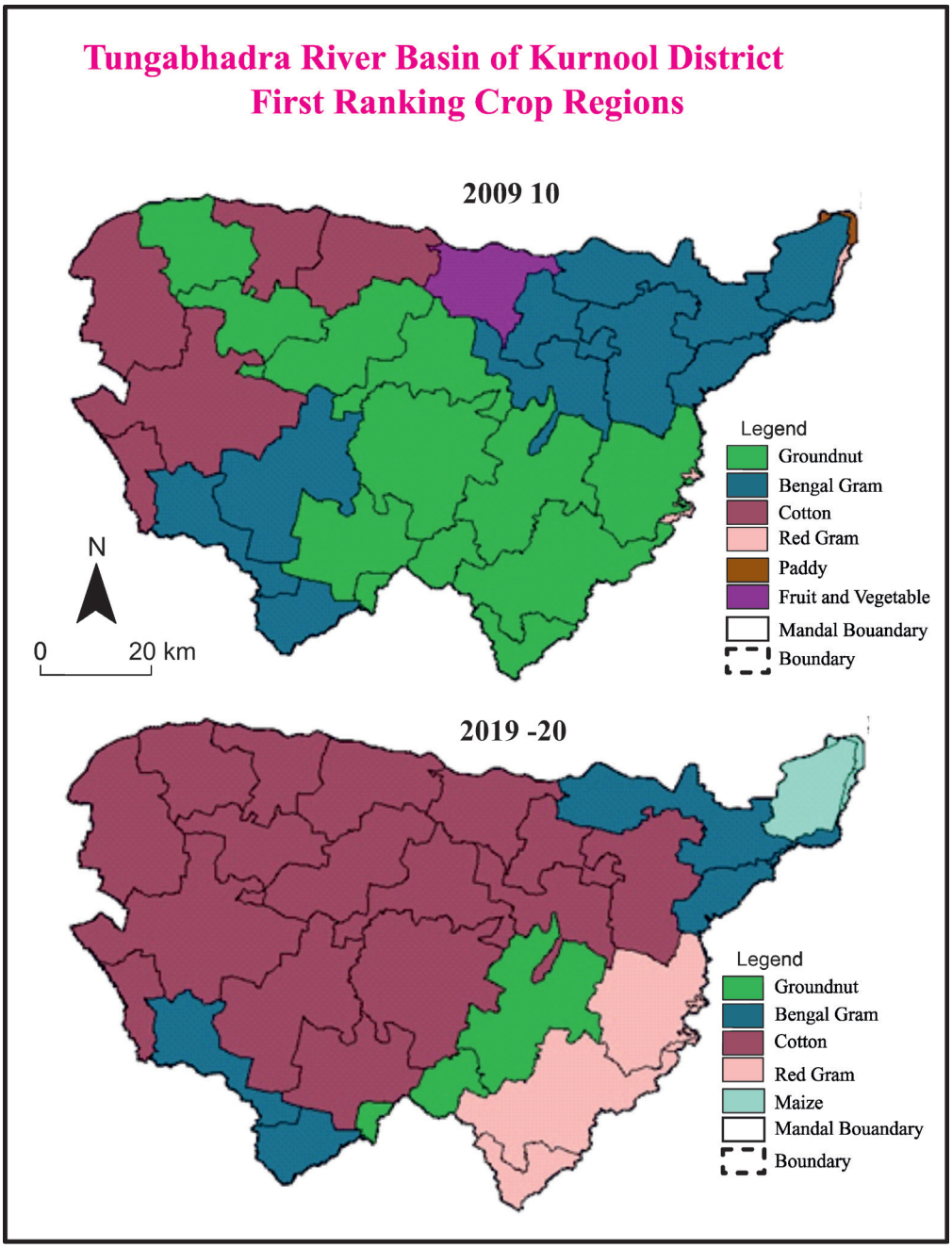

Tungabhadra River Basin of Kurnool District
First Ranking Crop Regions
2009 10
N
0
20 km
Legend
Groundnut
Bengal Gram
Cotton
Red Gram
Paddy
Fruit and Vegetable
Mandal Bouandary
Boundary
2019 -20
Legend
Groundnut
Bengal Gram
Cotton
Red Gram
Maize
Mandal Bouandary
Boundary

Fig. 1

Table-1: First Ranking Crop Regions in Tungabhadra River Basin 2009-10 & 2019-20

S.No	Crops in First ranking crop region	No. of Mandals in each individual crop region		Decrease/Increase in the number of Mandals during 10 Years Period
		2009-10	2019-20	
1	Ground nut	11	2	-9
2	Bengal gram	10	5	-5
3	Cotton	5	16	+11
4	Red gram	2	4	+2
5	Paddy	1	--	-1
6	Fruits &Vegetable	1	--	-1
7	Maize	--	3	+3
	Total Mandal	30	30	

Source: Computed by Authors

Next in importance among the second ranking of crops are maize, fruits, and vegetables. The cultivation of maize is limited to 2 mandals, namely Nandikotukur and Pagidayala mandals. Similarly, the cultivation of fruits and vegetables is restricted to 2 mandals, namely Kurnool and Orvakal. Furthermore, there are several other crops, namely paddy, red gram, cotton, and tobacco, which are classified as the second ranking of crops in individual mandals. For instance, paddy is cultivated in Yemmiganur, red gram in Veldurthy, cotton in Alur, and tobacco in Miduthur mandals. (**Fig.** 2 and **Table-**2).

Second Ranking Crop Regions or Second Order Crop Regions (2019-20)

In the year 2019–20, there are five crops that contribute to the establishment of second-order crop regions. Groundnut, in particular, holds the most prominent position in the formation of these regions. As the second most significant crop, groundnut is cultivated in 9 mandals within the basin, specifically situated in the western and southern areas. Bengal Gram holds a significant position among the secondary category of crops, following closely after the primary ones. Its cultivation spans across 8 mandals. The distribution of Bengal gram is primarily concentrated in the northeastern region, with a few mandals also found in the southwestern part of the basin. The cultivation of cotton is the third most significant crop in terms of ranking, grown in 7 mandals. Additionally, paddy and fruit and vegetable crops are cultivated in 4 and 2 mandals, respectively.

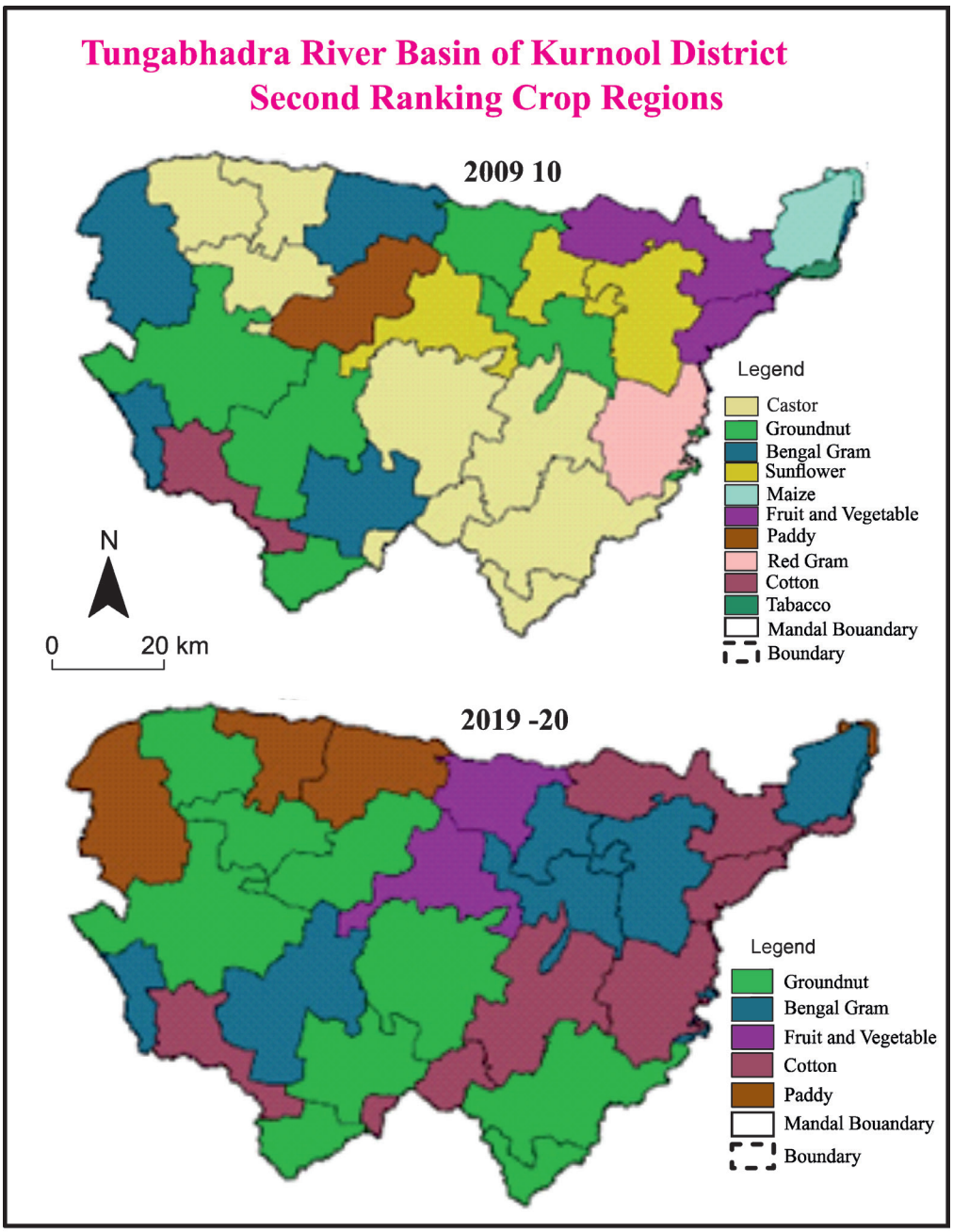

Tungabhadra River Basin of Kurnool District
Second Ranking Crop Regions
2009 10
N
0
20 km
Legend
Castor
Groundnut
Bengal Gram
Sunflower
Maize
Fruit and Vegetable
Paddy
Red Gram
Cotton
Tabacco
Mandal Bouandary
Boundary
2019 -20
Legend
Groundnut
Bengal Gram
Fruit and Vegetable
Cotton
Paddy
Mandal Bouandary
Boundary

Fig. 2

Changes in Second Ranking Crop Regions (2009-10 to 2019-20)

In the years 2009–10, ten crops were reported as secondary crop regions, whereas in 2019–20, approximately five crops constituted secondary crop regions. An increase in the spatial distribution has been observed in cotton (+6 mandals), groundnut (+3 mandals), Bengal gram (+3 mandals), and paddy (+3 mandals). Conversely, a decrease in the number of mandals has been identified in castor (8 mandals), sunflower (3 mandals), maize (2 mandals), red gram (1 mandal), and tobacco (1 mandal). The fruit and vegetable crop region remained unchanged in terms of area, with 2 mandals in both 2009–10 and 2019–20.

Table -2: Second Ranking Crop Regions –Tungabhadra River Basin (2009-10 & 2019-20)

S.No	Crops in First ranking crop region	No. of Mandals in each individual crop region		Decrease/Increase in the number of Mandals during 10 Years Period
		2009-10	2019-20	
1	Castor	8	--	-8
2	Ground nut	6	9	+3
3	Bengal gram	5	8	+3
4	Sunflower	3	--	-3
5	Maize	2	--	-2
6	Fruits & Vegetables	2	2	No change
7	Paddy	1	4	+3
8	Red gram	1	--	-1
9	Cotton	1	7	+6
10	Tobacco	1	--	-1
	Total Mandals	30	30	

Source: Computed by Authors

Third Ranking Crop Regions or Third Order Crop Regions (2009-10)

Among the third-ranking crop regions of 2009–10, about 10 crops have been recorded in the basin (**Fig.** 3). Of these, Castor, Cotton, and Sunflower cultivation occupied first place in forming the largest third-order crop regions, as they comprised 5 mandals each, i.e., Castor in Gudur, Veldurthy, Pattikonda, Maddikera, and Gonegandla; Cotton in C. Belagal, Kosigi, Yemmiganur, Aspari, and Tuggali mandals; and Sunflower in Kurnool, Kodumur, Krishnagiri, Nandavaram,

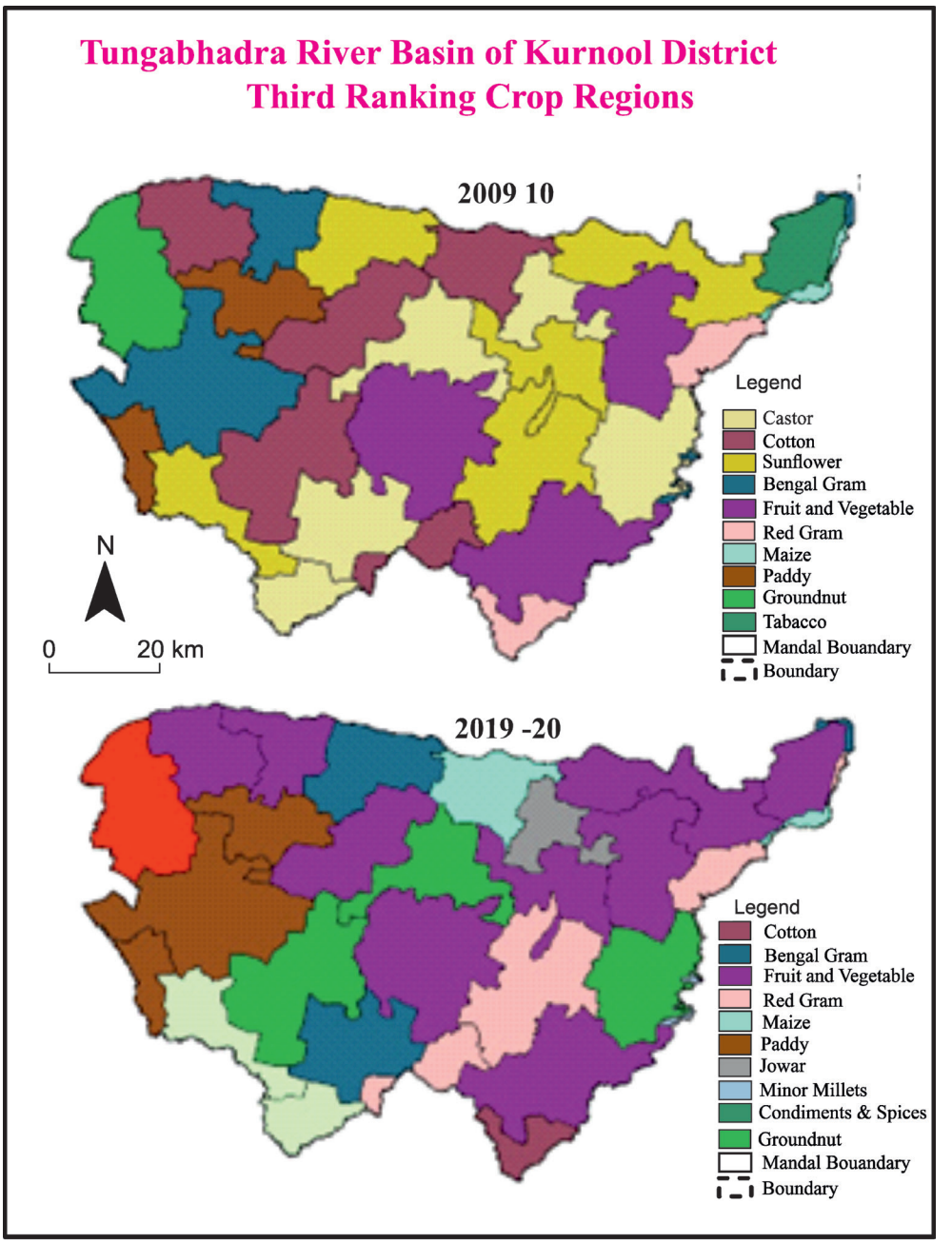

Tungabhadra River Basin of Kurnool District
Third Ranking Crop Regions
2009 10
N
0
20 km
Legend
Castor
Cotton
Sunflower
Bengal Gram
Fruit and Vegetable
Red Gram
Maize
Paddy
Groundnut
Tabacco
Mandal Bouandary
Boundary
2019 -20
Legend
Cotton
Bengal Gram
Fruit and Vegetable
Red Gram
Maize
Paddy
Jowar
Minor Millets
Condiments & Spices
Groundnut
Mandal Bouandary
Boundary

Fig. 3

Table -3: Third Ranking Crop Regions –Tungabhadra River Basin (2009-10 & 2019-20)

S.No	Crops in First ranking crop region	No. of Mandals in each individual crop region		Decrease/Increase in the number of Mandals during 10 Years Period
		2009-10	2019-20	
1	Castor	5	-	-5
2	Cotton	5	1	-4
3	Sunflower	5	-	-5
4	Bengal gram	4	3	-1
5	Fruit s& Vegetables	3	9	+6
6	Red gram	2	4	+2
7	Maize	2	2	No Change
8	Paddy	2	3	+1
9	Jowar	--	1	+1
10	Minor millets	--	1	+1
11	Chilies	--	1	+1
12	Condiments & Spices	--	2	+2
13	Ground nut	1	3	+2
14	Tobacco	1	--	-1
15	Total Mandal	30	30	

Source: Computed by Authors

and Alur mandal, followed by bengal gram (4 mandals); fruits and vegetables (3 mandals); red gram (2 mandals); maize (2 mandals); paddy (2 mandals); ground nut (1 mandal); and tobacco (1 mandal).

Third Ranking Crop Regions or Third Order Crop Regions (2019-20)

During the year 2019–20, eleven crops have been registered under tertiary crop regions with varied intensity. Fruits and Vegetables crop region emerged as the largest third ranking crop region with 9 mandals, followed by red gram (4 mandals), Bengal gram (3 mandals), paddy (3 mandals), groundnut (3 mandals), maize (2 mandals), condiments and Spices (2 mandals), cotton (1 mandal), jowar (1 mandal), minor millets (1 mandal), and chilies (1 mandal).

Changes in the Third Ranking Crop Regions (2009-10 to 2019-20)

Totally, about fourteen crops have been recorded in the study period under third ranking crop regions. They are castor, cotton, sunflower, Bengal gram, fruit and vegetables, red gram, maize, paddy, jowar, minor millets, chilies, condiments and spices, ground nuts, and tobacco. A decrease in the number of mandals under each third ranking region during the 10 years is observed in castor (-5 mandals), Cotton (-4 mandals), sunflower (-5 mandals), Bengal gram (-1 mandal), and Tobacco (-1 mandal). The increase in the number of mandals under each third ranking crop region during the 10 years of the study period is noticed in fruits and vegetables (+6 mandals), red gram, condiments and spices, and ground nuts (each with +2 mandals), paddy, jowar, minor millets, and chilies (+1 mandal). The maize region remained the same with two mandals, both in the 2009–10 and 2019–20 study periods.

Conclusion

During the years 2009–10, only six First Ranking crop regions, namely groundnut, Bengal gram, cotton, red gram, paddy, and fruits and vegetables, were noticed in the basin. Even after ten years, groundnut, Bengal gram, cotton, and red gram remained as First ranking crop regions. However, the crop regions of paddy and fruits and vegetables disappeared in 2019–20. A new crop region, maize, was recorded during this period. With regard to second ranking crop regions, ten crops were registered in 2009–10, and five crop regions, namely castor, sunflower, maize, red gram, and tobacco, disappeared in 2018–19, resulting in Five crop regions were recorded. About ten different third ranking crop regions have been reported in the year 2009–10 in the Tungabhadra River Basin, and eleven different third ranking crop regions have been noticed in the year 2019–20, with jower, minor millets, chilies, condiments and spices, and cotton as additional regions, replacing four crop regions of 2009–10, i.e., castor, Bengal gram, groundnut, and sunflower crop regions.

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ANNUAL WATER BALANCE AND STREAM DISCHARGE MODELLING AT SHIMSHA WATERSHED OF UPPER CAUVERY BASIN, KARNATAKA

Dr. Surendra P. and Ms. Sneha Singh

Abstract

The present study mainly focuses on identifying the factors influencing water balance and stream discharge in Shimsha Watershed. The attempt also been made to analyse the water balance and stream discharge using SWAT model in the study area. Along with the use of SWAT model, geographical information system (GIS) is also used to estimate the HRUs, land use / land cover, calibrate and validate model and sensitivity analysis of SWAT model parameters for the Shimsha Watershed. The results show that Overall model performance was found to be agreeable as indicated by close relation between observed and simulated runoff. Model performance has been done using statistical parameter called Coefficient of Determination (R2). The R2 value were found to be 0. 64864 and 0.639706 after the calibration and validation. The model indicated very good agreement between simulated and observed flow. Therefore, it can be concluded that the SWAT model helps as an effective tool for assessment of water functioning at basin scale.

Introduction

Water is one of the most important natural resource. The Earth's water cycle is a dynamic and intricate system that plays a vital role in sustaining life and shaping our environment. Understanding the complex interactions of precipitation, evaporation, infiltration, runoff, and groundwater flow is crucial for effective water resource management, flood forecasting, and environmental protection. Hydrological models are useful tools that have been used in recent years to provide a visual representation of hydrological processes as well as accurate flow simulations, especially when evaluating the effects of land-use change and climate variability on hydrological cycles and water balance components. It encompasses a range of computational techniques that simulate the behaviour of water within a specific geographical area or watershed. By employing mathematical equations and algorithms, these models replicate the hydrological cycle, allowing us to observe and predict the movement

and distribution of water through the landscape. Hydrological models consider a multitude of factors, such as topography, land use, soil properties, vegetation cover, and climatic conditions, to create realistic representations of how water flows through a particular region. Water balance and stream discharge are important components of the hydrological cycle and are crucial for the management of water resources. Hydrological models provide a means to study the complex interactions between various hydrological processes in the Shimsha Watershed. While studying this we can analyse the relation between different parameters and how it is affecting the watershed Shimsha watershed covered with coconut plantation and medium dense urban settlement with using swat model what is the impact how the parameters are behaving within the watershed determined using the swat model. It is also important for the assessing water quality and pollutant transport within the watershed. Understanding the volume of water flowing through the stream helps in assessing pollutant loads and designing appropriate water quality management strategies in Shimsha watershed.

Study Region

The Shimsha River basin is a sub-basin of the Cauvery basin located in Karnataka, India. Geographically, it extends largely over two districts Mandya and Tumkur. The river has a course length of 221 km and has a catchment area of 8469 km^2 before joining the river Cauvery at shimshapura near the border of Chamarajanagara district. Shimsha river is an important tributary joining from left. The extent of area is latitude 13˚44′0″ N to 12˚8′0″N and Longitude 76˚8′0″ E to 77˚28′0″ E During the course of its travel from the origin many sub-tributaries join the Shimsha river such as Veeravaishnavi, Kanihalla, Chikkahole, Hebbahalla, Mullahalla and Kanva. At the mouth of the Shimsha river, a waterfall is situated at shimshapura in Malavalli taluk located 30 kms from Mandya, which was used to generate Hydroelectric power with an installed capacity of 17,200 kw and is considered to be the first ever hydroelectric project in Asia. The power generated during that time was used to light the Kolar gold fields. The Markonahalli dam, a multi-purpose reservoir has been erected across the river after it originates in Tiptur, Tumakuru district. It is reported to have been erected primarily as a flood-prevention measure for communities lying downstream, as well as to safeguard the safety of the nearby revered Yediyur Siddhalingeshwara Temple. Also, a barrage named after former Prime Minister H.D Devegowda has also been encountered during the course of its travel at Channapatna taluk, Ramanagara district – Igloor Dam Devegowda Barrage. The river then continues a southerly route and reaches

the Mandya district. The river travels in a south-eastern direction through Mandya district, with a waterfall at Shimshapura in Malavalli Taluk. Shimsha river is often referred as Madduru hole as the river passes through Maddur town and many villages of Maddur taluk. Shimsha is the principal irrigation supply for thousands of farmers in Nagamangala, Maddur, and Malavalli taluk, as well as hundreds of riparian villages in Tumakuru, Mandya, and Chamarajanagar taluks. The Shimsha Watershed is a geographical area in Karnataka, India, that is drained by the Shimsha River.

Objectives

(1) To analyses the water balance and stream discharge using SWAT model in study area.

(2) To identify the factors influencing water balance and stream discharge in study area.

Database and Methodology

In the present study following datasets were used to analysis the annual water balance and the stream discharge using SWAT model. Topography map was generated from the USGS-ASTER DEM with the spatial resolution of 30m. FAO – Digital soil map at the scale of 1:500000 used to create soil map. Land use and land cover map was derived from the ESRI Sentinel data with 10m spatial resolution. Followed by the rainfall data from IMD for the following years (1999-2022) and runoff (discharge) data from India water resources information system (WRIS) from 2001-2013 was used in this analysis. The following brief methodology was applied to assess the runoff and the water balance. The input data sets were derived from the above said data sources. Topography, soil texture, lulc, slope and rainfall layers were utilized as baseline parameters. From the DEM data watershed delineation and stream networks were generated. Followed by HRU analysis was carried with the support of DEM, Soil texture, lulc and slope along with rainfall in the SWAT model (SWAT RUN). Finally, surface runoff and the annual water balance were estimated for the Shimsha River basin.

Result and Discussion

SWAT Model Setup

The first step in model setup is to use a DEM raster file to delineate the watershed, sub- basins, and reaches. The definition of the watershed

gave a drainage pattern of land surface terrain, including the stream network and river basin outlets. The model used a DEM-based automated technique to delineate watershed. In which the watershed was divided into 7 sub watersheds, after providing a LU/LC map, soil map, and slope variation, they were further subdivided into 29 HRUs by the model (Hydrologic Response Units). HRUs, on the other hand, are combined units made up of homogeneous land-use and soil characteristics. A 10% threshold percentage has been implemented for all land use, soil, and slope classes in order to exclude minor land use, soil, and slope. The HRU report was then generated which included area of watershed (8694.15 km^2), detailed descriptions of the land use, soil, and slope classes in each sub- watershed.

Model Configuration

The SWAT model, is jointly developed by the United States Department of Agriculture – Agricultural Research Services (USDA–ARS), and Agricultural Experiment Station in Temple, Texas (Singh et al. 2013). By (Michael and Jain 2013), the computational components can be placed into eight major divisions namely: hydrology, weather, soil temperature, crop growth, sedimentation, pesticides, nutrients, and agricultural management, and uses physical inputs such as weather variables, topography, soil properties, land-management practices, and vegetation occurring in the catchment. SWAT explicitly models the physical processes related to water flow, sediment transport, crop growth, nutrient cycling etc. The form of water balance equation used to simulate the hydrologic cycle is depicted through equation.

(1) SWt = SWo + [Rday + Qsurf + Ea + Wseep + Qgw]

(2) SWt = Final soil water content in mm H2O,

(3) SWo = Initial soil water content in mm H2O, t time in days,

(4) Rday = Amount of precipitation on day i in mm H2O,

(5) Qsurf = Amount of surface runoff on day i in mm H2O,

(6) Ea = Amount of evapotranspiration on day i in mm H2O,

(7) Wseep = Amount of percolation and bypass exiting the soil profile bottom

(8) Qgw = Amount of return flow on day i in mm H2O

Watershed Delineation

Watershed is a hydrological unit from which runoff resulting from precipitation flows past a single point into a large stream, river, lake or pond. Watershed delineation

plays an important role in watershed management. Watershed delineation was performed in Arc GIS 10.4.1software. Digital Elevation Model (DEM) was use for watershed delineation. As top sheets provide information related to the location, drainage network and contours. Delineation of watershed has done using the dem, flow direction on map, flow accumulation on map, creation of outlet, snap pour point and watershed delineation.

SWAT Model Run

In this SWAT model to assess based on the Hydrological Response Units (HRUs) with the support of DEM (stream networks, watershed delineation, outlets for monitoring and sub basin parameter) and other thematic layers such as Land use land cover, soil, slope through overlay method. Include with this climatic dataset like rainfall and temperature which has been generated from the SWAT weather database (WGEN), followed by run the model to generate the runoff for the required number of years.

Hydrological Response Units (HRUs) Formation

The model simulates variations in evapotranspiration and other hydrological conditions for various land cover / crops and soils by subdividing the river basin into areas of exclusive land use and soil variations. The source of the hydrological modelling in SWAT is the HRU, which is a lumped land area within the sub-basin that is comprised of exclusive land cover, soil and slope. The sub-basin separation into HRUs improves precision and offers a much clearer physical description of the water balance. There are two options in SWAT for HRU allocation: either to assign a single HRU to each sub-basin or to assign multiple HRUs to each sub-basin (Srinivasan et al. 1998). If a single HRU per sub-basins is selected, the prevailing land use class and soil type surrounded by each river basin determines the HRU. If multiple HRUs are selected, the user must give a threshold level to ensure each grouping of land use and soil category within the sub-basin.

Sensitive Parameters

Sensitivity analysis can give a better understanding of the impact of change in an individual input parameter of the model response and can be performed using various methods. The method in the Arc SWAT interface combines the Latin Hypercube (LH) and One-factor-At-a-Time (OAT) sampling. Van Griensven et al. (2006), characterized Global rank 1 as “very important”, rank 2 to 6 as ‘important”,

rank 7 to 19 as "slightly important" and rank 28 as "not important". Sensitivity analysis was performed on 16 different SWAT model parameters for the Shimsha Watershed. Parameters and parameter ranges used in the sensitivity analysis. By using default upper and lower boundary parameter values, the parameters were tested for sensitivity using without observed streamflow data. The most sensitive factor governing the streamflow for the Shimsha Watershed was SCS runoff curve number for moisture condition II (CN2). This indicates that base flow is very significant in the water yield.

The Effective hydraulic conductivity in main channel alluvium (Ch_K2), threshold depth of water in the shallow aquifer required for return flow to occur (Gwqmn), available water capacity (Sol_Awc) and soil evaporation compensation factor (Esco) are also important parameters. Alpha_Bf and Sol_Awc were correlated to base flow and that could be the reason for their higher ranking in the sensitivity analysis. The sensitive parameters for the present study were selected based on the study conducted by Douglas – Mankin et al., (2010) on 64 selected watersheds. SWAT simulates the interaction of processes; many parameters affect more than one process. It's a kind of ripple effect. (For example, CN has direct impact on runoff; however, change in runoff changes other components of hydrology. There is direct impact of runoff change on soil erosion and nutrient transport affecting plant growth and nutrient cycling). So, Santhi et al., (2001) highlight this as the primary reason for manual calibration to start with hydrology balance and surface runoff, then sediment, and finally calibrating nutrients. From the above studies it was concluded to use the sensitive parameters such as CN2, ESCO, ALPHA_BF, SOL_AWC, SURLAG and RECH.DP and their initial and final values have been illustrated. The sensitive parameters are explained are as follows: Before calibration of CN2, ALPHA BF, GWQMN, ESCO, SOL AWC (84, 0.95, 0.8, 0.95, and 0.05) and after calibration of (35, 0.01, 0.05, 0.08, 1) respectively.

CN2

CN2 Initial SCS runoff curve number for moisture condition II. The SCS curve number is a function of the soil's permeability, land use and antecedent soil water conditions. The Soil Conservation Service Curve Number (SCS-CN) method is widely used in conceptual rainfall-runoff models for describing the runoff response with a curve, which is a function of the cumulative storm rainfall and antecedent wetness conditions. To improve the SCS- CN method.

ALPHA BF

ALPHA_BF Base flow alpha factor (1/days). The base flow recession constant, αgw, is a direct index of groundwater flow response to changes in recharge. Values vary from 0.1-0.3 for land with slow response to recharge to 0.9-1.0 for land with a rapid response. Base flow is the portion of streamflow that is delayed subsurface flow and generally maintained by groundwater discharge. Regardless of the specific climatic environment, its main features are tightly related to geological catchment properties. Base flow is the streamflow that constitutes the majority of the streamflow on a day when rain does not occur or has not occurred recently. Understanding the base flow process is important to deal with various water resources issues, such as water resources management strategies, low flow conditions assessment, hydrological modelling calibration, and water quality studies.

GWQMN

"GWQMN" stands for "Groundwater Quick Flow Manning's n" and it is a parameter used to represent the Manning's roughness coefficient for quick flow from the groundwater zone to the stream channel. In the SWAT model, accurate representation of groundwater dynamics and the interaction between groundwater and surface water is essential for realistic hydrological simulations. The GWQMN parameter contributes to this by influencing the rate of quick flow from the groundwater to the stream channel.

ESCO

ESCO stand for Soil evaporation compensation factor. This coefficient has been incorporated to allow the user to modify the depth distribution used to meet the soil evaporative demand to account for the effect of capillary action, crusting and cracks. ESCO must be between 0.01 and 1.0.

SOLAWC

It refers as the Soil Available Water Capacity parameter. This parameter is a key component of the model's representation of soil properties and their influence on water balance and hydrological processes within a watershed. Available Water Capacity (AWC) represents the amount of water that soil can hold and make available to plants for their growth and development. It is a crucial factor in determining how well a soil can retain and supply water to vegetation. The AWC parameter considers the soil's characteristics, such as texture, depth, and organic

matter content that influence its ability to retain water. Different soil types can have varying AWC values, and these values play a significant role in simulating various hydrological processes, including infiltration, runoff, evapotranspiration, and groundwater recharge. In SWAT, soil data are typically divided into different hydrologic response units, and each unit can contain multiple soil types. The "solawc" parameter is assigned to each soil type within an HRU, allowing the model to estimate how water moves through the soil layers, affects plant growth, and contributes to runoff and other hydrological responses.

Observed Discharge Data

The Runoff values for 18 years from 2004-2022 at the T.K Halli was simulated by the SWAT model and the comparison of output values with the observed data have been presented from which it can be seen that for most of the year, SWAT simulation seemed to overestimates the discharge when compared observed values. This is because of uncertainties in input data, model structure and model parameters. The calibration was carried out as a process of adjustment for these uncertainties. Due to continuous changes in the parameters the model simulated runoff and the observed discharge will correlate. The comparison between the observed and simulated discharge shows between 2004 to 2013. The Runoff values for 18 years from 2004-2022 at the T.K Halli was simulated by the SWAT model and the comparison of output values with the observed data have been presented from which it can be seen that for most of the year, SWAT simulation seemed to overestimates the discharge when compared observed values. This is because of uncertainties in input data, model structure and model parameters. The calibration was carried out as a process of adjustment for these uncertainties. Due to continuous changes in the parameters the model simulated runoff and the observed discharge will correlate. The comparison between the observed and simulated discharge shows between 2004 to 2013 (**Fig.** 1).

Surface Run-off Calibration

Most of the model inputs are physically based. The successful application of the model which are depends on how well the model is calibrated. The model will be calibrated using observed runoff data from the entire river basin. The calibration tool in the simulation menu of SWAT allows performing global changes on input parameters that are commonly modified during the calibration process. Calibration was performed manually from 2004 to 2005, and validation was performed from 2012 to 2013 run-off matches fairly well with observed runoff in trend and

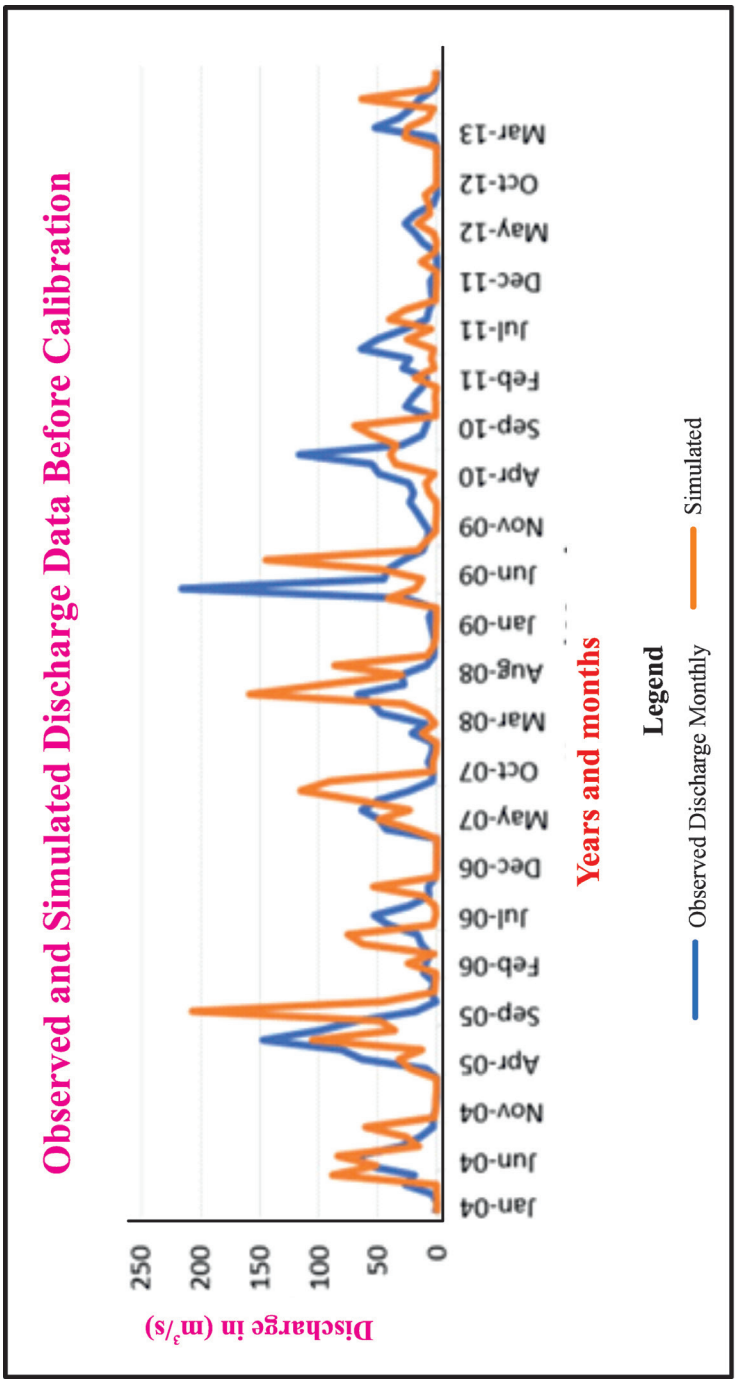

Observed and Simulated Discharge Data Before Calibration
Discharge in (m³/s)
250
200
150
100
50
0
Jan-04
Jun-04
Nov-04
Apr-05
Sep-05
Feb-06
Jul-06
Dec-06
May-07
Oct-07
Mar-08
Aug-08
Jan-09
Jun-09
Nov-09
Apr-10
Sep-10
Feb-11
Jul-11
Dec-11
May-12
Oct-12
Mar-13
Years and months
Legend
Observed Discharge Monthly
Simulated

Fig. 1

magnitude. Overall, model performance was found to be agreeable as indicated by close relation between observed and simulated runoff. Due to changes in the sensitive parameters the model calibration done. The model efficiency checked using coefficient of determination or R square. This is a good method to signify the consistency among observed and good method to signify the consistency among observed and simulated data by following a best fit line. It ranges from zero to 1.0 with higher values indicating less error variance, and values greater than 0.50 are considered acceptable. In the calibration the R square was 0.64864 that's why this model is acceptable (**Fig.** 1).

Model Validation

Proper validation of the calibrated model is essential to understand its performance without any change in the input files except the climatic parameters. The monthly values of the maximum and minimum temperature for the time period for which the model is being validated is set as the input data for the model. The model was validated for similar parameters. Monthly run-off was compared for the river basin, as per the availability of observed data. In validation of the model the R square was 0.639706 which is acceptable. In the calibration and validation, the values of R square are more than 0.5 which is acceptable and is a good sign of model efficiency. So, the model is running properly and due to this model can run the future simulation also but in some points in graph the simulated and the peaks and are not matching is due to the uncertainty in the model's parameters and the input dataset. But the overall model is working properly and efficiently. The discharge is simulated in between 2020 to 2022. Due to the validation and calibration of model is running properly and can be used for future reference. This will help in future simulation as well managing the water movement in the study area will become very efficient. But there is still scope for future use ability of the model (**Fig.** 2).

Water Balance

This is the balance between the inputs and outputs of a drainage basin. Water balance is expressed as:

$$P = Q + E \text{ (+/- change in storage)}$$

Whereas:

P = precipitation Q = run-off

E = evapotranspiration

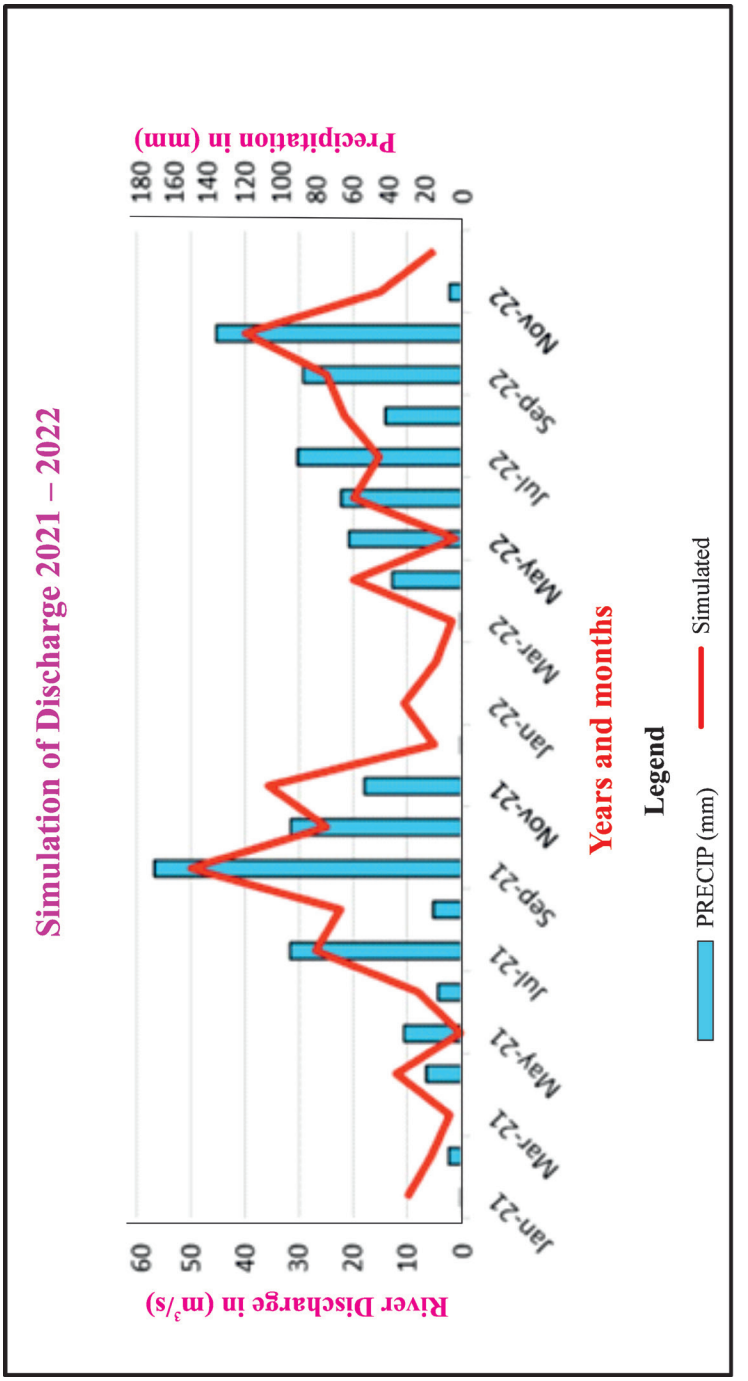

Simulation of Discharge 2021 – 2022
Precipitation in (mm)
180
160
140
120
100
80
60
40
20
0
River Discharge in (m³/s)
60
50
40
30
20
10
0
Jan-21
Mar-21
May-21
Jul-21
Sep-21
Nov-21
Jan-22
Mar-22
May-22
Jul-22
Sep-22
Nov-22
Years and months
Legend
PRECIP (mm)
Simulated

Fig. 2

Rivers will always have a regime which they follow, in that some months the discharge of the river will be higher than others. The water balance looks at how the amount of precipitation compares with the water leaving the system as runoff or as evapotranspiration. This balance will change throughout the year and will be affected by the overall climate of the area near to the river. For example, under 'usual' conditions the precipitation will be matched by run-off and evapotranspiration giving a 'normal' river level. If evapotranspiration becomes greater for a few months in summer while precipitation and run-off remain the same, the river will flow below normal level. Key terms to describe various water balance conditions are, namely, (1) Water Surplus: there is excess water available to the system. This occurs when precipitation exceeds evapotranspiration and the excess is not being used by plants (2) Deficiency: there is a reduction of water available within the system. This occurs when evapotranspiration exceeds precipitation (3) Recharge: after a period of deficiency precipitation will occur and replace the lost water in the soil. This needs to occur before a period of surplus can reoccur (4) Field Capacity: The maximum amount of water that soil can hold before it becomes saturated. A surplus can result in wet soils, high river levels and additional run-off whereas a deficit lead to dry soil, falling river levels and possibly a drier micro climate. The soil water content is around 4%, the surface runoff is 38%, percolation is 26% and the evapotranspiration is 32%.

The percolation of water is less in the Shimsha watershed; this study area is facing problem in the depletion of ground water. The main reason for this area is due to deep bore well digging which cause the problem in the area. It's necessary to understand the relation between the various water balance components. Using swat model, it is easy to understand how water is actually behaving in the study area and how the role of water is changing. In this study results shows that overall, model performance was found to be agreeable as indicated by close relation between observed and simulated runoff. The Calibration and validation were performed manually for the year 2004 to 2005 and 2012 to 2013 respectively on monthly basis. The Model performance has been done using statistical parameter called Coefficient of Determination (R2). Also shows that after calibration and validation R2 value were found to be 0.64864 and 0.639706 respectively. The model indicated very good agreement between simulated and observed flow. Therefore, it can be concluded that the SWAT model helps as an effective tool for assessment of water functioning at basin scale.

Conclusion

As the population growing impulsively, demanding urbanization, the expansion of industries and development in agricultural practices adds up to the increasing demanding for water and it is very much essential to manage the resource wisely. In the present study, to understand the status of water resources as well as hydrological process in the Shimsha river basin, SWAT model was applied. Since the river Shimsha waters vast areas of cultivation land our study at estimating the surface runoff at ungauged stations for effective watershed management practices. Calibration and validation were performed manually for the year 2004 to 2005 and 2012 to 2013 respectively on monthly basis. Model performance has been done using statistical parameter called Coefficient of Determination (R2). After calibration and validation R2 value were found to be 0. 64864 and 0.639706 respectively. The model indicated very good agreement between simulated and observed flow. Therefore, it can be concluded that the SWAT model helps as an effective tool for assessment of water functioning at basin scale. Under practical conditions it may be difficult to install discharge gauges everywhere along the stretch of stream, and may be in the future it is necessary to know the surface runoff at a required stretch where the discharge gauge station facility is not available or gives faulty measurements.

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ETHICAL DIMENSIONS OF PROMOTING GIRL CHILD EDUCATION FOR SOCIAL EMPOWERMENT

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Abstract

This research paper explores the ethical considerations and societal implications of promoting girl child education as a means of social empowerment. It examines the intersecting factors of ethics, education, and society, focusing on the ethical challenges faced in ensuring equal access to education for girls and the transformative potential of education in fostering gender equality and social progress. The paper investigates the ethical dilemmas associated with gender disparities in education, the social barriers impeding girls' education, and the role of society in addressing these challenges. By analysing existing research and case studies, it aims to provide insights into the ethical dimensions of girl child education and its impact on the empowerment of girls and the broader society.

Introduction

Education is a fundamental human right that plays a pivotal role in individual empowerment and societal development. This is particularly true for girls, as girl child education has far-reaching implications for gender equality, poverty alleviation, and overall social progress. According to the United Nations (UN) Sustainable Development Goals (SDGs), ensuring inclusive and quality education for all, including girls, is a critical target to achieve by 2030 (UN, 2015). This brief overview will highlight the significance of girl child education, emphasizing the transformative power it holds for individuals and societies. Individual Empowerment. Access to education equips girls with knowledge, skills, and confidence, enabling them to make informed choices, fulfil their potential, and participate actively in society. Education empowers girls by broadening their horizons, expanding their opportunities, and breaking the cycle of poverty. Studies have shown that educated girls are more likely to marry later, have healthier families, and pursue higher education and career aspirations (UNESCO, 2018). Furthermore,

education empowers girls to exercise their rights, promotes critical thinking, and fosters leadership qualities, enabling them to contribute meaningfully to their communities and advocate for their own rights (Ghosh, 2016).

Societal Development

Investing in girl child education yields significant societal benefits and contributes to broader development goals. Educated girls become agents of change, driving social progress and economic growth. Research indicates that increasing girls' education results in reduced infant and maternal mortality rates, improved child nutrition, and healthier communities (Lloyd, 2016).. Moreover, educated women tend to have fewer children, which positively impacts population growth and allows for greater focus on quality education and healthcare for future generations (World Bank, 2018). Educated girls also have a higher likelihood of participating in decision-making processes, contributing diverse perspectives, and promoting gender equality in all spheres of society (UNESCO, 2020). Girl child education is of paramount importance for both individual empowerment and societal development. It not only empowers girls to break barriers and fulfil their potential but also yields far-reaching benefits for communities and nations as a whole. By investing in girl child education, we foster a more equitable and inclusive society, where girls can thrive and contribute meaningfully to the social, economic, and cultural fabric of their communities (Ali, M., & Kamraju, M. 2022. Gender disparities in education give rise to various ethical concerns that highlight the need for equal opportunities for girls.

These concerns revolve around principles of fairness, social justice, human rights, and the promotion of inclusive societies (UNESCO, 2017). Firstly, gender disparities in education violate the principles of equality and non-discrimination, as equal access to education is a fundamental human right (UNESCO, 2017). Denying girls, the same opportunities for learning and personal development that boys enjoy raises ethical concerns about fairness and equal treatment. Secondly, gender disparities in education perpetuate social injustices by reinforcing and perpetuating gender-based stereotypes and norms (Sen, 1999) . Such disparities limit girls' ability to realize their full potential, pursue their interests, and contribute meaningfully to society. Ensuring equal educational opportunities is a matter of social justice, aiming to rectify historical disadvantages and create a level playing field for girls. Moreover, education is a crucial tool for individual empowerment and agency. It equips individuals, including girls, with knowledge,

skills, and critical thinking abilities necessary for making informed choices and pursuing their aspirations (Nussbaum, 2000). Denying girls access to education denies them the opportunity to develop their potential, exercise their agency, and actively participate in shaping their lives and communities. In addition to ethical concerns related to individual empowerment, gender disparities in education hinder socioeconomic development at individual, community, and national levels. Education is strongly linked to economic growth, poverty reduction, and improved health outcomes (World Bank, 2018). By excluding girls from education, societies miss out on their potential contributions to economic productivity, innovation, and social progress. Addressing these ethical concerns requires concerted efforts from various stakeholders, including governments, policymakers, communities, and families. It involves implementing policies and interventions that promote gender equality, eliminate discriminatory practices, and ensure inclusive and quality education for all (UNESCO, 2017). By providing equal opportunities for girls to access education, societies can uphold ethical principles, promote social justice, and foster inclusive and equitable societies. Promoting girl child education. Promoting girl child education holds significant transformative potential and has far-reaching societal implications. By ensuring equal access to education for girls, societies can experience positive changes across various dimensions. Here is an overview of the societal implications and transformative potential of promoting girl child education:

(1) Gender Equality and Women's Empowerment: Girl child education is a critical step towards achieving gender equality. It enables girls to break free from traditional gender roles, challenge stereotypes, and pursue their aspirations. Educated girls are more likely to participate in decision-making processes, advocate for their rights, and contribute to policy discussions, leading to greater gender equality and women's empowerment within societies.

(2) Economic Development: Education plays a crucial role in driving economic growth and reducing poverty. Promoting girl child education leads to a more skilled and educated female workforce, enhancing productivity and innovation. Educated women can secure better employment opportunities, earn higher incomes, and contribute to the economic development of their families and communities. The World Bank estimates that investing in girls' education can lead to significant economic returns for societies.

(3) Health and Well-being: Educating girls has a positive impact on health outcomes for both individuals and communities. Educated girls are more likely to make informed decisions regarding their health, seek healthcare services, and adopt healthy behaviors. They are also better equipped to address maternal and child health issues, leading to improved healthcare practices and reduced mortality rates. Promoting girl child education contributes to better overall health and well-being outcomes for societies.

(4) Social and Political Participation: Education empowers girls to actively engage in society and participate in social and political processes. Educated girls develop critical thinking skills, become more aware of their rights, and are more likely to challenge social norms and discriminatory practices. Their participation in community development, civic activities, and political decision-making brings diverse perspectives and contributes to more inclusive and representative societies.

(5) Sustainable Development: Promoting girl child education aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 5 (Gender Equality). Education is recognized as a catalyst for achieving multiple development goals. Educated girls become agents of change, promoting sustainable practices, addressing environmental challenges, and contributing to sustainable development in their communities.

By recognizing and investing in the transformative potential of girl child education, societies can break cycles of poverty, discrimination, and inequality. Empowered and educated girls become catalysts for positive change, creating more inclusive, equitable, and sustainable societies for present and future generations.

Ethical Considerations in Girl Child Education

Exploring the ethical dimensions of gender disparities in access to education sheds light on the underlying issues of discrimination, cultural biases, and social norms that hinder girls' educational opportunities. The following points delve into these ethical considerations:

(1) Discrimination: Gender disparities in education are rooted in discriminatory practices that systematically disadvantage girls. Denying girls equal access to education based solely on their gender violates principles of fairness, equality, and human rights. Such discrimination perpetuates social and economic inequalities and denies girls the opportunity to develop their potential.

(2) Cultural Biases: Cultural norms and beliefs can reinforce gender-based stereotypes, limiting girls' educational opportunities. Societies that assign traditional roles to girls often prioritize domestic responsibilities over education. Challenging cultural biases and norms requires careful navigation, considering the need to respect cultural diversity while ensuring equal educational opportunities for girls.

(3) Social Norms: Social norms shape attitudes and expectations surrounding girls' education. These norms can discourage families from investing in their daughters' education, perpetuating the cycle of gender disparities. Addressing the ethical dimensions of social norms entails challenging traditional perceptions of gender roles and promoting a shift towards valuing and prioritizing girls' education.

(4) Intersections of Discrimination: Gender disparities in education intersect with other forms of discrimination, such as those based on socioeconomic status, ethnicity, disability, or geographic location. These intersecting dimensions exacerbate the challenges faced by marginalized girls, compounding the ethical concerns surrounding their access to education. Efforts to address gender disparities in education should consider and address these intersecting forms of discrimination.

(5) Human Rights and Social Justice: Ensuring equal access to education for girls is not only a matter of human rights but also an ethical imperative rooted in principles of social justice. Every child has the right to education, regardless of their gender. Failing to address gender disparities in education perpetuates social inequalities and hinders societies from achieving inclusive and equitable development.

Recognizing and addressing these ethical dimensions requires a multifaceted approach. It involves promoting inclusive policies, challenging discriminatory practices, and fostering societal shifts towards gender equality and girls' empowerment. Ethical considerations in girl child education call for proactive measures to dismantle barriers, challenge biases, and ensure equal educational opportunities for all children, irrespective of their gender. Addressing gender disparities in education and ensuring equal educational opportunities for girls presents several ethical challenges. These challenges arise from complex social, cultural, and economic contexts and require thoughtful consideration and action. The following points discuss the ethical challenges associated with addressing these disparities:

(1) Cultural Sensitivity and Respect: Promoting girls' education while respecting cultural diversity can be a delicate balancing act. It requires acknowledging and appreciating diverse cultural norms and values while challenging discriminatory practices that hinder girls' education (Freeman, 2004) . Ethical challenges arise in navigating cultural sensitivity and ensuring that interventions do not inadvertently undermine cultural identities or perpetuate cultural imperialism.

(2) Overcoming Resistance and Changing Attitudes: Resistance to change and deeply ingrained attitudes and beliefs can pose significant ethical challenges. Challenging deeply rooted gender biases and stereotypes requires engaging with communities and addressing their concerns and misconceptions. Ethical considerations include promoting dialogue, fostering understanding, and building consensus to overcome resistance to girls' education (Sutton, 2011).

(3) Resource Allocation and Prioritization: Ethical dilemmas emerge when limited resources must be allocated among competing priorities. Governments and organizations face challenging decisions in distributing resources to address gender disparities in education. Balancing investments in girls' education with other pressing needs, such as infrastructure development or healthcare, requires ethical considerations in ensuring equitable resource allocation (Zaidi, 2012)..

(4) Sustainable and Context-Specific Interventions: Implementing sustainable interventions that address gender disparities in education necessitates understanding the specific contexts, needs, and aspirations of girls within different communities. Ethical challenges arise in developing interventions that are contextually relevant, sensitive to local dynamics, and responsive to the unique challenges faced by girls in various socio-cultural settings (Moosa, 2020) .

(5) Intersectionality and Inclusivity: Ethical considerations arise from the recognition that gender disparities intersect with other dimensions of identity, such as socioeconomic status, ethnicity, disability, or geographic location. Ensuring inclusivity and addressing the needs of marginalized girls requires an intersectional approach that acknowledges and responds to the unique challenges faced by different groups of girls (Crenshaw, 1989).

Addressing these ethical challenges requires a comprehensive approach that incorporates principles of justice, fairness, and respect for human rights. It involves engaging with communities, fostering dialogue, and tailoring interventions to specific contexts. Furthermore, addressing gender disparities in education should involve collaboration with diverse stakeholders, including governments, communities, civil society organizations, and international bodies, to collectively navigate the ethical challenges and work towards achieving equal educational opportunities for all children. Investing in girl child education carries significant ethical implications and has the potential for positive impacts on society. By understanding and addressing these ethical implications, societies can promote social justice, equality, and sustainable development. The following points examine the ethical implications of investing in girl child education and its potential positive impact on society:

(1) Ethical Imperative of Equal Opportunity: Investing in girl child education aligns with the ethical imperative of providing equal opportunities for all individuals. Education is a basic human right, and denying girls access to education is a violation of their rights to equality and non-discrimination (UNESCO, 2015) . By investing in girls' education, societies uphold principles of fairness, justice, and human rights.

(2) Empowerment and Agency: Education empowers girls, enabling them to exercise their agency, make informed decisions, and participate actively in society. Ethically, investing in girl child education acknowledges and supports the agency and autonomy of girls, enabling them to shape their lives and contribute to the betterment of society (Nussbaum, 2000) . Empowered girls become agents of change, promoting gender equality, social progress, and sustainable development.

(3) Breaking the Cycle of Poverty: Education is a powerful tool for breaking the cycle of intergenerational poverty. Investing in girl child education can lead to improved economic opportunities, higher incomes, and enhanced socioeconomic well-being for girls and their families (World Bank, 2018) . Ethically, by breaking the cycle of poverty, societies reduce inequalities and promote social inclusion.

(4) Health and Well-being: Education is closely linked to improved health outcomes for individuals and communities. Educated girls are more likely to make informed decisions regarding their health, adopt healthier behaviours, and contribute to healthier families and communities (UNESCO, 2017).

Ethically, investing in girl child education contributes to the promotion of health, well-being, and the fulfilment of individuals' right to health.

(5) Sustainable Development: Investing in girl child education is a strategic investment in sustainable development. Educated girls become agents of change, promoting sustainable practices, addressing environmental challenges, and contributing to the achievement of the United Nations Sustainable Development Goals (SDGs) (UNESCO, 2018) . Ethically, investing in girls' education acknowledges the interconnectedness of social, economic, and environmental well-being and the need for a holistic approach to development.

By recognizing the ethical implications and investing in girl child education, societies promote social justice, gender equality, and inclusive development. Empowering girls through education not only benefits individuals but also leads to positive societal transformations, fostering a more equitable, prosperous, and sustainable future.

Societal Barriers and their Ethical Implications

Societal barriers to girl child education pose significant ethical implications as they perpetuate inequality, restrict opportunities, and hinder social progress. These barriers arise from deep-rooted social norms, cultural practices, and systemic issues that must be addressed to ensure ethical and equitable access to education for all children. The following points examine some societal barriers and their ethical implications:

(1) Gender-Based Discrimination: Gender-based discrimination is a pervasive societal barrier that denies girls equal access to education. Discriminatory practices, such as early marriage, gender stereotypes, and biased cultural norms, limit girls' educational opportunities. Ethically, such discrimination violates principles of equality, fairness, and human rights, undermining girls' potential and perpetuating social inequalities.

(2) Child Marriage and Early Pregnancy: Child marriage and early pregnancy are significant barriers to girls' education. These practices not only deny girls the opportunity to complete their education but also expose them to health risks and limit their future prospects. Ethically, addressing child marriage and early pregnancy is crucial for protecting girls' rights, promoting their well-being, and ensuring their equal access to education.

(3) Socioeconomic Constraints: Socioeconomic barriers, including poverty, lack of financial resources, and economic inequalities, hinder girls' access to education. Ethically, it is imperative to address these constraints to ensure equal opportunities for all children, irrespective of their economic background. Tackling socioeconomic disparities requires targeted interventions, resource allocation, and equitable policies that prioritize education as a fundamental right.

(4) Cultural Norms and Stereotypes: Cultural norms and stereotypes often reinforce traditional gender roles and perpetuate biases against girls' education. Ethical considerations arise in challenging these norms while respecting cultural diversity. Balancing cultural sensitivity with the promotion of equal educational opportunities requires engaging with communities, fostering dialogue, and promoting awareness about the importance of girls' education.

(5) Lack of Infrastructure and Resources: Inadequate educational infrastructure, such as schools, classrooms, and sanitation facilities, can disproportionately affect girls' access to education. Limited availability of educational resources, including textbooks, teaching materials, and technology, further exacerbates disparities. Ethically, addressing these barriers requires investment in infrastructure development and resource allocation to ensure inclusive and quality education for all children.

(6) Gender-Based Violence and Safety Concerns: Gender-based violence and safety concerns in and around educational institutions create a hostile environment for girls, deterring them from attending school. Ethical implications arise in ensuring a safe and secure learning environment that protects the rights and well-being of girls. Combating gender-based violence and addressing safety concerns is essential to creating an ethical educational ecosystem (Pranathi, O., & Kamraju, M. 2023) .

Addressing these societal barriers requires collective action, involving governments, civil society organizations, communities, and individuals. Ethical considerations call for transformative measures that challenge discriminatory practices, promote gender equality, and uphold the principles of fairness, justice, and human rights. By removing these barriers, societies can create an inclusive and equitable education system that empowers girls, promotes social progress, and fosters a more just and sustainable future.

Role of Society in Promoting Girl Child Education

(1) Ethical Responsibilities of Stakeholders: Various stakeholders, including governments, policymakers, educational institutions, communities, and families, have ethical responsibilities in promoting girl child education. Governments and policymakers bear the responsibility of enacting and implementing policies that ensure equal access to education for all children, regardless of their gender (UNESCO, 2015) . Educational institutions should create inclusive environments free from discrimination, while communities and families must actively support and encourage girls' education, challenging harmful gender norms and stereotypes.

(2) Importance of Community Involvement: Community involvement plays a crucial role in promoting girl child education. Communities can create a supportive environment by recognizing and valuing the importance of girls' education. Engaging community leaders, parents, and local organizations in dialogue and decision-making processes helps address cultural barriers, dispel myths, and foster acceptance of girls' education (Gupta, 2013) . Ethically, community involvement ensures that interventions are contextually relevant, sustainable, and respectful of local customs.

(3) Awareness Campaigns and Advocacy: Raising awareness about the importance of girl child education is essential for creating a supportive environment. Awareness campaigns and advocacy efforts can challenge societal perceptions, highlight the benefits of educating girls, and mobilize public support (Ghosh, 2019) . Ethically, advocacy campaigns promote social justice and human rights by challenging discriminatory practices and influencing societal attitudes towards girls' education.

(4) Successful Initiatives and Interventions: Numerous successful initiatives and interventions have addressed ethical challenges and promoted girl child education. For example, the Kishoree Kontha program in Bangladesh focuses on empowering adolescent girls through education, life skills training, and community engagement (World Bank, 2020) . The Room to Read organization implements interventions that address cultural and economic barriers, providing girls with access to quality education in various countries (Room to Read, n.d.). These initiatives highlight the importance of context-specific approaches, community involvement, and multi-stakeholder partnerships in promoting girl child education ethically.

Integrating ethical considerations into interventions involves promoting social justice, equity, and human rights. It requires engaging with stakeholders, fostering dialogue, and ensuring the participation of marginalized communities. By recognizing and fulfilling their ethical responsibilities, stakeholders can collectively contribute to creating an enabling environment that supports and promotes girl child education.

Conclusion

In conclusion, the research highlights the ethical dimensions of promoting girl child education and the transformative potential it holds. It emphasizes the ethical responsibilities of various stakeholders, including governments, policymakers, educational institutions, communities, and families, in ensuring equal access to education for girls. The research underscores the importance of addressing societal barriers, such as discrimination, cultural biases, and social norms, which hinder girls' education and perpetuate inequality. Investing in girl child education is not only an ethical imperative but also a pathway to empowering girls and fostering social progress. Education equips girls with knowledge, skills, and agency, enabling them to overcome challenges, make informed decisions, and contribute positively to society. By providing equal educational opportunities, societies can promote social justice, gender equality, and sustainable development. However, there are ethical challenges associated with addressing gender disparities in education. These challenges include cultural sensitivity, overcoming resistance to change, resource allocation, developing context-specific interventions, and addressing intersectionality and inclusivity. Tackling these challenges requires collaborative efforts, dialogue, and transformative measures that uphold principles of fairness, justice, and human rights. Further research is needed to deepen our understanding of the ethical implications of promoting girl child education and to identify effective strategies to overcome barriers. Policy changes should prioritize girls' education, allocate resources equitably, and address systemic issues that perpetuate gender disparities. Collective action involving governments, communities, civil society organizations, and individuals is necessary to ensure equal access to education for all children, irrespective of their gender. In conclusion, promoting girl child education is not just an ethical imperative but also a means to create a more inclusive, equitable, and prosperous society. By recognizing and addressing the ethical challenges, we can unlock the full potential of girls, empower them as agents of change.

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GEOPOLITICAL CONFLICT SITUATION AND PERSPECTIVE- A CASE STUDY OF INDIAN OCEAN

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Abstract

The geopolitics of the Indian Ocean region holds paramount significance in the contemporary global landscape. This paper delves into the multifaceted dimensions of Indian Ocean geopolitics, encompassing historical, economic, environmental, and strategic considerations. Employing a comprehensive methodology that incorporates geopolitical databases, economic and trade statistics, environmental data, and historical archives, the study aims to unravel the intricate interplay of actors, interests, and power dynamics in the region. The Indian Ocean, boasting critical choke points like the Strait of Hormuz and Bab-al-Mandeb, serves as a nexus for international trade and political activities. As the repository of a substantial share of the world's oil, gas, uranium, gold, and diamond reserves, the Indian Ocean region emerges as a focal point for global economic dynamics. Furthermore, it houses vital minerals, amplifying its strategic importance. The region's geopolitical landscape is marked by the presence of diverse littoral states, each with its unique historical trajectory, economic aspirations, and security concerns.

Introduction

Geopolitical analysis often examines the Earth's composition of land and water, a concept with a long history spanning hundreds of years. This perspective considers the interconnectedness of humanity, states, and the environment. The Earth can be categorized into hemispheres based on water and land distribution. The rise of globalization has amplified the importance of the Indian Ocean in economic affairs. In terms of size, the Indian Ocean ranks third globally, holding approximately 20% of the world's water. Analyzing the world map through Mercator's projection provides insight into the geopolitical importance of the Indian Ocean, which extends from 20 degrees E to 120 degrees E longitude. Notably, all nations along the Indian Ocean coastline, excluding Australia and South Africa, fall within the underdeveloped or developing categories. Furthermore, the majority of these nations comprise a significant portion of the Third World, sharing common

characteristics, notably having been part of colonial empires of Western European nations until gaining independence, primarily between the 1940s and 1960s. With limited exceptions, these nations were integral components of the colonial empires of Western European nations for substantial durations throughout the 19th and 20th centuries. They achieved liberation, whether through peaceful methods or other means, from colonial dominion between the 1940s and 1960s.

Study Region

This article is study of Indian Ocean region. The emerging nation-states facing heightened vulnerabilities and instabilities due to their underdeveloped status. Their ambitions and frustrations stem from the allure of development benefits on one hand and the constraints of economic backwardness on the other. These nations collectively grapple with the challenges and disruptions associated with the shift from traditional cultural values to those required by industrial economies in the nuclear age. Access to the ocean can be gained through either two narrow northern "choke-points" – the Suez Canal/Horn of Africa and Singapore/Straits of Malacca – or two southern border "gateways" at the southern extremities of Africa and Australia. The southern Indian Ocean, in reality, provides the most direct route between the Pacific and Atlantic Oceans. Moving beyond the coastal states, the northern landmass is primarily shaped by the influence of the Soviet Union and China, both Communist powers in ideological conflict with the Western world. Specifically, the Soviet Union, as a superpower, has been in a conflict with the United States, the other superpower. Strategically, the Indian Ocean region represents a vulnerable aspect for the Soviet Union, with limitations in reducing its vulnerabilities. Following the British announcement in 1968 regarding their withdrawal from the Indian Ocean Region by 1971, the two superpowers – the United States and the Soviet Union – became deeply involved. The subsequent two decades witnessed an escalation in militarization and superpower rivalry. The economic and political aspects of the Indian Ocean have seen growth alongside the expansion of globalization.

Objectives

(1) The significance of Indian ocean in geopolitics of region

(2) How is Indian Ocean strategically important for India?

(3) Why United States is interested in Indian Ocean region?

(4) Why china wants its domination in Indian Ocean?

Database and methodology

This article used primary and secondary data. Articles, books, newspaper, government documents, reports. Utilize geopolitical databases that compile information on international relations, conflicts, and geopolitical events. Access databases that provide economic and trade statistics for countries in the Indian Ocean region. International organizations like the World Bank and the International Monetary Fund (IMF) offer comprehensive datasets. Explore historical archives and libraries for primary sources that offer insights into historical geopolitical events in the Indian Ocean region. The methodology used in article is qualitative. Analysis of indian ocean rgionis conducted to know its significance. Conduct a thorough literature review to understand existing theories, frameworks, and scholarly work on Indian Ocean geopolitics. Identify gaps or areas for further exploration. Analyze specific case studies within the Indian Ocean region to gain a nuanced understanding of geopolitical dynamics. Focus on historical events, conflicts, or cooperative efforts. Explore different scenarios and potential future developments in the region based on geopolitical, economic, and environmental factors.

Results and Discussion

Initially, the United States demonstrated a lack of interest in filling the gap left by Britain's withdrawal from the Suez Canal. However, developments in the 1970s and 1980s compelled the U.S. to become involved in the Indian Ocean region. The U.S. strategically nurtured relations with China, capitalizing on the rivalry between China and the Soviet Union. Simultaneously, the U.S. refrained from intervening in South East Asia to allow China to reap the benefits. The U.S. directed its efforts toward maintaining influence in South Asia, West Asia, and Southwest Asia for its own strategic advantage. In contrast, the Soviets adopted a policy of supporting anti-imperialist forces and advocating for the independence of nations in former colonies. The shared anti-imperialist sentiment served as a basis for cooperation among states aspiring for socio-economic improvement in partnership with the Soviet Union. The Soviet Union aimed to diminish the influence of the United States in newly independent and developing countries, particularly given the growing collaboration between the U.S. and China. The Indian Ocean holds significance for trade and commerce, serving as a crucial link between the East and West. The political importance of the Indian Ocean has grown due to the ideological conflict between the two superpowers. According to the United States, the Indian Ocean is pivotal to its strategy of fostering positive relations and exerting influence in newly independent states. Conversely, the USSR views the U.S. strategy as a potential

threat to the sovereignty of these newly independent states and a hindrance to its own security. The geostrategic relevance of the Indian Ocean is heightened by its access to sensitive global areas and key choke points, such as the Malacca Strait.

Strategic Significance of Ports

China and India are making substantial investments in the development of seaports in the Indian Ocean, recognizing its strategic significance. India is actively involved in the construction of the Chabahar port in Iran, aiming to secure access to landlocked Central Asian countries. In response, China is building the Gwadar port in Pakistan, directly challenging India's interests. The presence of an anti-Sunni regime in Iran introduces vulnerabilities in the operational efficiency of the Chabahar port, posing challenges to India's maritime interests. In 2008, the Chief of the Indian Navy highlighted the strategic implications of the Gwadar port, emphasizing its potential to empower Pakistan in controlling strategically important energy sea lanes in the Persian Gulf. The growing geopolitical importance and cohesion of the Indian Ocean region are substantiated by at least three factors: the proliferation of regional strategic connections, the Indian Ocean policies pursued by external powers, and the collective indigenous responses to external intervention. The proliferation of regional strategic linkages underscores the increasing interconnectedness of events in the Indian Ocean area.

These events may be linked in two primary ways. Firstly, through a "linkage of instabilities," wherein the instabilities and imbalances in one sub-region not only affect neighboring countries but can also extend into more distant parts of the region, forming a comprehensive "linkage of instabilities" throughout the area. The impact of a situation may vary based on its occurrence, with implications differing for events near and further away. For instance, the Vietnamese invasion of Kampuchea has led to a significant refugee crisis and concerns about a direct security threat in Thailand, while in Indonesia and Australia, it is perceived as an unwelcome and perilous manifestation of regional instability. Similarly, the Soviet invasion of Afghanistan raised fears of a direct Soviet threat to Pakistan and Persian Gulf oilfields, causing apprehension in distant parts of the region about the means and objectives of Soviet policy. Consequently, due to such developments over the past decade, it is now improbable that any event impacting the security of even the smallest state in the Indian Ocean region will be dismissed as inconsequential to the other states in the area. Subsequently, interconnections arise among sub-regions when individual states or groups of states deliberately implement security policies on a scale beyond their immediate sub-regional context.

An example is the collaborative efforts of black states in southern Africa, in conjunction with other African nations, actively working to isolate and apply pressure on white-ruled South Africa. Similarly, there is widespread support from the nations along the Indian Ocean coast for the proposal to designate the area as a zone of peace. Another illustration is Saudi Arabia's policy, which seeks to integrate security postures from the Red Sea area through the Gulf to the extremities of the Indian subcontinent. Presently, the process of linkage seems fragmented, with states in one subregion generally not seeking security alliances with those in another. Security linkages have primarily been extra regional, involving a local state and an external power, such as Australia with the United States, India with the Soviet Union, and Pakistan with China and the United States. Although limited, the success of formal alliances between states of different subregions, as seen in SEATO (South-East Asia Treaty Organization) and CENTO (Central Treaty Organization), suggests the potential for more formal sub-regional coalitions in the future. Additionally, the Gulf Cooperation Council is progressing towards forming a security alliance, as previously mentioned.

The strategies of the two superpowers hold paramount significance. Their immediate concerns in the region have intertwined with the broader dynamics of their global competition, making the Indian Ocean a strategically vital arena for both. In contrast to Japan and Western Europe, which relied on Gulf oil for approximately 90% and 75% of their respective needs during the 1973-1974 embargo, the United States did not have a comparable dependence on Gulf oil. The significant outcome of the embargo wasn't just the impact on Western economies but the intense discord and internal conflicts within the Atlantic alliance. Member states and Japan engaged in fierce competition for privileged access to unembargoed oil and future access to Arab oil. The United States is eager to avoid a prolonged denial of Persian Gulf oil to the West, not only for economic reasons but also to maintain alliance solidarity. Despite the current surplus in global oil supplies and declining prices, Persian Gulf oil, constituting about 55% of the world's proven reserves, will remain strategically crucial for the West until the end of the century. In the past, the United States leaned on local allies to protect its fundamental political, economic, and strategic concerns in the Indian Ocean region. Yet, a shift occurred in the late 1970s, with the U.S. adopting a new strategy for its security interests in the area. This approach actively aimed to enhance access to naval, air, and communications facilities across the region. It involved improving the operational capabilities of the British-owned Diego Garcia, increasing naval deployments in the Indian Ocean,

and establishing the Rapid Deployment Force. These initiatives significantly strengthened the U.S.'s capacity to exert influence in the Indian Ocean, indicating a commitment to a more engaged role in the region. While the focus of these efforts might appear centered on the Persian Gulf, it is crucial not to characterize the policy as exclusively Gulf-centered. Although additional forces and facility improvements suggest a concentrated approach, U.S. military resources are limited and must be allocated based on strategic priorities. The emphasis on the north-west quadrant of the Indian Ocean highlights the importance Washington attributes to its Gulf interests and an overarching concern for the stability of that subregion. However, the U.S. has not neglected its military and political interests in other parts of the region, as evidenced by recent endeavors to strengthen military capabilities in the eastern approaches to the Indian Ocean, including securing landing rights for B-52 bombers in Australia

Non State Actors and their Threat

Non-traditional threats to global security have experienced significant growth, and India is grappling with major challenges such as maritime terrorism, gun-running, drug trafficking, and piracy along its sea borders. Given the crucial shipping lanes traversing the region, India has been underscoring the significance of maritime security in the Persian Gulf and the Gulf of Aden. Various terrorist organizations, including Al Qaeda, utilize maritime routes around India in the Indian Ocean region for narcotics and arms trafficking, financing their operations. Indian intelligence agencies have cautioned the government about potential seaborne attacks by terrorist groups targeting the nation's oil rigs, encompassing production and support platforms along both coasts. Piracy poses a significant threat in various parts of the Indian Ocean, notably the Malacca Straits and the Horn of Africa, necessitating a robust Indian maritime presence. Reflecting this perspective, the Indian maritime doctrine asserts that the arc from the Persian Gulf to the Straits of Malacca is a legitimate area of interest for India in the twenty-first century. The majority of attacks and hijackings on the high seas concentrate in three key areas: the Gulf of Aden and the eastern coast of Somalia, the coast of West Africa (particularly off Nigeria), and the Indonesian archipelago. In the initial quarter of 2008, over half of all attacks occurred in the Gulf of Aden. In 2008, a significant surge in piracy incidents took place, with at least 92 ships attacked in and around the Gulf of Aden, surpassing the number in 2007. An estimated $25 to $30 million was paid in ransom to Somali pirates. Responding to heightened concerns,

particularly after the hijacking of the merchant vessel MT Stolt Valor off the coast of Somalia in September 2008, the Indian government authorized the Indian navy to initiate patrols in the Gulf of Aden and provide escorts to Indian merchant vessels. India holds an economic stake in safeguarding not only Indian-owned but also non-Indian-owned cargo ships in the Gulf of Aden shipping lanes. Approximately 85 percent of India's sea trade on this route is transported by foreign-owned ships, and about one-third of India's entire fleet of 900 cargo ships operating in international waters is vulnerable to risks. The patrolling conducted by the Indian navy aims to secure the nation's sea-borne trade, instill confidence in the maritime community, and serve as a deterrent to pirate activities. While Russia, NATO, and EU forces have initiated patrols in the region, coordination efforts remain disjointed. India argues for the establishment of a peacekeeping force under a unified command to ensure security in pirate-infested regions for international shipping.

In a noteworthy operation—the first of its kind since the 1971 war with Pakistan—India's stealth frigate, INS Tabar, engaged and sank a pirate "mother vessel" in the Gulf of Aden, later revealed to be a Thai trawler. The Indian naval vessel fired in self-defense as the trawler, commanded by pirates who refused to surrender, posed a threat. This incident underscored the Indian navy's capabilities on the high seas, previously demonstrated during tsunami relief operations and the evacuation of Indian nationals in the Lebanon War of July-August 2006. The Indian navy showcased its autonomy and proficiency in serving a collective good: the protection of global maritime trade. India utilized this demonstration to project itself as a nation capable of safeguarding its maritime interests and commercial sea routes in international waters. While this highlighted the Indian navy's prowess on the high seas, questions were raised about its ability to counter terrorism on the home front, especially following a severe assault on Mumbai in November 2008, where terrorists managed to outwit the Indian navy and Coast Guard.

The terrorists successfully infiltrated Mumbai using a trawler, revealing a systemic failure within Indian security agencies. India's Coast Guard is responsible for securing the Exclusive Economic Zone within 200 nautical miles, while the navy oversees the blue water beyond. Despite the clear recognition of the threat of terror attacks from the sea, no measures were taken to reinforce anti-terror defenses. India's extensive coastline, coupled with insufficient policing, facilitates the clandestine landing of arms and explosives at isolated coastal points. This method was exploited in 1993 for the bomb blasts in Mumbai, and it was employed again in the 2008 terrorist attacks. The Indian Naval Chief took

responsibility for the lapse, citing weak infrastructure for patrolling and surveilling coastal areas. Despite actionable intelligence, both the Coast Guard and the navy failed to detect or intercept the Pakistani ship transporting terrorists from an Indus creek near Karachi, Pakistan. The escalating global threats from non-state actors necessitate India's collaboration with other major naval powers, not only to address issues like piracy but also to tackle broader security concerns for maritime commerce. Given the Indian navy's demonstrated effectiveness in providing the government with operational leverage in the Indian Ocean, its role in projecting power and safeguarding national interests is expected to grow. However, a significant challenge to the Indian navy may emerge from the expanding influence of another major Asian power in the Indian Ocean i.e. China.

In 2006, China surpassed Japan as the largest military spender in the Asia-Pacific, now holding the fourth-largest defense expenditure globally. While there is contention over the exact figures, with estimates ranging from China's official claim of $35 billion to the US Defense Intelligence Agency's estimate of $80-115 billion, the clear trend is a significant increase in Chinese military spending, showing a 195 percent rise from 1997 to 2006. The official Chinese figures do not encompass costs for new weapons purchases, research, or other major items for its secretive military. Calls for transparency in China's military intentions and capabilities have arisen globally, from Washington to Tokyo, Brussels, and Canberra. According to the 2006 Defense White Paper, China's navy aims to gradually expand its strategic depth for offshore defensive operations, enhance capabilities in integrated maritime operations, and develop nuclear counter-attacks. The Chinese navy now ranks as the third-largest globally, surpassing the Indian navy both qualitatively and quantitatively.

Historically a coastal force with a continental security outlook, China's economic rise since the 1980s has led to a maritime orientation with intentions to project power into the Indian Ocean. China is investing significantly more in modernizing its armed forces, particularly its navy, than India currently appears willing or able to sustain. China's growing submarine fleet, including sophisticated submarines, ballistic missiles, and GPS-blocking technology, positions it to potentially challenge the United States. There are indications that China plans to build an aircraft carrier by the end of the decade, a departure from its earlier focus on Taiwan. As China's economic and political influence expands, its profile in the Indian Ocean region has grown, with efforts to acquire naval bases along crucial chokepoints for economic and strategic purposes. China's comprehensive development of maritime power reflects

its ambition to dominate the strategic maritime space in the Indian Ocean region. To overcome the geographical distance, China relies on bases in the littoral regions of the Indian Ocean. The "String of Pearls" strategy exemplifies China's increasing naval power and encircling approach, particularly evident in its efforts to dominate the South China Sea and deploy submarines near the Strait of Malacca, a vital entry point to the Indian Ocean. Despite India's geographical advantage, China's expanding naval capabilities pose a strategic challenge for India in the region. China is actively pursuing the development of its maritime economy and aims to establish the world's largest merchant fleet, backed by extensive port and shipbuilding infrastructure. While China-India relations have been steadily improving since the 1990s, there has consistently been an underlying sense of competition. China has effectively cultivated strong ties with Pakistan through its economic and military influence. Although China aspires to dominate the Indian Ocean and achieve naval supremacy, this goal remains a distant prospect.

Indian Response to China in Indian Ocean

Strategic Partnerships: India has fostered strategic partnerships with countries in the Indian Ocean region to counterbalance China's influence. Bilateral and multilateral engagements with nations like the United States, Japan, Australia, and those in Southeast Asia have become more pronounced. Naval Modernization: India has been investing in the modernization of its naval capabilities to enhance maritime security. This includes the development of a robust naval fleet, acquisition of maritime surveillance systems, and the establishment of coastal surveillance networks. Infrastructure Development: India has been working on enhancing its maritime infrastructure, including port facilities, to strengthen its presence in the Indian Ocean. Projects such as the development of the Chabahar Port in Iran aim to provide India with strategic access to Central Asia. Diplomacy and Regional Cooperation: India has engaged in diplomatic efforts and regional cooperation to address common security concerns. Initiatives like the Indian Ocean Naval Symposium (IONS) and the Indian Ocean Rim Association (IORA) have been platforms for dialogue and collaboration. Focus on Maritime Domain Awareness (MDA): India has increased its focus on MDA to monitor and respond to maritime security threats effectively. This involves intelligence-sharing agreements, joint patrolling, and coordinated efforts with partner nations. Anti-Piracy Operations: India has actively participated in anti-piracy operations in the Gulf of Aden. The Indian Navy has deployed warships to ensure safe passage for merchant vessels and counteract piracy in the region. It's important to note that the geopolitical

landscape is dynamic, and developments may have occurred since my last update in January 2022. For the latest and more detailed information, please refer to recent academic publications, official government statements, or reputable news sources.

Conclusion

The Indian Ocean has evolved into a focal point for global economic and political endeavors, attaining strategic significance due to key chokepoints like the Strait of Hormuz and Bab-al-Mandeb. There exists a need for a renewed geopolitical framework for the Indian Ocean region, departing from traditional military-centric perspectives, and challenging the imperialist history of international maritime relations. The notion of 'mastery' or 'conquest' of the oceans must be reevaluated, recognizing the finite capacity of the marine environment and prompting exploration of new perspectives. Establishing a peaceful, socially equitable, gender-sensitive, and environmentally sustainable 'order' for the oceans requires patient negotiations and consensus-building, steering away from exclusively state-led management or region-specific development approaches. The Indian Ocean region and its coastal areas harbor over two-thirds of the world's oil reserves, 35% of global gas reserves, and significant proportions of uranium (60%), gold (40%), and diamond reserves (80%). Moreover, the region's importance is underscored by its mineral wealth, encompassing reserves of beryllium, coal, copper, iron, tin, chromite, manganese phosphate, and lithium. Positioned strategically, the Indian Ocean holds a unique geopolitical status, being the only ocean named after a country.

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STUDY OF LITERACY GAP AMONG GENDER: A BLOCK LEVEL ANALYSIS OF LUCKNOW DISTRICT

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Abstract

Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy is considered an important key to social-economic progress. Literacy & education attainment are important indicators of the development of a society. It helps in eliminating gender disparity at all level. In India the reality of gender inequality is very complex and diversified because it exists in various fields like literacy, health, employment etc. According to the Census of India 2011, the overall literacy rate of India is 74% with male literacy being 82% & female literacy at 65%. A sizeable gender difference of 17% can be observed in the literacy rate. Such disparities between male and female literacy can be seen at both state and national levels. Recent decades manifest growth in literacy but the gap still exists and is predominant in rural areas. Lucknow district also witnesses gender disparity in literacy. The present study is an attempt to evaluate literacy gap among gender & its regional variations in the administrative blocks at the district level. This paper provides an insight into the Spatio-temporal patterns of male-female literacy & its level of disparity. This study is based on secondary sources of data collected from the District Census Handbook. The method adopted in the study to calculate the disparity in literacy is Sopher's Disparity Index (1974). Between the years 2001 and 2011, the study area has seen a fall in the gender gap and an increase in the male-female literacy rate. The gender literacy gap has been bridged largely due to initiatives like Beti Bachao, Beti Padhao, and the National Program of Education for Girls at the Elementary Level (NPGEL). But still, there is a scope for improvement in women's literacy levels for this the research will be useful in suggesting some relevant strategies and policies with implications for reducing gender inequality and promoting the dignified position of women.

Introduction

Literacy is a crucial indicator of the social and economic development of a nation. It plays a significant role in removing inequality along with the development of society and its individuals. It is the fundamental building block for a country's development. Literacy is a highly important tool for people to learn and develop skills that will enable them to understand and have a positive attitude for society. It also helps in analyzing the inequalities and factors responsible for poverty and exploitation in the society. Kofi Annan, Former Secretary General of the United Nations had quoted, "Literacy is a bridge from misery to hope. It is a tool for daily life in modern society. It is a bulwark against poverty and building blocks of development, an essential component to investments in roads, dams, clinics & factories. It is a platform for democratization & a vehicle for promotion of cultural & natural identity. It is the way to human progress & the means through which every man; woman & child can realize his or her full potential". The definition of literacy given by UNESCO (1957), "A person is literate who can with understanding both read and write a short simple statement on his/her everyday life". In simple words according to UNESCO it means "Literacy is the ability to identify, understand, interpret, create, compute & use printed & written material associated with varying contracts". According to Census of India 2011, "Any person (aged 7 & above) is considered a literate, if he or she can read & write in any language with complete understanding". Researchers, Academicians & policy makers have rated literacy as the starting point of development (Pattinson1982, Strect 1984).

Literacy unlocks the door to learning throughout life is essential, is essential to development & health & opens the way for democratic participation & active citizenship (Kofi Annan, Former Secretary General of the United Nations). Literacy influences & determines qualitatively & quantitatively not only human resources but also other demographic attributes like fertility, mortality, and economic participation of women &age of marriage ultimately aiming towards welfare of the society (Sawant & Lewis, 2004). Literacy is both the cause & result of development (Mohapatra,1993). Literacy is tool to empower women in the wider struggle against inequality & injustice in society (Patel & Dighe,1997). Higher levels of literacy are a good predictor of both a growing economy and a high standard of living. According to the Census of India 2011, the overall literacy rate of India is 74% with male literacy being 82% & female literacy at 65%. Uttar Pradesh recorded as a whole 77.3% of males & 57.2% of female literates. Lucknow district as a whole accounted for 82.6% of male & 71.5% of female literates respectively. At the national, state,

district, and block levels, disparities between males and girls in literacy can be observed. Recent decades have witnessed growth in literacy rate but the disparity in literacy still exists and can be predominantly seen in rural areas of the country. This is generally because the rural areas are dominated by agricultural activities while the urban regions are driven by the tertiary sector. Thus, a difference in economy, infrastructural facilities, accessibility, the standard of living, and women status can be observed. Differences in literacy are important for a variety of reasons. Due to the underutilization of potential human capital, a biased allocation of educational resources implies significant costs for social welfare. Some important factors like-poverty, early marriage, dowry, preference for boy's education, lower enrollment, etc are responsible for creating such disparities in literacy. Grover R.P., & Bhardwaj, R., (2002) have rightly pointed out that administrators & planners must pay greater attention in bridging the gap between literacy of males & females. As literacy is related to both social needs and economic development, there is a need to implement integrated literacy programs for rural development, with a particular focus on skill development and income generation programmes. A woman holds a pivot position & plays multiple roles in the development of modern society. It is widely argued, "When you educate a man, you educate a person; but when you educate a woman, you educate a generation." The Sustainable Development Goal (SDG) 4 also talks about ensuring inclusive & equitable quality education & promote lifelong learning opportunities for all. It will confront a holistic approach to educating people & boosting literacy levels to meet sustainable development goals that have yet to be made by 2030.

Study Region

Lucknow is the capital city of Uttar Pradesh which is located on the banks of river Gomti dividing the whole city diagonally into cis-gomti & trans-gomti regions . The total area of the district is 2528sq km. It exists between 26°30' to 27°10' North latitude and 80°34' to 81°12' East longitude. The district is surrounded in the northern side by district Sitapur, on the southern side by district Raebareli, on the eastern side by Barabanki district, on the south-western side by Unnao district & on the north-western side by Hardoi. The administrative setup of the district is divided into 4 tahsils & 8 development blocks namely Mal, Malihabad, Bakshi Ka Talab, Chinhat, Kakori, Sarojaninagar, Gosainganj & Mohanlalganj. There are total of 12 towns (10 statutory towns & 2 census towns. The adjoining districts are dependent on Lucknow district & mostly the Lucknow city for better education & health facilities & various job opportunities.

Objectives

(1) To find out the gender disparity in literacy rate.

(2) To suggest suitable measures for reducing disparities in literacy rate.

Database and Methodology

The present study is based on secondary data & sources obtained mainly from the Census of India, relevant issues, 2001 & 2011 & District Census Handbook of Lucknow-2001 & 2011. The block-wise data of the literate population & literacy rate for the 2001 and 2011 censuses are available. The tabulation and graphical representation of the data are done and represented through maps. The methodology adopted to measure gender disparity is Sopher's Disparity (1972). It is calculated using the following expression:

$$DI = \text{Log } X2/X1 + \text{Log } 100\text{-}X1/100\text{-}X2$$

Whereas: $X2 \geq X1$

DI- Disparity Index

X2- Percentage of Male Literates

X1- Percentage of Female Literates

Q- 100

To measure gender disparity in literacy, male literacy is taken as X2 & female literacy as X1, Where X2 is generally more than that X1. The Log value is taken to reduce the leveling-off effect (Sopher 1972). The value should range between +1 & -1. In the case of perfect equality, no disparity exists between the two variables. If the value is greater, it represents high disparity and if the value turns out to be lesser it shows low disparity. It is generally used in measuring the relative disparity. The study of the disparity index of literacy is grouped into 3 categories, namely, Low Disparity, Medium Disparity and High Disparity.

Results and Discussion

Being a universal phenomenon, the disparity in male-female literacy varies from region to region. The study area is also not free from this disparity. According to Census 2001, the total literacy rate of Lucknow district was 68.25% with male & female literacy rates being 75.98% & 60.47% respectively. With the passage of time, the study area witnessed a significant jump in total literacy by 77.3% with 82.6% as male literates & 71.5% as female literates in the 2011 Census (**Fig.** 1.)

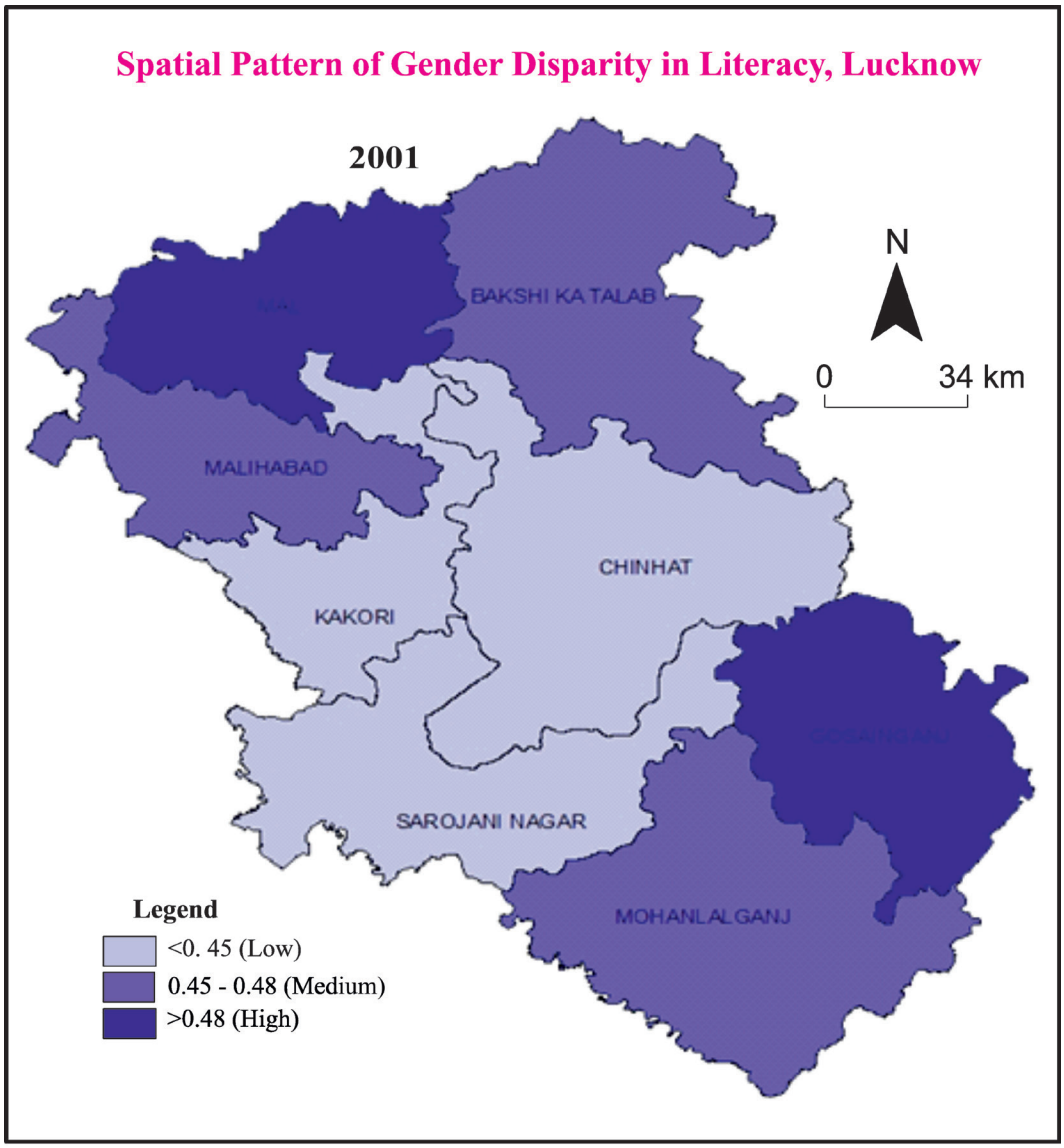

Spatial Pattern of Gender Disparity in Literacy, Lucknow
2001
N
0
34 km
BAKSHI KA TALAB
MALIHABAD
CHINHAT
KAKORI
SAROJANI NAGAR
MOHANLALGANJ
Legend
<0. 45 (Low)
0.45 - 0.48 (Medium)
>0.48 (High)

Fig. 1

Though, the disparity got narrowed down from the 2001 to 2011 census but, still, a large number of people are illiterates existing in the study region & acting as a major obstacle in the socio-economic development of the area. The present paper is an attempt to study regional variation of gender disparity in literacy in the study area by using Sopher's Disparity Index. This disparity is calculated for all the administrative blocks for the censuses 2001 & 2011. On the basis of values of literacy, the disparity index is calculated & by applying the standard deviation technique the study area is divided into low, medium & high disparity regions. The disparity was 0.45 in 2001 which came down to 0.36 in 2011 (**Table-**1 & **Table-**2 and Fig 2).

Table-1: Gender Disparity Index (GDI) in Literacy Rate, 2001

Blocks	% of literacy to the total population in Lucknow 2011				
	Total Literacy	Male Literacy Rate	Female Literacy Rate	Gap in Male-Female Literacy Rate (%)	Gender Disparity Index (GDI)
Mal	47.1	60.2	32.4	27.8	0.49
Malihabad	51.3	63.7	37.0	26.7	0.47
Bakshi Ka Talab	55.5	67.7	41.3	26.4	0.47
Chinhat	55.8	67.1	42.8	24.3	0.43
Kakori	50.4	61.2	37.9	23.3	0.41
Sarojaninagar	58.4	69.5	45.5	24	0.43
Gosainganj	53.7	66.7	39.0	27.7	0.49
Mohanlalganj	55.6	67.7	42.1	25.6	0.45
District (Rural)	53.9	65.9	40.1	25.8	0.45

Source: District Census Handbook of Lucknow, 2001

Areas of Low Disparity

In 2001, low disparity range (Below 0.45) was observed in 3 blocks namely Chinhat (0.43), Kakori (0.41) & Sarojaninagar (0.43). The highest rural literacy of 58.4% with 69.5% of male literacy & 45.5% of female literacy was recorded in Sarojaninagar block. In 2011 the same blocks except Sarojaninagar (0.38) i.e. Chinhat (0.33) & Kakori (0.32) were in the low disparity range (Below 0.36). This low disparity in these blocks can be attributed to good socio-economic development, high literacy, better opportunities for women, suitable environment etc.

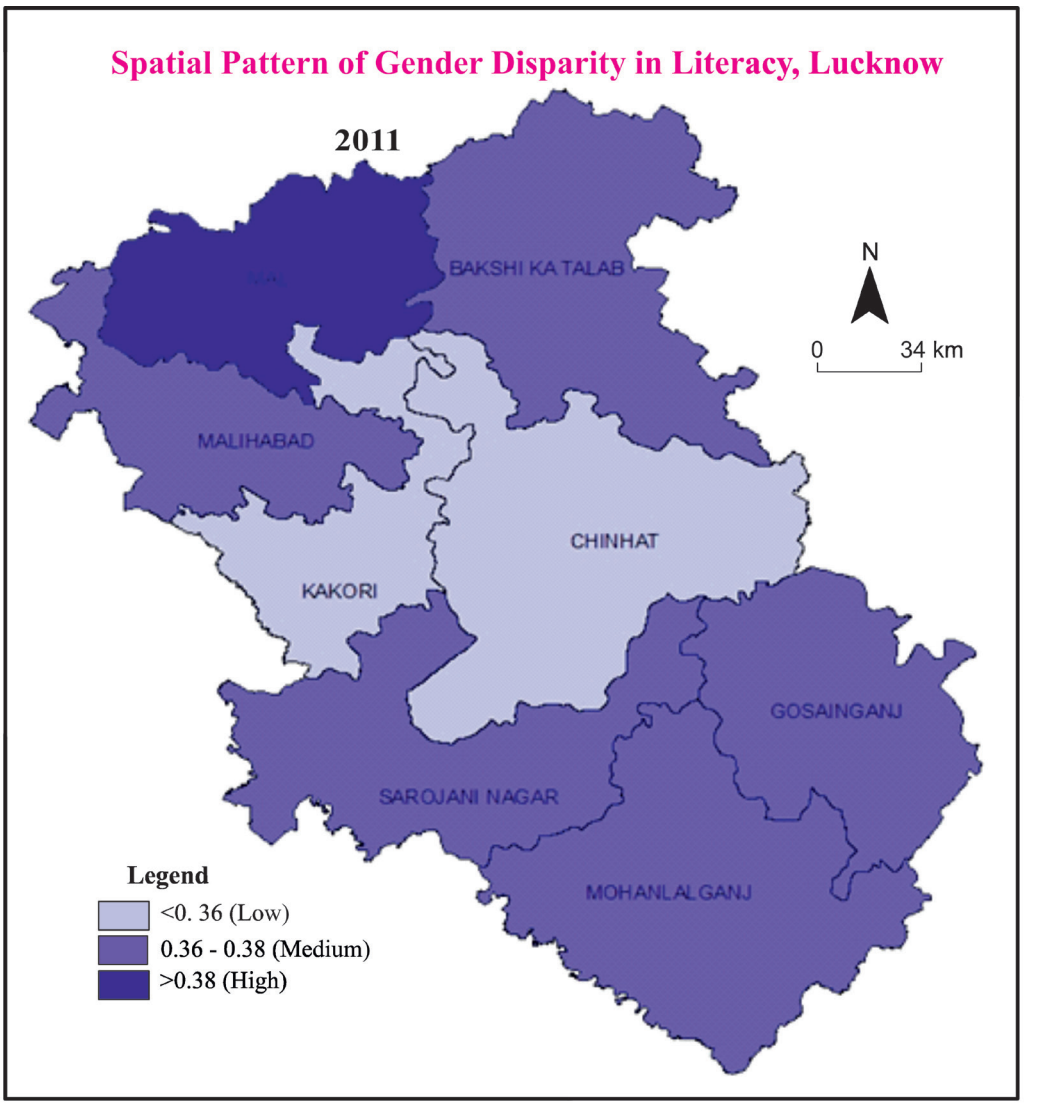

Spatial Pattern of Gender Disparity in Literacy, Lucknow
2011
BAKSHI KA TALAB
MALIHABAD
CHINHAT
KAKORI
GOSAINGANJ
SAROJANI NAGAR
MOHANLALGANJ
N
0
34 km
Legend
<0. 36 (Low)
0.36 - 0.38 (Medium)
>0.38 (High)

Fig. 2

Table-2: Gender Disparity Index (GDI) in Literacy Rate, 2011

Blocks	% of literacy to the total population in Lucknow 2011				
	Total Literacy	Male Literacy Rate	Female Literacy Rate	Gap in Male-Female Literacy Rate (%)	Gender Disparity Index (GDI)
Mal	64.3	74.3	53.3	21.0	0.40
Malihabad	65.7	74.7	55.6	19.1	0.37
Bakshi Ka Talab	67.1	76.0	57.2	18.8	0.37
Chinhat	73.5	80.5	65.8	14.7	0.33
Kakori	66.8	74.4	58.2	16.2	0.32
Sarojaninagar	73.0	81.1	64.1	16.9	0.38
Gosainganj	64.3	73.3	54.6	18.7	0.36
Mohanlalganj	68.1	76.7	58.3	18.4	0.37
District(Rural)	67.8	76.4	58.3	18.1	0.36

Source: District Census Handbook of Lucknow, 2011

Areas of Medium Disparity

In 2001, the medium disparity was between (0.45-0.48) range. Under this range, there were 3 blocks namely Malihabad (0.49), Bakshi Ka Talab (0.47) & Mohanlalganj (0.45). In 2011, medium disparity range (0.36-0.38), 2 more blocks were added in the range, now there were 5 blocks in total namely, Malihabad (0.37), Bakshi Ka Talab(0.37), Sarojaninagar (0.38), Gosainganj (0.36) & Mohanlalganj (0.37) (Fig 2 and **Table**-3 and 4).

Table-3: Gender Literacy Rate in Census, 2001

Low Disparity Region (< 0.45)	Medium Disparity Region (0.45-0.48)	High Disparity Region (>0.48)
Chinhat, Kakori, Sarojaninagar	Malihabad, Bakshi Ka Talab, Mohanlalganj	Mal, Gosainganj

Source: Calculated by Authors

Areas of High Disparity

In 2001, high disparity range (Above 0.48) was observed in 2 blocks namely Mal (0.49) & Gosainganj (0.49). The lowest literacy rate is witnessed in Mal block

with total literacy being 47.1%, the male & female literates being 60.2% & 32.4% respectively. In 2011, there was only 1 block i.e. Mal (0.40) which showed high disparity range (Above 0.38). Though, the overall iteracy was improved in the block with 64.3% with 74.3% & 53.3% as male and female literates but, the gender gap was widest with 21%.

Table-4: Gender Literacy Rate in Census, 2011

Low Disparity Region (<0.36)	Medium Disparity Region (0.36-0.38)	High Disparity Region (>0.38)
Chinhat, Kakori	Malihabad, Bakshi Ka Talab, Sarojaninagar, Gosaingan, Mohanlalganj	Mal

Source: Calculated by Authors

Policy Measures

Being the largest populous state, Uttar Pradesh requires more efficient & inclusive policies to attain high literacy levels. The government needs to address the urgent needs in the education sector. To achieve socio-economic development following measures should be initiated: Education being a state subject, it is the responsibility of each state government to ensure the proper infrastructure of schools in rural areas, increase the number of teachers, incentives like textbooks, scholarships & free uniforms. The accessibility of educational facilities should be penetrated more in rural areas. All the administrative machinery at different levels should ensure proper functioning. Committees should be formed to ensure the proper utilization of funds allotted for improving literacy levels with a dedicated monitoring mechanism. (1) Social awareness campaigns should be launched to fight against the social evils existing in society like dowry the system, preference for a male child, child marriage, female infanticide, etc. The issues with education and literacy should be addressed by society as a whole. NGOs & civil society organizations play a vital role in enhancing awareness in society & educating individuals about the consequences of illiteracy (2) Due to various socio-economic constraints, the problem of early dropouts in rural areas can be observed. The National scheme Beti Bachao, Beti Padhao (BBBP) shows great success in encouraging the education of the girl child. Schemes like- UP Free Education Scheme, Kanya Sumangala Yojana (KSY), Bhagya Laxmi yojana, and Abhyudaya yojana, are important initiatives launched by the government to improve gender inequality.

'Mid-Day Meal' scheme is a scheme launched by the central government, under which mid-day meals are provided free of cost to the students of primary & junior primary schools. This programme has been a big success, but it should also focus on providing village children with sufficient nutrition & nourishment in addition to enrolling them in school. Recently, the Tamil Nadu government has supplemented midday meals in government schools with a breakfast scheme which is changing the dynamics of primary education & gross enrollment & active participation of the children in schools. (4) Job-oriented skill training, workshops, etc at secondary & higher secondary levels for girl children should be conducted to minimize gender discrimination. Vocational courses for- farming, dairy farming, handloom & textiles, poultry farming etc should be provided to the women of rural areas.

Conclusion

The paper is an attempt to evaluate the existing patterns of literacy rate & the level of the male-female disparity in literacy in the Lucknow district. The study area witnesses an increase in literacy rate from 53.9% in 2001 to 67.8% in 2011. However, a wide gap between male & female literacy can be observed. Though great numbers of female literacy can be seen from 40.1% in 2001 to 58.3% in 2011 in the study area, female literacy still lags behind male literacy. The female literacy rate of 58.3% is lower than the literacy rate of the male 76.4% population in 2011. The lowest literacy in 2001 was recorded in Mal & Kakori block with 47.1% & 50.4% respectively & in 2011, Mal & Gosainganj block recorded the lowest literacy with 64.3%. In 2001, the largest gap in gender literacy was seen in Mal & Gosainganj block with almost the same numbers of 27.8% & 27.7% while in 2011, the maximum gender disparity in literacy was seen in the Mal block with 21%. Chinhat block recorded a higher proportion of literacy rate in the urban area. Thus, it can be concluded that there exists an inverse relation between literacy & gender disparity. The literacy gap between men and women has narrowed through time, and this pattern should be continued in the future years.

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CHALLENGES FACED BY WOMEN STREET VENDORS OF VARANASI CITY

Nitish Kumar Bhardwaj and Vishal Vikram Singh

Abstract

With the increasing rate of unemployment street vending has become a source of livelihood for a larger section of population. Uttar Pradesh records highest number of vendors followed by Madhya Pradesh. Vending is a source of livelihood with low capital and a temporary structure, which fulfills the goods and services need of the public. They mostly Belongs to the lower section of the society, and don't have the opportunity, education or skill to work in formal sector. So, they operating in the informal economy with no job security and uncertainty. The aim of this paper is to study the challenges faced by women street vendors in Varanasi city. For this purpose100 women street vendors were selected through simple random sampling method. The respondents were interviewed accordingly in order to access the information. Through the survey it was found that most of the female street vendors are between age group of 30-55 years. They are mostly married and sell fruits, flowers, vegetables, food items, clothes and other groceries. These women street vendors face many problems at their home and workplace. Lack of proper sanitation, unhygienic environment, unavailability of toilets are prominent issues as well as misbehaving of police personnel and local authorities at the workplace are common. The respondents told that working late night is also not safe. As a result of the efforts made by various NGOs and organizations for years, the Government of India has focused on the plight of street vendors and has created some policy and schemes for their progress like Street Vendor Act 2014, PM SVANidhi Scheme 2020. Nevertheless, most of the street vendors are deprived of these schemes due to ignorance and accessibility.

Introduction

Despite the existence of various constitutional and legal provisions safeguarding women's employment a large number of women workers, particularly in the unorganized sector suffer from various disadvantages relating to their

working lives as well as home. In 2005 the Confederation of Indian Industries (CII) commissioned a study titled 'Understanding the Levels of Women's Empowerment in the Work Place' revealed that women constitute only 6% of total workforce in corporate houses. The percentage of women in leading managerial positions is abysmally low. Only 7% labour force is in the organized sector and 93% work in unorganized or informal sector. Most of them are in street vending and others are engaged in household activities. The reason for the employment of women in such large numbers in the informal sector is women's weaker bargaining power, low skilled labour, generally lower wages than men and lack of unionization. Street vendors are those one who buy the goods at whole sale and sell it at retail price in the streets, road side, at bus stand or at other places of decent crowd for their daily livelihood. NASVI has defined street vendors as "a person who offers goods or services for sale to the public without having a permanently build structure but with a temporary static structure or mobile stall". Street Vending is one of the most visible aspects of the informal sector and practiced globally.

The major characteristics of street vending are low level of income, ease of entry, self-employed and it involves large number of people. About 80% of the population is engaged in the street vending. It does not only provide self-employment but also a means to provide affordable and convenient service (Jaishankar and Sujata, 2016). Street vending serves as important income generating activity which gives employment to sufficient number of poor women living in urban peripheral areas or slums. Street vendors sell their goods mostly on pavement and streets. However, street vending can be considered as an integral part of rural and urban economy characteristized with specific insecurities and challenges. The contribution of street vendors in generating a considerable amount of money in to the informal sector is often a crucial factor in driving the economy. Street vendors fulfill the requirements of the society and cater to the need of a sufficient number of customers especially from middle- and lower-income class. Women can be seen doing street vending along the pavements and streets. Mostly women enter in the street vending due their poor economic conditions. Their motive is to maintain their financial condition so as to fulfill their daily needs of the family. Apart from the problem of earning money for survival, women street vendors face several issues of uncertain and insecure working conditions at the workplace. Some major issues and problems faced by street vendors are lack of support, regular threat of eviction, and harassment by local officials and authorities. According to the report of ILO, 85 % of the street vendors face several health hazards.

It includes disease like increased depression, acidity, high blood pressure and increased blood sugar and others health complications. Except this, women face problem, related to sanitation, economic pressure, social cultural challenges, adverse political conditions and operational challenges (Tambunam. 2009). During COVID- 19 period Most of the women street vendors lost the means to work and livelihood which witnessed a significant fall in their income and earnings. With the loss in employment opportunities during COVID period, many of the women street vendors were not able to shift to alternative employment opportunities and were forced to continue with the same street-vending activity.

Study Region

Varanasi lying between 82°56' E to 83°03' E and 25°14'N. (also known as kashi or Banaras) is one of the oldest living cities in the world dating back 3000 to 5000 years. Being located on the crescent shaped bank of the Ganga River it is considered as cultural and spiritual capital of India. Due to high population growth and rapid development of the city during the decades of 1991 and 2000 it became a million city. Rapid urbanization has led to many urban problems such as pollution, living space, sanitation and unemployment. The increasing population and faulty government policies has forced a large segment of people towards the informal sector. In this Street vending has become a major source of livelihood for the people living in peripheral urban spaces. These people face several issues and challenges at their workplace. The present study is an attempt to highlight those issues and provide a better understanding of the factors operating therein.

Objectives

(1) The present study seeks to provide a better understanding of the demographic characteristics of women street vendors in the study area.

(2) To know the socio-economic and political constraints of women street vendors in Varanasi city.

(3) To evaluate the relevant issues and challenges faced by women street vendors at their Workplace and to provide insights of policy implications and remedial measures to deal with the issues and challenges faced by women street vendors.

Database and Methodology

The study is entirely based on primary data which have been collected through personal level survey in the study area. A structured interview schedule

containing pertinent questions related to the issues and problems faced by women street vendors in the Varanasi city was used in order to access the required data. Some open-ended questions were also incorporated in order to know the views and opinions of the women street vendors towards government policies, officials and local authorities. For the purpose of study, the samples have been choosen from five administrative zones of the Varanasi city namely, Varuna par, Kotwali, Bhelupur, Aadampur and Dashaswamedh. On the basis of simple random sampling method 20 sample have been taken from each zone and interviewed accordingly. Total 100 respondents have been interviewed and data have been analysed in order to draw conclusions. Data have been analysed and interpreted with the help of different tools like MS Excel 2012 and SPSS-22 version. Maps, charts and diagrams are incorporated wherever necessary. Maps have been prepared with the help of ARC GIS 10.3 software.

Results and Discussion

Results have been derived from the responses collected through the interview schedule which contained questions related to the respondent's demographic characteristics and the challenges being faced by them at their work place. An attempt has been also made to suggest the remedial measures and expected solutions.

Age; During the survey it was found that majority of the women street vendors were above 41-60 age-group. In most of the cases she herself was the head of the house and therefore they had taken the responsibility of earning the bread for themselves and their families. They also take care of other amenities in the house. It was also observed that 22 percent of women street vendors were between age group of 51-60. The younger age groups witnessed comparatively low proportion of women street vendors. Feeling unsafe is major factor behind such low proportion of women street vendors in the younger age groups. Being asked, the vendors told that their husband either do farming in the village or earn in the outer region through daily wages or help them in vending along road side, streets and pavements.

Marital Status: Marital status is another significant demographic characteristic which was considered during the survey. The data recorded reveales different nuptial categories of women street vendors in the Varanasi city. The highest percentage (78 percent) of women street vendors are married followed by 8 percent of unmarried women. This is because of the fact that married women street vendors of higher age groups feel more confident regarding feeling safe at the workplace in comparison to married and und unmarried women of the younger age groups.

Another significant demographic feature of the table is the proportion of widowed women street vendors in the city. It was recorded that 13 percent of women street vendors were widowed. This is the bitter fact of the Indian society that whenever a woman is widowed, she becomes economically vulnerable which forces her to do vending and other low level economic activities to run the livelihood of her family. Type of Street Vending: The responses during the survey portraits the proportions of women street vendors engaged in different stuffs in different zones of Varanasi city. It was observed that highest percentage (37 percent) of women street vendors were engaged in selling vegetables and fruits along the pavements and streets followed by 25 percent in tea and food stuffs while 25 percent of them were engaged in selling flowers and garlands. The highest proportion of women street vendors in selling vegetables and fruits along with other food items is due to easily availability of these items in the market. Another significant factors behind this may be the good returns and affordability of these items.

Access to Workplace Amenities

During the field survey the data was also collected regarding access to work place amenities like toilet facilities, availability of fresh drinking water, storage and alike in order to measure hygiene and sanitation at work place. The results found are quite disgusting that above 90 percent of women street vendors don't have facility of toilets, safe drinking water, storage and other amenities. Due to working in such a unhygienic environment the women street vendors are prone to several diseases like stress, hypertension and acidity (**Fig.** 1).

Awareness about Right and Interests: Responses were also recorded regarding the awareness of women street vendors towards their rights and interests. The data reveals that Majority of the respondents (88 per cent) disagree that the government protects the rights and interests of women street vendors. Another significant factor behind such situation is the ignorance and high level illiteracy among the women street vendors. Due to this most of the women street vendors are unaware of their rights and are often harassed by government officials and local authorities. Because they are illiterate or less educated and have no information about the government's plans and policies made for street vendors; local police exploit them at the workplace. These factors play crucial role behind the vulnerable conditions of women street vendors in Varanasi city. Proper measures and steps should be taken in order to safeguard the rights and interests of women street vendors in the study area. Harassed and Abused by the Authorities: In order to analyses the factors behind the vulnerable condition of women street vendors in Varanasi city

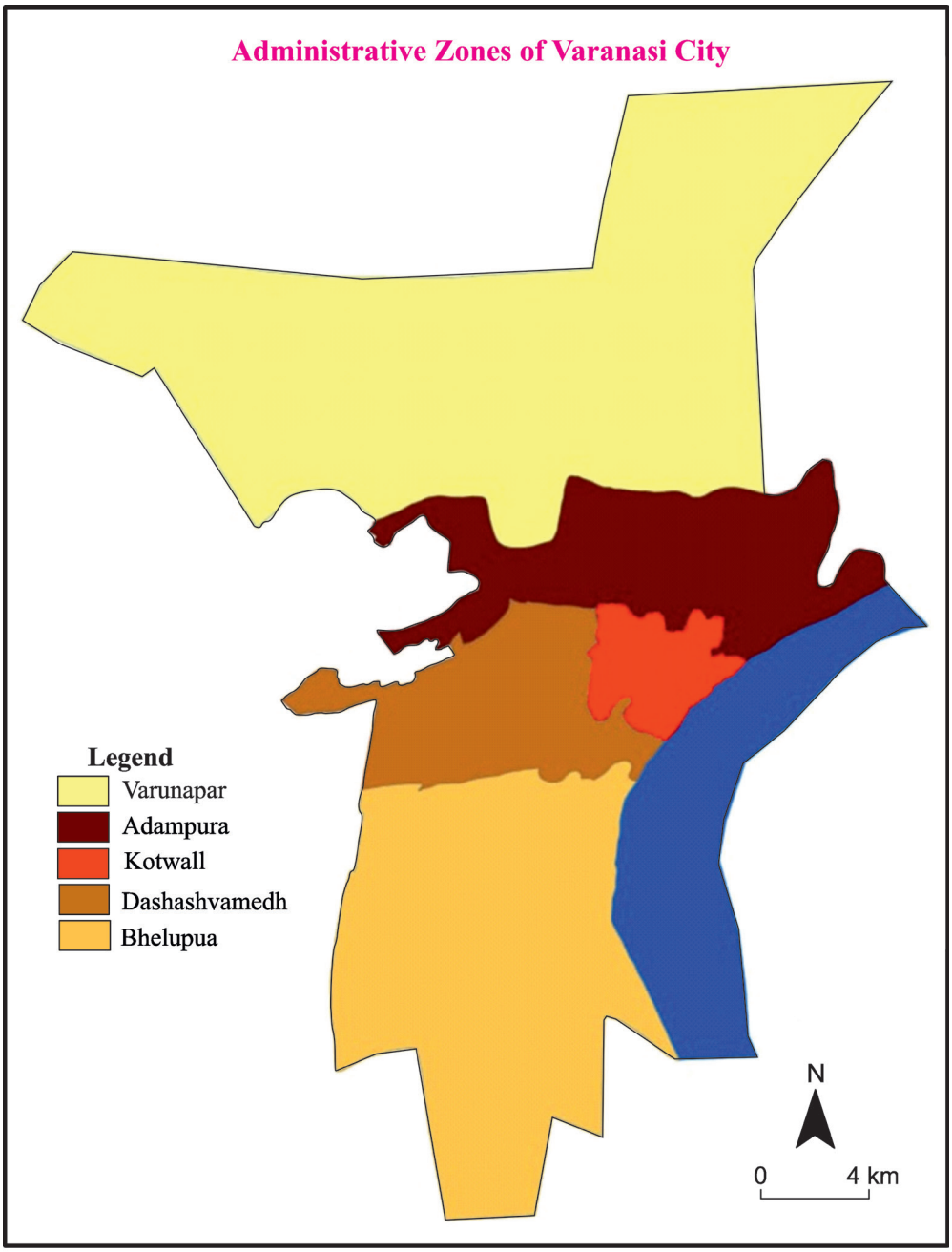

Administrative Zones of Varanasi City
Legend
Varunapar
Adampura
Kotwall
Dashashvamedh
Bhelupua
N
0
4 km

Fig. 1

the responses were also recorded know the status of being harassed, teased or abused by concerned government officials and local authorities. The study reveals that 70 per cent of the women street vendors in the city reported that they are being harassed and abused by the concerned city authorities or police at the workplace while 30 per cent of the respondents said that they are not being harassed by the city authorities or police. Being ignorant of their rights and safeguards provided by government policies these women street vendors are prone to exploitation through several means by police and local authorities. (**Fig.** 1)

Security at Work Place: Among the several significant constraints of women street vendors the prominent one is security at the workplace. There are sufficient number of studies which advocates for the safety of women street vendors while working late hours in the night. Due to several efforts government has drafted policies to safeguard the interests and rights of the women street vendors. In spite of this insecurity is the major issue for the women street vendors while working late hours in the Varanasi city. On the basis of responses recorded during the survey it was observed that 92 per cent of the women street vendors in the Varanasi city do not feel safe and secure while working late hours in the night. While only 8 per cent said that they feel secure even while working late hours in the market. As mentioned above security is the key issue among the several socio-economic barriers being faced by women street vendors in the Varanasi city.

Health Issues

Many studies reveal that street vendors work in severe unhygienic environment because of this they are prone to several diseases. In the Varanasi city an effort was made to record the responses of the women street vendors in order to know the status of hygiene and health issues. However the study conducted reveals that 41per cent of the women street vendors stated that they have health related disorders like blood pressure, Sugar, deafness, low vision while 59 per cent of the respondents said that they don't have any kind of health issues. As the study found that women street vendors don't have proper sanitation measures like toilets, fresh drinking water and air they are prone to several diseases.

Remedies

Some responses were also recorded in order to know the status of remedial measures. The data reveals quite disgusting factor that the women street vendors in Varanasi city don't believe that their status can be improved through policies and safeguards provided by government or some NGO organization. Most of the

women street vendors are of the view that their status can be improved only by themselves. According to the responses recorded 12 percent of the women street vendors said that their condition can be improved with the help of government initiatives, 15 percent said, it can be improved with the help of NGOs & their association and lastly, 73 percent said that it can be improved only through him/her self. The recorded responses show that there are many drawbacks and Loopholes which need to be taken care of while drafting and implementing the policies for women street vendors. It is also a bitter fact that association and NGO organization are not working well.

Conclusion

As mentioned, total 100 women street vendors were interviewed and their responses were recorded. 1. One significant demographic feature is that majority of women street vendors are between age group of 41-60. It may be because of the fact that women in comparatively older age groups feel more confident and safer at the workplace than those who are unmarried or in younger age groups. 2. Because of easy availability of in the local market majority of the women street vendors in Varanasi City were engaged in selling vegetables and fruits. Very few Of them are engaged in other economic activities. 3. Major socio-economic and administrative constraints being faced by the women street vendors are those of their basic necessities and amenities at the workplace like lack of hygienic space, toilets, feeling unsafe at the workplace during late hours and continuous harassment by local authorities, government officials and police. 4. The responses recorded during the survey reveals the fact that the policies and safeguards provided by government have some loopholes and drawbacks due to this most of the women street vendors are unaware of these policies. Other factors behind this may be the ignorance and illiteracy among the women street vendors or lame efforts of government officials in implementation and execution of these policies. However, it has been also reported that few of the women street vendors are receiving some kind of benefits from the government and they are keenly looking forward for their support and guidance. 5. There is a urgent need to take care of the issues and challenges being faced by the women street vendors in Varanasi city. The policies and safeguards should be implemented in a very effective manner so that it can cover most of the women street vendors. Other remedial measure which is to be taken is the proper education of the women street vendors so that it can enable them towards their rights and interests. Other amenities which are necessary at the workplace should also be taken care of like permanent place for vending, proper sanitation and hygiene etc.

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BALANCING AGRICULTURAL DEMAND AND WATER RESOURCES: A STUDY OF IRRIGATION INTENSITY TRENDS IN MANDYA DISTRICT, KARNATAKA

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Abstract

Irrigation intensity in agricultural regions is influenced by various factors, including water source, quantity and quality, and channel network density. This study explores irrigation intensity variations in Mandya District, Karnataka, over the period 1991-2017, considering factors like cropping patterns, land-use efficiency, and adoption of cultivation methods. Mandya District, located in South India, is dissected into seven taluks. The study examines changes in irrigation intensity across these taluks, highlighting the district's geographical and agricultural diversity. The primary objective is to assess irrigation intensity changes in Mandya District from 1991 to 2017. Using historical documents and government reports, the study traces the evolution of water management in Mandya. Statistical analyses of net irrigated areas for 1991, 2001, and 2017 reveal shifts in irrigation methods. The intensity of irrigation is calculated using the ratio of net irrigated area to net sown area. Taluk-wise analyses and categorizations are conducted to understand spatial patterns. The findings indicate a significant increase in irrigation intensity from 41.4% in 1991 to 75.7% in 2017. Taluk-wise analyses reveal dynamic changes, with Mandya taluk consistently showing high intensity. Positive changes are attributed to canal construction, increased cultivable areas, well irrigation, and advancements in agriculture. Despite advancements, certain areas in Mandya remain rainfall-dependent, impacting crop productivity and income inequality. The study suggests utilizing rainwater through farm ponds and watershed structures. Emphasizing efficient canal water usage, including lining distributaries and field channels, is recommended. The district irrigation plan aims to mitigate drought, expand irrigated areas, and optimize water usage through innovative cropping patterns. This research provides valuable insights into the evolving landscape of irrigation intensity in Mandya District, offering a foundation for sustainable water resource management strategies.

Introduction

The term "irrigation intensity" usually refers to the amount of water used to irrigate a specific area of land. It measures how effectively water is used during the irrigation process. Irrigation intensity is commonly expressed in millimeters or inches and is calculated by dividing the total volume of water applied by the irrigated area. Irrigation intensity varies across agricultural regions due to a variety of factors such as irrigation source, water supply quantity and quality, and water channel network density. Cropping seasons, crop types, and other factors all have an impact on it. Cropping patterns, land-use efficiency, area yield efficiency, and the adoption of improved cultivation methods all benefit from increased irrigation intensity. The intensity of irrigation has a significant impact on agricultural productivity, water conservation, and environmental sustainability. Water stress and reduced crop yields can result if the amount of water applied is insufficient for the needs of the crops. Inadequate irrigation can also cause soil degradation and harm the agricultural ecosystem's overall health. Excessive irrigation, on the other hand, can result in waterlogging, soil salinity, and water resource waste. High irrigation intensity can also contribute to environmental issues like runoff, fertilizer and pesticide leaching, and negative impacts on local water bodies. Irrigation intensity is typically low in areas with limited infrastructure for expanding irrigation or where irrigation is used as a precautionary measure to address moisture scarcity in areas prone to heavy rainfall. All else being equal, irrigation intensity increases with decreasing rainfall and decreases with increasing rainfall in agricultural contexts. Irrigation intensity is typically low and negligible in rain-fed areas with constrained surface water, saline subsoil, and hilly or undulating topography. Typically, irrigation intensity is expressed in two ways, namely, the ratio of gross irrigated land to net irrigated land. The proportion of net irrigated land to net sown land.

Study Region

Mandya District is located in the South Indian Peninsula on the Mysore plateau, between 76° 19' and 77° 20' East Longitude and 12° 13' and 13° 04' North Latitude. It is bounded to the north by Hassan and Tumkur districts, to the east by Tumkur and Bangalore districts, to the south by Mysore district, and to the west by Hassan and Mysore districts. Mandya is the 19th largest district in Karnataka, covering a total area of 191,976 square kilometres (**Table-**1). Nagamangala, K.R. Pet, Mandya, Malavalli, Maddur, Pandavapura, and Srirangapatanna are the district's seven taluks. Notably, Nagamangala has the largest geographical area at 1,044.7 square kilometres, accounting for approximately 21% of Mandya's total area.

Table-1: Talukwise Irrigation Intensity in Mandya District 1991-2017

Sl No	Taluk	1991			2001			2017			Irrigation intensity change in 1991-2017
		Net Irrigated area	Net Sown area	Intensity of Irrigation in %	Net Irrigated area	Net Sown area	Intensity of Irrigation in %	Net Irrigated area	Net Sown area	Intensity of Irrigation in %	
1	K.R. Pet	16865	38890	43.4	20263	48646	41.6	25016	40407	61.9	+ 18.5
2	Maddur	20827	41161	50.6	22586	39794	56.7	20919	30202	69.3	+ 18.7
3	Malavall	15832	36254	43.7	17931	42245	42.4	22190	31568	70.3	+ 26.6
4	Mandya	25127	44966	55.9	19588	28560	68.6	28148	33268	84.6	+ 28.7
5	Nagamangala	2845	38772	7.3	4307	42234	10.2	6329	29691	21.3	+ 14
6	Pandavapura	6654	22862	29.1	10131	25598	39.6	14834	22185	66.7	+ 37.6
7	Srirangapattana	11413	17874	63.8	12146	20311	59.8	9752	14057	69.4	+ 5.6
	Total	99563	240779	41.4	106952	247388	43.2	127188	168110	75.7	+ 34.3

Source: Data compiled from Directorate of Economics and Statistics, Government of Karnataka, Bangalore.

Despite having a higher population density, Mandya taluk ranks fourth in terms of area, covering 699.06 square kilometres. Srirangapatna, on the other hand, has the smallest area, accounting for only 6.9% of the district's total area.

Objective

The present paper attempted to study the irritation intensity in Mandya district, Karnataka.

Methodology

In order to conduct a thorough investigation, I reviewed a large body of existing literature on water resource utilization, irrigation methods, and disparities within comparable geographic regions. My focus was on the Mandya District in South India, a region chosen for its importance in terms of water resource imbalances and diverse irrigation practices. I traced the evolution of water management in Mandya District using historical documents, research papers, and governmental reports. Supplementary data was obtained from the Government of Karnataka's Directorate of Economics and Statistics, which provided critical historical records of irrigation sources and trends. I assessed changes in net irrigated area using statistical analyses for the years 1991, 2001, and 2017, using percentages to identify shifts in the dominance of specific irrigation methods. I investigated specific instances of water resource utilisation within Mandya District using a case study approach, delving into local contexts, socioeconomic factors, and infrastructure development nuances. The findings were systematically compared to historical data, revealing insights into changes in irrigation methods, areas covered, and the overall landscape of water resource utilisation in the Mandya District. In the present study researcher has used the second method to express the intensity of irrigation in the region. Here the intensity has been calculated with the help of following formula.

$$\text{Intensity of irrigation} = \frac{\text{Net irrigated area}}{\text{Net sown area}} \times 100$$

Result and Discussion

The present study reveals that the variation in the intensity of irrigation. **Table-**1 and 2 explain that the Mandya district has about 41.4% of irrigation intensity in the year 1991 and it has been increased to 43.2% in the year 2001, further it has increased to 75.7% in 2017 (**Fig.** 1 and **Table-**2). The analyzing of spatial pattern of intensity of irrigation in Mandya district shown in **Table-**2 there is a significant change has been observed in the intensity of irrigation in the region from 1991-2017,

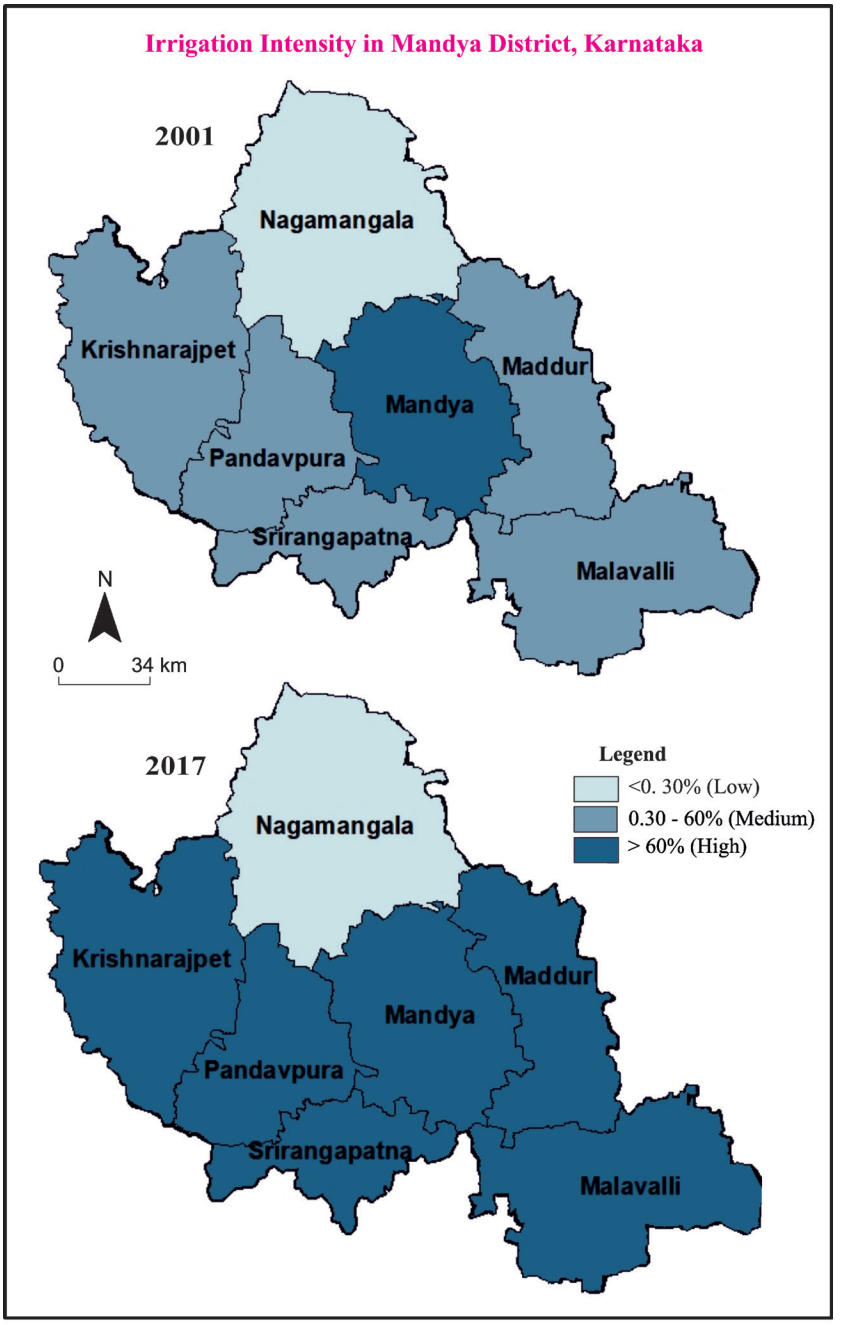

Irrigation Intensity in Mandya District, Karnataka
2001
Nagamangala
Krishnarajpet
Maddur
Mandya
Pandavpura
Srirangapatna
Malavalli
N
0
34 km
2017
Nagamangala
Krishnarajpet
Maddur
Mandya
Pandavpura
Srirangapatna
Malavalli
Legend
<0. 30% (Low)
0.30 - 60% (Medium)
> 60% (High)

Fig. 1

Table-2: Irrigation Intensity in Mandya District, 1991.

Sl. No.	Irrigation intensity Range	No. of Taluks	Name of the Taluks
1.	< 30% Low	02	Pandavapura, Nagamangala
2.	30-60% Medium	04	Mandya, Maddur, Malavalli, K.R. Pet
3.	> 60% High	01	Srirangapattana
Categories of Irrigation Intensity in Mandya district 2001.			
1.	< 30% Low	02	Pandavapura, Nagamanagala
2.	30-60% Medium	04	Srirangapattana, Maddur, Malavalli, K.R. Pet
3.	> 60% High	01	Mandya
Categories of Irrigation Intensity in Mandya district 2017.			
1.	< 30% Low	01	Nagamangala
2.	30-60% Medium	00	
3.	> 60% High	06	Mandya, Malavalli, Srirangapattana, Maddur, Pandavapura, K.R. Pet

Source: Computed by Authors

the taluk wise analysis reveals that in 1991 Srirangapattana (63.8%) taluk have recorded high (More than 60%) intensity of irrigation. The medium irrigation intensity (30%-60%) is noticed Mandya (55.9%), Maddur (50.6%), Malavalli (43.7%), K.R. Pet (43.3%) taluks of the region. The taluks like Nagamangala (7.3%) and Pandavapura (29.1%) fall in low intensity of irrigation (less than 30%). The taluk wise analysis reveals that in 2001 Mandya (68.6%) taluk have recorded high (More than 60%) intensity of irrigation. The medium irrigation intensity (30%-60%) is noticed Srirangapattana (59.8%), Maddur (56.7%), Malavalli (42.4%), K.R. Pet (41.6%) and Pandavapura (39.6%) taluks of the region. The Nagamangala taluk (10.2%) fall in low intensity of irrigation (less than 30%) (**Fig.** 1). The taluk wise analysis reveals that in 2017 Mandya (84.6%), Malavalli (70.3%), Srirangapattana (69.4%), Maddur (69.3%), Pandavapura (66.7%), K.R. Pet (61.9%) taluks have recorded high (More than 60%) intensity of irrigation and Nagamangala taluk (21.3%) fall in low intensity of irrigation (less than 30%). In the study period there is positive change in irrigation intensity. It is because of the progress in the construction of new canals to provide water for tank irrigation and every year more and more cultivable areas are brought under cultivation and also increased number of well irrigation and advanced agriculture due to development

of transportation facility. During the study period (1991-2017) the district as whole has shown a significant change in the intensity of irrigation. These taluks have shown a positive change in the intensity of irrigation. It is clear that during the year 1991 the irrigation intensity was about 41.4% and it increased to 75.7% in 2017. The net increase in the volume of intensity of irrigation was about 34.3%. The taluk wise changes in the intensity of irrigation during the study period depicts that only Pandavapura taluk have shown high percentage of change i.e., 37.6%, Srirangapattana taluk have shown less change in intensity of irrigation i.e., 5.6%.

Taluka wise Analysis

The intensity of irrigation in Mandya district increased from 41.4% in 1991 to 43.2% in 2001 and further to 75.7% in 2017. The spatial pattern analysis indicates a significant change in irrigation intensity from 1991 to 2017. In 1991, Srirangapattana taluk had the highest intensity of irrigation (63.8%), classified as high. Mandya, Maddur, Malavalli, and K.R. Pet taluks had medium intensity (30%-60%). Nagamangala and Pandavapura taluks had low intensity (less than 30%). In 2001, Mandya taluk now has the highest intensity (68.6%). Srirangapattana, Maddur, Malavalli, K.R. Pet, and Pandavapura taluks had medium intensity. Nagamangala taluk remained in low intensity. In 2017, Mandya, Malavalli, Srirangapattana, Maddur, Pandavapura, and K.R. Pet taluks recorded high intensity. Nagamangala taluk remained in low intensity. Positive changes in irrigation intensity are attributed to the construction of new canals, increased cultivable areas, well irrigation, and advanced agriculture facilitated by improved transportation. (**Fig.** 1) The overall district experienced a significant increase in irrigation intensity from 41.4% to 75.7% during 1991-2017, representing a net increase of 34.3%. Pandavapura taluk showed the highest percentage change (37.6%). Srirangapattana taluk showed the least change in irrigation intensity (5.6%).

Conclusion

Despite being irrigated by two commands, Mandya district has 1.46 lakh ha fully dependent on rainfall. The crop productivity in such areas is limited to dry crops like ragi, horsegram, avare, maize, groundnut etc. Irrigated area predominantly grows paddy and sugarcane. Irrigated farmers invariably record higher incomes, while farmers from dry areas continue to reel under poverty. The inequality of growth rate in income of these two distinctly different areas has not been able to be neutralised by any other sources of irrigation, including well irrigation. Mandya district has only 5000 ha under bore well irrigation, while open wells irrigate around 6800 ha.

However, there is excellent scope to harvest rain water in smaller structures like farm ponds, check dams, nala bunds and other water shed structures in un-irrigated areas. The present district irrigation plan focuses on use of rain water more efficiently by various water shed structures for protective irrigation as a measure of drought mitigation. Further, nearly 630 tanks are available in Mandya district. They have created irrigation potentiality of around 16000 ha. But, there is need to utilise this tank irrigated area, by effective measures like tank desilting, renovation or filling tanks with canal/ lift irrigation schemes. There is general lacuna in utilizing the canal water, in terms of efficiency. Most distributaries/ field channels unlined and there is vast scope to improve the irrigation efficiency by proper lining to these structures, and attending to other canal maintenance works timely. This way, the created potential can be utilized fully. All these aspects are considered, while Mandya district Irrigation Plan is developed- with the ultimate objective of utilizing the created potential with expansion, wherever possible irrigated area and drought mitigation in non- command areas. A new cropping pattern involving regulated sugarcane cultivation and reducing other water intensive crops can save large quantity of water and this can ensure water availability to tail end areas.

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WORKFORCE ASSESSMENT OF PRINCIPAL EMPLOYEES AND AGRICULTURAL WORKERS IN KANNAUJ DISTRICT, UTTAR PRADESH

Kalpana Devi and Dr. Shashi Bala Singh

Abstract

The research focuses on assessing the workforce dynamics within Kannauj district for the year 2021-22, emphasizing the distribution and prevalence of principal employees and agricultural workers across its development blocks. The study examines the proportions of principal employees in comparison to the total population in various blocks. Umaruda and Gugarapur exhibit notably high percentages, signifying substantial principal employment, followed by Talgram with a significant figure. Haseran and Jalalabad portray a slightly lower ratio, while Kannauj, Saurikh, and Chhibramau demonstrate relatively comparable patterns. These percentages elucidate the distribution and concentration of principal employees, showcasing varying proportional representations among the development blocks. Moreover, the study investigates the proportions of agricultural workers within the total principal employee workforce across the district. Areas like Saurikh, Haseran, and Chhibramau showcase high percentages of agricultural workers among the principal employees, indicating significant agricultural employment. Umaruda and Kannauj also demonstrate substantial agricultural labour presence, while Gugarapur shows a slightly lower ratio. Talgram and Jalalabad exhibit relatively fewer agricultural workers compared to the total principal employees in those specific blocks. These percentages offer insights into the distribution and concentration of agricultural workers concerning the total principal workforce across different development blocks in the Kannauj district, reflecting distinct levels of agricultural employment across these regions during the specified period. The study utilized data sourced from official government records, statistical reports, and surveys conducted by relevant authorities, encompassing population figures, principal employee counts, and specific employment statistics for agricultural workers. The research aims to depict variations in employment patterns and workforce concentrations, focusing on the proportional representations of principal employees and agricultural workers across the district's diverse blocks during the specified period.

Introduction

Kannauj district in the year 2021-22 witnessed varied proportions of principal employees and agricultural workers dispersed across its distinctive development blocks, portraying notable employment diversities. This study scrutinizes the intricate dynamics of workforce distribution within the district, focusing on the prevalence of principal employees and agricultural workers across different regions. The analysis reveals significant disparities in the proportion of principal employees concerning the entire population across various development blocks. Umaruda emerges as a frontrunner, boasting the highest percentage of principal employees at 27.44%, closely shadowed by Gugarapur at 27.07% and Talgram at 26.59%. Contrastingly, Haseran, Jalalabad, Kannauj, Saurikh, and Chhibramau exhibit relatively lower percentages, portraying a discernibly varied distribution of principal workers within these areas. Moreover, the study unveils an intriguing variation in the proportion of agricultural workers relative to the total principal employee workforce across the district's development blocks. Saurikh, Haseran, and Chhibramau stand out with notably high percentages of agricultural workers among the principal employees, ranging from 84.74% to 84.13%. Umaruda and Kannauj display substantial agricultural labour presence, whereas Gugarapur, Talgram, and Jalalabad depict relatively lower ratios of agricultural workers compared to the total principal employees in their respective blocks. This research draws upon comprehensive data sourced from official government records, statistical reports, and surveys conducted by relevant authorities. Employing a meticulous methodology involving precise demographic data collection, and cross-referencing of population figures with employment records identified principal employees across development blocks. Additionally, statistical calculations discerned the distribution and concentration of agricultural labour within the principal employee workforce across diverse areas within the Kannauj district.

Objectives

(1) The primary objective is to analyze the distribution of principal employees across different development blocks within Kannauj district during 2021-22.

(2) To examine the variation in the proportion of agricultural workers relative to the total principal workforce across different development blocks.

Database and Methodology

The data used for analyzing the distribution of principal employees and agricultural workers in the Kannauj district for the year 2021-22 was sourced from

official government records, statistical reports, and surveys conducted by relevant authorities. This data includes information on the total population figures, the count of principal employees in various development blocks, and the corresponding employment statistics specific to agricultural workers. The methodology involved collecting accurate demographic data from the census and employment records for the Kannauj district. The total population figures were cross- referenced with employment records to identify principal employees in different development blocks. The percentage of principal employees relative to the entire population was calculated for each block to ascertain their proportional representation. Analyze agricultural employment, the total count of agricultural workers within the principal employee category was identified based on official records. The percentage of agricultural workers concerning the total principal employees in each development block was computed to discern the distribution and concentration of agricultural labor across various areas within the district. This analysis involved statistical calculations, ratios, and percentage computations to understand the representation of principal employees and agricultural workers concerning the total population and the total principal employee workforce, respectively. The study aimed to depict variations in employment patterns and workforce concentration across the diverse development blocks within the Kannauj district for the specified period.

Results and Discussions

Principal Employees

In the Kannauj district for the year 2021-22, the percentage of total principal employees about the entire population varies across its development blocks. Among these blocks, Umaruda stands out with the highest percentage, comprising 27.44% of principal employees. Compared to the overall populace. Gugarapur closely follows with 27.07%, demonstrating a significant presence of principal workers within its boundaries (**Table-**1 and **Fig. 1**). Talgram maintains a substantial figure at 26.59%, indicating a considerable proportion of principal employees relative to the population. As we move further, Haseran and Jalalabad exhibit 24.5% and 24.32% percentages, signifying a noticeable but slightly lower ratio of principal workers compared to the total population. The district's administrative centre, Kannauj, registers a percentage of 23.87%, suggesting a slightly lower presence of principal employees concerning the overall populace (**Fig. 1** and 2). Overall, these percentages delineate the distribution and concentration of principal workers across the development blocks within the Kannauj district, portraying variations in their proportional representation concerning the total population for the specified period.

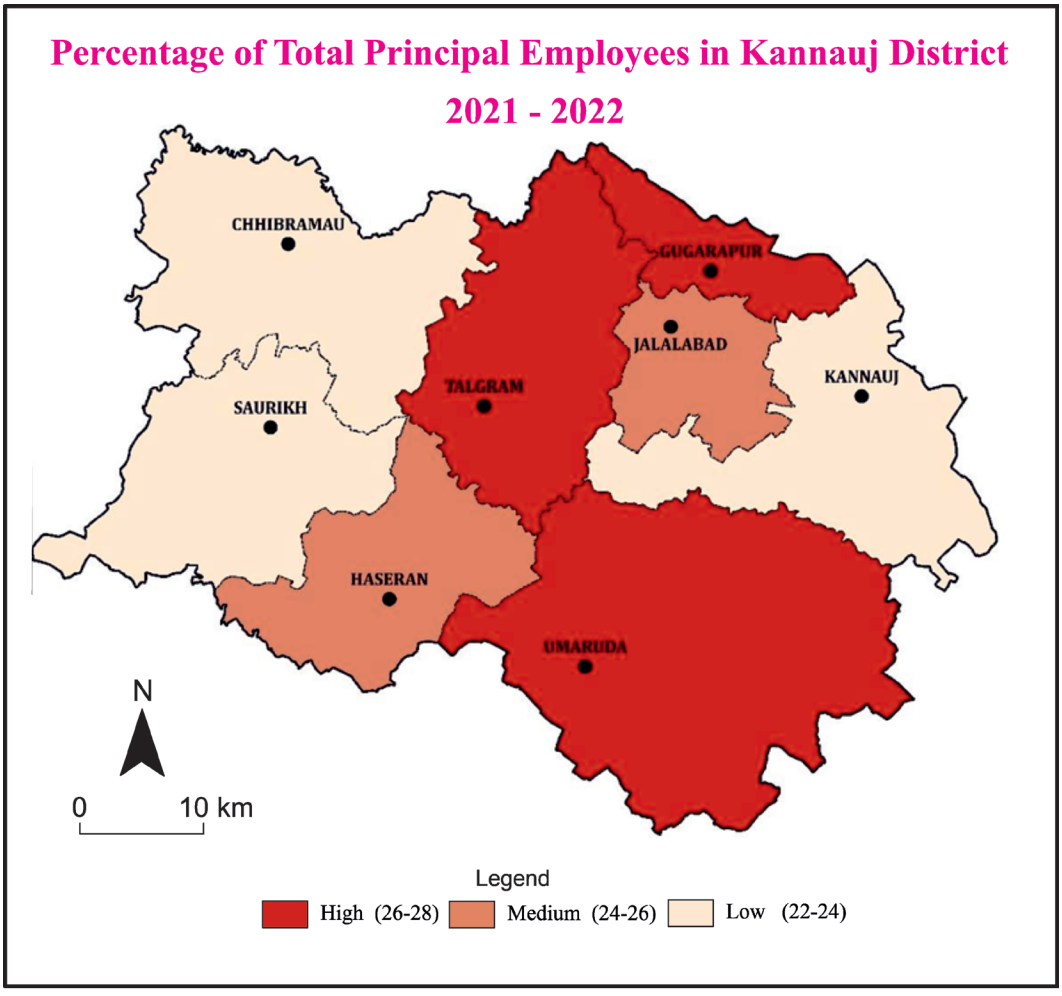

Percentage of Total Principal Employees in Kannauj District
2021 - 2022
CHHIBRAMAU
GUGARAPUR
JALALABAD
KANNAUJ
TALGRAM
SAURIKH
HASERAN
UMARUDA
N
0
10 km
Legend
High (26-28)
Medium (24-26)
Low (22-24)

Fig. 1

Table-1: Percentage of Total Principal Employees and Population in Kannauj District, 2021-22

Development Blocks	Percent	Development Blocks	Percent
Umaruda	27.44	Jalalabad	24.32
Gugarapur	27.07	Kannauj	23.87
Talgram	26.59	Saurikh	23.67
Haseran	24.5	Chhibramau	23.62

Source- https://updes.up.nic.in

Agricultural Workers

In the Kannauj district for the year 2021-22, the percentage of total agricultural workers in comparison to the total principal employees varies across its development blocks. The blocks of Saurikh, Haseran, and Chhibramau exhibit the highest percentages, with 84.74%, 84.55%, and 84.13% respectively. This indicates a significant portion of agricultural workers about the total principal workforce within these areas. Umaruda and Kannauj showcase percentages of 83.71% and 83.69% respectively, signifying a substantial presence of agricultural workers among the principal employees within these blocks. Gugarapur, with a percentage of 79.96%, with the highest percentage of principal employees at 27.44%, indicating a significant presence of this workforce category in comparison to the total population. Gugarapur and Talgram followed closely, showcasing noteworthy figures of 27.07% and 26.59% respectively, underlining substantial concentrations of principal employees in these regions. Haseran, Jalalabad, Kannauj, Saurikh, and Chhibramau exhibited percentages ranging from 23.62% to 24.5%, depicting a lower but noticeable representation of principal employees relative to the overall populace. The findings demonstrate varying degrees of proportional representation of principal workers across the development blocks, signifying localized employment patterns within the district. Saurikh, Haseran, and Chhibramau emerged as areas with the highest percentages of agricultural workers among the total principal employees, ranging from 84.13% to 84.74%. This signifies a predominant agricultural workforce in these regions. Umaruda and Kannauj exhibited substantial proportions of agricultural workers at 83.71% and 83.69% respectively indicating a significant presence of agricultural labour within the principal employee category. Gugarapur displayed a considerable but slightly lower ratio of agricultural workers at 79.96% compared to the total principal employees,

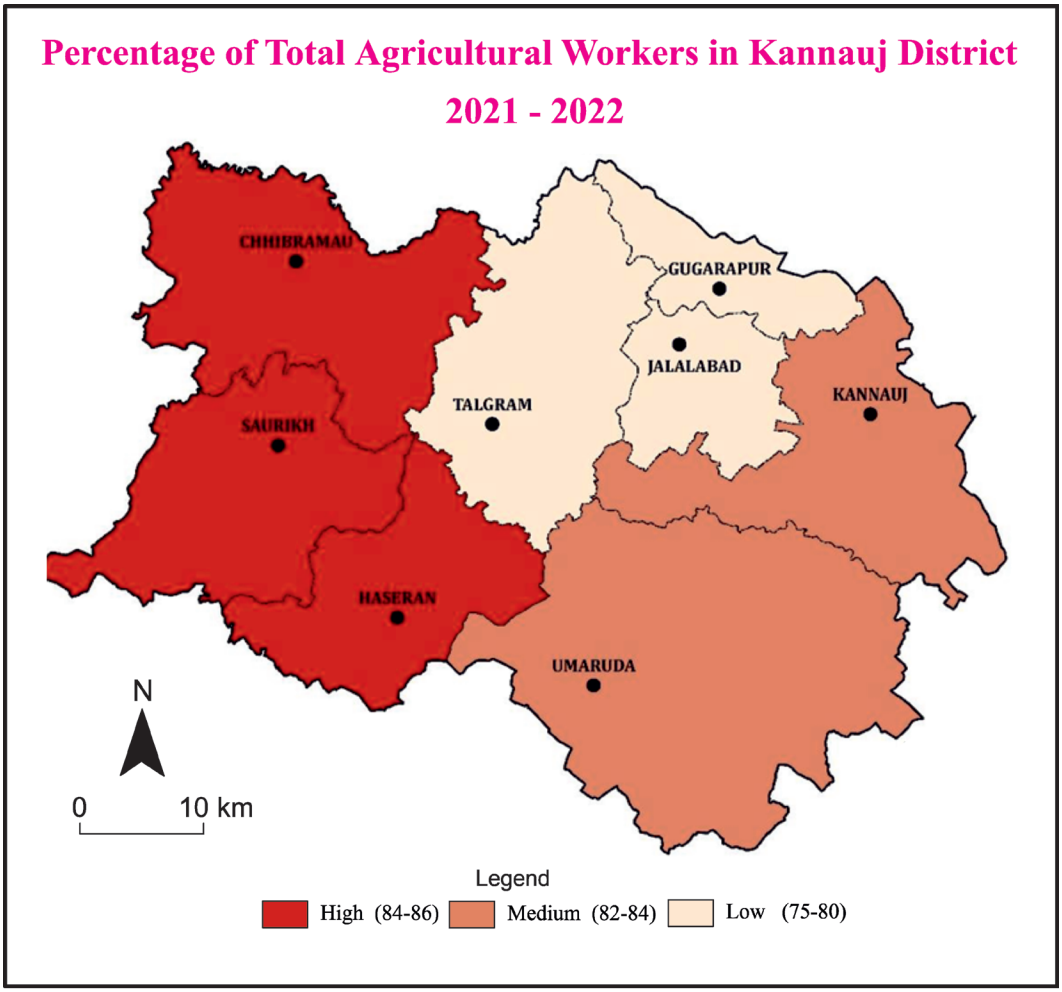

Percentage of Total Agricultural Workers in Kannauj District
2021 - 2022
CHHIBRAMAU
GUGARAPUR
JALALABAD
TALGRAM
KANNAUJ
SAURIKH
HASERAN
UMARUDA
N
0
10 km
Legend
High (84-86)
Medium (82-84)
Low (75-80)

Fig. 2

Table-2: Percentage of Agricultural Workers to Principal Employees in Kannauj District in 2021-22

Development Blocks	Percent	Development Blocks	Percent
Saurikh	84.74	Kannauj	83.69
Haseran	84.55	Gugarapur	79.96
Chhibramau	84.13	Talgram	77.62
Umaruda	83.71	Jalalabad	75.86

Source- https://updes.up.nic.in

showcasing a moderate agricultural employment level. Talgram and Jalalabad depicted relatively lower proportions of agricultural workers at 77.62% and 75.86%. Overall, these findings provide valuable insights into the employment patterns and the prominence of principal employees and agricultural workers across diverse development blocks within the Kannauj district, shedding light on the multifaceted nature of employment dynamics within the region.

Conclusion

In conclusion, the analysis of principal employees and agricultural workers across the development blocks within the Kannauj district for the year 2021-22 offers valuable insights into the employment landscape of the region. The findings highlight distinctive patterns in the distribution and concentration of principal employees and agricultural workers, underscoring the variations in their proportional representation concerning the total population and the total principal employee workforce. The examination of principal employees revealed significant disparities across development blocks, with Umaruda, Gugarapur, and Talgram recording notably higher percentages compared to other areas. These figures depict areas with substantial employment in non-agricultural sectors, suggesting a potentially diverse employment landscape with varying opportunities in industries beyond agriculture. Understanding the dynamics of principal employees and agricultural workers across different blocks is crucial for informed policy formulation and resource allocation, aiming to address regional disparities, promote inclusive growth, and enhance overall socio-economic development within the Kannauj district. Further research and ongoing monitoring of employment patterns will be vital to track changes, identify emerging trends, and implement strategies that foster balanced and inclusive development across the region's diverse socio- economic landscape.

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DYNAMICS OF ELECTORAL BEHAVIOR OF PANCHAYAT ELECTION IN NADIA DISTRICT, WEST BENGAL

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Abstract

The present study investigates the events and circumstances that shape the voter's decisions and their involvement in the electoral process. It also aims to analyze factors that have affected electoral politics and voting behavior in the Nadia District Panchayat election. India's geo-political, socio-economic, cultural, and religious conditions played an important role in the formation, identity, and growth of the political parties in West Bengal. The present study deals with the comparative analysis of the major political organizations and their role in future political developments in the province. This research article also provides a deep political insight into the nature and quality invested in the leadership of the West Bengal political parties. The paper analyzes the analytical overview of Nadia's electoral politics from the 2008 to 2018 Panchayat elections. The study examines the causes of the Trinamool Congress's landslide victory in the Nadia district elections and why residents overwhelmingly voted for the Maa Mati Manus model of development promised by the party in the state's Panchayat election. The present study is based on both Primary and secondary data sources and adapted the qualitative and quantitative methods. The fundamental approaches include participatory research methods, narratives, discourses, and grounded theory. The data has been analyzed and interpreted with the help of various statistical methods like Factor Analysis, Correlation, and cartographic techniques for analyzing data like percentages, choropleth, line Graphs, and Arc GIS 10.2. It is being observed that political party-based association, local groupings, language, class, factors of caste, social welfare policy, ideology, and religious identities are the main contributing factors in defining the trend of voting behavior in Nadia District, West Bengal.

Introduction

Democracy embodies public participation and people empowerment necessary to address the power inequities in social, economic, and political spheres

(Bandyopadhyay, 2012). It affects real change in society. Democratic participation of the grassroots in policy formulation and execution is necessary to bridge the gap between the people and the policy-makers at the highest levels (Dasgupta 2020). The decentralization of state power is essential to ensure developing societies' democratization (Biswas & Mondal 2019). Therefore, the Panchayat election is an integral part of the decentralization and democratization process in the rural areas of India. The village Panchayat existed even before independence, but they were unofficial, informal bodies without significant power. After independence, reference to the village Panchayat in the Directive Principles of State Policy of the Indian Constitution did not give much leeway to Panchayat formation in the country. "The states shall take steps to create village Panchayat and invest them with such rights and authority as necessary to allow them to function as self-government units," the Indian Constitution's Article 40 declared. Long after the adoption of the Indian Constitution, the Panchayats were recognized as an important political tool for involving the vast majority of the rural population in public policy-making at the grassroots level. The idea of the Panchayati Raj system has been prescribed in the preamble of our constitution, which speaks about the right of liberty of thought, expression, belief, faith and worship, equality of status and opportunity, fraternity, as well as to participate in all types of functions and to have faith in any religion (Banerjee, 2012).

Local government strengthens the foundation of democracy. It links people at the grass-root level and the central or state level. The basic idea behind the formation of Local Government is people's participation in their day-to-day developmental activities. But elections are examined from various angles, including political, social, cultural, and geographic ones. A politically organized community's socio-cultural aspiration is reflected in its elections. Caste and religion are the main variables affecting voters' political participation and casting their ballots. Caste issues, however, have largely taken control of political participation in Indian states after the Mandal Commission Report's 1991 recommendations (Jeffrey & Young, 2012), most notably in northern states. Though linked with the electoral politics in the West Bengal political space, it can be claimed that as a social space, Bengal has a very different political and cultural ethos rooted in the identity of place. From the very perspective of humanistic geography through phenomenological inquiries, the place and lived experiences of "beings" largely control the "subjectivity" of electoral responses. Bengal can be adjusted to this theoretical frame of place connections because of its specific genre. However, political movements like the Renaissance,

social reform, and the communist-peasant movement further enhanced the state's political value on the phenomenological–existential ground—the persistence of social movements caused normative standardization and politicized this particular place (Biswas et al 2018). The Left Front government has fostered an environment where caste and religious politics are no longer valid, in line with the Marxist theoretical framework that only applies to superstructure (Bandyopadhyay, 2012). When the Left Front lost its majority in the Panchayat election for the first time since 1975, West Bengal politics underwent a significant upheaval. The primary supporters of the left, such as landless and marginal landowners, Scheduled Castes (SC), and Scheduled Tribes, are becoming more anti-incumbent due to increased accountability constraints brought on by changes in voter characteristics and more substantial governance failures. New youthful voters, aggressive anti-incumbency, and the Nandigram and Singur issue significantly altered West Bengal's political scene (Chatterjee, 2018), and the Nadia district was no exception. Hence, the long-term regime of the left front subsided the caste issue in electoral politics in Bengal. However, "class" was a key component of social stratification during the communist regime. Class constitutes the central focal theme in political discourse. The concept of "class" offers a contemporary foundation for political parties founded on Marxism.

However, it is believed that the left's demise has allowed identity politics; significantly, caste and religious identities are centrally involved in post-communist West Bengal electoral politics. Combined efforts of Abdur Razzak Mollah, a former member of the Communist Party of India (Marxist) CPI (M) and current minister of the AITMC and Matua Mahasangha helped Mamata Banerjee win the 2013 and 2018 Panchayat elections (Biswas et al 2022). In 2018, the Bhartiya Janata Party (BJP) structured planned electoral mobilization techniques to mobilize the Hindu voters in West Bengal (Palshikar, 2015). Additionally, the BJP, led by Narendra Modi, made a conscious effort to intermix pan-national identity, nationalism, and economic developmental issues (Shastri, 2019). He nurtured the idea that nationalism is correlated to Hindutva's national frame. Developmental issues were a fundamental drive within the electoral principles. The BJP's success in the 2018 Panchayat elections is notable for the geographic scope of its triumph, the increase in vote share, its capacity to convert votes into seats, and the broad socio-economic coalition that made this victory possible. However, recent observations of the Nadia district's political culture have revealed several traits. The communal versus non-communal fault line is one of the most important political fault lines in West Bengal.

The "communal" viewpoint frequently asserts that India's nationhood is founded on the Hindu community's cultural, religious, and ethical practices. The non-communal perspective, in contrast, holds that India's nationalism is not based on any particular community or culture. The socio-cultural existence of India is increasingly complicated and pluralistic as a result. The dominance of regional parties and the continued rise of national parties are reflected in how Nadia politics have changed over the past ten years. However, in recent years, caste and religious affiliation have been important factors in the Nadia election. Power-driven identity politics damage the ideal of democracy and draw attention away from other socio-economic problems, including unemployment, poverty, crime, corruption, the safety of women, and farmer suffering. Caste, class, and community divisions sometimes result in political violence, conflict, and tensions.

Objective

The main objective is to examine the factors that influence the voting behavior of the people in the Nadia District of West Bengal.

Database and Methodology

The present study based on both the arm of research primary and secondary source of data. The primary data constituted the significant input for the study. Primary data was collected from voters through a field survey. For that, a total of 500 voters have been selected from twenty Panchayat segments of Nadia district. In addition, direct field observations and a focus group discussion (FGD) have also been carried out to supplement the survey data. Qualitative methods and approaches are this research work's dominating tools and techniques. Participatory research methods, narratives, discourses, and grounded theory are the fundamental approaches for this study. It analyses the grounded theory of cultural space and place's identity influencing electoral behavior and its variations across the state. The study is also based on historical and analytical methods. The historical method helps understand the past experiences of electoral behavior of certain issues and challenges pertaining to voting behavior and party performances in Nadia District, West Bengal. This study is based upon secondary data sources collected from the Election Commission of India, New Delhi. The data has been analyzed and interpreted with the help of various statistical and cartographic tools and techniques like percentage. The Newspaper report, election documents, and manifesto are the archival sources consulted to explain political parties' role in the electoral campaigns and mobilization.

Results and Discussions

Electoral Politics in West Bengal with Special Reference to Nadia District

As a social space, Nadia District has produced a distinct political culture since the historical memoir. The meaning of place intrinsically nurtured its cultural evolution. Monarchical and feudal regimes have significantly influenced the political history of Nadia District in addition to democratic civic administration (Sinharay, 2012). However, the extreme political socialization of the residents of Nadia District, who predominantly reside in rural areas, largely governs the district's electoral dynamics. The people are controlled by the levels of social stratification based on caste and class identities. People will not be free but respond as members of a particular social group (McMillan 2012). Political parties use voters' cognitive frames for their electoral mobilization in this social context. However, the recent elections in West Bengal, where populist inclinations attempted to supplant the pre-existing political environment, were influenced by general influences of "waive elections" and their characteristics. Media, propaganda, and other outside entities work to instill their justification in voters' minds as "bio colonization" tools. A few political parties are trying to erode caste distinctions and make them more fluid to influence voters more broadly. Political parties make an effort to participate in accommodation politics.

They form alliances and use their identities to mobilize voters and win elections (Nath & Ray, 2022). However, religion has become a significant factor in controlling voters' imaginations and voting behavior in Bengal. Religion is one of the most important factors that can quickly mobilize a wider range of demographic compositions (Hasan 2010). Religion and caste are important tools to mobilize voters and win elections in the Nadia District. This particular emotion develops the environment of "self and other selves," "binary structuralism," and "bipolar religious order of society." Social feelings and already-existing social order serve as a ready-made canvas for political parties' electoral campaigns (Jungherr 2016). The Nadia District elections served as an important case study for empirical research on the effects of various socio-economic instruments on electoral politics. In this context, it is viable to feature these elements and their consistent impact on elections. Therefore, this study investigates the role of caste, class, religion, historical memories, iconization, and populism in the Panchayat election of the Nadia district. The political culture of the Nadia district is significantly different from that of the rest of the state. Caste and religion were declared invalid by the left-front government. Marxists are the proper form of social organization since it

offers a current framework for categorizing, organizing, and mobilizing individuals (Chakrabarty 2017). In the decline of the left as a significant force in the district, caste played an important role. In the politics of postcolonial West Bengal, no doubt left culture has produced the sense of ideological essence of electoral politics. However, caste-based identity politics has transformed the values of left politics in the state. It is a fact that caste played a significant role in Nadia district's Panchayat elections. The Matua Mahasangha's growing affiliation and support with BJP, a mainstream political party. Abdur Razzak Mollah's recent efforts to forge a united political front of Dalits and Muslims (Sinharay 2019). Although most of the left-front leadership in Bengal comes from the upper castes, the communists have always enjoyed unwavering support from the Dalits. The Dalits have never felt the need for their independent political platform. The left front's apparent awareness of his demise creates a favorable environment for identity politics. In such circumstances, West Bengal will unquestionably see a rise in identity-based political mobilization. The past election witnessed a bipolar contest between the CPIM and the AITMC.

However, the last two elections have seen the emergence of the BJP as a significant political force in Nadia district politics. The BJP performed very well in the 2013 and 2018 Panchayat elections. The inherent values of imagined identities nurtured the cognitive environment of individual voters. However, identity associations on the emotional line are short-lived and challenged by the existential reality and rooted intentionality of "self" performing in individuals as electorates (Bondi 2004, Fukuyama 2018). Caste, community, clan, and kinship are the identities drastically involved in elections for large-scale political mobilization. These variants undermine the ideal democratic spirit and divert focus from other "realistic" socio-economic issues like poverty, unemployment, crime, corruption, women's security, and farmer unhappiness. The politics of daily life geography raises political questions as emerging disparities based on caste, class, and community. It may occasionally lead to hate, conflict, and even violence. Instead, regionalism and the multi-party system have created a new political environment where voter expectations are evaluated following variances in voter consciousness and information flows (Biswas, 2022). The decline of Congress and CPIM created an atmosphere for the Bhartiya Janata Party (BJP) in the Nadia district of Bengal politics.

Electoral Trends and Performance of Political Parties in Nadia District Panchayat Election from (2008- 2018)

Our study deals with the spatial and temporal variations of electoral behavior in the three Panchayat elections in the political space of Nadia district, West Bengal.

It covers the elections of 2008, 2013, and 2018. The primary focus of the study is to identify, describe, and analyze the participation patterns and associated parameters with the help of electoral data, maps, and empirical observations. The electoral seat of a political party in the legislature reflects its relative strength and determines which party will form the government. The percentage of seats won and overall seats contested is used to measure a political party's level of success. In comparison to other political parties, Trinamool Congress had the highest success rate in the Panchayat election of 2018, with a score of 67.7 percent. It shows that, under Mamata Banerjee's leadership, Trinamool Congress enhances its electoral value by capturing voters' imaginations at a larger scale, covering a larger segment of social groups. In the 2008 Panchayet election, the Communist Party of India (CPIM) was the leading political party, winning more than 30% of the vote. However, in the 2013 panchayet election, its performance slipped. From the 2008 Panchayat elections to the 2018 Panchayat elections, the Indian National Congress's performance has declined on trends. Voter behavior in the Nadia District observed a paradigm shift from 2008 to the 2018 Panchayat elections. **Table-**1 displays the performances of political parties based on the percentage of seats and votes they got in the 2008, 2013, and 2018 Panchayat elections (**Table-**1).

Table-1: Patterns of Party Performances

Political Party	Patterns of Party Performances					
	2008		2013		2018	
	No of Seats	% of Votes	No of Seats	% of Votes	No of Seats	% of Votes
CPIM	891	28.22	547	22.16	340	16.2
AITMC	809	30.22	1384	39.3	1595	44.79
INC	650	14.3	515	13.12	379	3.61
BJP	205	7.14	385	13.14	759	26.7
CPI	20	3.6	10	1.6	4	0.5
AIFB	37	4.12	27	3.12	15	1.1
SUCI	26	4.7	20	1.8	11	0.8
CPIML	5	1.8	5	0.8	0	0.4
RSP	5	1.2	5	0.5	0	0.3
IND	43	4.7	72	4.46	106	5.6
Total	2691	100	2970	100	3209	100

Source: Based on Statistical Report in West Bengal Panchayat Elections from 2008 to 2018. West Bengal State Election Commission, Kolkata

Table-1 shows the TMC won 809 out of 2691 seats in the 2008 Panchayat election, with a vote percentage of 30.22. It gained 1384 seats out of 2970 in the 2013 election. It shows the increasing tendencies as 1595 seats were positively secured out of 3209 in the 2018 election. It achieved a vote percentage of 44.79 in this election. Compared with the 2013 Panchayat election, AITMC's party performances have improved regarding seats and vote share from 2008 to 2018. With this outcome, Trinamool Congress and Left political organizations dominated most of the political spaces in the Nadia district up to the 2013 Panchayat election. With the widespread criticism of the Leftist government, particularly in light of the Nandigram and Singur crises, the Trinamool Congress established itself in the Nadia district. Later, state politics viewed Mamata Banerjee as an influential leader in the state. In the struggle of Mamata Banerjee against the left, she proved herself to be the true alternative to the opposing voice. She was the only opposition leader who relentlessly opposed the left, which yielded her electoral benefit. Muslims constitute about 23 percent of the votes. Their votes are decisive, constituting 30 percent of the seats in the Nadia district. Trinamool Congress Government gives a monthly stipend of 2500 imams and muezzins. It distributed bicycles to girl students enrolled in madrassas. Provided scholarships for minority students.

Trinamool Congress offered reservations to Muslim OBC and declared Urdu the second language in the Muslim-populated district. Trinamool Congress intact Muslim voters due to the factors mentioned above that gave Trinamool Congress massive electoral victory in the Panchayat elections. The numerous welfare policies initiated by Mamata Banerjee, like the Rupashree Scheme, Kanyashree Scheme, Sabuj Sathi Scheme, Khadya Sathi Scheme, Swasthya Sathi, Imam Bhata, Pandit Bhata, etc., are the most popular schemes that influenced the voters and culminated in the resulting outcome of 2008, 2013 and 2018 Panchayat elections. **Table-**1 shows the 2008 Panchayat election; BJP won 205 out of 2691 seats with a vote percentage of 7.14. It got 385 out of 2970 seats, with a vote percentage of 13.14 percent in the 2013 election, and 759 out of 3209 seats in the 2018 election, with a vote percentage 26.7. In the 2008 Panchayat elections, the Bhartiya Janata Party did not have a significant impact. However, in 2008, left-wing organizations had more influence over a wider range of voters. The Trinamool Congress and the Left Front even balanced the 2013 Panchayat elections. It implies that the Bhartiya Janata Party's arrival strongly impacted the Panchayat elections in the Nadia district in 2013 and 2018. It means that the iconized political spaces have transformed with Narendra Modi's ascent to the position of a national populist leader. In these Panchayat elections, there were considerable differences between the seat and vote shares.

Compared to the 2013 Panchayat election in West Bengal's Nadia district, the BJP's party performance in the 2018 Panchayat election improved in terms of vote and seat share. The charismatic leadership of Narendra Modi, given his Gujarati roots belt, was largely nurtured through dedicated work as a skillful state leader. Hindu voters were not only institutionalized in saffron ideology and remained electorally loyal to Modi but also became the torchbearers of his novel brand of right-wing Hindutva politics. Saffron color comprises three political components: charismatic leadership, the strength of electoral rhetoric, and a vision of transformational governance. This pattern of party performances demonstrates the Trinamool Congress and BJP's intense electoral competition. The BJP has slightly benefited from capturing seats in the Blocks with more Hindu voters. This electoral situation highlights that CPIM, formerly the dominant force in state politics, has a lower voting percentage and likely switched to BJP. In recent elections, votes may have shifted more due to historical conflicts between BJP and AITMC officials and volunteers. The claim is that CPIM has weakened its ideological grip, and its traditional supporters have switched to another political party. The most likely explanation for this phenomenon falls into two categories. First, the CPIM voters have been split into two groups, and they now want the BJP to spread a negative message about the Mamata-led AITMC. Iconized politics, sentiment-based mobilization, and populist politics are other strong factors for the BJP.

The welfare policies that Modi has introduced include Jan Dhan Yojana, one of the largest financial schemes in the world, which opens bank accounts for 30 crore unbanked households, and Kisan Yojana, a direct income support program for the farming community. Awas Yojana, which offered to house 1.5 crore low-income people; Pradhan Mantri Ujjwala Yojana, which installed smoke-free kitchens in 70 million homes; and Swachh Bharat Abhiyan (Clean Bharat), which provided toilets to nearly ten crore people, were other significant programs (Heath & Tillin 2018). Gujarati Model and Narendra Modi's charismatic leadership is important in mobilizing ground-level leaders and voters. Hindu voters stayed electorally loyal to Modi, institutionalized the saffron ideology, and took up the mantle of his innovative form of right-wing Hindutva politics (Dasgupta 2020). The BJP criticized the Trinamool Congress for allegedly favoring Muslims. 'Nation First, national security, zero-tolerance approach to terrorism, the welfare of soldiers, battling infiltration, implementing the Citizenship (Amendment) Bill, combating left-wing extremism, Ram Mandir, Jammu & Kashmir - Article 370' were some of the key themes of Modi's populist campaign. **Table-**1 shows that in the Panchayat

elections of 2008, CPIM won 891 out of 2691 seats, with a vote percentage of 28.22; in the elections of 2013, it got 547 out of 2970, with a vote percentage of 22.16; and in the election of 2018, it occupied the 340 out of 3209 seats having vote percentage of 16.2. Compared to the 2008 Panchayat election in Nadia district, there is a declining pattern of party performance for CPIM in the 2013 and 2018 Panchayat elections regarding vote share and seat share. The CPI(M) cultivates a powerful organization with a broad network to keep a firm hold on the cadres and voters. As a result, Chief Minister Buddhadeb Bhattacharya created the new slogan, "Agriculture is our base, industry our future" (Jaffrelot & Verniers 2020). After acquiring agricultural plots from small farmers and landowners, he zipped across the state, setting the cornerstones for new townships, food parks, industrial units, shopping malls, and catering training facilities. The Left Front Government in West Bengal had created a positive and healthy environment in the industrial sector. The electoral success of the Left Front cannot be explained by economic parameters alone. The fact that the CPIM is a disciplined political party should be kept in mind in understanding the dynamics of power relations in West Bengal. Party discipline facilitates a strong link between the party leadership and the cadres.

This enables the leadership to translate effective organizational goals into grassroots action. The active involvement of the party cadres in the people's everyday life gives the CPIM strategic advantages in election campaigns. In the urban areas, the party maintains mass contact through the local committees and 'Mahila Samiti (Ghosh 2022). The Panchayati Raj revolutionized rural Bengal's economy and created a significant market for industrial goods during the Left regime in the state. The favorable industrial environment strengthened the Left Front Government. It triumphed in the 2008 Panchayat elections. Rising voter unhappiness with local incumbents on corruption, health, education provision, and other local public goods like roads and irrigation are examples of Left Front governance failures. Other programs include private benefit schemes like the Mahatma Gandhi program for drinking water, ration cards, bank loans, agricultural micro kits, old-age pensions, and the Indira Awas Yojana. Failures of state-wide programs, such as the stagnation of employment in rural areas, the inability to contain inflation, and issues with the Left Front's land acquisition practices close to Singur and Nandigram, might be attributed to non-local leaders. All of these problems, taken together, impacted the performance of the left front in the 2013 and 2018 Panchayat elections (Nath & Ray, 2022). The absence of left political force in the state and among the rural masses projects the historical visualization of its emergence in 1977.

Left Front government emerged, riding the wave of anti-Congress mass resentment. In the initial years, it undertook some popular measures like distributing vested lands among the landless, registering the names of the sharecroppers under Operation Barga, and reviving the Panchayati Raj institutions. At the same time, these democratic reforms helped consolidate the new communist party in the rural areas. However, undemocratic measures were followed later to eliminate opposition forces from the countryside. CPIM Neglected the voice of opposition to devalue and suppress the inherent identity forces that led to the decay of left rule even in the rural areas of West Bengal. In this regard, the Left Front rule that systematically and meticulously tried to direct consolidation as a dominating single party, even at the expense of all opposition parties, even junior partners, particularly in rural Bengal, has become irrelevant in electoral mobilization. **Table-**1 shows that in the 2008 Panchayat election, INC won 650 out. During the 2013 elections, INC won 515 out of 2970 seats with a vote percentage of 13.12; in the 2018 election, it won 379 out of 3209 seats with a vote percentage of 3.61. Comparing the 2008 Panchayat election in the Nadia district to the 2018 Panchayat election, there is a declining pattern of INC party performance regarding vote share and seat share. As a result, the INC party's performance has suffered as voters from the upper caste, Dalits, and Muslims have stopped supporting it. The majority of those who vote for Congress are from socially and economically disadvantaged groups. However, AITMC, which speaks directly to these communities, poses a real threat to Congress in the race for their votes.

The identity of the Dalit was historically less politicized. CPIM and Congress both had mileage in the reserved category voting performance, according to behaviors drawn from past electoral behavior of electorates in the Nadia district of West Bengal. It is because voting behavior's class-based orientation overshadowed caste-based mobilization or politics of identities. However, the recent Panchayat elections in 2018 showed the emergence of caste-based identity politics, as the BJP chose a Dalit as its state president. The Nadia district has been using the state president's identity. However, the deterioration of left politics in the state and rural West Bengal also destroyed the ideological essence of West Bengal politics. The ways of electoral mobilization consequently transformed into a pragmatic turn. The issues of labor and class identity-based mobilization are deformed into religion, caste, and identity politics. The features of national identity and issues and national tendencies overshadowed the regional identity of place and local social questions. The instrumental agencies like media and populism drastically shaped the authentic

political voices of rural society. The politics in West Bengal observed a drastic change and transformation from the Left-based political constructs to the emergence of Trinamool as a powerful political voice in the state. The changing demography and political situations are the vital cause of this transformation. Rising population growth, demographic fragmentation, middle-class dissatisfaction, and social and economic detachment are the general factors in the change of political regime.

Caste and Voting

The caste system largely affects the electoral campaign in rural areas, where caste and Baradari (Kinship) loyalty is seen as one of the most decisive factors determining the voting behavior of the villagers (Bandyopadhyay, 2012). In the Nadia district, individuals simultaneously hold multiple ethnic identities of language, religion, politicized umbrella caste categories (such as Upper Castes, Backward Castes, and Scheduled Castes), and highly localized sub-caste/kinship groups biradari or jati. Ethnicity matters in voting behavior and depends on the differences in the economic well-being of ethnic groups in a system (**Table-**2). When some ethnic groups are wealthy and others are poor, the silence of ethnicity in politics should increase. BJP's propaganda invites all majority community members to look at themselves as Hindu first and members of some caste groups second because of the socio-economic differentiation in the society. In a caste group, the richer people were more pro-BJP; they tended to be because of caste and class (mainly because of the party's reservations vis-à-vis caste-based quotas). It is still valid, but some changes have occurred in the context of post-1991 liberalization. Respondents believe Trinamool Congress got full majority support from the minority community (**Table-**2).

Table-2: Caste and Voting Preference of Respondents

Category	Voting Preference of the Political Party (%)			
	AITMC	BJP	Left	Others
General	35	40	20	5
OBC	40	35	18	7
SC	35	45	15	5
ST	30	50	15	5
Minority	82	3	10	5

Source: Field Survey, 2020-21

Factors Influencing Voting Behavior

A number of factors influence an individual's voting behavior. It is mainly determined by race, religion, caste, community, region, language, charismatic leadership, ideology, local issues, political wave, etc. Thus, an attempt has been made to determine the sources of voting behavior (**Table-**3).

Table-3: Distribution of Respondents According to Factors Influencing Voting Behaviour

Factors affecting Voting Behaviour	Number of Respondents	Percentage
The ideology of the Party	100	12.7
Programmes and Policies of the Party	160	15.88
Personality of the Candidate	140	7.94
Religious Consciousness	400	22.22
Caste Consciousness	250	17.46
Local issues of Electricity, Road, and Water	140	15.87
Any Other	10	7.93
Total	1200	100

Source: Field Survey, 2020-21

The reason is that Muslims see the BJP as a party threatening their interests. BJP has successfully increased its popularity among SC/ST community voters with the help of pro-poor policies like the Ujjala Yojana, Pradhan Mantri Awas Yojana, Swatch Bharat Mission free toilet, Free Ration, and CAA/NRC Issues. **Table-**3 displays that the majority of respondents, i.e., 22.22%, gave importance to 'religious consciousnesses in deciding on whom to vote for in the election, while 17.46% of respondents emphasized caste consciousness and 19.20% of respondents emphasized 'local issues of electricity, road, and water of electricity. Other factors viz., 'programs and policies of the party,' 'ideology of the party had received preference of the electorates at the rate of 12.70%. It shows that religion and caste is the most important factor in voting behavior in Nadia district voters. The candidate's personality has minimal influence on the voting decisions of the region's people. Apart from these factors, priority has also been given to other factors like political parties' leadership and their representative's work or performance while voting. Therefore, it is essential to study the voters' preferences regarding political parties' leadership and their representative's work. Considering that the respondents' questions were asked, their opinions are classified below.

Conclusion

Trinamool Congress is becoming increasingly popular in Nadia district, West Bengal. BJP's political performance is a little better where the proportions of Hindu and Matua populations are high. It is a party with a strong ideological foundation that may appeal to the masses of one particular religion. On the other hand, the mutual political rivalries between CPIM and Trinamool congress voters also caused the massive success of the BJP in the Nadia district. The traditional vote banks of CPIM have also transformed their vote and support in favor of the BJP to degrade Trinamool, which has covered the voting scale in the political space of West Bengal. The leadership's quality is still a factor for the Muslim electorate. In regions where Muslims predominate, all major political parties often choose a Muslim as their candidate. They support those parties that promise them more security, respect, and identity. It provides them structurally a wide range of protection. CPIM and AITMC use Muslims as an electoral support base in their respective era of influence. Strategically, both parties succeeded in creating fear and threat of the BJP and rising communalization in the state. Although caste, class, and religion are significant factors in elections and maintaining strong control over people's perceptions. It functioned by identities in general and caste politics in particular. In the Nadia District, these imagined identity variables are particularly crucial and visible in electoral behavior and mobilization in the rural Nadia district. The CPIM has sustained its pro-poor policies for a longer duration. Its policies always benefited the scheduled castes, the Scheduled tribes, and the Muslims in Nadia district, West Bengal. It provided CPIM the power hold for the long term. So, the result revealed that the Trinamool Congress has the more prominent mass acceptance in the Nadia district Panchayat elections. Consequently, an electoral pattern indicates the ideological shifting in order from Left to Centre and now emerging trends of right in the Nadia district.

The politics in West Bengal observed a drastic change and transformation from the Left-based political constructs to the emergence of Trinamool as a significant political voice in the state. The changing demography and political situations are the vital cause of this transformation. Rising population growth, demographic fragmentation, middle-class dissatisfaction, social and economic detachment are the general factors in the political regime change. The emergence of the new middle class in the West Bengal demographic scene caused the degradation of voting influences of left parties. Remarkably, the left's support base was diminished with a long-time sustained problem, including a lack of industry, job opportunities,

and declining health and educational systems in the state. Overall, the civic memories and rise of Mamta Banerjee at a populist scale further challenged the CPIM space among the common masses. The left found the issue of land acquisition in Singur and Nandigram too expensive. In the Nadia district of West Bengal, Most SCs and STs voted for the left until it benefitted their caste interests. The left's policies, such as Land Reform and Panchayati Raj, offered the lower castes a sense of social advancement. It gave them political power at the local level and protected them from the powerful upper-caste landowner class. As a result, the left continued to get support up to the 2008 Panchayat elections. Even after the thirty years of rule by the left parties, the caste and religious consciousness was inherently located among the mindset of electorates. The religious sentiment of social groups was not changed into class consciousness. Economic diversification was not achieved, and the left regime did not address unemployment issues. The socio-economic backwardness of religious minorities projected the inter-ethnic, inter-community gap that leads to the degeneration of left politics. It seemed that the populist movement of TMC and the political iconization of Mamata Banerjee provided a sense of hope among the long-term subjugated social groups. Therefore, it benefitted the TMC in electoral victory.

The numerous welfare policies initiated by Modi, often based on earlier Congress planning, including Jan Dhan Yojana, one of the biggest financial schemes in the world, opening bank accounts for 30 crore uncovered households, and Kisan Yojana, a direct income support scheme for the farming community. Other mega programs were Awas Yojana, which provided housing to 1.5 crore poor people; Pradhan Mantri Ujjwala Yojana, which created smoke-free kitchens for 70 crore families; Swachh Bharat Abhiyan (Clean Bharat) and provided toilets to around ten crore people. The BJP criticized the Trinamool Congress for allegedly favoring Muslims. 'Nation First, national security, zero-tolerance approach to terrorism, the welfare of soldiers, battling infiltration, implementing the Citizenship (Amendment) Bill, combating left-wing extremism, Ram Mandir, Jammu & Kashmir - Article 370' were some of the key themes of Modi's populist campaign. Communalism plays a determining role in the electoral politics in Nadia district, West Bengal. Political parties and politicians use the communal division in population as the primary card during elections. As a result, the voters of the Nadia district very often vote based on religious considerations and local problems and issues.

However, the trend is changing slowly yet gradually. The sign of such consciousness is reflected in the voters' opinion regarding the most crucial issue

in the 2018 Panchayat election. However, there are visible signs that Bengal electorates are maturing, and the election is becoming more competitive. Nadia district is also no exception to that. Maybe in the coming days, communalism in politics may not remain a solid card to win regional elections. It is changing the course of electoral politics in the Nadia district. An electoral pattern indicates the ideological shift from Left to Centre and now emerging right-wing trends in the Nadia district electoral politics.

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ASSESSMENT OF RURAL TOURISM DEVELOPMENT IN KALIMPONG DISTRICT, WEST BENGAL, INDIA

Amita Halder and Sanjay Kumar

Abstract

Rural Tourism is understanding and going through the rural lifestyle, nature-based activities, natural products or it could be a modified form of ecotourism. In India it is growing in a vast scale. This paper aims to provide a holistic view of rural tourism sites and the success factors for the development of rural tourism in Kalimpong district, West Bengal. Based on an empirical study with the help of secondary data sources and observation of field study. A qualitative method is used to review the current scenario of the rural tourism sites in Kalimpong District. A SWOT analysis method is also used to identify success factors working behind developed rural tourism in the study area. The study highlights, Kalimpong district as a popular rural tourism destination and recognized the strength, weaknesses, opportunities, and threats of rural tourism in the study area.

Introduction

To enhance and sustain the quality of rural life, tourism is one of the essential sector and act as contributor. Rural tourism (RT), not a new concept for World (Gao & Wu, 2017; Roslina, Dupre & Wang, 2021) but this trend has emerged from last ten years in India. Rural tourism evolved in mid 70s in developed countries (Lane, 1994; Verma and Jain, 2018; Duha, 2021), its interest raised among people in the second half of the 20th century and became a useful tool for the development of rural areas (Duha, 2021). Indeed, globalization and urbanization have had a significant impact on the international, national, and regional tourism industries, leading to increased priority and profitability in many cases (Lane, 1994; Duha, 2021). This combines rural amenities and activities to offer visitors an authentic and enriching experience in rural areas (Fleischer and Tchetchik, 2005; Gartner, 2005). According to the United Nations of World Tourism Organization (2017), this form of tourism focuses on providing tourists with a deeper connection to the countryside (remote or rural areas), local culture, and traditional ways of life and characterize on the basis of population density and settlement size,

land use and economy, and traditional social structure (Lane, 1994). This provides tourist relax from their busy schedule with pollution-free environment, fresh air, open-wide space, connecting with nature, and going back to their roots i.e. far away from the city (Irshad, 2010;). It has many subsets like agri-tourism, cultural tourism, homestay tourism, eco-tourism, etc. (Irshad, 2010; Fleischer and Tchetchik, 2005; Ashtani, 2005). According to the Ministry of Tourism of India (2022), rural tourism is working as an integrated model, because it took account of various resources like cultural, Social, economic, and environmental aspects and the role of the stakeholders (Cawley & Gillmar, 2007). Indian government had indeed been promoting rural tourism as a means of sustainable development in rural areas so that people can become self-reliant or Atma-Nirbhar. It is an effective tool to eradicate poverty, increase the quality of life of local people, development of remote areas (Roberts & Mitchell, 1998). In today's world homestay business is a perfect option for rural tourism and indeed a component of the broader tourism and hospitality industry, and it shares some key characteristics with other service-based businesses within this sector. Rural homestay is an important part; because without staying with local people, tourists cannot participate actively in rural activities. Facilities like accommodation, food, beverages, Products, and infrastructures are taken into consideration to develop rural tourism. Rural tourism gives new rise in generating employment and income, entrepreneurship, and empowering local people and women (Das, 2021). It is also preventing the out-migration of youth from rural areas. Rural tourism not only gives work opportunities but also promotes the environmental, economic, and socio-cultural sustainability of rural areas.

Study Region

Kalimpong district was selected for this research work, as its 21st district of West Bengal in 2017 carved out from the Darjeeling district. The district extents from 26°51'N and 27°12'N latitude and 88°28'E and 88°53' E longitude. The district has consisted of three community development blocks and shares boundary with Sikkim, and Bhutan. It is famous for Orchids and known as the "Land of Orchids". Kalimpong has hilly areas, natural beauty, picturesque villages, river valleys, culture, heritage, etc. It is observed in (**Table-**1) that this district comes under rural areas, bounded by forests, and diversities of flora and fauna. The main source of economy and livelihood is agriculture. There are many variations in agriculture. Cash crops (Ginger, Large Cardamom), Plantation crops (Tea, Medical plants, Cinchona, Pineapples), Horticulture (Orange), floriculture, and Orchid culture are also the attractions of this region.

Kalimpong is recognized as a natural greenhouse region (Sharma & Mandal, 2020), traditionally different from other districts of West Bengal and inhabited by ethnic groups (**Table-**1).

Table- 1: General Information on Kalimpong District to Develop Rural Tourism.

Attributes	C. D Blocks of Kalimpong District		
	Kalimpong I	Kalimpong II	Gorubathan
Total Population	74746	60663	66830
Area (Sq.km)	360.40	241.26	442.72
Density (Sq.km)	210	280	140
Number of households	15358	13172	12662
Rural Areas	Mostly rural areas except one census town Kalimpong	Consist only rural areas	Consist only rural areas
Forest area	Forest area is 52% of the total district		
Bio-diversity	This region comes under eastern Himalayas. It is rich with different types of flora and fauna i.e. Mammals - 90species, Orchids - 300 species Birds- 550 species.		
Economy	Mainly depend on agriculture. About 80% people of this district associated with farming for their livelihood.		
Agricultural Landuse under Cultivate (Percentage)	37.19	34.5	44.17
Variation of Agriculture	Subsistence farming, Cash crop raising, Plantation farming, Horticulture, Floriculture, Orchid culture, Sericulture		
Accommodation for tourist	Homestays		
Tradition	Society is traditional because of inhabited by ethnic people like Gorkha, Lepcha, Bhutia, Etc. Religions are Buddhist, Hindu, Christian, Islam		
Small scale industries	Handicrafts, Agro-based products, Homestay		

Source: District census handbook of Darjeeling (2011)

It is one of the most popular tourist destinations among other destinations of West Bengal, but comparatively is a latecomer on the tourist map. It is attractive for its landscapes, pleasant weather, and richness of biodiversity, ethnic culture, historical heritage, handicrafts, and panoramic view of Mount Kanchenjunga. In current times, tourists prefer niche types of tourism, in which locations are off-beat destinations, rather than known tourist places. This year, eight villages from Kalimpong district have been nominated for the annual "Best Tourism Villages" by UNWTO.

Objectives

The major objective of the present study is to review the current scenario of rural tourism sites and to identify key to success factors of rural tourism in Kalimpong district.

Database and Methodology

For the study, both primary and secondary data have been used. Primary data was gathered from personal observations and interactions with local people and homestay owners and online with local. Secondary data have been collected from relevant documents of published research papers, reports, and books. This dataset include- District census handbook of Darjeeling (2011), Kalimpong the Nest of smile (2018), Kalimpong Calling (2019), document on Homestays of Kalimpong (2022), and Homestays of Kalimpong (2023) published by District Magistrate of Kalimpong, West Bengal Homestay Tourism Policy (2022) published by Government of West Bengal, District survey report of Kalimpong (2022) etc. Reports and books are published by the district administration of Kalimpong. Schemes and policies-related documents published by West Bengal Government in 2022. All these are used to meet the objectives of the study. Based on the primary and secondary data, a SWOT (Strength, weakness, opportunities and threat) analysis has been done to identify key success factors for rural tourism development in the study area. SWOT analysis is a Conceptual Framework (**Fig. 1**) for identifying and analyzing an organization's strengths, weaknesses, opportunities and threats. Strength characterizes business as competitive advantage over others; Weakness characterize business as disadvantage relative to its competitors; Opportunities elements in the external environment that allows it to formulate & implement growth strategies; Threats elements in the external environment that can endanger the business and its ability to operate. The primary goal of SWOT analysis is to increase awareness of the factors that go into making a business decision or establishing a business strategy.

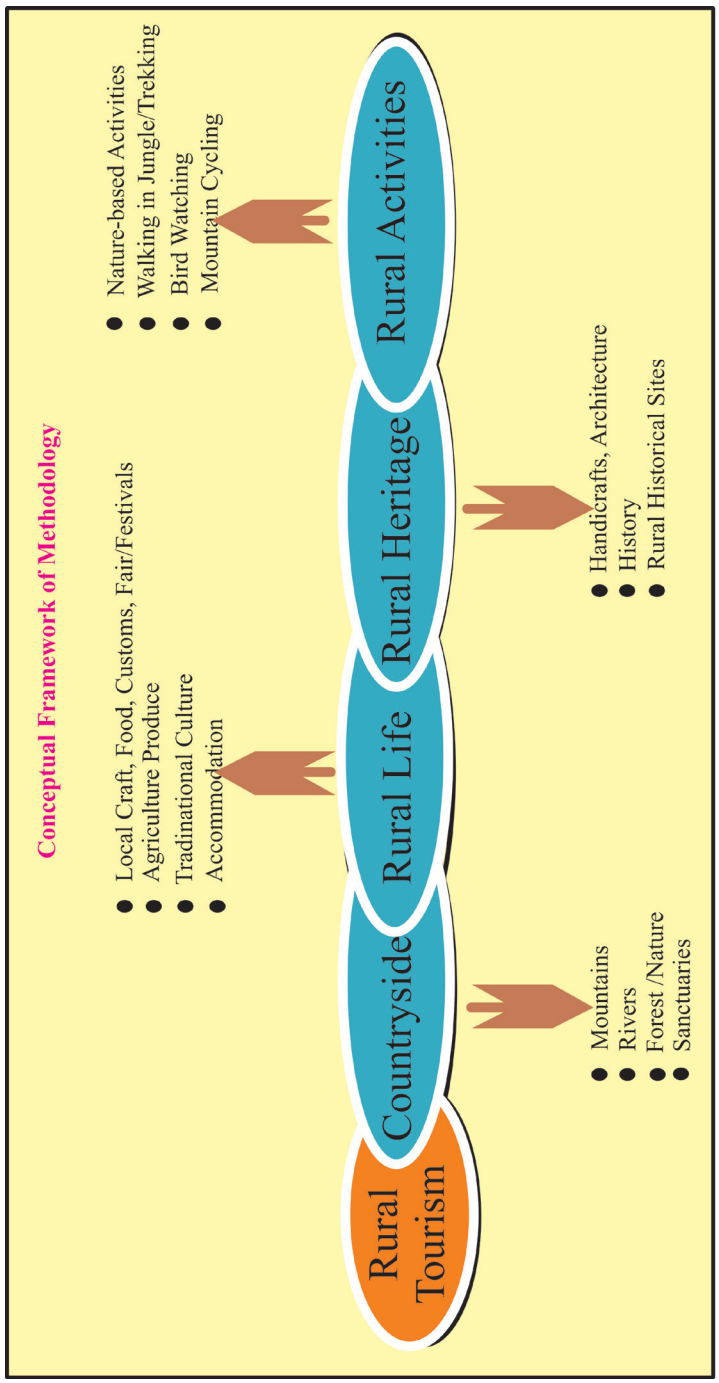

Conceptual Framework of Methodology
Rural Tourism
Countryside
Rural Life
Rural Heritage
Rural Activities
Mountains
Rivers
Forest /Nature
Sanctuaries
Local Craft, Food, Customs, Fair/Festivals
Agriculture Produce
Tradinational Culture
Accommodation
Handicrafts, Architecture
History
Rural Historical Sites
Nature-based Activities
Walking in Jungle/Trekking
Bird Watching
Mountain Cycling

Fig. 1

Result and Discussion

The current scenario of rural tourism sites in Kalimpong District

Kalimpong District is a hill station covered with reserve forests, river valleys, and foothills of the Himalayan region. Its elevation varies from 131 meters to 3163 meters (**Fig.** 2). Out of the total population in Kalimpong, 9.1% of people live in urban areas, while 90.9% of people live in rural areas (Census, 2011). People in rural areas are connected with agriculture with vast area of floriculture and agrarian resources and a few tea gardens along the southern Tarai and Dooars region of Gorubathan block (Podder, 2020). Most of the villages of three blocks of Kalimpong district are inhabited by ethnic people like Tamag and Lepcha. Based on natural and human resources, rural tourism has been growing in different villages of Kalimpong District since 2011-2012 (Sharma & Chettri, 2023, Das, 2021). Mostly tourism sites have been developing in remote villages within the forest and hilly tracts in the Kalimpong region (Das, 2021). Every three blocks of Kalimpong have rural tourism sites, from them some are very popular destinations and others are little known.

Kalimpong-II has the greatest number of rural tourism destinations because it comes under the old silk route circuit, which is connected to Sikkim. Homestays are one of the key factors to develop rural tourism in this area, which varies from 1015 meters to 3163 meters. In Kalimpong I and Gorubathan block, rural tourism sites have been developed at middle altitudes (1015 meters to 2024 meters) and nearby roads and rivers. Kalimpong I mostly come under urban areas. So, here new rural tourism sites are now developing like Chuikhim, and Nimbong. Gorubathan block comes under in Dooars region and due to accessibility hotels are grown up, that's the reason homestays are not more developed here. These rural tourism sites are also known as eco-tourism villages. These are Ramdhura, Sillary Gaon, Ecche Gaon, Rikisum, Loly gaon, Chuikhim, Kagey, Jhandi etc. These villages are picturesque, lush green trees, traditional homes, hills side cultivation, home of Orchids and different flowers, cinchona plantation, tea gardens, and majestic views of Kanchenjunga and hospitality of local people.

Strength

In the study area, under strength mainly 5 factors identified based on literature review and observations, which the potential resources are playing important role in the success of rural tourism (**Fig.** 2 and 3).

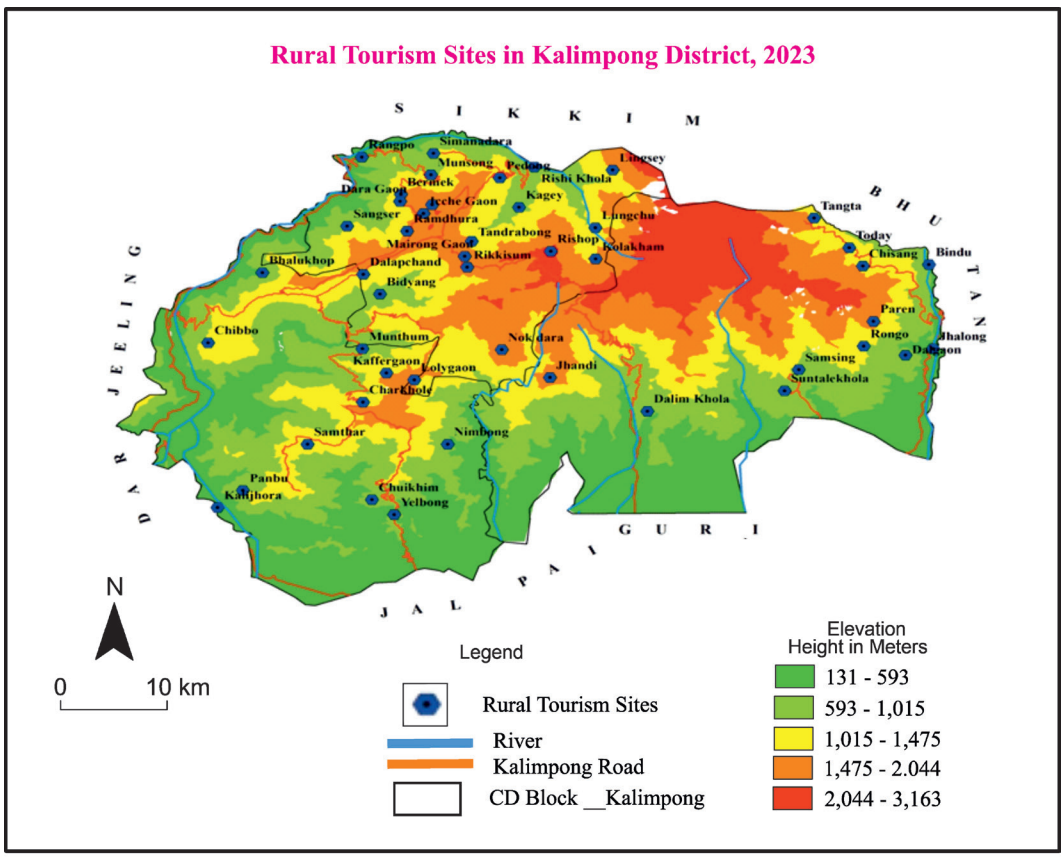

Rural Tourism Sites in Kalimpong District, 2023
S I K K I M
D A R J E E L I N G
J A L P A I G U R I
B H U T A N
Rangpo
Simanadara
Munsong
Pedong
Rishi Khola
Lingsey
Dara Gaon
Berenick
Kyche Gaon
Kagey
Sangser
Ramdhura
Tandrabong
Rishop
Lungchu
Kolakham
Tangta
Today
Chisang
Bindu
Mairong Gaon
Rikkisum
Bhalukhop
Dalapchand
Bidyang
Chibbo
Munthum
Nok dara
Paren
Rongo
Jhalong
Kaffergaon
Lolygaon
Jhandi
Samsing
Suntalekhola
Charkhole
Dalim Khola
Samthar
Nimbong
Panbu
Kanjhora
Chuikhim
Yelbong
N
0
10 km
Legend
Rural Tourism Sites
River
Kalimpong Road
CD Block __Kalimpong
Elevation
Height in Meters
131 - 593
593 - 1,015
1,015 - 1,475
1,475 - 2.044
2,044 - 3,163

Fig. 2

The factors are identified by using SWOT (Strength, Weakness, Opportunities, and Threats) analysis. Strength and Weakness are considered as internal factors i.e. activities involved in these factors are controllable and can be changed like location, team, intellectual properties etc. And on the other hand, Opportunities and Threat are external factors i.e. activities involved in these factors cannot be changed as under opportunities advantage can be taken but under threat only precautionary measures are taken. Ex. competitors, prices and customers (**Fig.** 3).

Historical

Natural: Natural resources are the Potential component to the development of rural tourism in the Kalimpong District (**Table-**3). The unique mountainous topography, river valleys, mesmerizing weather, majestic view of Mount Kanchenjunga, Night view of various cities from the hill region, diversities of flora and fauna, picturesquare villages and lush green trees and forest of pine and Oak, tea garden attracts a huge number of domestic and foreign tourist (Das, 2021: Bhutia, 2014: Khan and Mitra, 2017: Bhattacharya et. al, 2014). These are the key reasons for the successful development of rural tourism in Kalimpong district, Darjeeling Himalayan region.

Cultural

In rural tourism, tourist gains experiences from the local art, culture, and lifestyle of local people (Bhutia, 2014). Kalimpong is a full variation of traditional art, culture, communities, and religions. Because of the trade route to Tibet, this is earlier known as the old silk route passed through Kalimpong. In this region, various types of tribal people inhabited like the Rai, Damis, Limbus, Gurungs, Bhutia, Sanki, Sherpa, Khas, Yolmo, Magar, Newars, Tamangs, Bhujel, Kami, Lepcha, etc. The Lepchas are the original indigenous tribes in the study area. Each of these people is very unique in their culture, religion, and heritage. Most people practice Hinduism, followed by Buddhism, Christianity, and Islam. Their main languages are Nepali, Hindi, Bengali, and English. Here, Hinduism is pre-dominated, but Buddhist and Christian culture is also an attraction of this region. There are so many popular monasteries, temples, and churches (tab no. 3) in the three blocks of Kalimpong District. Kalimpong is also known for its traditional handicrafts, wood carvings, embroidered items, bags & purses with tapestry work, copperware, and Tibetan jewellry. Cuisine: In Kalimpong district, another attraction is delightful ethnic cuisine like Momo, Gundruk, Ko Jhol, Thukpa, Kinema KO Jhol, Sel Roti, Aalu Dum, and Ningroo with Churpi (One Kind of Cheese), Shya Phaley, etc.

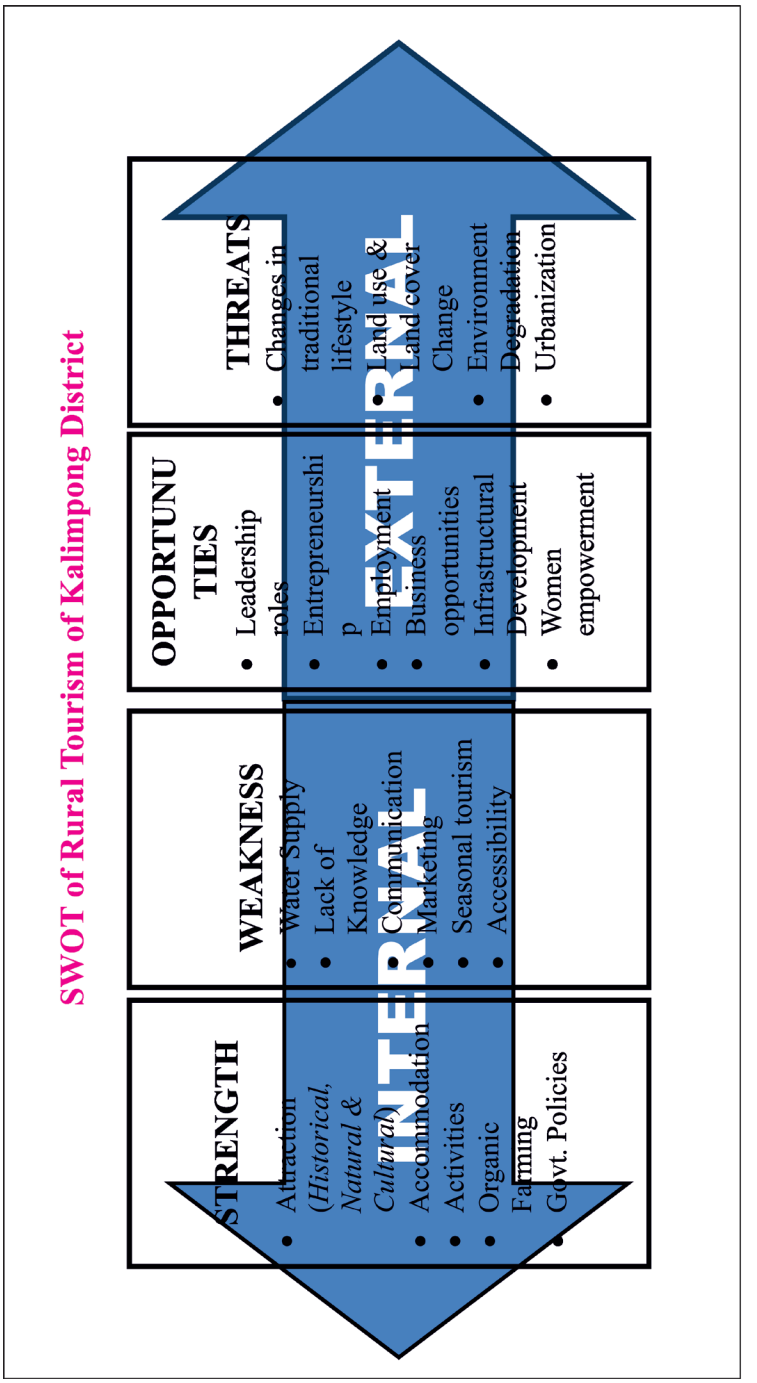

SWOT of Rural Tourism of Kalimpong District
STRENGTH
Attraction (*Historical, Natural & Cultural*)
Accommodation
Activities
Organic Farming
Govt. Policies
WEAKNESS
Water Supply
Lack of Knowledge
Communication
Marketing
Seasonal tourism
Accessibility
OPPORTUNITIES
Leadership roles
Entrepreneurship
Employment
Business opportunities
Infrastructural Development
Women empowerment
THREATS
Changes in traditional lifestyle
Land use & Land cover Change
Environment Degradation
Urbanization
INTERNAL
EXTERNAL

Fig. 3

This region is also renowned for cheese, noodles, and lollipops. Organic Vegetables and homely food of local people are preferred by tourists. It changes the taste buds of tourists and attracts tourists to rural tourism. Fair and Festivals: The people have come from different ethnic groups. There are so many fairs and festivals celebrated with great joy like Christmas, Diwali, Dusshera, and Losar. A large fair is held at Beni (the Confluence point of river Teesta and Rungeet) on the 14th of January every year. They are celebrated their fair and festivals with traditional dance and music like ghatu dance, dhan, damphu, Kaura, Maruni etc.

Historical

Kalimpong has its unique history. Firstly, Kalimpong was ruled by Sikkim still 1706 when Bhutan invaded Sikkim (Podder, 2020). Then it was acquired by the British and established colonial rule. Kalimpong is connected with Tibet, Nepal, and Bhutan by trading and sharing the national and international border. That's the reason many ethnic cultures mixed over. Donzong kingdom of Sikkim and British ruled over Kalimpong. They left their culture, Architecture (tab. no. 3) and artifacts like Tibetan style, Scottish, Roman, etc. In 1947 Kalimpong become a part of West Bengal (**Table-**2).

Table-2: Attractions of Three C.D. Blocks in Kalimpong District.

Attractions	Name of the C.D. Block		
	Kalimpong I	Kalimpong II	Gorubathan
Natural	7th Mile viewpoint, Panbu Dara viewpoint, Deolo viewpoint, Deolo Park, Pine view Nursery, Teesta River Valley, Relli river Valley, Coronation Bridge, Patima Devi Tagore House etc.	Ramtey viewpoint, Jalsa viewpoint, Ramdhura viewpoint, Tiffin Dara viewpoint, Lava viewpoint, Munsong Teesta viewpoint, Sillary Gaon viewpoint, Rishop view point, Tiffin Dara view point. Cinchona Plantation, Neora valley National Park, Dhoksing Waterfall, Changey waterfall. Etc.	Organic Tea Garden, Suntaley viewpoint, Gumba Dara viewpoint, Triveni viewpoint, Dalgaon viewpoint, Bindu viewpoint, Jhandi Dara view point, Bindu barrage, Gorubathan Tar, Bhutan Tendu Valley etc.

Contd...

Religious	Zang Dhok Patri Phodang Monestry, St. Teresa's Church, Dharmodaya Bihar, Macfarlane Church, Gaden Tharpa choling Monestry, Mangal Dham, Kali Mandir, Tongsa Gumba etc.	Gumba Dara Monastery, Kagyu Thekchen Ling Monastery.	Chyakung Dara
Historical	Morgan House, Nature Interpretation center ecological Museum, Dr. Graham's home, Lepcha Museum etc.	Jalsa Bunglow	Damsang Fort

Source: Kalimpong Calling (2019), District Magistrate office

Accommodation

In Kalimpong region, tourism developed in the remote areas, which have natural landscapes, and pollution-free, fresh air. Rural tourism has been implemented in the various villages from three community block of Kalimpong district. The Sites are known as the off-beat destination of rural tourism for their crowded and hassle-free environment from urban areas. Rural Homestays are playing a vital role in rural tourism (Ministry of Tourism, 2023). Here, Homestays are the main accommodation and one of the attractions for tourists in rural tourism in this area. Homestay is an affordable alternative accommodation for tourists (Sharma & Chettri, 2023; Kumaran et. al, 2019). Where tourists are staying with local families, thus enabling them to gain knowledge and experience the culture, cuisine, and lifestyle of local people (Ministry of Tourism, 2023). Also, tourists are welcomed and can experience the traditional hospitality of the host family and the local community. It gives a unique and gracious feel to the tourist. In Kalimpong District, Homestays are a growing phenomenon in rural tourism in the study area (Das, 2021). In 2022,

there were 402 registered homestays in the three blocks of Kalimpong district. Now, it has increased to 1009 in 2023. It has increased significantly around 60% within one year. Mostly Homestays are concentrated in the Kalimpong II block (73%), followed by Kalimpong I block (20%) and Gorubathan block (7%). Kalimpong-II block is highest in the growth of Homestays than the other two blocks (**Fig.** 4). Because of some factors are working in this area like high altitude, conducive climate, large forest area, organic farming and silk route region, etc.

Activities

Kalimpong District has mostly hilly areas except for the South-eastern part of Gorubathan block. The people are associated with agriculture and the nature of this region. They are transforming their traditional agriculture, and nature-based knowledge into tourism activities. These activities are trekking, hiking, camping, river rafting, walk-in Jungle, identifying the plants and organic farming and harvesting, local festivals, nature photography, Mount biking and cycling, and bird watching. The Neora Valley National Park and forest are known as the "Paradise of Birds" in Kalimpong block II. The villagers in a group or individual are working as a guide. These activities keep engaging tourists with the local people.

Organic Farming

Kalimpong district has potential in organic farming and agro-horticulture for its temperate climate. According to Census (2011), more than 80% of people in Kalimpong depend on farming to manage their livelihood. The district is producing paddy, maize, millets, pulses, oilseed, and potatoes in small amounts, and medicinal plant varieties with the help of organic cultivation (Bhattacharya et. al, 2014). But it is widely known as one of the leading producers of large amounts of cardamom, flowers, and various cash crops like ginger, betel-nut, oranges, organic tea, Dalle Khursani (small chilies), and Mulberry Seri-culture (Chakraborty, 2023; Ram and Maji, 2018). The tribal people of Kalimpong like Lepcha, Bhutia, Rai, etc have utilize their family members as agriculture labour and using local resources, through traditional knowledge and methods for organic farming (Patel and Lepcha, 2023). These methods are more environments friendly (Biswas et. al., 2011). Over time period organic farming has been growing interest among tourists. It's become an opportunity for villagers and a success factor of rural tourism. Various villagers (rural tourism sites) of Kalimpong district, offers tourist to stay in farm-stay and homestay to gain knowledge of organic farming and the livelihood of local people.

Government Policies

Government policies are an important factor to develop rural regions through rural tourism. The entire stakeholders, who are related to tourism activities is bounded by local government and state government regulates. The government of West Bengal has taken many initiatives to growth of rural tourism through creating alternative income generate, employment, business opportunities, and community development. Rural homestay is an integral part of rural tourism. To promote homestay and increase local entrepreneurship, the state government gives the incentives of 1.5 lac rupees to each eligible homestay owner to achieve and maintain basic standards of homestay. Also gives subsidies on electricity and homestay businesses. No commercial taxes are levied on homestay owners, who have not more than 6 rooms (**Fig. 4**).

Homestay owners can register their homestay in the District Magistrate office and taken benefits from homestay tourism policy 2022. According to the Department of Tourism (West Bengal), tourism policy (2019) and recognition of tourism service provider policy (2021) promoted guidelines and different criteria to grant loans to tour operators, travel agents, and tourist transport operators. The policies are mainly focused on standards of infrastructure, and quality service through appropriate standardization certification and regulation. It's categorized homestay into two categories i.e. silver and gold, which are based on availability of facilities and infrastructure in homestays. The Department of Tourism associated with the Department of Agriculture of West Bengal encourages indigenous communities to adopt organic farming. Tourists can learn the practices of organic farming procedures from homestay owners and enjoy rural nature.

Opportunities

Rural tourism is focused on rural areas for sustainable rural development (Das, 2021). It has brought many opportunities in rural areas like employment, business, entrepreneurship, women empowerment, and infrastructural development (Wilson et. al, 2014). It also helps to boost self-confidence, leadership role, and various skills in local people.

Employment

In this region, rural tourism has been giving work opportunities to the local people (Bhutia, 2014). Their main economy is depending on Agriculture (Census, 2011). After agriculture, tourism is another main economic source for local people.

Rural tourism is creating an alternative income and employment opportunity for young and old people as well as women in this area. In this region, most of the people are directly and indirectly connected with the tourism industry. At present, the district has many registered and un-register homestays. The total number of registered homestays is 1009. Officially, this 1009 household is working under rural tourism. In rural homestays, women are the main worker, and other family members are also involved in the work. Most of the rural tourism destinations are not accessible by public transport, only private cars as an option. A large portion of local people associated with transportation business. From 2022 to 2023, 60% of Homestays have increased. So, it is also increased employment opportunities. In the study area, floriculture is one of the important components of the development of tourism and employment opportunities for local people (Sharma & Mondal, 2020).

Business Opportunities

Tourism gives new business opportunities in any region. In Kalimpong district, rural tourism boosts the local economy and much more in the peak season of tourism during Mid- February to June and October to Mid-December. People engaged in different types of works, because of the diversification of nature. The people are working as tour guides, car drivers, homestay owners, and cooks, and helping hand in the homestay, entrepreneurs, and handicraft makers. Some people are working as restaurant workers, sellers of local food vendors, etc (Bhutia, 2014; Das, 2021). It can be observed that employment and business opportunities have been increased in the study area.

Entrepreneurship

In rural tourism, rural homestay is an integral part. It is playing a vital role in the development of rural tourism in Kalimpong district. According to Association for Conservation & Tourism (NGO) (2023), North Bengal has a total of 3000 homestays. Kalimpong District has a one-third portion of it. It is observed, that from 2022 to 2023, entrepreneurship has increased. Male entrepreneurship increased by 44.59% and female 15.55%.

Leadership Roles

Local leadership is a success factor in rural tourism development (Wilson, 2005). Leadership should be strong, committed, and effective in destinations across all levels like governments, business persons, and communities so that these

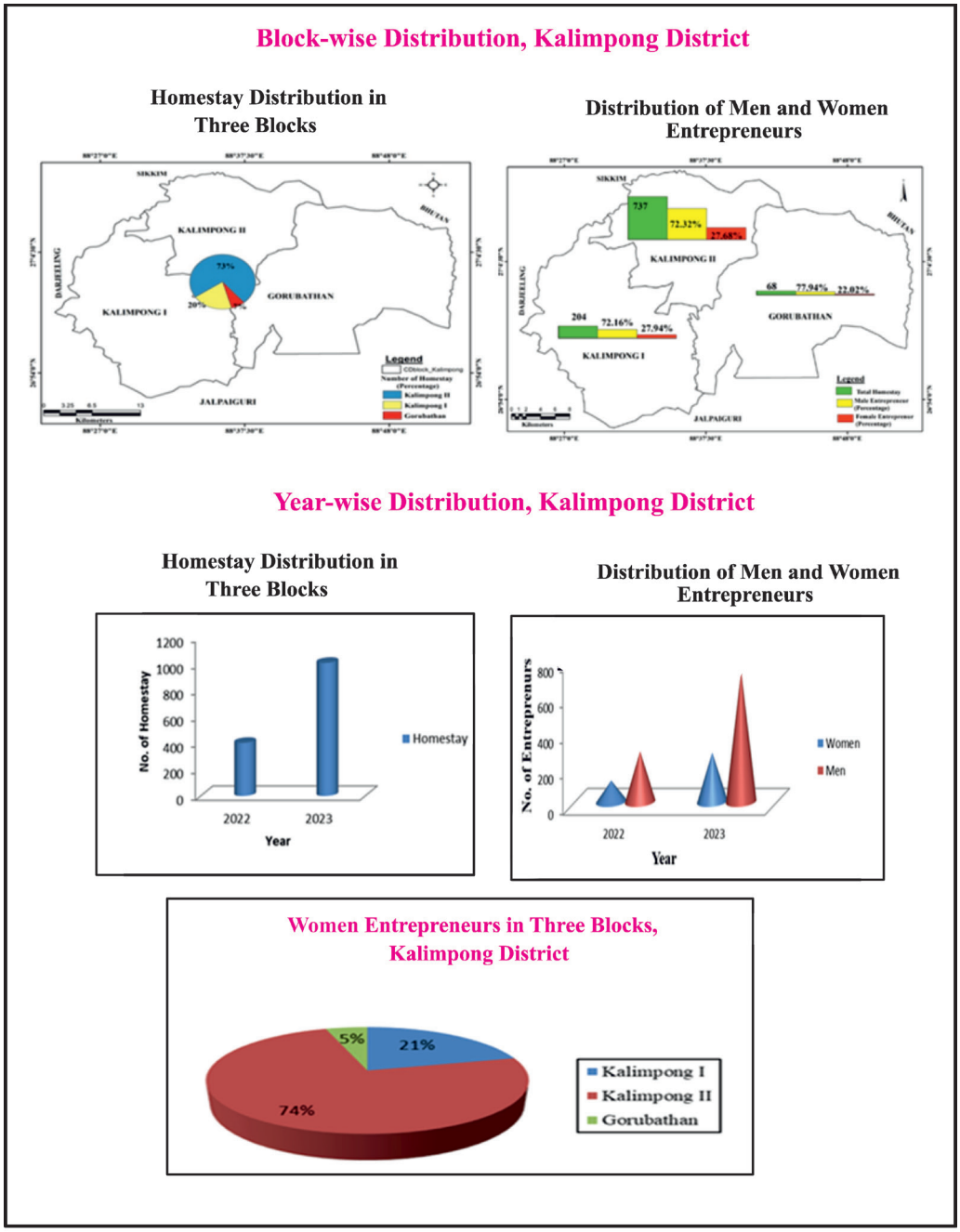

Block-wise Distribution, Kalimpong District
Homestay Distribution in Three Blocks
Distribution of Men and Women Entrepreneurs
SIKKIM
BHUTAN
KALIMPONG II
KALIMPONG I
GORUBATHAN
JALPAIGURI
DARJEELING
Legend
737
72.32%
27.68%
68
77.94%
22.02%
204
72.16%
27.94%
Year-wise Distribution, Kalimpong District
Homestay Distribution in Three Blocks
No. of Homestay
Year
2022
2023
Homestay
Distribution of Men and Women Entrepreneurs
No. of Entreprenurs
Women
Men
Women Entrepreneurs in Three Blocks, Kalimpong District
21%
5%
74%
Kalimpong I
Kalimpong II
Gorubathan

Fig. 4

stakeholders play a proactive role in rural tourism (Dwyer and Edwards, 2010). Destination leadership must include long-term strategic planning, that helps the destination to achieve its potential development (Haven-tang & Jones, 2012, Pp-30). Leadership encourages innovative development of the rural destination, which is creating more sustainable rural tourism with its society, economy, and environment (Mitchell and Hall, 2005; Haven-tang & Jones, 2012). In Kalimpong, rural tourism allows for increasing leadership quality for local people. It also gives support to get social, cultural, and environmental benefits to local businesses. Homestay owners, tourist guides, and small businesses like vendors, food sellers, and those connected with the rural tourism industry in Kalimpong, are gaining self-confidence, and economic independence. West Bengal Government and Various organizations are helping them through skill training to shape their life and build leadership qualities.

Infrastructure Development

Rural tourism gives a new shape of rural areas. Central Government and State Government are trying to rejuvenate the rural areas through better roads, communication, sanitation, electricity, and drinking water. Drinking water has supplying through 'Har Ghar Jol' project. National Highway 717A is under construction, which connects Kalimpong to Sikkim. It helps rural areas of Kalimpong to join the national highway grid.

Weakness

There is no doubt Kalimpong is a famous tourist destination and has potential to develop niche types of tourism. For some factors, it is lag behind in other parts of India. Kalimpong is connected mainly by roads to other districts and states. Most of the beautiful rural tourism destination is located in inaccessible areas. Village roads are in bad conditions like Ramdhura to Icche gaon, Algarah to Rishop, Lave to Kolakham, Simanadara, and a majority of Lingsey, Lingsekha, Kagey, and Gitdabling gram panchayat has no accessible road by Jeep in Kalimpong II block, Chuikhim, Yelbong part of Kalimpong I block and some parts of Gorubathan block, etc. Most of the destinations are accessible by Jeep. Its price is too high and tourists can't afford sometimes. Infrastructure is also not good enough like some destinations have no geyser option in homestay. There are some issues in water supply and communication. Mobile Network is not getting everywhere. For drinking water and domestic work, they are dependent on local Jhoras, Neora sources, Dhaula and Relli rivers, water reservoir. One of the biggest problems is that these tourist destinations are not suitable for all weather. Here tourism is a seasonal cycle i.e. Mid-February

to June and October to Mid-December. Kalimpong comes under seismic zone IV and landslip frequently occurs during monsoon season. Marketing strategies are not well maintained. There is also no option for online booking and online payment and have not any specific web portal. It cannot be reached by others states of India. Most tourists come from various districts of West Bengal, the neighboring state of Bihar Jharkhand, etc, and Bangladesh. Tourists are getting information about destinations from social media like Facebook, YouTube blogs, and family and friend circles. Hosts (local people) and guests (tourists) do have not much knowledge about rural tourism. Local people do have not proper training and skills, knowledge of rules and guidelines, and proper management of rural tourism.

Threats

Kalimpong district has a small area. Due to the improvement in tourism and floriculture, Kalimpong has witnessed urbanization (Subba, 2020). Growth of urbanization, there is a raising problem of traffic congestion. The reasons of traffic congestion are massive congestion of tourists, carrying capacity of roads and numbers of vehicles. It happened due to the pressure of the huge number of tourists at seasonal times in Kalimpong. It is noticed that the unplanned growth of homestays and tourist spots is increasing without proper planning and management. It has an impact on land cover and changing land use pattern of Kalimpong. Due to overcrowding by tourists, places are facing environmental problems like noise pollution, solid waste management, water crisis, etc. Tourists are coming from urban areas and stay with local people. It gives negative impacts on rural youth and changes their traditional lifestyle.

Conclusion

Rural tourism is a new phenomenon in Kalimpong. It reshapes rural areas and enhances the quality of life of local people as well. Kalimpong has many strengths of rural tourism. This gives many opportunities to local people i.e. employment, various business opportunities and economic independence. Here, women are actively participating in rural tourism through homestay. This leads them towards empowerment. With the help of these strengths and opportunities, weaknesses and threats should be overcome. It should be the collective effort of Government, local people as well tourists help to develop sustainable rural tourism. Local people and tourists must be aware of the rural tourism concept and its consequences. So that, through rural tourism creates a positive impact on socio, economic and environmental upliftment of the local communities in Kalimpong.

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Analysis of Rainfall Characteristics and Ground Water Recharge in Hundri River Basin of Kurnool District, Andhra Pradesh

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Abstract

The aim of the study is to examine the Rainfall characteristics, rainfall recharge, and water balance of the Hundri River basin. The basin is situated in a semi-arid climate with low precipitation and high evaporation rates. The primary geological formations in the basin are Granite and Gneisses, which constitute a hard rock terrain with varying degrees of permeability contingent on fracturing and weathering. Over a span of 30 years, monthly precipitation data from 19 stations have been collected, converted, and tabulated to derive seasonal and annual rainfall figures. The mean annual rainfall is distributed as follows: winter (5 mm), summer (68 mm), South-west monsoon (414 mm), North-east monsoon (130 mm), and annual (617 mm). The analysis of seasonal rainfall reveals that the basin experiences the highest precipitation during the south-west monsoon season. The total surface water resources available in the basin are estimated to be 2,189,116,000 m^3. Groundwater recharge through rainfall was estimated using eight different empirical equations proposed by Radhakrishna, U. S. Geological Survey method, Chaturvedi, U.P. Irrigation Research Institute, Bhattacharjee, Amritsar Formula, Kumar and Seethapathi, and Krishna Rao formula. The recharge percentages calculated using these empirical equations were found to be 10, 15, 20, 29, 18, 20, 14, and 8, respectively. The mean annual recharge for the basin is calculated to be 103 mm. Furthermore, the total groundwater resources are estimated to be 365,444,000 m^3, which accounts for approximately 17% of the annual rainfall.

***Key words*:** Mean rainfall, Rainfall variability, Rainfall ratio, Rainfall recharge, Water balance

Rainfall is a critical ecological parameter that has significant impacts on the ecosphere, ecological community, and economic development of any region. In India, a country with a strong agricultural sector, rainfall plays a pivotal role in shaping various aspects of agriculture, including land cover patterns, intensity of land use, farming operations, farming systems, and farm productivity levels [1]. The agricultural sector, which includes horticulture, animal husbandry, dairy, and fisheries, heavily relies on the monsoon rains, which are essential for crop growth and production. However, the distribution of rainfall across the country is irregular and unequal, leading to dry spells during the rainy season, resulting in crop failures and low yields in some areas.

Understanding the rainfall patterns, including total rainfall, daily, monthly, seasonal, and annual distribution, is vital for effective crop and water management planning. It helps in designing irrigation, drainage, erosion control, and flood control structures. Furthermore, the analysis of monthly, seasonal, and annual rainfall patterns is essential for ensuring a continuous water supply for domestic and industrial uses [2]. Therefore, it is crucial to monitor and analyze rainfall patterns to ensure sustainable agricultural practices and water management in India. Policy decisions regarding cropping patterns, sowing dates, and the provision of drinking water in both urban and rural areas are facilitated through the examination of rainfall data [3]. Furthermore, such analyses contribute to the comprehension of micro-level rainfall variability, which is of utmost importance for the planning of agriculture, land, and water resource development [4]. The evaluation of surface and subsurface water resources plays a crucial role in addressing future hydro-meteorological disasters and guaranteeing sufficient water availability for agricultural, irrigation, industrial, and domestic purposes. A normal distribution of rainfall is indispensable for the maintenance of favourable vegetation cover, the promotion of ecosystem health, the facilitation of groundwater recharge, and the assurance of robust crop production and food security.

The analysis of rainfall and studies on groundwater recharge are of utmost importance in comprehending the hydrological dynamics of the Hundri River basin, particularly within a semi-arid climate characterized by restricted water resources [5]. Through an examination of historical rainfall patterns spanning a duration of 30 years, and the subsequent classification of these patterns into distinct seasons, researchers can acquire invaluable insights into the temporal dispersion of precipitation. This enables them to identify the prevailing monsoon season (South-west monsoon) as well as the comparatively drier periods (winter and summer). Such information holds significant significance for the effective management of water resources, the formulation of agricultural

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plans, and the mitigation of potential water scarcity concerns within the region.

The assessment of the overall water balance of a basin is a crucial aspect of groundwater recharge estimation through rainfall. To accurately calculate recharge percentages, researchers utilize various empirical equations proposed by experts, which consider geological characteristics, soil type, and vegetation cover. This analysis aids in determining the replenishment rate of groundwater aquifers, which are vital for sustaining domestic water supply, supporting agricultural activities, and preserving the ecological balance of the region.

MATERIALS AND METHODS

Study area

The Hundri River, a tributary of the Tungabhadra River, originates in the fields of Maddikera in Maddikera Mandal (Fig 1). It receives a stream from Erramalas at Laddagiri in Kodumur Mandal and eventually joins the Tungabhadra River at Kurnool town. The river covers parts of 13 Survey of India Topsheets on a scale of 1:50,000. It drains a significant portion of the Maddikera, Pattikonda, Deverakonda, Gonegandla, Kodumur, and Kallur Mandals. The river falls within the survey of India (SOI) top sheet numbers 57E/6 to 57E/16 and 57I/1 to 57I/3. The river basin is in the southwestern part of the Kurnool district, lying between Northern latitude 140 35' 35" N-160 09' 36" N and longitude 750 58' 42" E to 780 56' 06" E. It covers an area of 3548 square kilometers and spreads across parts of 20 mandals, encompassing 205 revenue villages.

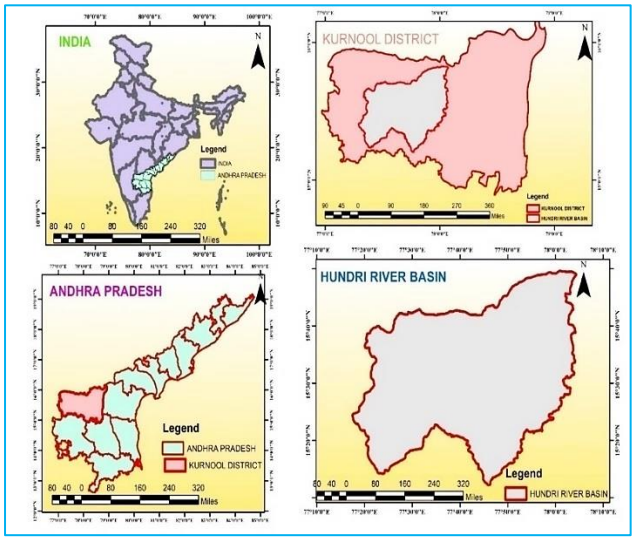


Fig 1 Location map of the study area

The investigation of the surface water resources within the Hundri River basin was conducted through an examination of the precipitation data obtained from 19 rain gauge stations. The monthly precipitation data spanning a duration of 30 years was procured from the Chief Planning Office of Kurnool district for these stations. To assess the precipitation data in terms of seasonal and annual patterns, the statistical methodologies outlined by Bhargava (1977) were employed. The average monthly precipitation, variability in precipitation, and precipitation ratio for each of the 19 stations were computed and organized in tabular form.

1). Mean rainfall = $\frac{\sum X}{N}$, Where X= variates and N = No. of. Varieties

2). Rainfall Variability = $\frac{SD}{AM} \times 100$, Where S.D =Standard deviation, AM =Arithmetic mean

3). Rain fall Ratio = $\frac{P_x P_n}{P_m} \times 100$,Where P_X = Maximum rainfall, P_N =Minimum rainfall

P_M and P_M =Average rainfall

In order to estimate groundwater recharge, a range of empirical methods proposed by Radhakrishna *et al*. [6], the U. S. Geological Survey method (1962), Chaturvedhi (1936), the Amritsar formula (1973), the U.P. Irrigation Research Institute Formula (1954), Krishna Rao (1970), Bhattacharjee (1954), and Kumar and Seethapathi (2002) were employed. The groundwater recharge was determined using each of these methods. Through the implementation of this comprehensive study, valuable insights into the surface water resources and groundwater recharge within the Handri River basin were acquired. These findings will contribute to enhanced water resource management, planning, and decision-making, thereby facilitating the sustainable utilization of water in the region.

Estimation of ground water recharge by using empirical formulas

4) Radhakrishna *et al*. (1974): 10% of the Annual Rainfall

5). U.S. Geological Survey method (1962): 15 % of the annual Rainfall

6). Chaturvedi formula (1936): R_g= 2(P-15) ^0.4

Where Rg is net Recharge and P is annual rainfall, both are measured in Inches

7). Amritsar Formula (1973): Rg= 2.5(P-16) ^0.5

Where R_g is net Recharge and P is annual rainfall, both are measured in Inches

8). U.P.I.R.I. Formula (1954): R_g= 1.35(P-14) ^0.5

Where R_g is net Recharge and P is annual rainfall, both are measured in Inches

9). Bhattacharjee Formula (1954): Rg =3.47(P-38) ^0.4

Where Rg is net Recharge and P is annual rainfall, both are measured in cm

10). Kumar and Seethapathi Formula (2002): Rg =0.63(P-15.28) ^0.76

Where R_g is net Recharge and P is annual rainfall, both are measured in inches

11). Krishna Rao Formula (1970): Rr = K (P-X)

Where R_r and P are measured in mm.

R_r =0.20(P-400) Where annual rainfall between 400- 600 mm

R_r =0.25(P-400) Where annual rainfall between 600- 1000 mm

R_r =0.35(P-600) Where annual rainfall greater than 2000 mm

RESULTS AND DISCUSSION

Seasonal analysis of rainfall of the handri river basin

Winter season

During the winter season, which comprises the months of January and February, the mean rainfall in the study area varies from a minimum of 3 mm at the Krishnagiri station to a maximum of 10 mm at the Asparistation (Table 1). The average rainfall for the entire basin is recorded as 5 mm (Table 1) indicating dry and arid conditions during this period. The Rainfall Variability analysis reveals fluctuations ranging from 155% at the Gudur station to 297% at the Kallur station with an average variability of 220 %. It suggesting significant Fluctuations in the amount of rainfall received during this period. Furthermore, the Rainfall Ratio, a measure of rainfall distribution, shows diverse patterns across the study area. It ranges from 521% at the Gudur station to 1561% at the Yemmiganur station, with average of rainfall ratio of 943%, it signifying substantial variations relative to the mean rainfall, which can have implications for water availability and agricultural planning [7-9].

Summer season

The summer season consists of March, April, and May Months. The values range from a minimum of 60 mm (Tuggali) to a maximum of 76 mm (Pattikonda) (Table 2). The overall average mean rainfall for all stations is approximately 68.5 mm (Table 2). which can be considered a relatively dry period Rainfall variability is a measure of how much the actual rainfall deviates from the mean rainfall. Higher variability indicates more significant fluctuations in rainfall amounts. The values range from a minimum of 47% (Alur) to a maximum of 87% (Bethamcherla). The overall average rainfall variability for all station is around 65.2%, indicating fluctuations in the amount of rainfall received this period. The Rainfall Ratio values ranges from minimum of 184% (Alur) to a maximum of 387% (Bethamcherla). The overall average rainfall ratio for all stations is approximately 264% reflecting considerable variations relative to the mean, which can have implications for water availability and agriculture [10-11].

Table 1 Mean rainfall, rainfall variability and rain fall ratio of the Handri River basin (Winter season)

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	5	223	1094
Alur	5	260	1390
Aspari	10	185	733
Bethamcherla	4	252	1086
Devanakonda	5	211	856
Dhone	3	197	771
Gonegandla	6	178	703
Gudur	5	155	521
Kallur	4	297	1542
Kodumur	6	230	933
Krishnagiri	3	196	815
Kurnool	5	178	718
Maddikera	6	190	700
Orvakal	5	275	1394
Pattikonda	4	220	916
Peapully	6	209	647
Tuggali	4	199	611
Veldurthi	3	232	931
Yemmiganur	6	294	1561

Table 2 Mean rainfall, rainfall variability and rain fall ratio of the Handri River

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	71	59	270
Alur	74	47	184
Aspari	65	53	211
Bethamcherla	67	87	387
Devanakonda	61	65	310
Dhone	67	71	311
Gonegandla	75	66	261
Gudur	68	66	283
Kallur	72	78	254
Kodumur	70	63	242
Krishnagiri	68	84	285
Kurnool	72	65	246
Maddikera	65	51	195
Orvakal	67	74	301
Pattikonda	76	61	251
Peapully	68	58	205
Tuggali	60	54	243
Veldurthi	67	77	316
Yemmiganur	69	62	252

South west monsoon

During the South West Monsoon season, which includes the months of June, July, August, and September, the mean rainfall in the basin varies between 318 mm at Maddikera station and 496 mm at Kurnool station (Table 3). The normal rainfall for the basin during this period is 414 mm (Table 3), Indicating the wettest season in the basin. The rainfall variability ranges from a minimum of 26% in Adoni to a maximum of 50% in Dhone station, with an average variability of 40% for the basin, indicating relatively stable and predictable rainfall patterns during this season. The rainfall ratio, of the basin varies from 110% at Adoni station to 257% at Dhone station, with an average rainfall ratio of 179% for the basin, indicating a relatively balanced distribution of rainfall compared to the mean, which can be favourable for agricultural activates [12].

Table 3 Mean rainfall, rainfall variability and rain fall ratio of the Hadri River basin (South west monsoon)

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	460	26	110
Alur	385	38	150
Aspari	388	35	136
Bethamcherla	411	45	202
Devanakonda	400	43	180
Dhone	405	50	257
Gonegandla	412	38	171
Gudur	469	39	195
Kallur	433	43	211
Kodumur	417	43	177
Krishnagiri	358	36	151
Kurnool	496	37	202
Maddikera	318	39	174
Orvakal	476	39	187
Pattikonda	400	43	173
Peapully	424	38	157
Tuggali	387	43	184
Veldurthi	392	35	162
Yemmiganur	439	45	228

Table 4 Mean rainfall, rainfall variability and rain fall ratio of the Handri River basin (North east monsoon)

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	131	79	401
Alur	142	76	350
Aspari	122	66	220
Bethamcherla	151	58	240
Devanakonda	120	69	244
Dhone	121	67	245
Gonegandla	133	80	410
Gudur	130	76	291
Kallur	126	79	268
Kodumur	113	69	295
Krishnagiri	124	69	284
Kurnool	129	76	261
Maddikera	127	56	249
Orvakal	134	70	270
Pattikonda	135	68	255
Peapully	143	56	216
Tuggali	118	62	231
Veldurthi	129	63	208
Yemmiganur	138	89	397

North east monsoon

During the North East Monsoon season, which covers the months of October, November, and December, the mean rainfall in the basin varies from a minimum of 113 mm at Kodumur station to a maximum of 151 mm at Bethamcherla (Table 4). The average rainfall for the entire basin during this period is 130 mm (Table 4), Making it moderately wet season. Rainfall Variability across the study area shows diversity, ranging from a minimum of 56% at Peapully station to a maximum of 89% at Yemmiganur station, with an average variability of 70%, suggesting fluctuations in rainfall amount during this period. The rainfall ratio in the basin has a wide range, with a minimum of 208% at Veldurthi station to a maximum of 410% at Gonegandla station. The normal rainfall ratio is recorded as 281%, Indicating significant variations relative to the mean, which may impact water resources and local ecosystem.

The basin experiences diverse rainfall patterns across the four seasons, with varying mean rainfall, rainfall variability, and rainfall ratio. Understanding these seasonal characteristics is crucial for water resource management, agricultural planning, and climate adaptation strategies in the region [13-15].

Annual rainfall

The annual rainfall in the basin shows significant variation, ranging from a minimum of 515 mm at Maddikera station to a maximum of 702 mm at Kurnool station (Table 5). The average annual rainfall for the entire basin is calculated to be 702 mm. Regarding rainfall variability, it varies across the stations, with Adoni station experiencing the lowest variability at 25%, and Dhone station witnessing the highest variability at 39%. On average, the rainfall variability for the basin is around 33 %. The rainfall ratio also displays diversity, ranging from 103% at Krishnagiri station to 186% at Yemmiganur station. The normal rainfall ratio is recorded as 140% [16].

Table 5 Mean rainfall, rainfall variability and rain fall ratio of the Handri River basin (Annual)

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	665	25	117
Alur	606	34	150
Aspari	585	29	112
Bethamcherla	632	38	172
Devanakonda	586	36	156
Dhone	597	39	178
Gonegandla	627	31	128
Gudur	673	30	125
Kallur	635	38	175
Kodumur	605	32	128
Krishnagiri	552	28	103
Kurnool	702	31	148
Maddikera	515	32	108
Orvakal	683	33	146
Pattikonda	615	35	115
Peapully	641	32	132
Tuggali	569	38	155
Veldurthi	590	29	118
Yemmiganur	652	37	186

The basin experiences varying amounts of annual rainfall, with some stations receiving higher rainfall (e.g., Kurnool) and others have relatively lower rainfall (e.g., Maddikera). The variability in rainfall amounts differs across the basin, with some stations showing more stable patterns (e.g., Adoni), while others exhibit higher fluctuations (e.g., Dhone). The Rainfall Ratio provides insight into how the mean rainfall relates to the rainfall variability at each station, indicating variations in the basin's overall rainfall patterns.

The Total Surface Water resources the Handri River basin: Total Geographical area of the basin × Mean annual rain fall 3548 Km^2 × 617 mm = 218, 911, 6000 m^3.

Ground water recharge

Radha Krishna method (1974)

The Radhakrishna approach (1974) proposes that the basin's aquifer recharge is equivalent to 10% of the total annual precipitation. The recharge rates fluctuate, with the lowest value being 51 mm at Maddikera station and the highest being 70 mm at Kurnool station (Table 6). The mean yearly groundwater recharge for the entire basin is estimated to be 62 mm.

U.S. Geological method (1962)

According to this According to the methodology proposed by the U.S. Geological Survey in 1962, the groundwater replenishment in the studied area, basin, or watershed corresponds to 15% of the total annual precipitation. According to this method, the recharge figures vary, with a minimum of 77 mm observed at Maddikera and a maximum of 105 mm recorded at Kurnool station (Table 6). On average, the annual replenishment of groundwater for the entire study area is assessed to be 93 mm.

Chaturvedi formula (1936)

Chaturvedi's formula (1936) derives the groundwater replenishment using the expression Rg = 2(P-15) ^0.4, with Rg and P expressed in inches. According to this method, the recharge amounts fluctuate, ranging from a minimum of 99 mm at Maddikera to a maximum of 140 mm in Kurnool District (Table 6). The average yearly recharge for the basin is determined to be 123 mm, constituting 20% of the overall annual precipitation.

Amritsar formula (1973)

Amritsar's method (1936) proposes the calculation of groundwater recharge using the formula Rg = 2.5(P-16) ^0.5, with Rg and P measured in inches. According to this approach, the recharge values exhibit variability, ranging from a minimum of 131 mm at Maddikera to a maximum of 217 mm in Kurnool District (Table 6). On average, the basin experiences an annual recharge of 182 mm, which constitutes 29% of the total annual rainfall.

U.P.I.R.I. formula (1954)

U.P.I.R.I has developed a method for estimating groundwater recharge using the formula Rg = 1.35(P-14) ^0.5, where Rg and P are measured in inches. According to this approach, the recharge values exhibit variation, ranging from a minimum of 86 mm at Maddikera to a maximum of 127 mm in Kurnool District (Table 6). On average, the basin experiences an annual recharge of 110 mm, which corresponds to 18% of the total annual rainfall.

Bhattacharjee formula (1954)

Bhattacharjee's approach has derived a means to estimate groundwater replenishment utilizing the equation Rg = 3.47(P-38) ^0.4, where Rg and P are expressed in centimeters. According to this method, the recharge quantities exhibit variability, spanning from a minimum of 98 mm at Maddikera to a maximum of 139 mm in Kurnool District (Table 6). The mean yearly recharge for the basin is determined to be 123 mm, corresponding to 20% of the entire annual precipitation.

Kumar and Seethapathi (2002)

Kumar and Seethapathi have formulated a method to calculate groundwater recharge using the equation Rg = 0.63(P-15.28) ^0.76, where Rg and P are measured in inches. According to this approach, the recharge values show variation, ranging from a minimum of 54 mm at Maddikera to a maximum of 108 mm in Kurnool District (Table 6). On average, the basin experiences an annual recharge of 123 mm, which constitutes 20% of the total annual rainfall.

Krishna Rao formula (1970)

In1970, Krishna Rao introduced an empirical relationship for approximating ground water replenishment, given by Rr = K(P-X), where Rr and P are measured in millimeters. According to Krishna Rao method.

For Regions with annual rainfall ranging from 400 to 600 mm, the recharge can be approximated using Rr =0.20(P-400)

For Regions with annual rainfall ranging from 400 to 600 mm, the recharge can be approximated using Rr =0.25(P-400)

For Regions with annual rainfall Exceeding 2000 mm, the recharge can be approximated using from 400 to 600 mm, Rr =0.35(P-600)

Based on this approach, the recharge values range from a minimum of 23 mm at Maddikera station to a maximum of 75 mm at Kurnool station (Table 6). On average, the basin experiences an annual recharge of 51 mm, which represents 8 % of the total annual rainfall.

Table 6 Average annual recharge of the Handri River basin

Mandal	Rainfall (mm)	Radhakrishna method (mm)	U.S. Geological method (mm)	Chaturvedi's formula (1936) (mm)	Amritsar's formula (1973) (mm)	U.P.I.R.I. formula (1954) (mm)	Bhattacharjee formula (1954) (mm)	Kumar and Seethapathi formula (2002) (mm)	Radha Krishna method (1970) (mm)	Recharge (mm)	Recharge (%)
Adoni	665	60.55	99.82	133.52	202.80	119.77	132.60	98.45	66.37	114.98	17.28
Alur	606	60.56	90.85	121.48	177.84	107.58	120.70	81.85	51.41	101.53	16.76
Aspari	585	58.45	87.68	116.79	168.16	102.95	116.05	75.74	36.91	95.34	16.31
Bethamcherla	632	63.19	94.79	126.98	189.21	113.10	126.13	89.26	57.98	107.58	17.02
Devanakonda	586	58.61	87.92	117.15	168.91	103.30	116.41	76.21	37.23	95.72	16.33
Dhone	597	59.67	89.50	119.53	173.81	105.64	118.76	79.28	39.34	98.19	16.46
Gonegandla	627	62.69	94.04	125.97	187.11	112.07	125.13	87.87	56.73	106.45	16.98
Gudur	673	67.32	100.98	134.95	205.79	121.25	134.02	100.52	68.29	116.64	17.33
Kallur	635	63.47	95.20	127.54	190.36	113.66	126.68	90.02	58.67	108.20	17.05
Kodumur	605	60.47	90.70	121.28	177.42	107.38	120.49	81.57	51.17	101.31	16.75
Krishnagiri	552	55.19	82.78	108.89	151.95	95.31	108.24	65.96	30.37	87.34	15.83
Kurnool	702	70.18	105.27	140.10	216.55	126.60	139.11	108.10	75.45	122.67	17.48
Maddikera	515	51.49	77.24	98.79	131.27	85.89	98.26	54.32	22.99	77.53	15.06
Orvakal	683	68.30	102.45	136.75	209.55	123.11	135.80	103.15	70.75	118.73	17.38
Pattikonda	615	61.54	92.31	123.56	182.14	109.66	122.75	84.62	53.84	103.80	16.87
Peapully	641	64.09	96.13	128.78	192.93	114.92	127.91	91.74	60.22	109.59	17.10
Tuggali	569	56.93	85.39	113.20	160.79	99.45	112.50	71.22	33.85	91.67	16.10
Veldurthi	590	59.04	88.57	118.13	170.92	104.26	117.37	77.46	38.09	96.73	16.38
Yemmiganur	652	65.18	97.77	130.91	197.37	117.09	130.02	94.73	62.94	112.00	17.18

The average annual recharge of the basin has been calculated by taking the average of eight different methods, resulting in a range of values from 78 mm to 123 mm. The overall average recharge for the entire basin is 103 mm. This average recharge accounts for 17% of the annual rainfall in the region. The recharge values vary across different stations in the basin. Maddikera and Krishnagiri stations have the lowest recharge values, being less than 90 mm. Apari, Devanakonda, Dhone, Tuggali, and Veldurthi stations experience recharge between 90 mm and 100 mm. On the other hand, Adoni, Alur, Bethamcherla, Orvakal, Pattikonda, Peapully, and Yemmiganur stations have the highest recharge values exceeding 100 mm.The total Ground water Potential of the basin is worked out by ground water recharge method.

Total water resources recharge to ground water = Geographical area of the basin × Average annual recharge
3548 Km^2 × 103 mm = 365,444,000 m^3

The total Ground water resources accounts to 16.7% of the total surface water resources.

Water balance of the Handri River basin

1). The total surface water resources = Geographical area of the basin × Average annual rain fall 3548 Km^2 × 617 m = 2189116000 m^3.

2). Total water resources Recharge to Ground water=Geographical area of the Basin × Average AnnualRecharge 3548 Km^2 × 103 m =365444000 m^3. (16.7%)

3). Total Water resources stored in Reservoirs, Ponds, lakes etc = 2189711600 m^3 (10%).

4). Total water resources lost in the form of run-off = 437823200 m^3. (20 %)

5). Water lost in the form of Evaporation and Evapotranspiration 2189116000 – 1022178800 = 1166937200 (53.3%)

From the above analysis it is found that out of 218911600 m^3 of water available 10% is stored in the ponds and tanks and reservoirs if the basin, 16.7% recharge to ground water, 20 %is lost in the form of run-off and 53.3% is lost in the form of evaporation and evapo-transpiration. The surface water loss in the form of run-off could be saved and stored efficiently by constructing check dams and percolation ponds in the basin [17-18].

CONCLUSION

In summary, the research reveals distinct seasonal rainfall patterns with significant fluctuations in the study area. Winter and summer experience dry conditions, impacting water resources and agriculture. The South West Monsoon brings the

wettest period with stable rainfall patterns, while the North East Monsoon is moderately wet with variable rainfall. The annual rainfall shows notable variation, affecting water availability and agricultural planning. The study analyzed multiple methods to estimate groundwater recharge, showing diverse values across different stations. The overall average annual recharge for the basin was 103 mm, accounting for 17% of the total annual rainfall. Understanding these variations is essential for effective water resource management and sustainable agricultural planning.

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Editor's Desk

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Finally, a blanket 'thank you' for all the contributors who chose our journal based on its quality and urge them to keep contributing and spread the news among institutions, researchers, professors and fellow colleagues. I do convey my heartiest congratulations to our Hon'ble Peer Reviewers, Copy Editors, Composer and the Website Manager for their sincerest efforts without which this issue could not be published on time.

I do hope this endeavor by the Indian Society of Spatial Scientists will continue to keep its tradition, style and objectives.

This particular issue is a tribute to our Late President, Prof. Avijit Gupta. An obituary has been added to make our readers, members and others informed about his contribution in the field of fluvial geomorphology, geomorphology of humid tropics, environmental management, and application of remote sensing in the study of geomorphology and environmental management.

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Groundwater Quality Assessment using Water Quality Index (WQI) in Tungabhadra River Basin of Kurnool District, Andhra Pradesh, India

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Abstract

Water is precious in the areas like drought-prone due to inadequate rainfall and surface water. The available drinking water sources are prone to pollution and contamination and content of high percentage of fluoride etc. In a region like Rayalaseema of Andhra Pradesh, which is prone to drought and identified as one of the country's driest regions. In these circumstances, potable water is essential to assess the water quality for Drinking. Groundwater is the rural population's main drinking source in the proposed study area. Therefore assessment of water quality is essential and has far the most important. The present paper is intended to assess the water quality in the Tungabhadra River Basin of Kurnool district to determine the suitability of available Groundwater for drinking purposes. In this connection, the water quality index(WQI) has been applied to determine the different physico-chemical parameters of the Groundwater at various locations in both pre and post-monsoon seasons for 2021. The distribution of water quality parameters across the basin is evaluated by the IDW interpolation method in GIS. The water quality index was calculated from the observed parameters indicating both pre-monsoon (79.68) and post-monsoon (86.82) seasons as poor water quality.

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Introduction

Water safety and security is an emerging issue worldwide which has compound effects on various sectors of the economy. The basin area lies in the semiarid region of Rayalaseema region. The basin faced a severe crisis in managing water resources to meet all requirements, viz., drinking, households use, irrigation and industrial development. In general, surface water is scant in the semiarid regions owing to the inconsistency of monsoon rainfall and high rate of evaporation. Hence, people in such areas must depend more on groundwater resources for life support. The Tungabhadra and its tributary Hundri in Kurnool district are the major sources for increasing groundwater potential. Groundwater makes up most of the drinking water source of the basin area.

Over the years, groundwater has been contaminated, and the quality of the basin area has deteriorated. A common source of contamination of groundwater in the basin area is open defecation, inadequate sanitation facilities, especially in rural areas. Discharge of untreated sewage (Reddy, 2014, Prabavathi, 2015), municipal sewage, chemicals and waste materials (Rajeswari, 2009), construction material and cement manufacturing activities (Tharani, 2021), runoff and seepage of residues of chemical fertilizers and pesticides (Rayudu, 2020) industrial effluents and various malpractices related to waste disposals. The contamination of groundwater can have adverse effects on human health. There is a prime necessity to control water contamination and deterioration substances in the ecology and ecosystem of the Tungabhadra river basin.

Water quality Assessment is an important measure to the health of a basin to make necessary management and decision to control current and future pollution of receiving water bodies. Water quality is inherently linked with public health, food security, livelihoods and preservation of ecosystem and ecology, and socioeconomic growth of our societies (UNESCO, 2015). It is very much needed for policymakers, administrators, and water

quality management; if the quality has deteriorated, remedial measures are to restore it. To assess water quality, the values obtained were compared with standards prescribed by the Bureau of Indian standards (BIS) and the Indian council for medical research (ICMR).

The water quality index (WQI) Is a mathematical instrument which provides a single number that expresses overall quality at certain locations and times based on several water quality parameters (Hulye (2009), Pathak et al., 2015). Therefore, the study's objective was to calculate the water quality index of the Thungabhadra river basin to assess its suitability for Drinking. A similar type of study has been done in India by Chatterjee et al. (2007), Miraj et al. (2017), Jagadeeswari (2012), and Das Guptha (2001).

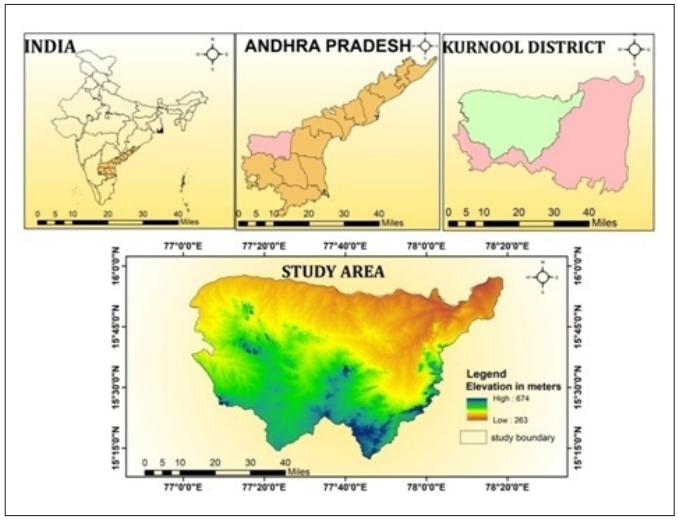


Fig.1: Location Map of the Study Area

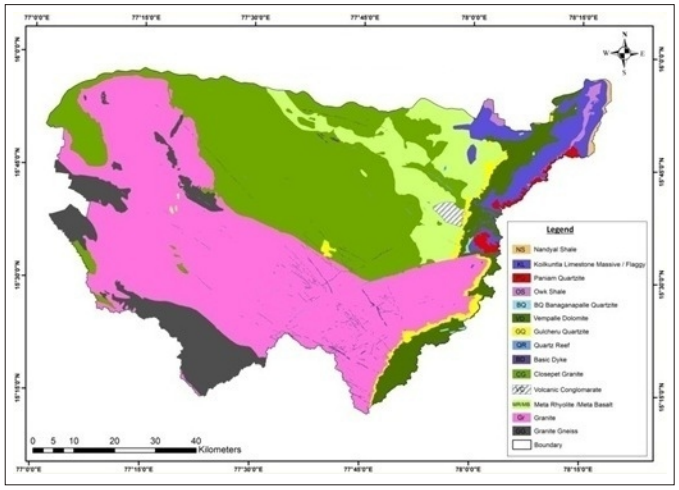


Fig.2: Geological Map of the Study Area

The Study Area

The study area of the Tungabhadra River basin is situated in the northwestern part of the Kurnool district in the state of Andhra Pradesh (India) and occupies an area of 6,993.95 sq. km. It is the southwestern district of Andhra Pradesh, and is one of the country's frequently drought-affected districts, Mainly in the western part of the district, with an average annual rainfall of about 670 mm. The main occupation and source of livelihood for this basin is agriculture. More than 70 % of the people in the basin are engaged in farming. It is predominantly an area of rain-fed agriculture. The climate of Kurnool is tropical, with temperatures ranging from 26^0 c to 46^0 c in the summer and 12^0 c to 31^0 c in the winter. Due to continuous drought, Agriculture is not the main source of income for the last decade. It lies Between North Latitude 15^0 15'00" to 16^0 0'00" and East longitude 77^0 0'00" to 78^0 15'00". It is falling in the survey of India (SOI) Toposheet No 57E/ 1 to 57E/16 and 57I/1 to 57 I/5. Geologically the basin is underlined by the crystalline rock of the peninsular gneissic complex(PGC), comprising the granitic gneisses, and granites in the west and southern part of the basin. The K-rich granite (equivalent to close pet granite) of the lower Proterozoic age, distributed in the northern part of the basin. Conglomerates, quartzite, shale, limestone, and dolomite were found as small patches in the northeastern part of the basin. The basic dykes and quartz veins are noticed in the west and southern part of the basin.

Objectives of the Study

1) To evaluate the groundwater quality in the Tungabadra river basin for drinking purposes by using the water quality index.
2) To explore physico-chemical parameters of groundwater at different locations in the study area.

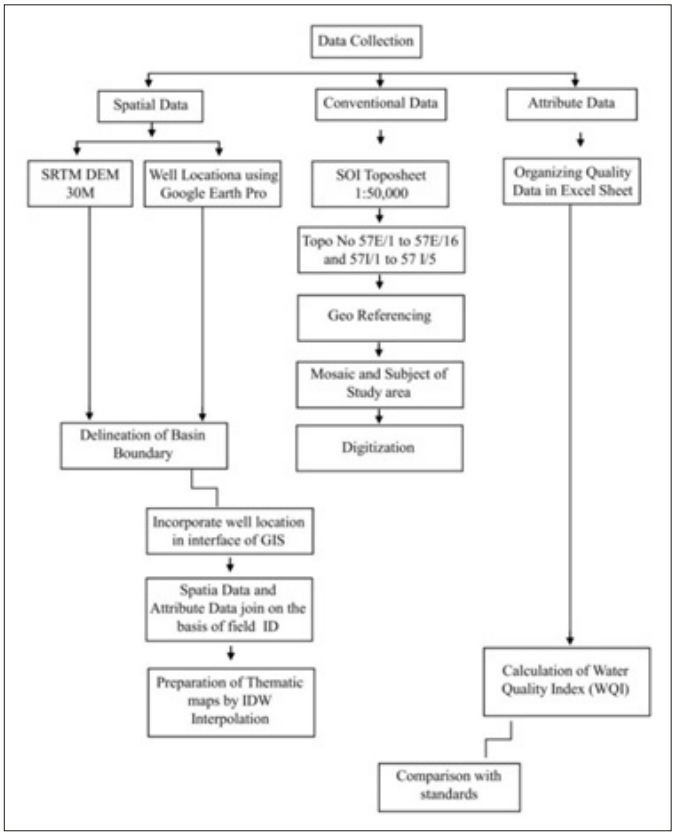


Fig.3: Methodology adopted in the present study

Methodology

The Methodology adopted for the current study is shown in Fig 2. To delineate Basin Boundary, we have used SRTM DEM 30 M Resolution, downloaded from https://earthexplorer.usgs.gov/ and Survey of India (SOI) Topographic maps of 1972 with No 57E/ 1 to 57E/16 and 57I/1 to 57I/5on the Scale 1:50000 were collected from https://www.surveyofindia.gov.in/. Downloaded SRTM DEM data were processed by using the Hydrology tool, and

topographical maps were rectified/referenced and mosaic with the help of Arc GIS 10.3 Software and the extracted basin assigning Universal Transverse Mercator (UTM), world Geodetic system (WGS from 1984) and 44 N zone projection system. The well locations at which quality data are collected from the District Water board are from Google Earth Pro. The well locations in terms of Latitudes and longitudes are written down in a notepad and then converted to a point shape file in GIS Interface. Attribute data corresponding to water quality parameters for the pre-monsoon and post-monsoon of 2021 is properly organized and organized in an Excel sheet. Spatial and attribute data are joined together based on field I.D. using the join and relate tool in Arc GIS. The Water Quality index for the current study is based on eight parameters. The calculation of the WQI was done using the Weighted Arithmetic water quality index, originally proposed by Horton (1965) and Developed by Brown et al. (1972). The first step in the calculation is to rate the quality of each parameter. Let q_n be the quality rating of each parameter where n is the no. of each parameter. It is given by Eq.1

$$q_n = 100 (V_n - V_o) / (S_n - V_o) \ldots\ldots\ldots (1)$$

Where
Q_n =Quality rating for the nth water quality parameter, V_n= Estimated value of the n^{th} parameter at the given sampling station, V_o= Ideal value of n^{th} parameter in pure water, S_n = Standard permissible weight of the nth parameter.

Computation of Quality Rating for pH

For pH, the ideal value is 7.0 (for natural water), and the permissible value is 8.5

Therefore, the quality rating for pH is calculated with the help of the following equation:

$$q_n = 100 (V_{pH} - 7.0) / (8.5 - 7.0) \ldots\ldots (2)$$

Where, V_{pH} = observed value of pH

Each parameter is given a unit weight for water quality index calculation by the Bureau of Indian Standards (BIS) And the Indian Council for Medical Research (ICMR). The standard permissible values according to IS 10500 and unit weights for each parameter are given in table 1.

Computation of Unit Weight

Unit weight has been calculated by a value inversely proportional to the recommended standard values Sn of the corresponding parameters.

$$W_n = k/S_n \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where, Wn = Unit weight of the nth parameter, Sn = Standard value of the nth parameter, K = Constant for proportionality

The overall quality index (WQI) has been calculated by linearly aggregating the quality rating with the unit weight.

$$WQI = \sum Wn*q_n / \sum Wn \ldots\ldots\ldots\ldots (4)$$

Where, WQI = water quality index, W_n = unit weight of the n^{th} parameters q_n =quality rating of the n^{th} parameter.

Results and Discussion

To assess the water quality for drinking purposes, concentration of physico-chemical parameters presents 62 samples have been analyzed for pre and post-monsoon seasons in 2021. The seasonal analysis helps to assess the changes in the concentration of minerals during dry and wet periods due to the fluctuations in the groundwater table, amount of runoff water, duration of contact period with rock strata of the aquifer etc.

Table-3 and Table-4 provide all information about the physico-chemical parameters of the samples. Table-5 shows the descriptive statistics (maximum, minimum, and average) of the physic-chemical parameters of the groundwater samples.

The distribution of water quality parameters across the basin has been mapped by the IDW interpolation for each parameter class. Fig.3 and 4 show the spatial pattern of pH, TDS, SO_4^{2-}, No_3^-, Cl^- ,Ca^{2+},Mg^{2+} and TH in the pre-monsoon period and Fig.5 and 6 show the spatial pattern of pH, TDS, So_4^{2-}, No_3^-, Cl^-, Ca^{2+}, Mg^{2+} and TH in the post- monsoon season.

a. pH

pH is one of the significant parameters of water and decides the Acidic and basic form of water. According to BIS and ICMR, the pH of Good Quality of Water ranges from 6.5-8.5. In the pre-monsoon season, the pH of the study area groundwater sample ranges from 7.1(min) to 8.5 (max) with a mean value of 7.9, and in the post-monsoon, the importance of p^H varies from 7.2 (min) to 8.5(max) with a mean value of 8 respectively. The pH variation shown in Fig. 3-A and 5-A depicts that all the groundwater samples in the pre and post-monsoon seasons were within the permissible limits.

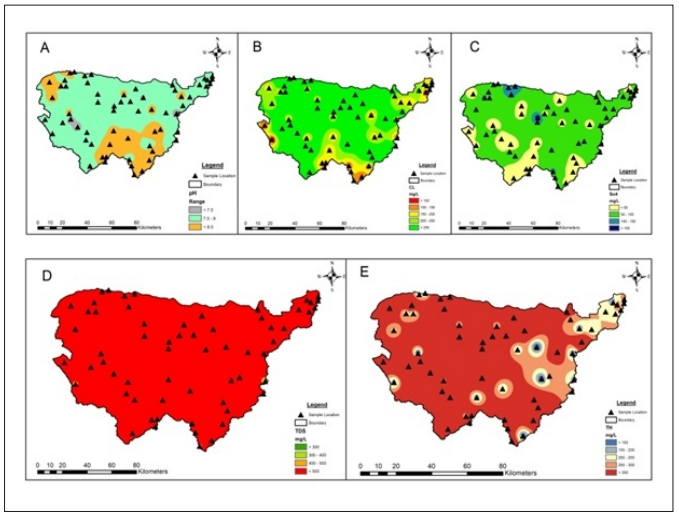


Fig.4: The spatial distribution of pH, Cl^-, So_4^{2-}TDS, and T.H. during the pre-monsoon period

b. Total Dissolved Solids(TDS)

The total dissolved solids in the basin vary from 291.84 mg/l to a maximum of 3962 mg/l with a mean value of 1246.11. The post-monsoon season TDS value ranges from 231.04mg/l to 6304 mg/l with a mean value of 1338.62 mg/l (Table - 5).out of 62 samples, 8 per cent of samples in premonsoon season and in post-monsoon season, 13 per cent of samples were found to have TDS values below the acceptable limits (Fig. 3-D, and Fig. 5-D). In contrast, the rest of the samples had higher values of TDS.

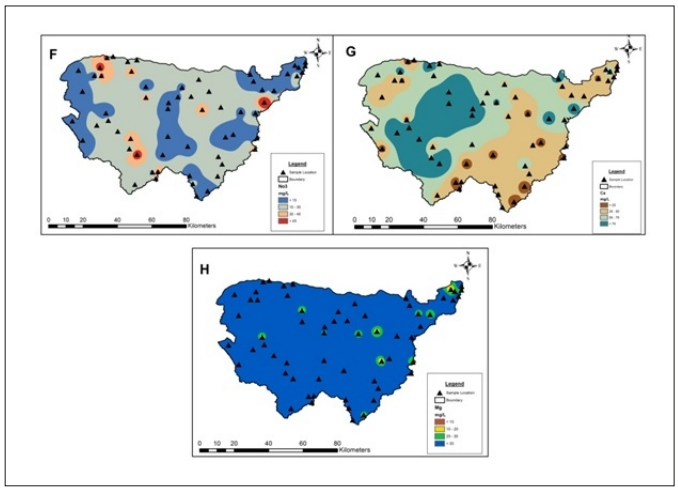


Fig.5: The spatial distribution of No_3^-, Ca^{2+}, and Mg^{2+} during the pre-monsoon period

c. Sulphates

The sulphate distribution in groundwater samples of the basin ranged from 4 to 199 mg/l. The mean value of 65 mg/l indicates that most of the wells in the study area are within the acceptable limit (Table - 5). Percentage-wise, 95 % of the sample in the pre-monsoon season had So_4^{2-} within the acceptable limits (Fig 3-C). In the post-monsoon season, So_4^{2-} ranged from 10 to 210 mg/l with a mean value of 103 mg/l (Table 5). From Fig (5-C) can be said that 72% of the area has sulphate content within the permissible limits.

d. Nitrates

In this present study area, No_3^- ranged from 1 to 83 mg/l, for which the mean value of 19 mg/l during the pre-monsoon season and in post-monsoon season No_3^- varied from 1.5 to 87.3 mg/l with the mean value of 31.16 mg/l respectively(Table-5). The spatial distribution maps(Fig. 4-F and Fig. 6-F) show that 90% of samples in pre-monsoon season and 85 % in post-monsoon season No_3^- were within the acceptable limits per BIS Standards.

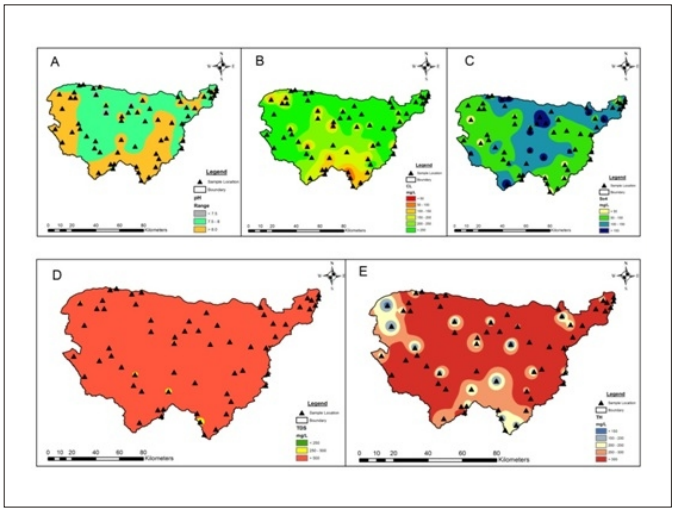


Fig.6:The spatial distribution of pH, Cl^-, So_4^{2-}TDS, and T.H. during the post-monsoon period

e. Chlorides

The chloride in the groundwater samples in the basin varies from 54 to 850 mg/l during the premonsoon season, with a mean value of 273 mg/l (Table-5). Fig 3-B shows that 56% of the area chloride concentration samples were within the permissible limits. For the post-monsoon season, Cl^- concentration ranged from 40 to 930 mg/l, with the mean value at 275 mg/l (Table-5). Fig 5-B shows that 66% of the area has chloride concentration within the permissible limits.

f. Calcium

In the current study area, the Concentration of Ca^{2+} in groundwater samples varied from 8 to 248 mg/l with a mean value of 56 mg/l, whereas, in the post-monsoon Concentration of Ca^{2+} groundwater samples, it ranged from 16 mg/l to 192 mg/l with a mean value of 57 mg/l respectively (Table-5). Figures 4-G & 6-G show that 77 % of groundwater samples in pre-monsoon season and 75 % of post-monsoon samples have Ca^{2+} content within permissible limits per the BIS and ICMR standards.

g. Magnesium

Mg^{2+} Concentration ranged between a minimum of 5 mg/l to a maximum of 97 mg/l during the pre-monsoon period resulting in a mean value of 51 mg/l (Table 5). From Fig 4-H, 21 % of the groundwater samples were found within the permissible limits in pre-monsoon. The remaining samples (79%) have more concentration than the allowable limits. For the post- Monsoon period, Mg^{2+} Concentration varies from 10 to 146 mg/l with a mean value of 50 mg/l. Fig 6-H represents that 37 % of the groundwater samples were within permissible limits. At the same time, the rest of the samples had higher values than BIS standards.

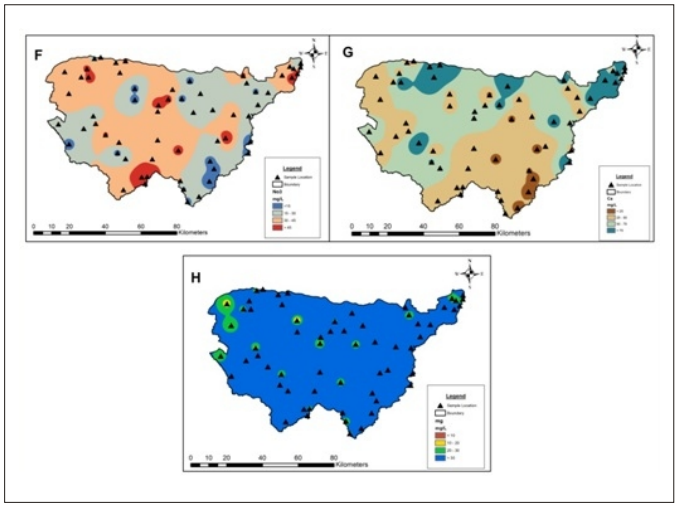


Fig.7: The spatial distribution of No_3^-, Ca^{2+}, and Mg^{2+} during the post-monsoon period

h. Total Hardness(TH)

As per the BIS and ICMR standards, acceptable limits of T.H. in natural water are usually less than 300 mg/l, while water with more than 300 mg/l is unsuitable for Drinking. In premonsoon, the Total Hardness of the Groundwater sample in this basin ranged from 82 mg/l to 978 mg/l with a mean value of 348 mg/l and in post-monsoon season, T.H. varied from 102 mg/l to 899 mg/l with a mean value of 350 mg /l respectively (Table -5). Fig 3-E represents 51 % of samples in the premonsoon season, and Fig 5-E represents 54 % of groundwater samples in the post-monsoon season within the permissible limits.

Water Quality Index

A Water quality index (WQI) summarises a large amount of data into simple terms (excellent, good, poor, very poor, unfit for drinking, irrigation etc.) For reporting to policymakers, administrators, and users consistently. The groundwater quality of the present study area, the Tungabhadra River basin of Kurnool district, Andhra Pradesh, is calculated using different physico chemical parameters such as pH, total dissolved solids, sulphates, nitrate, chlorides, calcium, magnesium and total hardness. The data collected regarding physico-chemical parameters is during pre-monsoon and post-monsoons of 2021.

The physico-chemical properties of groundwater of the Tungabhadra River Basin have been computed for pre-monsoon, and post-monsoon period (Table - 6 and Table - 7). It is followed by the computation of the water quality index (WQI), as follows:

$$WQI = \sum w_n * q_n / \sum w_n$$
$$= 86.82$$

Pre and post-monsoon water quality index values are compared with Chatterjee and Raziuddin, 2002 (Table - 2). we conclude that the water of the Tungabhadra river basin is of very poor quality for drinking purposes and must therefore be treated before use to avoid water-related diseases.

Conclusion

The results obtained from Physico chemical parameters were analyzed to calculate the water quality index during the pre and post-monsoon period (2021). The water quality index values of the Tungabadra river basin can be concluded that water is not fit for drinking purposes. Therefore, an urgent effort should be taken to monitor. Indigenous technologies should be adopted to make them suitable for drinking after treatment (filtration, disinfection etc.) by using remote sensing and GIS technologies to identify and mapping of potential groundwater zones and construction of rainwater harvesting structures such as percolation tanks, recharge pits etc. for suitability of quality of Groundwater.

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Table – 1: Drinking Water Standards and Unit Weights

Sl. No	Parameters	Standards	Recommended Agency	Unit Weight
1	pH	6.5 - 8.5	ICMR/ BIS	0.2190
2	TDS	500 in mg/L	ICMR/ BIS	0.0037
3	Sulphate	150 in mg/L	ICMR/ BIS	0.0124
4	Nitrate	45 in mg/L	ICMR/ BIS	0.0413
5	Chloride	250 in mg/L	ICMR	0.0074
6	Calcium	75 in mg/L	ICMR/ BIS	0.0250
7	Magnesium	30 in mg/L	ICMR/ BIS	0.0620
8	Total Hardness	300 in mg/L	ICMR/ BIS	0.0062

Table – 2: Water Quality Index Standards (after Chatterjee and Raziuddin, 2002)

Sl. No	Parameters
0 - 25	Excellent
26 - 50	Good
51 - 75	Poor
76 - 100	Very poor
>100	Unsuitable for Dirking

Table - 3: Results of Laboratory Investigation (all values except pH and EC are in mg/L)
Pre - Monsoon (2021)

S.No	Mandal	Village	Latitude	Longitude	pH	TDS	SO_4^{2-}	No_3^-	Cl^-	Ca^{2+}	Mg^{2+}	TH
1	Adoni	Peddaharivanam	15.620712	77.090981	7.9	598.4	29	3	90	48	44	301
2	Adoni	Baichigerri	15.623373	77.278075	7.1	2451.2	59	21	540	200	52	714
3	Adoni	Kallubavi	15.604135	77.264472	7.5	2809.6	68	23	623	120	96	695
4	Adoni	Virupapuramu	15.567078	77.328135	7.2	2752	38	19	564	184	75	769
5	Adoni	Adoni	15.631882	77.275883	8.3	742.4	17	1	100	8	15	82
6	Aspari	Aspari	15.475671	77.388425	8	549.7	52	18	361	72	39	340
7	Aspari	Haligera	15.529282	77.3956	8	618.24	31	43	100	24	53	278
8	Bethamcherlla	Cement nagar	15.502514	78.206479	7.9	291.84	76	1	90	40	19	178
9	Bethamcherlla	Bethamcherlla	15.457589	78.151844	7.8	1235.2	63	39	390	16	57	275
10	C.Bellagal	Polakal	15.837671	77.75093	7.5	1510.4	11	20	400	48	62	375
11	C.Bellagal	Kothakota	15.288435	77.767297	8.3	1696	87	13	390	48	34	260
12	Devanakonda	Eduladevarabanda	15.344261	77.812426	8.1	736	30	1	140	56	92	519
13	Dhone	Dhone	15.396043	77.873241	8.4	1907.2	30	23	480	24	82	397
14	Dhone	Kothaburuju	15.324588	77.690832	7.9	615.04	120	9	110	32	58	319
15	Dhone	Malkapuram	15.40214	77.866862	7.7	1228.8	44	18	450	72	74	485
16	Dhone	Kothacheruvu	15.392616	77.862485	8.1	542.72	5	18	100	16	87	398
17	Gonegandla	B.Agraharamu	15.704912	77.595085	7.9	596.48	98	2	130	80	24	299
18	Gonegandla	Gonegandla	15.716249	77.593462	7.8	998.4	199	9	350	120	49	502
19	Gonegandla	H.Kairavada	15.711762	77.632499	7.4	1824	22	13	540	72	53	398
20	Guduru	Guduru	15.77486	77.804787	7.4	2892.8	82	18	520	40	97	499
21	Holagunda	Yellarthi	15.478299	77.124786	7.8	424.32		48	5	60	16	34	180
22	J.Banglow	Pothalapadu	15.867418	78.388355	7.9	869.12		176	1	200	32	44	261
23	Kalluru	Chinnatekuru	15.668367	77.97101	7.8	1256.32		33	13	420	104	51	470
24	Kodumuru	Kodumuru	15.686007	77.770956	8.2	482.56		51	27	100	16	15	102
25	Kodumuru	Pulakurthy	15.748453	77.710971	7.5	2118.4		48	32	580	80	58	439

26	kosigi	Vandagallu	15.857754	77.206024	8.1	442.24	120	6	70	32	34	220
27	kosigi	kosigi	15.856266	77.243149	7.9	1168	64	59	330	104	87	618
28	kosigi	Satanuru	15.857069	77.242216	7.8	2752	74	49	780	16	39	200
29	Kowthalamu	Erigeri	15.774899	77.143827	8.1	718.72	98	2	200	24	44	241
30	Krishnagiri	Lakkasagaramu	15.488707	77.693695	8.3	1273.6	106	12	360	16	39	200
31	Kurnool	Panchalingala	15.864032	78.019876	7.8	1189.76	77	13	380	104	34	400
32	Kurnool	Gargeyapuram	15.779621	78.144329	7.7	750.08	96	10	160	40	24	199
33	Kurnool	Kurnool	15.828126	78.037279	7.8	903.68	77	9.5	210	32	44	261
34	Maddikera	Maddikera	15.938688	77.427974	7.4	1212.8	39	24	380	48	78	441
35	Mantralayamu	Malapalli	15.938688	77.427974	7.7	1117.44	136	21	300	64	92	539
36	Mantralayamu	Suguru	15.940625	77.424316	7.4	3962	112	39	136	48	51	330
37	Mantralayamu	Thungabadra	14.991309	76.888626	7.8	721.92	49	7	130	24	34	200
38	Mantralayamu	Chetnihalli	15.935758	77.418762	8.1	1937.92	157	23	850	120	83	642
39	Nandavaram	Mugathi	15.800127	77.474499	7.8	552.32	11	3	160	72	15	242
40	Nandikotkur	Nandikotkur	15.855593	78.264589	7.9	3917	65	33	54	42	32	237
41	Nandikotkur	Alluru	15.86651	78.2151	7.7	1026.56	74	9	280	16	49	242
42	Nandikotkur	Buujinivemula	15.899278	78.272531	7.9	542.08	4	36	170	40	5	121
43	Nandikotkur	Madigatla	15.900147	78.273167	8	787.84	16	3	270	104	24	359
44	Orvakallu	Nannuru	15.718402	78.093717	7.7	1484.8	61	83	270	104	68	540
45	Pagidiyala	Pagidiyala	15.93548	78.340129	7.6	521.6	103	9	120	32	53	298
46	Pagidiyala	Eastpratakota	15.917306	78.36423	7.8	619.52	50	7	130	16	19	118
47	Pathikonda	Devanbanda	15.446352	77.428601	7.8	1625.6	61	61	440	192	71	772
48	Pathikonda	Pandikona	15.444923	77.562548	8.2	688	42	5.5	130	8	34	160
49	Peapully	Kalichetla	15.261195	77.697813	8.1	669.44	75	17	150	24	82	397
50	Peapully	Racherrla	15.230753	77.740059	8.2	613.12	30	9	90	16	19	118
51	Peapully	Yegnaramapuramu	15.23076	77.739871	8.1	467.2	101	5	110	32	73	380
52	Thugalli	Pendekal	15.86728	77.26925	8.3	758.4	10	9	140	8	58	259
53	Thugalli	Pagidirayi	15.275885	77.590597	8.4	782.72	44	32	110	16	78	361
54	Thugalli	Thugalli	15.31422	77.544029	8.2	635.52	29	51	140	32	82	417
55	Veldurthhy	Veldurthhy	15.550873	77.931028	8	1062.4	90	3	250	16	55	266
56	Yemmiganuru	Gudikallu	15.743274	77.475216	7.5	1843.2	25	36	610	248	87	978
57	kosigi	Halvi	15.884432	77.122629	8.1	738.56	20	2	150	56	73	440
58	Mantralayamu	Narayanapuram	15.950965	77.271869	8.5	1218	96	52	300	8	44	201
59	Kodumuru	Kodumuru	15.686007	77.770956	7.6	3795	39	42	240	46	22	206
60	Veldurthy	Cherukulapadu	15.537138	77.891032	8.5	711.04	85	4	120	24	10	101
61	Kurnool	Sudireddipalli	15.7838	78.082665	8.4	780.8	95	6	150	24	24	159
62	Orvakallu	Orvakallu	15.684056	78.177819	7.1	1521	52	12	242	51	39	158

Table – 4: Results of Laboratory Investigation (all values except pH and EC are in mg/L)
Post-Monsoon (2021)

Mandal	Village	Latitude	Longitude	pH	T D S	SO_4^{2-}	No_3^-	Cl^-	Ca^{2+}	Mg^{2+}	TH
Adoni	Peddaharivanam	15.620712	77.090981	8.2	5452.8	97	25.5	310	64	19	238
Adoni	Baichigerri	15.623373	77.278075	8	1491.2	65	31	240	40	49	302
Adoni	Kallubavi	15.604135	77.264472	8.1	2886.4	17	19.7	850	40	97	499
Adoni	Virupapuramu	15.567078	77.328135	7.9	6304	156	47.4	230	155	90	758
Adoni	Adoni	15.631882	77.275883	8	807.68	53	23.2	110	24	15	122
Aspari	Aspari	15.475671	77.388425	7.4	1312	47	8.49	330	80	49	402
Aspari	Haligera	15.529282	77.3956	7.9	231.04	67	39	50	24	19	138
Bethamcherlla	Cement nagar	15.502514	78.206479	8.1	591.36	74	1.5	80	40	29	219
Bethamcherlla	Bethamcherlla	15.457589	78.151844	7.4	1574.4	82	10	370	140	68	630
C.Bellagal	Polakal	15.837671	77.75093	8.1	2822.4	151	11	760	176	87	798
C.Bellagal	Kothakota	15.288435	77.767297	7.3	666.24	196	44	130	16	24	139
Devanakonda	Eduladevarabanda	15.344261	77.812426	8.1	1051.52	167	31.1	240	40	73	400
Dhone	Dhone	15.396043	77.873241	8.4	1676.8	115	10.6	350	16	107	480
Dhone	Kothaburuju	15.324588	77.690832	8.5	569.6	34	31.3	40	48	39	280
Dhone	Malkapuram	15.40214	77.866862	8.1	648.32	14	9.6	90	24	53	278
Dhone	Kothacheruvu	15.392616	77.862485	8.1	668.8	36	3.75	120	16	53	258
Gonegandla	B.Agraharamu	15.704912	77.595085	8	423.68	193	27.7	40	56	15	202
Gonegandla	Gonegandla	15.716249	77.593462	8.3	678.4	79	67.1	160	56	29	259
Gonegandla	H.Kairavada	15.711762	77.632499	7.5	1817.6	167	52	500	48	92	499
Guduru	Guduru	15.77486	77.804787	8	2636.8	80	14.6	600	24	53	278
Holagunda	Yellarthi	15.478299	77.124786	8.5	1201.28	158	9.3	340	40	73	400
J.Banglow	Pothalapadu	15.867418	78.388355	8.2	769.92	199	86	240	40	34	240

Kalluru	Chinnatekuru	15.668367	77.97101	8.3	1964.8	63	42	570	96	121	738
Kodumuru	Kodumuru	15.686007	77.770956	8.2	1187.84	51	27.3	190	48	82	457
Kodumuru	Pulakurthy	15.748453	77.710971	8.2	2585.6	206	6.56	640	96	146	841
kosigi	Vandagallu	15.857754	77.206024	8	543.36	38	29	70	40	24	199
kosigi	kosigi	15.856266	77.243149	8	648.32	84	49.1	100	40	53	318
kosigi	Satanuru	15.857069	77.242216	8.2	3206.4	102	57.7	210	120	42	473
Kowthalamu	Erigeri	15.774899	77.143827	8.3	2604.8	26	39	850	24	19	138
Krishnagiri	Lakkasagaramu	15.488707	77.693695	7.8	1054.72	182	51.5	150	16	24	139
Kurnool	Panchalingala	15.864032	78.019876	7.6	1817.6	138	48.8	450	96	44	421
Kurnool	Gargeyapuram	15.779621	78.144329	8.2	1760	188	22.9	420	104	63	519
Kurnool	Kurnool	15.828126	78.037279	8.3	1251.2	190	19.9	250	24	19	138
Maddikera	Maddikera	15.938688	77.427974	8.5	643.2	190	34.6	190	40	39	260
Mantralayamu	Malapalli	15.938688	77.427974	8.2	1843.2	183	46.2	450	120	97	699
Mantralayamu	Suguru	15.940625	77.424316	7.2	3001.6	119	34.4	930	192	102	900
Mantralayamu	Thungabadra	14.991309	76.888626	7.4	1262.08	56	42	290	32	63	339
Mantralayamu	Chetnihalli	15.935758	77.418762	7.9	2291.2	210	43.3	560	80	102	620
Nandavaram	Mugathi	15.800127	77.474499	8.1	439.04	37	10	70	40	10	141
Nandikotkur	Nandikotkur	15.855593	78.264589	7.6	1251.84	126	53	340	96	63	499
Nandikotkur	Alluru	15.86651	78.2151	8.1	1278.08	148	42.7	270	96	44	421
Nandikotkur	Buujinivemula	15.899278	78.272531	7.7	804.48	10	29.6	180	32	24	179
Nandikotkur	Madigatla	15.900147	78.273167	8.4	1229.44	19	26.5	400	184	15	522
Orvakallu	Nannuru	15.718402	78.093717	7.4	597.12	153	23.5	190	32	53	298
Pagidiyala	Pagidiyala	15.93548	78.340129	7.5	727.04	168	12.9	260	104	58	499
Pagidiyala	Eastpratakota	15.917306	78.36423	8.1	735.36	138	13.5	160	40	15	162
Pathikonda	Devanbanda	15.446352	77.428601	8	557.44	109	23.1	230	56	63	399
Pathikonda	Pandikona	15.444923	77.562548	8	381.44	123	43.5	90	24	34	200
Peapully	Kalichetla	15.261195	77.697813	8	340.48	53	13	50	24	24	159
Peapully	Racherrla	15.230753	77.740059	8	570.88	87	22	90	16	34	180
Peapully	Yegnaramapuramu	15.23076	77.739871	8.3	829.44	22	11.4	110	40	29	219
Thugalli	Pendekal	15.86728	77.26925	8.2	1078.4	34	66	140	48	44	301
Thugalli	Pagidirayi	15.275885	77.590597	8	517.12	150	87.3	90	32	24	179
Thugalli	Thugalli	15.31422	77.544029	7.9	825.6	64	44.2	150	40	63	359
Veldurthhy	Veldurthhy	15.550873	77.931028	8	1536	53	72.1	460	24	112	521
Yemmiganuru	Gudikallu	15.743274	77.475216	7.2	718.08	59	7.7	170	40	49	302
kosigi	Halvi	15.884432	77.122629	8	441.6	88	34	80	24	15	122
Mantralayamu	Narayanapuram	15.950965	77.271869	8	845.44	147	23	220	48	19	198
Kodumuru	Kodumuru	15.686007	77.770956	7.5	482.56	51	27.3	100	16	15	102
Veldurthy	Cherukulapadu	15.537138	77.891032	8.4	458.88	175	20.7	100	16	29	159
Kurnool	Sudireddipalli	15.7838	78.082665	8	679.04	51	11.2	190	32	29	199
Orvakallu	Orvakallu	15.684056	78.177819	7.5	1721.6	70	15.6	390	64	44	341

Table -5: Descriptive Statistics of Physico-chemical Parameters of Ground Water
(Pre - and Post - Monsoon Seasons, 2021)

Sl. No.	Parameter	Pre - Monsoon			Post - Monsoon			BIS and ICMR Limits	Samples Exceeding BIS and ICMR	
		Min	Max	AVG	MIin	Max	AVG		Pre Monsoon	Post Monsoon
1	pH	7.1	8.5	7.9	7.2	8.5	8	6.5-8.5	____	____
2	T D S	291.8	3962	1246.11	231.04	6304	1338.62	500	57	54
3	SO_4^{2-}	4	199	65	10	210	103	150	3	18
4	No_3^-	1	83	19	1.5	87.3	31.16	45	6	10
5	Cl^-	54	850	273	40	930	275	250	26	24
6	Ca^{2+}	8	248	56	16	192	57	75	12	16
7	Mg^{2+}	5	97	51	10	146	50	30	48	39
8	TH	82	978	348	102	899.75	350	300	31	31

Table – 6: Computation of Water Quality Index Calculation for Pre-Monsoon Season, 2021

Parameter	Average of the Observed Parameter	Unit Weight (W)	Quality Rating (q)	W*q
PH	7.88	0.2190	59.00	12.92
TDS	1246.11	0.0037	249.22	0.92
SO4	64.52	0.0124	43.01	0.53
NO3	19.26	0.0413	42.80	1.77
CL	273.23	0.0074	109.29	0.81
CA	55.92	0.0250	74.56	1.86
MG	51.02	0.0620	170.05	10.54
TH	347.68	0.0062	115.89	0.72
		Total = 0.3770		Total = 30.08
WQI = 30.08 / 0.3770 = 79.78				

Table – 7: Computation of Water Quality Index Calculation for Post-Monsoon Season, 2021

Parameter	Average of the Observed Parameter	Unit Weight (W)	Quality Rating (q)	W*q
PH	7.97	0.2190	64.84	14.20
TDS	1338.62	0.0037	267.72	0.99
SO4	103.35	0.0124	68.9	0.85
NO3	31.16	0.0413	69.24	2.86
CL	274.68	0.0074	109.87	0.81
CA	57.15	0.0250	76.19	1.90
MG	52.26	0.0620	167.53	10.39
TH	350	0.0062	116.56	0.72
		Total = 0.3770		Total = 32.73
WQI = 32.73/ 0.3770 = 86.82				



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(e) …… (Sarkar, et al., 2012)

Books:
[1] Sarkar, A (2008): Practical Geography -a systematic approach, Orient BlackSwan, Kolkata.

Chapters in Books:
[2] Sarkar, A (2012): Disaster Management with special reference to Flood in West Bengal - issues, policy and plan framework, in Desai, M and Halder, S (ed): *Coping with Disasters: Mitigation Strategy, Preventive Action and Recovery,* Abhijeet Publications, New Delhi, pp86 -105.

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Articles in Journals:

[3] Sarkar, A (2011): Urbanization and City Size Distribution of West Bengal, India 1901 2001, *Journal of Regional Science*, Kolkata, 43 (1), pp9 -16.
[4] Patel, P. P and Sarkar, A (2010): Terrain Characterization using SRTM Data, *Journal of the Indian Society of Remote Sensing* 38 (1), March 2010, pp11- 24.

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Land use and Land cover analysis of Tungabhadra River Basin, Kurnool District of Andhra Pradesh using remote sensing and GIS

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Abstract

The present study aims to determine the land use/land cover features of the Tungabhadra River basin of Kurnool District, Andhra Pradesh, for 2023 using remote sensing and GIS Technologies. The study used the Survey of India topographic maps 57E/1 to 57E/16 and 57I/1 to 57I/5 and the remote sensing data of LISS III, 2023 processing in Arc GIS 10.3 and ERDAS software. Understanding existing land use and land cover in a region is crucial for maximizing land efficiency. It allows informed decision-making in urban planning, agriculture, conservation, and resource management. Accurate knowledge empowers stakeholders to optimize land utilization for sustainable development. The analysis reveals that the study area contains components such as Agricultural land, Built-up areas, Forests, Wasteland, Water bodies, and Transportation. Most of the study area is occupied by agricultural land 77.03%, followed by Wastelands 10.68%, Forest land 4.58%, Water bodies 3.90%, Built-up land 3.53%, and Transportation 0.28%.

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Introduction

Land is one of nature's most valuable gifts, and humans perform different activities on it. Sustainable utilization of available land resources determines a region's socio-economic and cultural progress. Land cover refers to the surface cover on the ground, which includes weather, vegetation, urban infrastructure, water rocks, bare soil, or other elements used for identifying, delineating, and mapping purposes. Land use refers to man's activities and the various uses that are carried out on land. Land use involves the manipulation of land's biophysical attributes and the intended purpose for its use.

Understanding the current land use and cover is crucial due to significant environmental challenges such as habitat loss, biodiversity decline, and climate change. The rapid changes caused by urbanization, agriculture, and deforestation put ecosystems and natural resources at risk. Analyzing land use patterns helps inform sustainable development strategies, conservation efforts, and policy interventions to secure a more resilient future. The scope of this analysis ranges from local to global scales, and it involves monitoring changes, assessing impacts, and identifying vulnerable areas. Doing so makes it possible to implement targeted interventions for sustainable land management and adaptation to environmental change. Integrating remote sensing, GIS, and modelling enhances spatial analysis and decision-making. The current land use and land cover significantly shape global environmental, social, and economic outcomes. Managing these dynamics preserves biodiversity, ensures food security, and mitigates climate change impacts. Sustainable strategies promote resilience and adaptability, fostering equitable access to resources, enhancing community well-being, and safeguarding ecosystem health benefits for current and future generations.

Accurate land use information is crucial for properly planning, managing, and monitoring natural resources (Vishwanath, 2014). Effective land use and cover information is crucial for implementing management strategies to meet the rising demands of the growing population for basic human needs and welfare.

(Nagaraju et al. 2016, Veeraswamy, 2019). Land cover mapping is being undertaken at various scales, from local to national to global. Using panchromatic, medium-scale aerial photographs to map land use has been widely accepted since the 1940s. Recently, small-scale aerial and satellite images have been employed for land use and land cover mapping. Land use and land cover are crucial factors in various fields such as hydrogeology and mining, urban planning, agriculture, hydrology, and soil. Accurate land cover identification is critical for various purposes, including global monitoring studies, resource management, and planning activities. It serves as a foundation for change detection and thematic mapping. Land use describes how land apparel is used (for agriculture, residence, or industry). Land use applications require initial mapping and ongoing monitoring to ensure current information on the quantity and type of land use and to detect any changes in land use over time (Haque & Basak, 2017).

Chatterjee (1941) emphasized the importance of studying India's different types of land use cover. He noted that this intricate pattern requires geographical investigation of the physical environment. To this end, he conducted a land use land cover survey in Howrah district and 24 Parganas of West Bengal (Chatterjee 1945, 1952). The study revealed that the district had poor drainage conditions despite having large rivers. It also discussed the impact of soil and climate on land utilization, population pressure on land, trade and transport, nature of land utilization, and agricultural implements. Mukherjee (1967) observed the changing land use pattern in Howrah district and suggested planning strategies for agricultural land use. Roy (1972) emphasized the relationship between land use and agricultural characteristics of the Damodar-Saraswati Doab area. Chatterjee and Jana (1975) studied the pattern of land utilization around Tarakeswar town of Hooghly district.

Singh RB and Dilip Kumar (2012) used remote sensing and GIS to map land use and cover and integrate land management in the Middle Ganga plain. They recommended alternative land use systems and the integration of livestock enterprises with the agricultural system for effective land resource management. In 2014, Sreenivasulu conducted a study using IRS LISS III data to map the land use and land cover of Rajampeta in the Kadapa district. The study revealed a worrying trend of rapid decrease in water bodies and marshy areas and a significant change in land use from agricultural to residential. Additionally, water bodies were converted into marshy terrain and marshy areas into either residential or agricultural land. These findings indicate substantial urbanization and alteration of natural landscapes in the region. In 2017, Gopenaik investigated the land utilization patterns in and around the Dosalavanka watershed in the Chittoor District. Similarly, in 2021, Vinodh Kumar conducted a study on land use and land cover analysis in the Uddanam area of Srikakulam District. Their study revealed that agricultural land occupation was predominant, while uncultivated land was occupied somewhat.

Land use and land cover mapping can be done using satellite sensing data to create a reliable database that includes information on Kharif, Rabi, and Zaid crops, greening of wastelands, surface water bodies, forest vegetation, and other high temporal land-use practices. The National Remote Sensing Agency developed the land use and land cover data in 1989, and it has been updated using visual interpretation techniques recommended by NRSA in 2019.

e and Land cover, Remote sensing, GIS, Tungabhadra River Basin

The Study Area

The study area of the Tungabhadra River basin is in the north-western region of the Kurnool district in Andhra Pradesh, India. It lies between North Latitude 15^0 15'00" to 16^0 0'00" and East Longitude 77^0 0'0" to 78^0 15'00". The area falls within the Survey of India (SOI) Toposheet Nos. 57E/1 to 57E/16 and 57I/1 to 57I/5. The total area of the basin is 6,934 square kilometers. The basin consists of 30 mandals, with 21 mandals fully covered and the remaining nine mandals partially covered. The Tungabhadra River basin receives an average annual rainfall of 670 mm and experiences temperatures ranging from 12°C to 31°C in the winter. Moreover, summer temperatures range from 26°C to 46°C. Agriculture is the primary occupation and main source of livelihood for the people residing in the Tungabhadra River basin. Over 70% of the basin's population is involved in farming. Rainfed agriculture is the most practiced type of farming in the region. The "fallow-chickpea" cropping system is the preferred method for farming by most farm households.

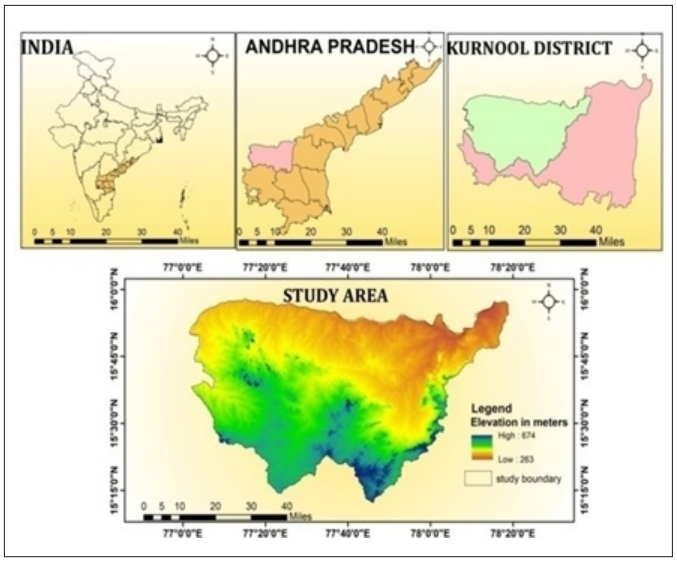


Fig.1 Location map of the Tungabhadra River basin

Objective

This study aims to conduct a comprehensive land use and land cover (LULC) analysis of the Tungabhadra River Basin in Kurnool District, Andhra Pradesh, utilizing remote sensing and Geographic Information System (GIS) techniques.

Database and Methodology

In the present study, we have mainly used two types of data. These are Topographic maps and Remote sensing data. Satellite imagery from the IRS P6 LISS III at a 23m resolution was used to classify land use and cover in 2023. The topographic map 57E/1 TO 57 E/16 and 57I/1 TO 57I/5(1:50,000 scale) is obtained from the survey of India, Hyderabad, surveyed and prepared in 1976; it is converted to digital mode using scanning. The topographic map is georeferenced with longitude and latitudes using the ArcGIS 10.3 software and spatial analyst tools to demarcate the drainage basin. The classification scheme used was developed by the National Remote Sensing Agency (NRSA) in 1995. Visual interpretation techniques were employed to classify features on the satellite images, using a key that helps distinguish features based on patterns, tonal variation, associations, and texture. These data sets

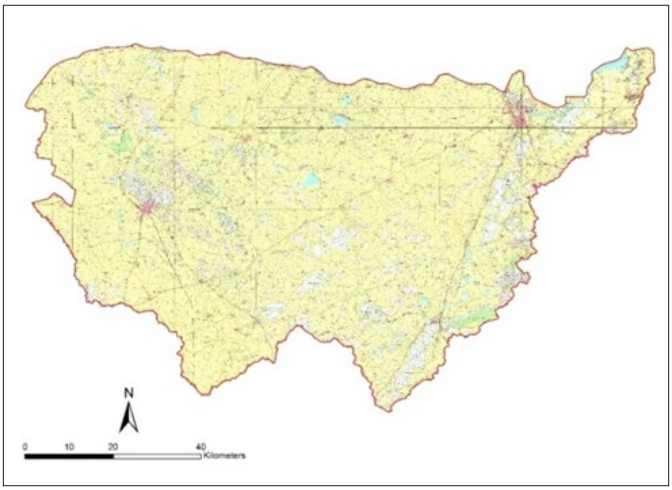


Fig:2: Topographical Map of the Tungabhadra River Basin in Kurnool District

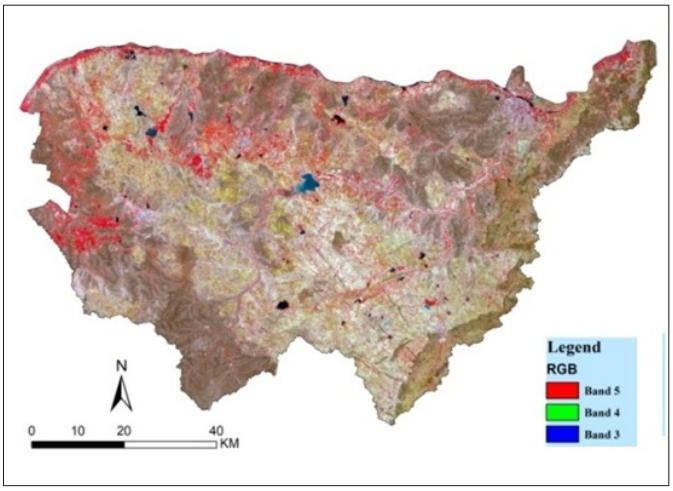


Fig:3: False Colour Composite Map of the Tungabhadra River Basin in Kurnool District

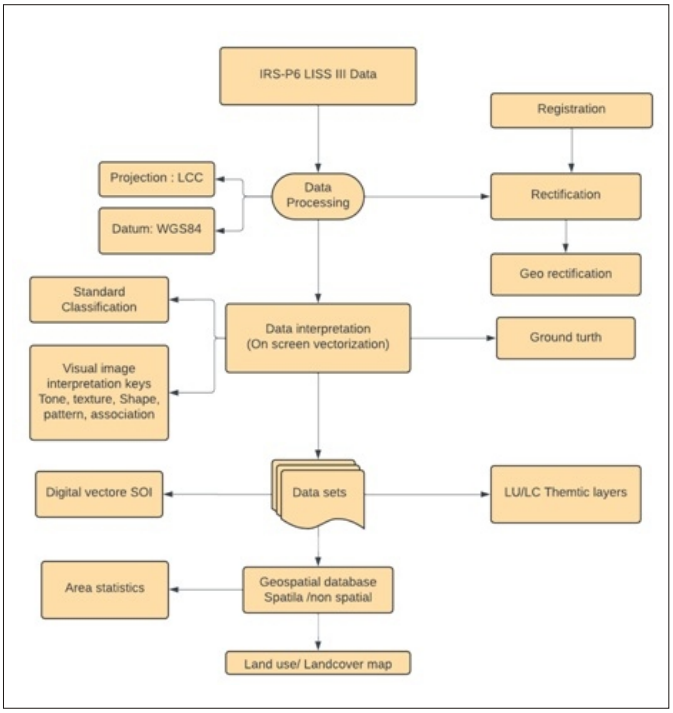


Fig.4. Flowchart of Methodology for LU/LC Map

were imported into ERDAS Imagine, a satellite image processing software, and a false color composite (FCC) was generated. The image interpreter toolbox's layer stack selection produced FCCs for the study area. Georeferencing, subset, mosaic, and projection were performed using ERDAS Imagine 9.0 and ARC GIS 10.3.

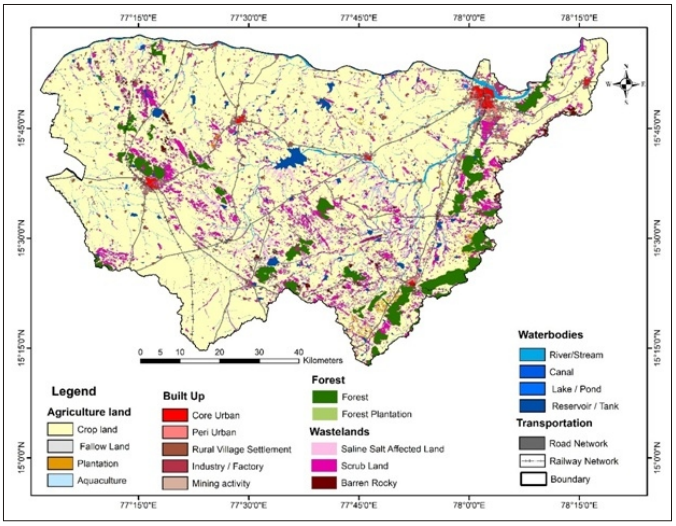


Fig.5: Landuse and Land Cover Map of the Tungabhadra River Basin in Kurnool District

Results and Discussion

Agricultural land

The land use category primarily produces food, Fiber, and other commercial and horticultural crops. It includes land under crops, namely cropland, fallow land, agricultural Plantation, and aquaculture. The agricultural category is the primary category, covering 5341.04 sq. Km (77.03%) during 2022-23.Table.1 & Fig.5

Crop Land: Croplands are typically categorized into Kharif, Rabi, and Zaid crops. Kharif crops, sown during the monsoon season, rely on irrigation rainfall, including paddy, Jowar, maize, chilies, cotton, and others. Rabi crops, planted between October and December, thrive in areas with assured irrigation or residual soil moisture, such as Bengal gram. Zaid crops, cultivated in summer months, primarily in irrigated regions, encompass crops like melons and cucumbers. This classification facilitates understanding seasonal agricultural practices and water management needs in diverse regions, with the total cropland area in the basin is 5279.93 sq. Km (76.15%) during 2022-23. This categorization helps understand the seasonal agricultural practices and water management requirements across different regions.

Fallow Land: Fallow land refers to agricultural areas deliberately left uncultivated for one or more seasons, allowing the soil to recuperate for up to five years. This practice aids in preserving soil fertility and productivity by preventing degradation, erosion, and nutrient depletion. Incorporating fallow periods into crop rotation systems supports sustainable farming, reduces reliance on chemical inputs for weed and pest management, and restores natural balance. With a total area of 13.94 sq. km, representing 0.20% of the land, fallowing plays a crucial role in maintaining soil health and ensuring long-term agricultural sustainability.

Agriculture Plantation: Agricultural plantations encompass

areas dedicated to cultivating tree crops, employing specialized agricultural management techniques. These regions also encompass land use systems integrating the intentional cultivation of herbs, shrubs, and vegetable crops alongside conventional crops, often under irrigated conditions, motivated by ecological and economic considerations. The distinguishing characteristics of these areas include their separability from cropland, which is particularly evident during the rabi/zaid season. Empirical findings for 2022-23 reveal that 43.19 sq. km (0.62%) of land was devoted to plantation crops during this period.

Aquaculture: Aquaculture ponds are areas where fish and shrimp are bred and reared commercially. They are usually located along the coast or in lakes, rivers, and estuaries. This category is mainly found along the coast and occupies an area of 3.98 sq. km (0.06%).

Built-Up Area

These are the areas where people live, work, and communicate with each other. They include buildings, transportation systems, utilities such as water and electricity, and agricultural and industrial areas. These areas are core urban, peri-urban, rural, industrial, and mining/quarry. They cover 244.69 square kilometers, approximately 3.53% of the region's total geographical area. Rural areas account for 1.92% of the total area, more than half of the developed land. Table.1 & Fig.5.

Core Urban Area: Structures, highways, and artificial surfaces cover most of the terrain, encompassing nearly the entire land surface. The built-up-compact class is assigned when the urban structures and transport network (i.e., impermeable surfaces) occupy more than 35% of the surface area. This category occupies 38.10 sq. km (0.55%) and is in urban areas.

Peri-urban Area: Most of the land is covered by buildings, roads, and artificial surfaces, with vegetated areas and bare soil occupying significant but discontinuous surfaces. Between 20 and 40 % of the total surface should be impermeable. This category delineates scattered blocks of residential flats, hamlets, and small villages. It contributes an area of 37.44 sq. km (0.54%).

Rural Village Settlements: Rural settlements have relatively less human habitation than urban settlements, where most people farm. These settlements are categorized as built-up (rural) areas and are associated with non-commercial and allied classes. The rural area accounts for approximately 133.25 square kilometers, representing 1.92% of the total area.

Industrial Area: This class includes non-linear impervious surfaces related to trade, manufacturing, distribution, and commerce. These areas are characterized by human activity in manufacturing and supporting establishments for maintenance. Industrial areas occupy 13.39 square kilometers (0.19% of the total) and are typically found in and around towns.

Mining activity: Mining areas refer to the regions utilized for surface operations to extract valuable ores from the ground. These activities leave a noticeable impact on the landscape, with massive pit mines covering vast areas. The current mining operations are primarily large-scale surface operations that aim to remove economically significant ores. The total area contributed by the active mining operations is 22.51 sq. km, which accounts for only 0.32% of the total area.

Forests

A forest is defined as an area with a tree canopy cover of over 30% and a size greater than 0.5 hectares, characterized by trees reaching at least 5 meters in height. It serves as a vital source of timber and wood products and offers opportunities for outdoor recreation. Forests are pivotal in shaping environmental aspects such as air and water quality, wildlife habitat, climate, and other factors.Currently, the forest cover occupies about 317.63 square kilometers, which is approximately 4.58% of the total land area. Table -1 & Fig.5

Forest Plantation: These are the areas where tree species of forestry importance are grown and managed, especially in notified forest areas. Most of these areas are found in uplands and coastal regions within the notified areas. Many can be identified based on their sharp boundaries. The total area covered by forest plantations is 5.41 sq. km, only 0.08% of the total area.

Wastelands

Wasteland is a term that describes degraded land that can be restored to a vegetative state with reasonable effort but is currently underutilized. This type of land can deteriorate due to a lack of appropriate water and soil management or natural causes. Wastelands can also result from inherent or imposed disabilities, such as location, environment, soil chemical and physical properties, or financial or management constraints. Currently, the total area under this category is 735.59 sq. km, approximately 10.68% of the total land area. Table -1 & Fig.5

Salt-affected Land: These lands have excessive salts (soluble salts, exchangeable saline, or both). If canal irrigation water is not managed correctly, it can lead to salinization. This phenomenon occurs when the groundwater level increases, causing salts to accumulate within the root zone in arid, semi-arid, and sub-humid (dry) environments. Salinization can also occur in coastal regions due to seawater ingress or the utilization of groundwater with high salt content. These lands can also become saline if soils have developed on salt-containing parent materials or have saline groundwater. Coastal saline soils may or may not be inundated by seawater. These lands account for only 120.96 sq. km (1.74%) of the total area.

Scrubland : The scrub is typically found in the elevated regions of hillsides, which are usually surrounded by agricultural lands. These areas have shallow and skeletal soils, which can be chemically degraded. Scrubs dominate the landscapes due to the extreme slopes, severe erosion, and excessive aridity. The scrub can be found in a contiguous or dispersed pattern in small to large areas. The dense scrub is mainly found on hills, while the open scrub is found in foothills surrounded by agricultural lands, which occupy an area of 565.56 sq. km, which accounts for 8.16% of the total land area.

Barren Rocky/Stony Waste: It is mainly found in hilly areas with slopes, rocky outcrops, and stony fragments. The total area under this category is 49.07 sq. Km (only 0.71% of the total area.

Water Bodies

This category includes visible surface water, ponds, lakes, tanks, reservoirs, or flowing water bodies such as streams, rivers, and canals. Depending on the water depth, these areas appear blue to dark blue or cyan on satellite images. The water body category covers approximately 270 square kilometers and represents 3.90% of the basin. Table -1 & Fig.5

Rivers/Streams (Perennial): Rivers and streams are natural water pathways flowing across land, either continuously or intermittently, toward seas, lakes, or other water bodies. They play pivotal roles in the hydrological cycle, shaping landscapes and ecosystems and sustaining biodiversity. Additionally, they facilitate transportation and influence regional climates, marking their significance across ecological, geographical, and geological domains. Rivers and streams represent dynamic forces of nature, carving out valleys, nourishing fertile plains, and providing habitats for diverse aquatic and terrestrial life forms. It contributes an area of 138.12 sq. Km(2.0%).

Canals/Drains: Canals and drains are artificial waterways used for irrigation, navigation, or drainage of excess water from agricultural lands. They are primarily found in coastal plains, covering an area of 21.84 sq km (0.31%).

Tanks/Ponds : Tanks and ponds serve as crucial reservoirs, storing water for irrigation year-round, especially in areas lacking natural water sources like rivers. They enable efficient water management, aiding farmers in optimizing irrigation schedules and minimizing wastage. These reservoirs supplement irrigation supplies during droughts, helping sustain crop growth and mitigate losses. Additionally, they support aquaculture, bolstering food security and rural economies. Overall, creating tanks and ponds significantly enhances agricultural productivity and resilience. This category occupies 5.24 sq. km (0.08%) of the land, highlighting its importance in land use classification and resource management.

Reservoirs/Tanks: Reservoirs, formed by damming rivers, serve diverse purposes like hydropower generation, irrigation, and flood control, while tanks, smaller bodies of water, are mainly for localized irrigation in croplands. Reservoirs are large-scale and cater to multiple needs, whereas tanks, typically found in lowland areas, serve specific irrigation requirements. Both are crucial for managing water resources, sustaining agriculture, and mitigating flood risks across various landscapes. This category occupies an area of 104.79sq. Km (1.50%).

Transportation

The transportation infrastructure in the region is intricately linked with a comprehensive system of roads and railways, facilitating the smooth and effective transportation of goods and individuals. The road network includes significant highways and arterial routes, complemented by an extensive railway system that connects essential destinations. This robust transportation grid is crucial in supporting economic activities, improving accessibility, and fostering regional development. Moreover, continuous efforts to modernize and expand these networks aim to strengthen connectivity and mobility across the region further. This category occupies an area of 19.65sq. Km (0.28%). Table -1 & Fig.5

Conclusion

The Tungabhadra River Basin has diverse land use categories, such as agricultural land, built-up areas, forests, wastelands, water bodies, and transportation infrastructure. The region's agricultural land is essential for food production and economic sustainability, and we need to focus on enhancing agricultural productivity through modern techniques and sustainable practices while preserving fallow lands and promoting aquaculture for diversified income streams. Built-up areas signify urban, peri-urban, rural, industrial, and mining zones, highlighting the region's economic and social development. We need to continue investing in infrastructure, urban planning, and industrial growth, but we should also balance it with environmental conservation and sustainable resource management.

Forests are a significant portion of the Tungabhadra River Basin and are crucial for biodiversity conservation, climate regulation, and recreational activities. We must invest in conservation efforts, afforestation initiatives, and sustainable forest management practices to maintain ecological balance and support ecosystem services. Wastelands present opportunities for restoration and rehabilitation to reclaim degraded lands for productive use. Targeted interventions focusing on soil and water conservation, afforestation, and land reclamation can revitalize these areas and enhance their contribution to sustainable development. Water bodies like rivers, streams, ponds, tanks, and reservoirs are vital for irrigation, aquaculture, and water supply. Conserving and managing water resources involves ensuring sustainability, improving quality, and mitigating human activities and climate change impacts. Transportation infrastructure is pivotal in facilitating connectivity, trade, and economic growth. We must invest in modernizing and expanding transportation networks to enhance accessibility, efficiency, and mobility while minimizing environmental impacts.The findings presented in this report can be used as a foundation for informed decision-making, sustainable land management, and resource planning initiatives to foster environmental conservation and socio-economic development within the Tungabhadra River Basin.

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Table 1: Landuse/ Land Cover in Tungabhadra River Basin in 2023

S.No	Landuse /Land Cover Categories	Area (sq. km)	%
1	Crop Land	5279.93	76.15
2	Fallow Land	13.94	0.20
3	Plantation	43.19	0.62
4	Aquaculture	3.98	0.06
5	Core Urban	38.10	0.55
6	Peri-Urban	37.44	0.54
7	Rural Village Settlement	133.25	1.92
8	Industry / Factory	13.39	0.19
9	Mining Activity	22.51	0.32
10	Forest	317.63	4.58
11	Forest Plantation	5.41	0.08
12	Saline Salt Affected Land	120.96	1.74
13	Scrub Land	565.56	8.16
14	Barren Rocky	49.07	0.71
15	River/Stream	138.12	1.99
16	Main Canal	21.84	0.31
17	Lake / Pond	5.24	0.08
18	Reservoir / Tank	104.79	1.51
19	Road Network	13.37	0.19
20	Railway Network	6.28	0.09
	Total	6934.01	100.00



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Geographical Study of Crop Concentration and Crop Diversification in Tungabhadra River Basin of Kurnool District, Andhra Pradesh

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Abstract

The aim of the Present study is to analyze the spatial distribution of agricultural crops in the Tungabhadra River basin of Kurnool district using statistical techniques such as Crop Concentration and Crop Diversification. The study focuses on the mandal level, covering a total of 30 mandals within the basin. The data used in this study is secondary data obtained from the Chief Planning Office of Kurnool District (C.P.O) and the Handbook of Statistics, Kurnool District, for the year 2019-20. A total of seventeen crops were considered for this study. The Bhatia's Location Quotient method (1965) was employed to calculate the crop concentration, while the Gibbs and Martin's Quantitative technique (1962) was used to compute the crop diversification index. To visually represent the cropping patterns across the entire basin, the mandal was chosen as the base unit for areal mapping. Among the seventeen crops analyzed, Cotton (37%), Groundnut (15%), Bengal gram (13%), and red gram (9%) were found to be the most widely cultivated crops in the basin. The diversification of crops was found to be high in three mandals, moderate in fourteen mandals, and low in thirteen mandals.

***Key words*:** Cropping pattern, Crop concentration, Crop diversification, Bhatia's location quotient method, Gibbs and Martin's quantitative technique, Arc GIS 10.4

The Tungabhadra River basin, located in the western part of the Kurnool district, is characterized by its unique agricultural landscape. More than 75% of the region comprises Pedi plains, with 45% of the soil being cotton-rich black soils and 30% being red soils due to its geological connection to granite and gneisses. The primary mode of agriculture in this region is rain-fed, and agriculture stands as the predominant land use. Over 70% of the population relies on agriculture for their livelihoods. However, the agricultural system here is primarily based on traditional practices and operates at a subsistence level due to the limited availability of irrigation facilities and the prevalence of marginal and small landholdings. A significant portion of the working population is engaged in agricultural labour.

In this context, the study of crop concentration and diversification becomes essential to assess the state of crops in terms of their distribution across the area, the number of crops grown, spatial variations, and agricultural practices. [1] brought out the patterns of Crop concentration and Diversification in India. This information is critical for regional agricultural planning [2-3]. Crop concentration refers to the density variation of a particular crop in a specific area at a given point in time, while crop diversification represents the opposite, indicating a balanced mix of crops within a region [4]. Both these aspects not only provide insights into areas dominated by specific crops but also play a pivotal role in bolstering the agrarian economy and aiding in land-use planning [5]. The spatial variations in the degree of crop concentration in the area are influenced by various factors, including topography, climate, hydrology, socio-economic conditions, and technological factors. These interactions shape the agricultural landscape of the region, making it crucial to consider these factors when devising strategies for sustainable agricultural development [6]. The studies Crop concentration and crop diversification has been widely studied and mapped by various researchers in India. Among them who have studied crop concentration and diversifications are [7-17].

MATERIALS AND METHODS

Study area

The study area of the Tungabhadra River basin is in the north-western region of the Kurnool district in the state of Andhra Pradesh, India. It lies Between North Latitude 15° 15ˈ00” to 16° 0ˈ00” and East longitude 77° 0ˈ00” to 78° 15ˈ00”. The area falls within the survey of India (SOI) Toposheet No 57E/ 1 to 57E/16 and 57I/1 to 57 I/5. The total area of the basin is 6,934 square kilometers. The basin consists of 30 mandals, with 21 mandals fully covered and the remaining 9 mandals partially covered. The basin receives an average annual rainfall of 670 mm and experiences temperatures ranging from 26°C to 46°C in the summer and 12°C to 31°C in the winter. The northwestern portion, which includes Adoni, Peddakadubur, Alur, Aspari, Chippagiri, Halaharvi, Holagunda, Pathikonda, Devanakonda, Krishnagiri, Veldurthy, Kodumur, and Kallur mandals, has a desolate appearance with vegetation mostly limited to small pockets of reserve forests. This portion of the basin covers an area of 41,712 hectares, which accounts for

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4.46% of the total geographical area. The terrain in this region slopes from south to north and is drained by the river Hundri, which joins the river Tungabhadra at Kurnool. The soils in the north-western parts traversed by the river Hundri are black cotton, while the south-eastern parts are predominantly pure red soils. Geologically, the basin is underlying by the crystalline rock of the Peninsular Gneissic complex (PGC), which includes the Granitic Gneisses and Granite in the western and southern parts of the basin.

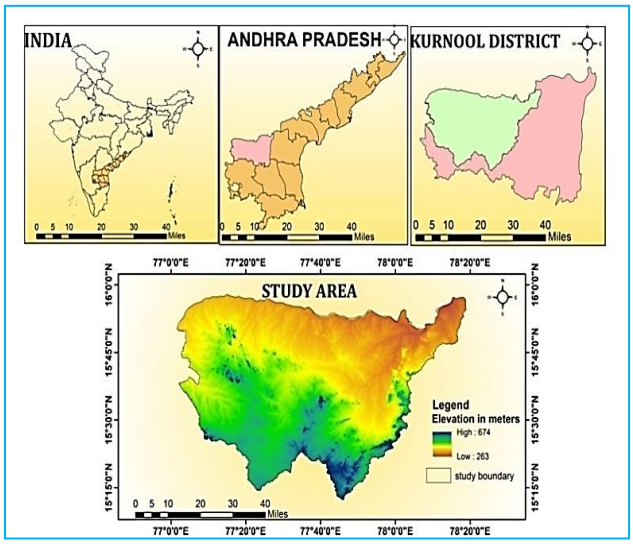


Fig 1 Location map of the study area

The present study utilized secondary data obtained from the Chief Planning office of Kurnool District (C.P.O) and the Handbook of Statistics, Kurnool District, 2019-20. Additionally, relevant information pertaining to physiographic, climate, and soil characteristics was collected from the Andhra Pradesh Satellite Application Centre (APSAC) Manuals and survey reports. To analyze the crop concentration index at the mandal level and its regional variations, Bhatia's Location Quotient Method was employed. This method considers the index values to be directly proportional to the levels of crop concentration.

$$\text{Crop concentration index (CCI)} = \frac{a/b}{a'/b'}$$

Where, a is the area of particular crop in the unit area
b is the total cropped area in the unit area
a' is the area of crop in the entire region
b' is the area of all crops in the entire region

(B). for the delineation of Crop Diversification regions in the study area, Gibbs and Martin Technique (1962) has been used which is Expressed as follows:

$$\text{Crop diversification index} = 1 \frac{\Sigma X^2}{(\Sigma X^2)}$$

Where;
X is the percentage of total cropped area occupied an individual crop.

RESULTS AND DISCUSSION

Spatial patterns of crop concentration in Tungabhadra River Basin of Kurnool district in 2019-20

The index of concentration of paddy, jowar, bajra, maize, total minor millets, red gram, Bengal gram, other pulses, chillies, condiments and spices, fruits and vegetables, cotton, ground nut, sunflower, castor, other oil seeds, tobacco crops for the year 2019-20 has been worked out adopting Bhatia method. The basin comprises of 30 mandals, out of which 21 mandals are fully covered while the remaining 9 mandals are partially covered. Consequently, we have collected complete data from the 9 mandals that were fully covered. so, the total geographical area is 935665 ha [18-19].

Paddy

The total cultivated land area within the basin for the given year amounts to approximately 643,521 hectares, representing 68.77% of the basin's total geographical area. Amongst this, 16,696 hectares are specifically allocated for the cultivation of Paddy, accounting for 2.59% of the overall cropped area. The crop concentration index reveals that there are fourteen mandals with a high concentration of crops, three mandals with a medium concentration, and eleven mandals with low concentration and two mandals are no concentration. Spatial distribution analysis indicates that the northern and north western mandals within the basin exhibit a high concentration of crops. In contrast, the eastern and southern regions of the basin demonstrate a low concentration. Notably, three mandals, namely Orvakal, Miduthur, and Krishanagiri, display a medium level of crop distribution. The Spatial distribution of crop concentration is shown in the (Fig 2, Table 1).

Jowar

The Jowar crop encompasses a total cropped area of approximately 15,319 hectares, representing 2.38% of the overall cropped area. Analysis of the crop concentration index reveals that there are eleven mandals exhibiting a high concentration of Jowar cultivation, while ten mandals display a medium concentration, and nine mandals exhibit a low concentration. Spatial distribution patterns indicate that Jowar cultivation is predominantly concentrated in the north-eastern and south-eastern regions of the basin, with a medium concentration observed in the western and southern areas. Conversely, the central and north-western mandals of the basin exhibit a low concentration of Jowar cultivation. The Spatial distribution of crop concentration is shown in the (Fig 3, Table 1).

Bajra

The present study reveals that the total cropped area under bajra cultivation in the basin is approximately 7023 hectares, which accounts for 1.09% of the total cropped area. The concentration index analysis indicates that the bajra crop concentration is high in eight mandals, medium in seven mandals, and low in twelve mandals of the basin. Notably, the concentration is found to be nil in Kurnool, Miduthur, and J. Bunglow. The spatial distribution analysis further reveals that the concentration of bajra cultivation is high in the north-central and a few mandals in the south, while it is of medium concentration in the central part of the basin. Conversely, the low concentration of bajra cultivation is observed in the eastern, north-western, and south-western mandals of the basin. The Spatial distribution of crop concentration is shown in the (Fig 4, Table 1).

Maize

The present study reveals that the total cropped area dedicated to Maize cultivation in the basin is approximately 24,263 hectares, which accounts for 3.77% of the total cropped area. The concentration index analysis indicates that there are nine mandals with high concentration, two mandals with medium concentration, and fourteen mandals with low

concentration. Additionally, five mandals exhibit no concentration. The spatial distribution analysis reveals that the Maize cultivation concentration is high in the north-eastern part of the basin. Furthermore, the medium concentration is observed in two mandals, namely Kodumur and Yemmiganur mandals, while the low concentration is found in the north-western, central, and western parts of the basin. The spatial variation in maize cultivation within the Tungabhadra River basin indicates significant differences. The Spatial distribution of crop concentration is shown in the (Fig 5, Table 1).

Table 1 Mandal wise crop concentration Iin Tungabhadra River basin of Kurnool district

S.no	MANDAL	RICE	JOWER	BAJRA	MAIZE	MINOR MILLETS	RED GRAM	BENGAL GRAM	OTHER PULSES	CHILLIES	CONDIMENTS AND SPICES	FRUITS AND VEGITABLES	COTTON	GROUND NUT	SUNFLOWER	CASTOR	OTHER OILSEEDS	TOBBACCO
1	Kurnool	1.28	1.85	0.00	2.30	0.67	0.53	2.26	0.33	0.85	0.60	2.40	0.61	0.15	1.43	0.61	0.00	6.67
2	Kallur	0.23	3.46	0.08	1.79	1.39	0.93	1.23	0.14	0.02	0.95	1.44	1.04	0.21	5.25	0.70	3.38	1.79
3	Orvakal	0.61	2.26	0.03	1.51	1.15	1.40	2.04	0.60	0.12	1.37	1.38	0.64	0.09	4.60	0.60	1.12	10.03
4	Kodumur	0.36	1.69	0.94	0.53	2.08	0.70	1.90	0.04	0.00	0.51	1.33	1.04	0.55	2.87	0.78	0.22	0.06
5	Gudur	0.03	2.05	0.32	0.02	0.20	0.14	1.70	0.01	0.25	0.26	0.51	1.72	0.16	0.28	0.12	0.06	0.31
6	C.Belagal	1.75	0.74	0.59	1.56	0.54	0.22	0.29	0.02	0.86	0.58	3.53	1.32	0.38	0.44	0.08	0.61	0.00
7	Dhone	0.14	0.51	0.92	0.00	1.88	4.42	0.21	0.21	0.05	0.22	1.39	0.06	2.25	0.93	2.53	0.35	0.00
8	Bethamcherla	0.42	0.72	2.76	0.44	11.52	6.25	0.57	0.69	0.00	0.80	1.06	0.04	0.30	6.61	0.53	3.75	0.00
9	Veldurthy	0.09	1.66	0.15	0.24	2.27	3.14	0.50	0.15	0.79	0.80	0.56	0.78	1.06	1.44	2.09	0.17	0.17
10	Krishnagiri	0.51	0.35	1.11	0.11	0.27	1.25	0.25	0.00	0.00	0.18	0.76	0.58	3.07	0.34	3.36	0.84	0.02
11	Peapully	0.11	1.04	3.84	0.04	2.14	3.87	0.14	0.23	0.00	0.56	1.01	0.18	2.20	0.92	2.13	0.56	0.00
12	Nandikotukur	1.59	0.25	0.01	9.66	0.53	0.66	2.69	4.44	0.00	0.45	1.16	0.05	0.06	0.36	0.02	0.50	2.48
13	Miduthur	0.81	1.17	0.00	3.69	1.37	0.88	2.18	1.34	3.20	1.35	0.61	0.63	0.01	0.04	0.08	1.03	12.48
14	Pagidayala	5.44	0.35	0.02	11.98	0.07	0.58	1.10	9.31	0.68	0.32	0.36	0.09	0.11	6.35	0.01	0.18	0.95
15	J.Bunglow	1.78	0.53	0.00	9.62	0.14	1.34	1.38	6.17	0.31	0.36	0.89	0.33	0.06	0.94	0.03	0.00	0.93
16	Adoni	1.51	0.75	0.67	0.01	0.28	0.09	0.30	0.25	1.99	1.26	0.50	1.71	0.97	1.06	0.19	1.50	0.00
17	Kowthalam	2.25	0.70	0.28	0.01	0.21	0.07	0.12	0.17	3.18	1.13	0.33	2.07	0.17	0.26	0.14	0.08	0.00
18	Kosigi	2.90	0.24	0.82	0.03	0.08	0.12	0.01	0.31	2.46	0.89	1.36	1.63	0.84	0.00	0.75	0.05	0.00
19	Peddakadubur	3.34	0.01	0.30	0.18	0.22	0.08	0.04	0.20	4.76	1.24	0.95	1.56	0.95	0.00	0.31	0.32	0.00
20	Yemmiganur	1.26	0.63	1.49	0.62	0.83	0.16	0.17	0.48	2.53	0.98	1.29	1.63	0.61	0.18	1.02	0.00	0.00
21	Nandavaram	2.98	0.41	1.46	0.49	1.11	0.15	0.42	0.43	2.14	1.58	0.72	1.76	0.13	0.00	0.18	0.05	0.00
22	Mantralayam	2.59	0.43	0.27	0.02	0.12	0.17	0.27	0.49	1.74	0.56	0.59	2.08	0.07	0.00	0.11	0.00	0.00
23	Alur	0.01	1.94	0.31	0.00	0.45	0.04	3.28	0.20	0.27	1.67	0.21	1.08	0.32	0.28	0.15	0.03	0.00
24	Aspari	0.08	0.93	0.65	0.03	0.76	0.09	1.91	0.44	0.32	1.38	0.74	1.25	0.77	0.13	0.14	8.68	0.00
25	Holagunda	2.64	2.77	0.20	0.01	0.04	0.04	0.67	0.06	1.46	0.34	0.08	1.88	0.24	1.70	0.00	0.52	0.00
26	Pattikonda	0.00	0.73	0.36	0.00	0.10	0.34	1.61	1.52	0.37	0.77	1.01	0.88	1.85	0.00	1.12	0.87	0.00
27	Devanakonda	0.16	0.34	0.89	0.01	0.32	0.27	0.17	0.97	0.28	0.39	1.18	1.06	2.63	0.04	1.75	0.03	0.00
28	Tuggali	0.00	0.61	3.15	0.00	0.16	1.30	0.63	3.83	0.24	0.17	0.37	0.52	2.69	0.00	3.44	0.00	0.00
29	Maddikera	0.05	1.04	3.57	0.00	0.21	0.73	2.79	2.83	0.27	5.45	0.47	0.17	1.23	0.05	1.40	0.16	0.00
30	Gonegandla	1.15	0.42	1.72	1.08	0.93	0.36	0.21	1.62	1.64	0.94	2.45	1.11	1.04	0.07	1.73	0.31	0.00

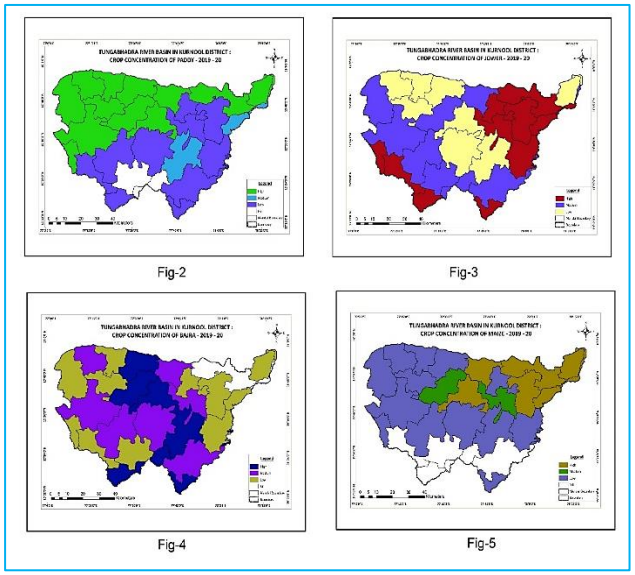


Fig-2 Fig-3

Fig-4 Fig-5

Minor millets

The minor millets exhibit a total cropped area of approximately 3,888 hectares, representing a mere 0.60% of the overall cultivated land. The concentration index analysis reveals a significant concentration of minor millets in nine mandals, a moderate concentration in six mandals, and a low concentration in fifteen mandals within the basin. Spatially, the eastern mandals of the basin exhibit a high concentration of minor millets, while the western and central mandals display a lower concentration. The Spatial distribution of crop concentration is shown in the (Fig 6, Table 1).

Red gram

The red gram crop encompasses a total cultivated area of approximately 60,564 hectares, representing 9.41% of the overall cultivated land within the basin. The concentration index reveals that red gram cultivation exhibits high concentration in eight mandals, medium concentration in seven mandals, and low concentration in fifteen mandals across the basin. Spatial analysis further indicates that the highest concentration of red gram cultivation is observed in the eastern and south-eastern regions of the basin, while the north-eastern region exhibits a medium concentration. Conversely, the western, northern, and central mandals of the basin display a low concentration of red gram cultivation. The Spatial distribution of crop concentration is shown in the (Fig 7, Table 1).

Bengal gram

The Bengal gram crop covers a total area of approximately 82,620 hectares, which accounts for 12.84% of the overall cropped area. The index of concentration reveals that this crop exhibits a high concentration in thirteen mandals, a medium concentration in four mandals, and a low concentration in thirteen mandals within the basin. The spatial distribution analysis indicates that the highest concentration of Bengal gram is observed in the north-eastern and south-western regions of the basin. Additionally, a medium concentration is observed in four specific mandals, namely Bethamcherala, Veldurthy, Holagunda, and Tuggali, within the basin. Conversely, the concentration of Bengal gram is low in the northwestern central and south-eastern parts of the basin. The Spatial distribution of crop concentration is shown in the (Fig 8, Table 1).

Other pulses

The total cultivated area dedicated to other pulses amounts to approximately 6,553 hectares, representing 1.02% of the overall cultivated area. The concentration index reveals that a significant concentration is observed in eight mandals, while a moderate concentration is found in three mandals, and a low concentration is recorded in eighteen mandals within the basin. Notably, no concentration is observed in the Krishanagiri mandal. The spatial distribution analysis indicates that the concentration is high in the mandals located in the north-east and southern regions of the basin. Additionally, a moderate concentration is observed in three mandals, namely Orvakal, Bethamcherla, and Devanakonda, with in the basin. Conversely, the concentration is low in the mandals situated in the north-western and eastern areas of the basin. The Spatial distribution of crop concentration is shown in the (Fig 9, Table 1).

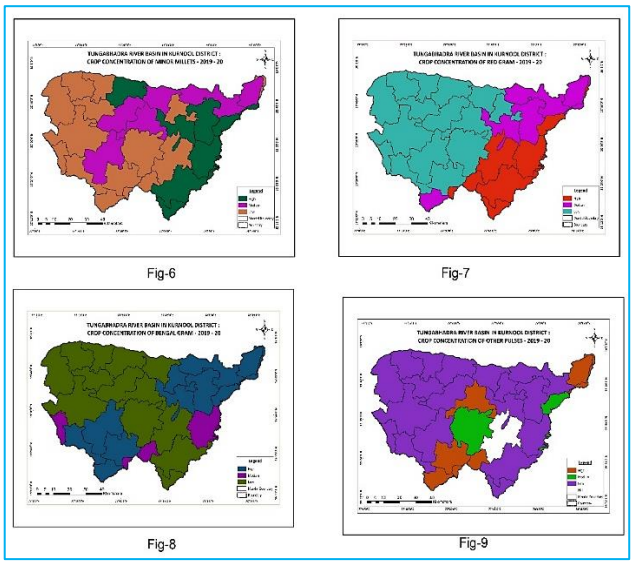


Fig-6 Fig-7

Fig-8 Fig-9

Chillies

The total cultivated area dedicated to chillies crops in the studied region amounts to approximately 7,427 hectares, representing 1.15% of the overall cultivated area. The concentration index reveals that chillies cultivation is highly concentrated in ten specific administrative divisions, moderately concentrated in four divisions, and minimally concentrated in ten divisions within the basin. Furthermore, the spatial distribution analysis indicates that chilli cultivation is predominantly concentrated in the western region of the basin. Additionally, moderate concentrations of chillies cultivation are observed in the mandals of Kurnool, C.Belagal, Veldurthy, and Pagidayala within the basin. Conversely, chili cultivation exhibits low concentrations in the southern and a few mandals in the eastern part of the basin. The Spatial distribution of crop concentration is shown in the (Fig 10, Table 1).

Condiments and spices

The total cultivated area dedicated to the cultivation of Condiments and Spices amounts to 19,230 hectares, representing 2.99% of the overall cultivated area. The distribution of this crop exhibits a high concentration in nine mandals, a medium concentration in twelve mandals, and a low concentration in nine mandals within the basin. Spatially, the condiments and spices crop concentration are notably high in the western and a few eastern mandals of the basin. Additionally, the concentration of this crop is of medium intensity in the northern, north central and southern mandals of the basin. Conversely, the southern mandals of the basin display a low concentration of Condiments and Spices cultivation. The Spatial distribution of crop concentration is shown in the (Fig 11, Table 1).

Fruits and vegetables

The aggregated cultivated land area dedicated to the cultivation of fruits and vegetables amounts to 41,850 hectares, representing 6.50% of the overall cultivated land area. The concentration index reveals that a significant concentration is observed in fourteen mandals, while a moderate concentration is found in ten mandals, and a low concentration is recorded in six mandals within the basin. Geographically, the concentration is spatially prominent in the mandals situated in the north-east, central, and southern regions of the basin. Conversely, the concentration is moderate in the mandals located in the western and eastern parts of the basin. Furthermore, the concentration is relatively low in the western and south-western mandals of the basin. The Spatial distribution of crop concentration is shown in the (Fig 12, Table 1).

Cotton

The total cultivated land area dedicated to Cotton is 40,182 hectares, representing 37.32% of the overall cultivated land area. The concentration index reveals that this crop exhibits a high concentration in sixteen mandals, a medium concentration in seven mandals, and a low concentration in seven mandals within the basin. Spatial analysis indicates that the highest concentration of Cotton is observed in the western, northern, and central regions of the basin. In the eastern mandals, the concentration of this crop is moderate. Conversely, the north-eastern and southern mandals of the basin exhibit a low concentration of cotton cultivation. The Spatial distribution of crop concentration is shown in the (Fig 13, Table 1).

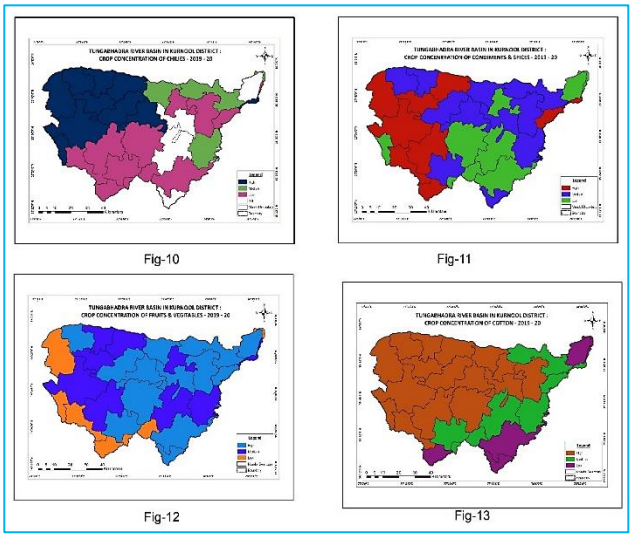


Fig-10 Fig-11

Fig-12 Fig-13

Groundnut

The cumulative cultivated land area within the Ground is measured at 95,239 hectares, representing 14.80% of the overall cultivated land area. The distribution of this crop exhibits a high concentration in nine mandals, a medium concentration in six mandals, and a low concentration in fifteen mandals within the basin. Spatial analysis reveals that the southern and central regions of the basin exhibit a high concentration of ground nut cultivation. Conversely, the western mandals of the basin demonstrate a medium concentration, while the northern, north-eastern, and select south-western mandals exhibit a low concentration of ground nut cultivation. The Spatial distribution of crop concentration is shown in the (Fig 14, Table 1).

Sunflower

The total cultivated area dedicated to sunflower cultivation amounts to 925 hectares, representing a mere 0.14% of the overall cultivated area. The distribution of sunflower cultivation exhibits a high concentration in nine mandals, a medium concentration in three mandals, and a low concentration in twelve mandals within the basin. However, sunflower cultivation is completely absent in six mandals. The spatial analysis reveals that the eastern and certain western mandals exhibit a high concentration of sunflower cultivation, while the central and north-eastern regions of the basin display a low concentration. Furthermore, sunflower cultivation is nonexistent in the north-western and certain southern mandals of the basin. The Spatial distribution of crop concentration is shown in the (Fig 15, Table 1).

Castor

The total cultivated area dedicated to castor is 16,067 hectares, representing 2.50% of the overall cropped area. The distribution of Castor cultivation varies across the basin, with high concentrations observed in ten mandals, medium concentrations in six mandals, and low concentrations in thirteen mandals. Notably, the mandal of Holagunda does not engage in Castor cultivation. Spatially, the southern and central mandals of the basin exhibit a high concentration of Castor cultivation, while the north-eastern part of the basin demonstrates a medium concentration. Conversely, the western and northern regions of the basin display a low concentration of Castor crop cultivation. The Spatial distribution of crop concentration is shown in the (Fig 16, Table 1).

Other oil seeds

The total cultivated area dedicated to other oil seeds is 2,078 hectares, which accounts for 0.32% of the overall cultivated area. The index of concentration reveals that this crop exhibits high concentration in six mandals, medium concentration in five mandals, and low concentration in fourteen mandals within the basin. Approximately five mandals do not cultivate this crop at all. The spatial distribution analysis indicates that the highest concentration of other oil seeds is found in the mandals of Kallur, Orvakal, Bethamcherla, Miduthur, Adoni, and Aspari within the basin. On the other hand, the concentration of other oil seeds crops is medium in C. Belagal, Krishnagiri, Peapully, Holagunda, and Pattikonda mandals of the basin. The concentration of other oil seeds crops is low in the central, north-western, and a few mandals in the eastern and south-western regions of the basin. The Spatial distribution of crop concentration is shown in the (Fig 17, Table 1).

Tobacco

The total cultivated area dedicated to tobacco cultivation in the basin amounts to 3,595 hectares, representing a mere 0.56% of the overall cultivated area. The index of concentration reveals that tobacco cultivation is highly concentrated in five mandals, moderately concentrated in two mandals, and has a low concentration in four mandals within the basin. Approximately nineteen mandals do not engage in tobacco cultivation. The spatial distribution analysis indicates that tobacco cultivation is highly concentrated in the mandals of Kurnool, Kallur, Orvakal, Nandikotukur, and Miduthur. The concentration of tobacco cultivation is moderate in Pagidayala and J.Bunglow mandals. Conversely, the mandals of Kodumur, Gudur, Veldurthi, and Krishnagiri exhibit a low concentration of tobacco cultivation within the basin. The Spatial distribution of crop concentration is shown in the (Fig 18, Table 1).

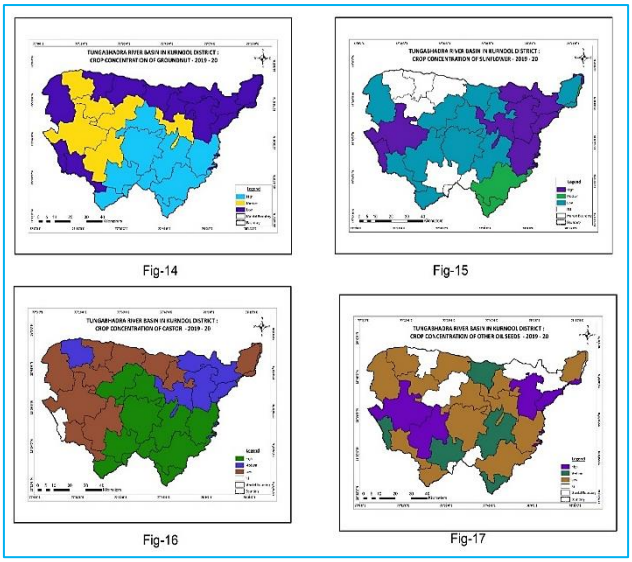


Fig-14 Fig-15

Fig-16 Fig-17

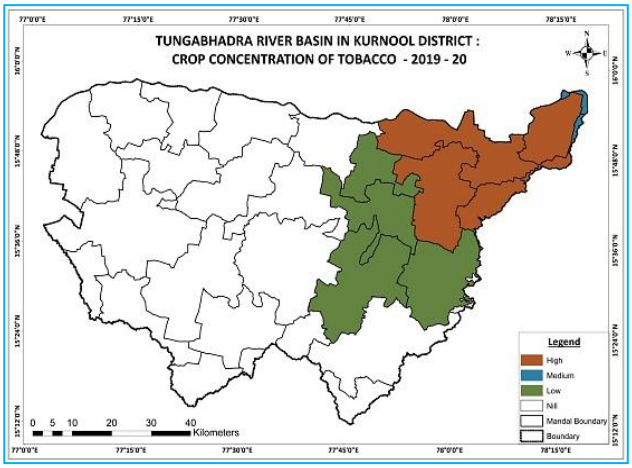


Fig 18

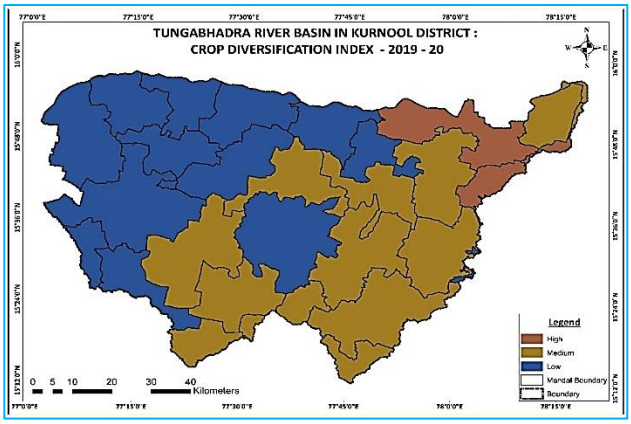


Fig 19

Crop diversification

Crop diversification plays a crucial role in enhancing agricultural productivity and sustainability. Identifying areas with high, moderate, and low levels of diversification can help policymakers and farmers implement targeted strategies to promote diversification and improve overall agricultural outcomes.

Areas with high crop diversification (> 0.80)

High level of crop diversification is found in Kurnool (0.82), Orvakal (0.84) and Miduthur mandal (0.83). Spatially these mandal are in North eastern part of the basin. The Spatial distribution of crop concentration is shown in the (Fig 19, Table 2).

Moderate crop diversification (0.70-0.80)

The mandals in the index exhibit a moderate level of diversification, ranging from 0.70 to 0.80. These mandals include Maddikera (0.80), J.Bunglow (0.80), Kallur (0.79), Veldurthi (0.79), Kodumur (0.77), Pattikonda (0.77), Tuggali(0.77), Gonegandla (0.77), Peapully (0.75), Pagidayala (0.74), Nandikotukur (0.73), Dhone (0.70), Krishnagiri (0.72), Aspari (0.70). The spatial distribution reveals that moderate diversification is observed in the eastern, southern, and a few mandals in the central part of the basin. The Spatial distribution of crop concentration is shown in the (Fig 19, Table 2).

Low crop diversification (>0.70)

The observation of a low level of crop diversification has been made in thirteen mandals, namely Gudur (0.54), C. Belagal (0.69), Devanakonda (0.68), Alur (0.65), Bethamcherla (0.63), Peddakadubur (0.62), Yemiganur (0.61), Mantralyam (0.61), Kosigi (0.60), Adoni (0.57), Nandavaram (0.55), Holagundra (0.49), and Kowthalm (0.39). The spatial distribution of these mandals indicates that they are situated in the north-western and western regions of the basin. The Spatial distribution of crop concentration is shown in the (Fig 19, Table 2).

Table 2 Mandal wise crop diversification index in Tungabhadra River basin of Kurnool district (2019-20)

S. No.	Name of the mandal	CDI	S. No.	Name of the mandal	CDI	S. No.	Name of the mandal	CDI
1	Kurnool	0.82	11	Peapully	0.75	21	Nandavaram	0.55
2	Kallur	0.79	12	Nandikotkur	0.73	22	Mantryalam	0.39
3	Orvakal	0.84	13	Midthur	0.83	23	Alur	0.65
4	Kodumur	0.77	14	Pagidayala	0.74	24	Aspari	0.70
5	Gudur	0.54	15	J. Bunglow	0.80	25	Holagunda	0.49
6	C.Belagal	0.69	16	Adoni	0.57	26	Pattikonda	0.77
7	Dhone	0.70	17	Kowthalam	0.39	27	Devanakonda	0.68
8	Bethamcherla	0.63	18	Kosigi	0.60	28	Tuggali	0.77
9	Veldurthy	0.79	19	Peddakadbur	0.62	29	Maddikera	0.80
10	KrishnaGiri	0.72	20	Yemmiganur	0.61	30	Gonegandla	0.77

CONCLUSION

The spatial variation of major crops in the basin indicates that the contrast is due to topography, climate, socio-economic, and technological factors. It can be observed that the cropping pattern in the Tungabhadra River basin is primarily focused on commercial crops, particularly cotton and groundnut, with food grains such as Bengal gram, red gram, fruits, and vegetables also being cultivated. Cotton is the dominant crop in this region, limiting agricultural diversification. As a result, most of the mandals in the area have a low to moderate index of diversification, with only three mandals, namely Kurnool, Orvakal, and Miduthur, exhibiting high crop diversification. More than 75% of the basin area consists of pediplains, and 70% of the population relies on agriculture for their livelihood. Therefore, crop diversification can be utilized as a tool to improve the economic conditions of small and marginal farmers. The traditional cropping pattern can lead to issues such as decreased productivity and soil fertility. To address these problems, crop rotation, intercropping, and the implementation of micro irrigation technologies such as drip, trickles, and sprinklers are effective measures to enhance soil health, minimize water usage, and reduce soil and water pollution. It is important to carefully manage surface and subsurface water resources and improve irrigation facilities by constructing check dams, percolation ponds, and interlinking canals and tanks to promote good agricultural production. Tungabhadra River basin's agricultural landscape is currently dominated by cotton and groundnut, with limited diversification. By adopting crop rotation, intercropping, and advanced irrigation techniques, and by improving water management infrastructure, the region can enhance its agricultural sustainability and improve the economic conditions of its farming community.

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* * * * *

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LANDFORMS AND LAND SYSTEMS OF CHITTOOR DISTRICT, ANDHRA PRADESH, INDIA

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Abstract
Landforms and Land systems are the collective form of Geomorphology, which contributes more to the ground water and agricultural resources of an area. Ground water and Agricultural resources are basic for the economic prosperity of a country. The various land systems and landforms include Mountains, Plateaus, Plains, Rocky mounds, Escarpments, Domal hills, etc. As the human settlements and activities are generally restricted in regions where mountains dominate, the population in such regions is comparatively sparse. Agriculture is not well developed because of the scarcity of level land, the problem of soil erosion and restricts the ground water flow in the area. Chittoor District, in which the present study is one, is one of the drought prone areas of the State of Andhra Pradesh due to its peculiar location in the leeward side of the Western Ghats. So, in the present paper an attempt has been made to identify various landforms and landsystems and examine how they contribute to ground water resources and allied agricultural activities.

Key Words: *Landforms, Land systems, Undulating terrain, Fluvial plains, Escarpments, Palaeo-channels, Landslides, Lineaments, Geological formations.*

Introduction

Geomorphology is the science of different Landforms. Since each landform has its own characteristic attributes that reveal the conditions that lead to its formation, reconstruction of the physical process that operated or operating in the area can be interpreted based on the identification of landforms in that area. As such geomorphology assumes importance, since it involves interpretation of the origin and dynamics of various Earth's surface features and thus provides essential inputs for evaluation of resources like groundwater, soils and materials; Civil engineering (i.e. for locating suitable sites for the construction of roads, canals, buildings, bridges and dams etc.) and other branches of knowledge which requires understanding of the Earth's surface. It also explains the occurrence of landslides, which is one of the natural hazards of this area. So, the identification and mapping of landforms and land systems is an important facet of geomorphology. They are treated as '**Land Resources'** of the study area. So the aim of the present study is to deciper the various land systems and landforms of Chittoor District keeping in view its role in the formation of soils, ground water flow and agricultural activities.

Study Area

Chittoor District derives its name from Chittoor, its head-quarters town from 1st April 1911. It was located 12° 37' to 14° 8'N and 78° 3' to 79° 55'E. It is bordered by Anantapur, Cuddapah and Nellore districts in the north and by Tamil Nadu State in the south and east and by Karnataka State towards the west. It is situated in the south-eastern fringe of Andhra Pradesh. It is the smallest district in area compared to all the districts of Rayalaseema, covering an area of 15,152 sq.km with a population of in 2001 census, Chittoor had a population of 37,45,875 of which males were 1,889,690 and remaining 1,856,185 were females. Survey of India (SOI) Toposheets bearing the numbers 57K, 57L and 57O on 1:50,000, 1:25,000 scale (1975) formed the base for mapping the region and the satellite imageries of IRS-IC (LISS-IV) (2006) and CARTOSAT for the study of temporal changes that occurred. That was centuries ago. All that has changed. The resources of land and water have become minimum and prosperity has yielded place to poverty. For the last hundred years, the economic history of Rayalaseema, in which the present study is one, has been the very history of droughts and famines mainly due to failure of monsoon and hence today "Rayalaseema is referred to as the "Famine Zone of South India", "the blakest spot on the famine map of India" and the Mezzogiorno" of Andhra Pradesh.

Review of Literature

Many attempts have been made by Geologists, Hydrogeologists, Geographers and other scientists to map various land resources, as they are extremely significant in the formation of soils, soil erosion, ground water occurrence and ground water flow etc. Such a study is also useful to note the areas of landslides, which is one of the natural hazards of this area. In this context, Jayaraju and Bhaskara Reddy (1989) worked much on the identification of Landforms of Chittoor district, basing upon LANDSATS on scale 1:250,000. The "Indian Photo interpretation Institute" at Dehradun and the 'National Remote Sensing Centre" at Hyderabad have been instituted by the Government of India to publish Aerial Photographs and LANDSATS, which are of great use in assessing land resources and landuse. Raghavaswamy and Vaidyanadhan (1981), worked on the Landforms of Visakhapatnam District. Sambasiva Rao and Nageswara Rao (1983), worked more on the Landforms of Godavari and Krishna rivers respectively. Vohara (2008) has published a paper on "Land and water management problem in India" basing upon the availability of landforms and landsystems.

Methodology

Remote Sensing and Geographical Information System (GIS) techniques were adopted to study the Landsystems, Landforms, Landuse, Lineaments and Relief etc. The studies were undertaken critically on Air Photos on scale 1:60,000, Landsats 1:1 million, 1:250,000 and False Color Composits (Fcc's) 1:1 million and 1:250,000. The Survey of India (SOI) Topographical numbers 57K, 57L and 57O on 1:50,000, 1:25,000 scale were used as the base maps.

Geological Formation

The nature and structure of geological formations have many indirect influences on agricultural lands. Geological formations provide the basic materials and structures for the parent materials of the soils. Through the relief, the geological formations have a strong impact on climate and hydrology. Hence, these geological formations were studied in greater depth, which is also a land resource. The rock types met within the district are of diverse types ranging in age from Archaean to recent. Most of the area in Chittoor district is covered by precambrian granites, which are highly magmatised. Cuddapahs and Upper Gondwanas occur as outliers at one or two places. The geological sequence of the district is given below.

Geology Map of Chittoor Distirct

Age	Formation
Quaternary	
Subrecent –alluvium	Gravels, course to fine sands, silts and clays 3 to 5mts. thick.
Recent –Talus	Pebbles and other debris in valley fill areas.
Pleistocene-Laterite	Very hard and compact rocks of fine quartz graining in ferruginous material
Upper Gondwanas	Conglomerates of quartizite pebbles embedded in ferruginous matrix.
Lower Cuddapahs – Nagari	Quartzites with intercalating shales.
Archaeans – Dharwars and other Crystallines	Dolerite Dykes, granites and gneisses with (Porphyritic) feldspar, quartz, mica and hornblende.

RELIEF AND LAND SYSTEMS

The influence of relief on agriculture is multifaceted. Relief is the expression of the interact ion of several different phenomena and processes within the earth Is crust and on its surface. Its forms and dimensions are primarily related to geological formations and to the climate, which have either directly or indirectly acted upon these formation through the process 3f weathering and the concomitant soil formation, So, relief is therefore typically connected with many of the other land resources. Its influence on climate (which was mentioned previously), hydrology and formation of soils (including its negative aspect of soil degradation) are largely dependent upon the nature of the relief. In the present course of investigation the interactions of relief can be observed clearly in *the* formation of soils, climate, hydrology, landforms, drainage and even in the distribution of population, etc. *The* study area lies in a morphologically transitional zone between the interior plateau and the coastal plain. In addition, the north-aouth running Eastern Ghat ranges run in the middle of the district forming its backbone and *the* water divide for many streams, The district slopes down from west to east from an average elevation of about 750 mts,, on the west to about 50

mts on the eastern margin. The district may conveniently be divided into 3 natural divisions as given below.

(a) The Western Hilly Region he Karnataka plateau)

Which comprises isolated hills and hillocks covering the areas of Punganur, Madanapalli and Thamballapalli.

(b) The Central Upland Region

Which comprises three ranges, i.e., (1) Mahendragiri hills covering the areas of Kuppam, Palamaner, Chittoor, Chinnagottigallu and Vayalapadu, (2) The southern portions of Palakonda and Velikonda ranges partly covering the areas of Vayalapadu, Srikalahasti and Chandragir Fort and (3) Nagari hill s covering parts of the areas of Puttur, Nagari and Satyavedu.

(c) **The Plain Region**

Which consists of the valley plains of Bahuda, Pincha, Swarnamukhi, Paler, Arani and Nagari rivers and the coastal plain which lies to the east of Palakondas and Nagari hils.

The relief and land systems of the study area have been delineated based on studies from topographic sheets and false colour composites (F.C.C'S) of LANDSATS. The land systems are delineated based on the assumption that similar grey tones under similar topographic expression reflect similar surface and subsurface moisture conditions, vegetation and organic content of the soils. Tentatively light tones were considered to reflect red soils, colluviurn and sands medium tones to reflect sandy soils to sandy loams on rolling plains and dark tones to reflect sandy, silty , clays on level plains, namely, flood plains, ancient channels, etc. These tones may help in deleneating areas of relative importance in locating groundwater. Field trips have been carried out to various parts of the district to counter check the various systems identified from the study of topographic and related fields. The various land systems identified are:

(1) Hilly terrain

The western part of the district is bordered by a group of hills which belong to Eastern Ghats trending NE-NNE and SE direction, These hills are composed of mainly granites, quartzites and charnockites, The general elevation in these hills range from 1,314 mts. (Horsely Hills) to 1,131 mts. (Tirumala hills) above MSL., with steep slopes exceeding 20 per cent. Field studies in these regions also throw light on differential weathering particularly in the regions where sections of folds are clearly exposed. The general alignment of the disturbed hills in the western and central parts presents that this region in the geological history could have been a major domal structure and this contention has been proved owing to the presence of general 'Radial pattern of drainage' in the district.

(2) Undulating terrain

The central undulating terrain constitutes the hilly slopes, pediments, piedmont plains, valley fills, pediplains and colluvial fans. The slope in this terrain varies from 5 to 25 per cent. The irregularity in the distribution of material in extent and thickness is due to irregular

bed profiles, slope and different geomorphic agents to work. The presence of piedmont plains and colluvial fans with convex facing slopes is an indication of the fact that the rate of accumulation is exceeding the rate of transportation.

(3) Rolling Plains

The slope in these plains is low and varies from 2 to 5 per cent or less than 2 per cent and constitutes of creep built plains, wash plains aid mixed soil plains. The rolling nature of the plains is attributed due to differential rate of weathering, erosion and deposition of materials by gravity stream and wind action. The rolling plains occupy the major part of the district constituting red sandy soils, sandy loans and black soil plainer and reflect low to medium grey tones on the LANDSATS. A few isolated hills/insul bergs stand out prominently in the plains along without crops and give hindrance to agricultural operations.

(4) Fluvial plains

The major rivers during their course of development of river valleys have deposited fine textured alluvial soils on either side of the banks especially on the eastern part and hence this region is 'somewhat plain' in nature, with less than 2 per cent slope, These soils are very fertile and are usually used for cultivation of Rice, Sugarcane, etc., which reflect in dark grey tones on LANDSATS of band 7. As the western and central parts of the district composed of a number of hills and hillocks with exposed outcrops, the panoramic view gives the idea that it is more slopy and undulating. As the rainfall is frackish and erosion of the top soil is more, agriculture in this region is more discouraging and uneconomic. The etymological study of some of the place names in the western part of the district may supports this contention, For example, Rallabuduguru (a place with stones), Bodabandla (etymology Bodibandla, which means 'a barren hill), Ghattu (a hillock), Peddatippa Samudram (Pedda means big, Tippa means rock ‘samudram’ denotes here the 'uncultivable) . In the same way, as the eastern part which is somewhat plain and low lying in nature, some place names like 'pallam' (low lying area) 'Thungundram' (slope of a hill) may supports this view.

3. LANDFORMS (GEOMORPHOLOGY)

The various landforms identified based on grey tonal variation, crustal trends, nature of vegetation, soil texture and drainage characteristics, etc., are classified into broad divisions based on major geomorphic processes involved in their formation. They are

I. Destructional Landforms

Landforms which are grouped to this category owe their origin predominantly by sheet movements of weathered material by erosion and deposition. Exogenetic process, namely, degradation, weathering, mass-wasting and erosion have collectively played important roles in the destruction of these landforms. Field checks to various parts of the district denote that predominantly mechanical weathering process dominates over chemical weathering process due to semiarid nature of climate. Differential weathering in different

parts of the hilly terrain particularly in Horsely Hills in the west and Nagari Hills in the east throw light that structural disturbances might have played significant role in partial destruction of granitic terrain in this part of the district.

(a) Remnants of planation surfaces

Relatively flat topped with gentle slopes with barren surfaces and isolated hills which reflect light to medium grey tons are recognized at an altitude of about 750 m., in the district are presumed to be some of the remenants of planation surfaces. However**,** these surfaces are not associated with lateritic cappings in the eastern part of the study area. Planation surface is an amnibus term and includes Davisian's peneplain, or peneplane concept (Fairbridge, 1968).

Subrahmanyam (1982) while studying the morphology and evolution of Dharmapuri district has identified a series of etchplains at different altitudes where stripping and dissecting are important processes which are involved in the development of these plains. However, such plains are hardly recognized in the study area. A series of profiles taken in E-W direction throw light that there could have been 4 denudational levels, namely, 150-300 m., 300-600 m., 600-900 m., and above 900 m., above MSL, of the 4 denudational levels, it is presumed that levels lying in between 150-300, 300-600 and 600-900 m.**,** clearly depict that these could have been planated surfaces.

Pediments

These are cut rock surfaces with thin to thick veneer of debris. According to Mabbut (1966) they are rarely composed of sub-alluvial semiments over the existing pediments possibly due to lateral deposition of sediments by fluvial action. The pediments are distinctly noticed in and around Tirumala hills and Kuppam hills, The main process involved in the moulding of pediments are back weathering, rain wash, sheet wash and sheet flow. The low angle of pediment and meagre relative relief of residual remnants are presumed to be due to uniform lithology. In a few pockets granites and charnockites are left as residual boulder remenants indicating that the pediments here owe t h e i r origin more too lithological control and differential erosion.

Pediplain

A pediplain is defined as a sum of all pediments, together with residual nubbins (monadnocks) on any flood plains of major rivers (King, 1962). 'Pediplanation is generally accepted as the process responsible for landscape evolution as an alternative to the concept of process of peneplanation. A pediplain is also considered as a plain resulting from coalescence of a number of pediments over a sizeable area developed by the process operating in a semiarid cycle of denudation (Bajada). In the study area, the pediplain is well marked on the northern and western part of the district. They are in continuation of the pedlplain described by Vaidyanathan (1975). These plains in Chittoor District are covered by red sandy soils with a few residual hills and reflect very light in grey tone in the LANDSAT band 7,

Escarpments

An escarpment or scarp is defined as steep rock faces of great length. Two general types are recognized, namely, structural and erosional escarpments. Structural escarpment is a direct product of fault displacement, In the present study area the Tirumala hills, Nagari hills, parts of Kupparn hills and other minor hill ranges show distinct steep escarpments, which run to a distance of about 2 to 5 km. The Tirumala escarpment might have been formed by the structural activity during the development of Tirupati valley upto Nagari nose.

Residual Hills

The multi cyclic residual mountains, namely, exfoliation domes, tors, boulders, domal hills are well distributed on the plains of piedmont colluvial plains, pediments and pediplains. Typical tors and boulders of granitic gneisses are numerous in and around the study area, which causes hindrance to agricultural operations.

Constructional Landforms

The term denudation should in strict sense relate to destructional farms, but has been widely used to constructional forms related to gravitational process could be included under the heading constructive denudational forms to conform to the IGU Classification (Denmek, 1972).

Creep built plains

These are the deposits composed of unassorted material with angular gravel, pebbles and cobbles in a matrix of coarse sand and grit. These creep built plains are partly derived from the bordering hilly terrain and the piedmont colluvial plains by gravity, sheet wash and sheetflow. The thickness of sediments in these plains also varies from 2 to 7 meters and the slope ranges from 2 to *5* per cent. The creep built plains are very widely deposited on the eastern and central parts of the district.

Wash plains

These are stretches of plains next to creep built plains and pediments near to residual hills, with less than 2 per cent slope. These are composed of mixed soils, namely, red sandy and silt soils, which might have formed partly due to overflowing of water over these plains during peak flood periods along major river courses. On the eastern part of the district, soma patches of black soil plains which have been derived from insitu biotite gneisses may also be noticed.

Valley fills

These are the deposits derived from the bordering hilly terrain by gravity, sheet wash and sheet flow. The valley fill deposits consist of fine to coarse textured sandy soils and sandy loams with a few pebbles and cobbles derived from the surrounding hills.

Colluvial fans

A fan is an accumulation of debris brought down by a stream descending through a steep ravine and debounching in the plain beneath, where the debris materials spread out in

the shape of a fan (Denny, 1967). A number of fans are noticeable on either side of Tirupati valley, where plantations of cashew nut and red sanders could be seen. The material is a well weathered colluviurn with stone layers separating successive contributory lobes. In each lobe, the basal horizon is usually constituted by a less weathered stone layer and the upper structure by a very well weathered colluvium.

Flwial plains

The river Swarnamukhi, Arani, and Ponnai have developed canspicuous flood plains which are likely to be inundated during peak flood periods. The plains relatively show law relief, A flood plain is usually built by later deposits with an overlay of vertical accration of flood deposits (Leopold, 1957). The river built plains are utilized for cultivation of rice, sugarcane and banana, Old channels of river Arani could be traced on LANDSAT and due to the change of river courses fluvial terrances could also be traced.

Aeolian deposits

Patches of aeolian sands are recognised in between Madanapalli and Thamballapalli on the piedmont colluvial plains. The extensions of these deposits are very limited.

LINEAMENTS

An analysis of lineaments of the district denotes that NE-SW and NNE-SSW trending lineaments predominate and lie more or less parallel to the structural trends of the hilly terrain. The district possesses hard rock terrain and therefore due importance has to be given to study the lineaments traced from LANDSAT for excavation of groundwater resources. The prominent hills, namely, Mahendragiri, Palakonda, Velikonda, Chandragiri hills, Tirumala hills and Nagari hills are subjected to have low to moderate lineaments, The dominant trend on these parts of the hills is NE-SH and NNE-SSW. Similar lineaments are also traced on plain and upland regions. A careful analysis in the study of name of structural trend, topographic variations and drainage denote that some of the rivers are structurally controlled. For example, the river Poini in Chittoor town which flows to south-east found to be genetically controlled by a fault, lying parallel to the river course. From the study of lineaments, it may be concluded that 14 lineaments lie in between 0°-So to 26'-30° NE in direction having a cumulative length of 314.42 kms., 32 lineaments lie in between 31°-3S0 to 56'-6S0 NE in direction, with a total cumulative length of 823.04 km., and 4 lineaments in between 61°-65' to 71°-7S0 NE in direction with cumulative length of 102-40 km. The total number of lineaments in north-west direction is 22. Out of them, 12 lineaments lie in between 0°-5O and 26O-35O NW in direction with cumulative length of 222.93 km., 10 lineaments lie in between 3b0-40° to 56°-600 NW in direction with a cumulative length of 302.08 km., and only one lineament lies in between 80°-85 NW in direction with a length of 10.24 km. Further studies with the help of air photos and geophysical studies may throw light on the Neotectonics of the district.

Conclusion

The various landsystems, hilly terrain, undulating terrain, leveled plains and fluvial plains and landforms identified with the help of LANDSATS (F.C.Cs) aerial photographs,

geological maps and survey of India toposheet comprise the fluvial landforms(Rapids, waterfalls, pediments, pediplains, terraced plains, riverbuilt plains, flood plains and palaeo channels). The Aeolian lanforms(Tors and mounds, residual hills, taluscones/Talus and Debris slides) structural landforms (Escanpments and landslides) and fluvial-colluviallandforms(Washplainsandcreepbuiltplains).Mostofthe plains in the study area are "creep-built plains', "wash plains", "pediment plains" and "fluvial plains', which hardly supports the agricultural development of the area.

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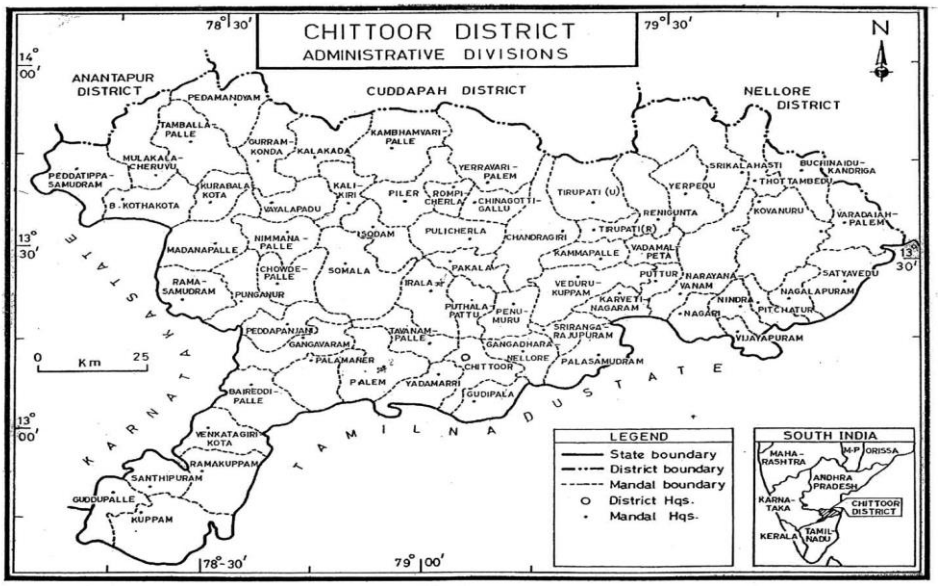
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Study Area Map



A comprehensive approach using remote sensing and geographic information systems (GIS) is proposed for the purpose of optimizing water resources in the Tirupati Revenue Division, located in the Chittoor District of Andhra Pradesh.

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Abstract: This research highlights the imperative need for the implementation of strategic water resource management strategies in order to address the increasing water scarcity resulting from population increase, industrialization, and urban development in the specific geographical region under investigation. The proposal suggests the implementation of small-scale projects along the Swarnamuki river belt with the objective of improving water resources for agricultural development in areas with high concentrations of water bodies in the eastern region, as well as addressing anticipated storage deficiencies. By using satellite data and the METRIC approach, this study computes the evapotranspiration (ET) for the Tirupati region, therefore uncovering significant water requirements for crops such as sugarcane. The research provides support for the use of drip and sprinkler systems as new irrigation technologies, emphasizing their potential to effectively reduce water usage. Furthermore, it proposes the use of drip irrigation techniques for sugarcane cultivation and the adoption of the System of Rice Intensification (SRI) for paddy farming as effective measures to mitigate water wastage, emphasizing the need of flexible agricultural approaches. In general, the research offers significant insights into irrigation methods that may effectively reduce water wastage and improve agricultural output, so making a vital contribution to the sustainable management of water resources.

1. Introduction:

Water supplies are being put under strain as a result of population growth, industrialization, and urbanization. Water scarcity is caused by factors such as large fluctuations in annual and inter-annual rainfall, ineffective infiltration, low hydraulic conductivity and storitivity, and high evaporative demand. The development and management of watersheds involve optimal use of water, land, and biomass resources in order to satisfy fundamental necessities in a manner that is environmentally sound. In order to accomplish this goal, runoff and soil loss must be reduced, and infiltration must be increased. Saving water can be accomplished by lowering surface runoff, increasing infiltration rates, and constructing buildings that are suited to their environments. Thematic data can be generated and analyzed with the use of remote sensing and GIS. However, remote sensing provides frequent synoptic coverage of the ground surface, which can be easily researched and represented in GIS. This is a significant advantage. For the purpose of runoff computation, it may include information on land utilization, land cover, and terrain topography (elevation, slope, and drainage network). Therefore, geospatial techniques may be used to select water harvesting sites in order to maximize the availability of surface and ground water for irrigation, domestic usage, and other purposes (Krishnan & Sankararajan, 2021).

The most severely impacted industry across the board is agriculture due to the global water crisis. Seventy percent of the world's freshwater is used for agriculture. Water is essential to the production of food. Since the production of biomass requires a significant amount of water, we could argue that agriculture is both the source of and a victim of water scarcity. The rising demands brought on by population growth come at

a high cost to the environment. The supply of water and the demand for it, in addition to agricultural practices, could be impacted by climate change and the generation of bioenergy. Agriculture, both rain-fed and irrigated, is impacted by climate change because of the way it alters hydrological regimes and the availability of freshwater (López-Mata et al., 2019). There has been an increase in temperature, as well as increased rainfall variability, semi-arid regions have seen a decrease in precipitation, while temperate regions have seen an increase in rainfall. This has a particularly negative impact on agriculture in tropical and subtropical regions. River runoff and aquifer recharge both have an effect on the amount of water that is available and enhance the demand that humans place on water resources.

Water is scarce in India since the country has 16% of the world's population but just 4% of its pure water supply. Irrigation accounts for the majority of water consumption. Agriculture consumes up to 80 percent of the world's fresh water resources. Irrigation uses up roughly 80 percent of India's available water resources. Given its size of 3.3 million square kilometers and annual rainfall of 1170 millimeters, it is estimated that India has water resources equal to 4,000 cubic kilometers. Over half of this water is lost through processes such as evaporation, percolation, and underground flow to the oceans, which leaves 1953 billion cubic meters (BCM) of water that can be accessed. According to Phansalker and Verma (2005), the amount of water that is available varies, bringing the total down to 1086 BCM. It is anticipated that by the year 2025, the Annual Water Resource will have decreased to 1496 cubic meters, from 2214 cubic meters in 1996. According to (Gulati et al., 2009) findings, just 25 percent of the water resource that is available has been developed

2. Materials and Methodology

Crop evapotranspiration refers to the combined process of evaporation from the soil surface and transpiration from plants. It is a ETc, or reference evapotranspiration, is a fundamental parameter used in the assessment of crop water needs and the development of effective irrigation management strategies. In this study, the estimation of crop evapotranspiration (ETc) was conducted using a combination of satellite-derived reference evapotranspiration (ETo) and the crop coefficient (Kcb) technique. Following the pre-processing of satellite pictures, the estimation of ETc was conducted over the whole of the research region. The FAO-56 technique is often used for calculating evapotranspiration (ETo) and is frequently accessed via the Google Earth Engine Flux (EEFlux) webpage on a daily basis. The estimation of the basal crop coefficient (Kcb) is conducted via the use of the normalized difference vegetation index (NDVI) in relation to Kcb. The procedure for this estimation is elucidated as follows.

2.1 Data Used

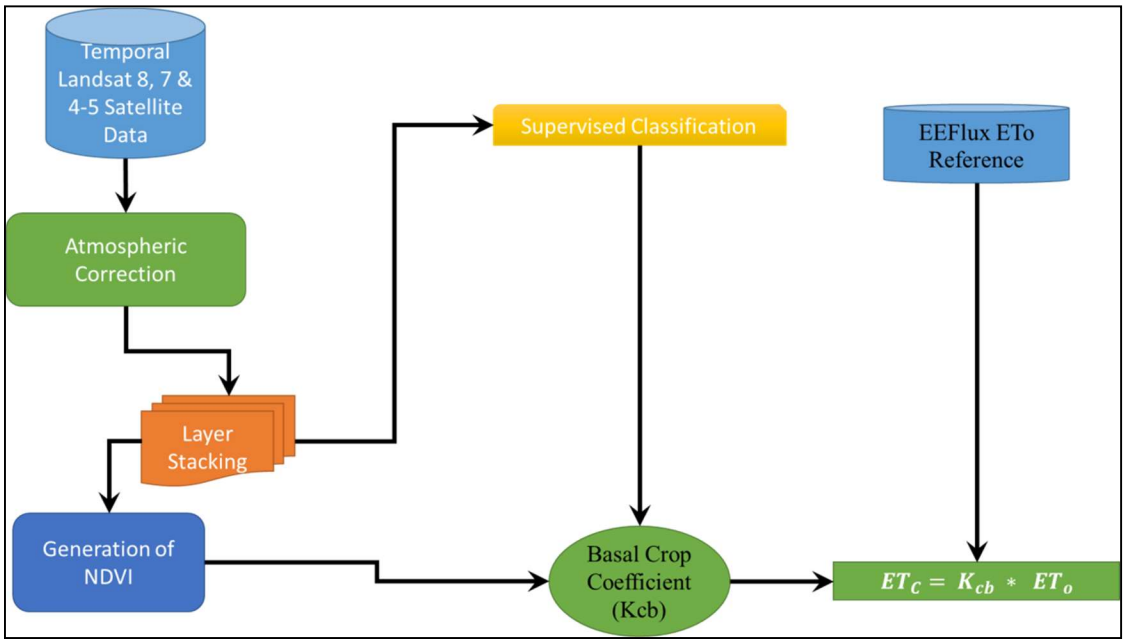
In order to accomplish the purpose of the current study, the researchers used several satellite products, supplementary data, and software tools.

Remote sensing data refers to the collection of information about an object or phenomenon from a distance, often using sensors or instruments.

The satellite dataset used in this work is shown in Table 1. Specifically, Landsat 8, 7, and 4-5 data were employed throughout the pre-monsoon and post-monsoon periods of the years 1997, 2008, and 2016.

S. No	Data Type	Date of Acquisition	Resolution	Source
1	Landsat - 8	April 2016 December 2016	30 m	https://earthexplorer.usgs.gov/
2	Landsat - 7	April 2008 December 2008	30 m	
3	Landsat 4-5	March 1997 December 1997	30 m	
4	METRIC (ET reference)	April 2016 December 2016	30 m	http://eeflux-level1.appspot.com/

Table 1 : Details of satellite data products used in this Study



Methodology flowchart

2.2 Ground Measurements

GPS coordinates were collected from study area for the sample sites for accurate identification of particular locations and for further analysis. Ground measurement site map is shown in figure 1.

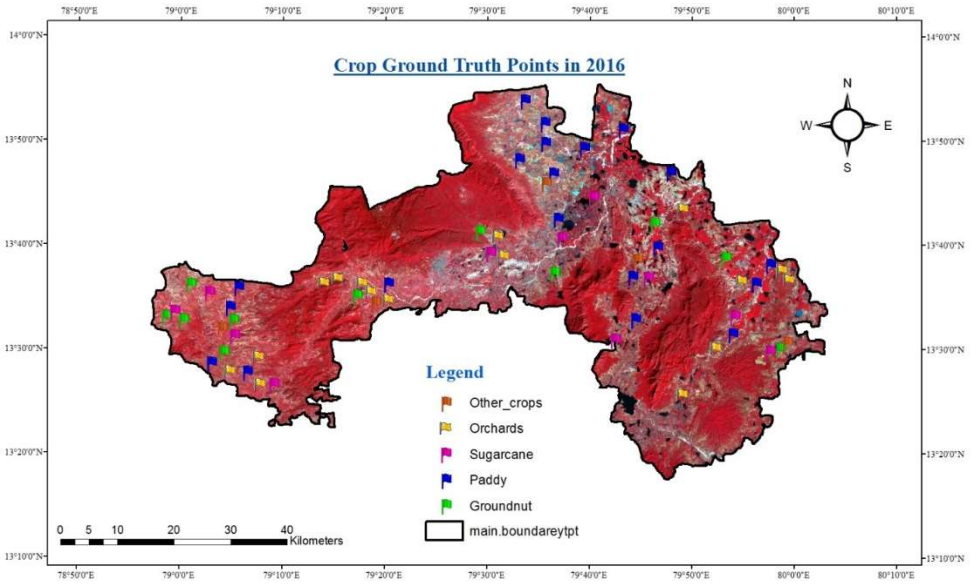


Fig 1: Ground truth measurement site map

2.3 Basal Crop Coefficient

The approaches for determining crop coefficients play a vital role in the estimation of crop evapotranspiration (ETc) and the formulation of irrigation scheduling strategies. The use of generalized coefficients often necessitates the implementation of local adjustments, hence generating inherent uncertainty. Vegetation indices (VIs) obtained using remote sensing techniques, such as the normalized difference vegetation index (NDVI), provide immediate and valuable information on crop variability. There is a scarcity of research available that indicates the potential of vegetation indices (VIs) in accurately estimating the basal crop coefficient (Kcb). The primary objective of this work is to use NDVI measurements in order to estimate Kcb values, with the ultimate goal of enhancing irrigation water management.

$$K_{cb} = K_{cb\max} \frac{(NDVI - NDVI_{min})}{(NDVI_{max} - NDVI_{min})} \quad (1)$$

Where $K_{cb\max}$ is Basal crop coefficient and $K_{cb\max}$ is Basal crop coefficient at effective full ground cover i.e., 1.3 (Hunsaker, 1994)

2.4 Potential/ Reference Evapotranspiration

The use of the METRIC technique, in conjunction with Landsat data and the Google Earth Engine Evaporation Flux (EEFlux), offers a straightforward and precise means of estimating soil water storage

capacity at a spatial resolution of 30m. Notably, this approach does not need the use of soil or vegetation maps. The process of evapotranspiration (ET) is of utmost importance in the hydrological cycle, and it is significantly influenced by sun radiation. The Potential Evapotranspiration (PET), also known as grass reference Evapotranspiration (ETo), plays a crucial role as an agrometeorological parameter, contributing to water balance models and regional evaluations of water demand for rainfed agriculture. The PET product has a precision level ranging from 80% to 90%.

2.5 Crop Evapotranspiration

Crop evapotranspiration (ETc) is defined as the combined process of evaporation and transpiration from a healthy crop, cultivated in expansive agricultural areas with enough water and fertilizer supply (Ding et al., 2013). The estimation of crop evapotranspiration (ETc) plays a crucial role in the calculation of the soil water balance and the development of effective irrigation scheduling strategies. The behavior of ETc is influenced by weather patterns and the state of the crops. Mathematically, the expression for ETc may be formulated as

3. Results and Discussion

3.1 Water Harvesting Sites

Dams block water or subsurface streams. They retain, gather, and store water for equal distribution (Zhang et al., 2023). Worldwide, dams have provided agricultural and urban water for millennia (Chelshi, 2023). The appropriateness of a built dam type in a possible dam site is always questioned. Dam type appropriateness decisions may include trade-offs between various intangibles.

Many methods are used to identify water collecting locations. The most prevalent method, AHP, combined with remote sensing and GIS, provides a worldwide site selection notion (Jayswal et al., 2023). Water harvesting and recharge locations rely on terrain, climate, precipitation, soil porosity, stream order, catchment area, and slope. These characteristics are acquired from various sources, incorporated into the GIS environment using multi-criterion decision making, and the location is chosen. The table below lists water harvesting site selection criteria.

Structure	**Slope %**	**Porosity and permeability**	**Runoff potential**	**Stream order**	**Catchment area (*10^4 m^2)**
Farm ponds	0–5	Low	Medium/high	1	1–2
Check dams	<15	Low	Medium/high	1-4	>25
Subsurface dyke	0-3	High	Medium/low	>4*	>5
Gully plug	15-20	Low	High	1	-
Percolation pond	<10	High	Low	1-4	25-40

Table 2: Selection criterion used for water harvesting sites

3.2 Slope Role

Line slope specifies its steepness and direction. It calculated slope steepness. One of the most essential elements in choosing locations for water collecting structures like check dams is topography steepness and surface runoff potential.

The slope indicates topography, which helps choose water gathering sites. The slope % is defined according to Integrated Mission for Sustainable Development (IMSD, 1995) and Food and Agriculture Organization (FAO, 1977) recommendations for choosing water collecting location. Present area slope classifications are displayed in the figure. CartoDEM (30m resolution) is used to generate % slope map in ArcGIS surface tools.

The slope map provides significant data on the zone's steepness, allowing us to estimate spillover. The region's slope may be divided into seven slant classes: (a) ‘nearly level’ (0–1%), (b) ‘very gentle’ (1–3%), (c) ‘gentle’ (3–5%), (d) ‘moderate strong’ (5–10%), (e) ‘strong’ (10–15%), (f) ‘moderate steep’ (15–30%), and (g) ‘very steep’ (> Slope grades 'nearly level' and 'sensitive' are increasingly suitable for water collection.

3.3 Runoff Generation

Runoff potential depends on DEM slope. According to slope-based criteria for surface runoff production, slope categories will be graded from least to most suited, with steeper slope categories generating more runoff. Runoff potential is classified as ‘moderate’ (200-300 mm), ‘poor’ (100-200 mm), and ‘very poor’ (<100mm).

Proposed aircraft for water resource management research. With above prospects and previous chapter studies of drainage morphometry, land resources, and land use land cover analysis and GIS integration, acceptable and necessary proposals are presented to the research region. Slop is the main source of runoff, thus the Tirupati Revenue Division receives water and soil conservation site suitability maps from slop and existing water resources location study.

Building modest irrigation projects

Apart from its tributaries, the Swarnamuki River runs 80 kilometers in Tirupati Revenue Division. Detailed examination after even shows no irrigation project except Kalyani tributary river. This river has greater discharge than others when it rains more. This project using natural briars is low-cost and beneficial for agriculture and drinking water.

3.4 Building medium and minor check dams

With serious stream network analysis and runoff calculations, a location map was proposed for the constriction of check dams like rock bonds, concrete dams, and earth bounds, especially in the west due to water scarcity. More check dams in that region will help recharge ground water and meet agricultural water needs Farm pound digging and contour ditching from the vast area of research, it is difficult to identify potential locations, but GIS was used to extract barren and fallow land locations suitable for these types of

construction to recharge ground water and expand the agricultural mask. This structure is simple and affordable. This style is also suggested for agricultural land and will assist farmers. Fig.5.5 shows where to build farm pound and contour ditches.

3.5 Other water-saving methods Except from above, this area has additional water saving methods like fallows.

3.5.1. Reusing wastewater Tirupati Revenue Division's largest city produces more urban waste water. Industrial and associated uses of urban waste water may boost indirect agricultural development using waste water cleansing plants. As fresh water can be converted to agriculture, more irrigated land is feasible. However, adopting and managing it is more expensive, so the government may lead water conservation.

3.5.2. Modernized irrigation

Modern drip, sprinkler, and subsurface irrigation minimize water evaporation compared to surface irrigation. It also waters plants straight at their roots. Thus, water waste will decrease and production will increase. According to FAO, converting traditional irrigation methods to modern irrigation will increase the irrigated area by three times. A small attempt was made to irrigate the area with 100% modern irrigation methods using existing water.

The calculation of Evapotranspiration values was conducted during the pre-monsoon and post-monsoon seasons of 2016. This was done in order to provide accurate ground truth data on crop conditions for that specific year, enabling the categorization of crops for the same time period. The subsequent years, namely 1997 and 2008, were analyzed by referring to the District Hand Book and assuming ET values similar to those of 2016.

3.6 Pre-Monsoon Water Requirement

The reference data for evapotranspiration (ET) has been multiplied by the basal crop coefficient (Kcb). The following ranges of evapotranspiration (ET) were observed for the key crops during the Pre-monsoon season of 2016.

S.No	Crop	Range (mm/day)
1.	Groundnut	3.5 to 4.01
2.	Paddy	5.7 to 6.12
3.	Sugarcane	4.16 to 4.438
4.	Orchards	2.271 to 3.246

5.	Other Crops	1.545 to 2.116

Table 3: ET ranges in 2016 pre-monsoon

The Paddy crop exhibits a wider range of ET values during the pre-monsoon period in 2016, with Sugarcane and Groundnut following suit. The range of evapotranspiration (ET) values for orchard crops is quite low due to the prevalence of younger plantings, which constituted around 20% of orchard crops between 2008 and 2016, as reported in the handbook. Younger plants typically need less water during their first growth phases.

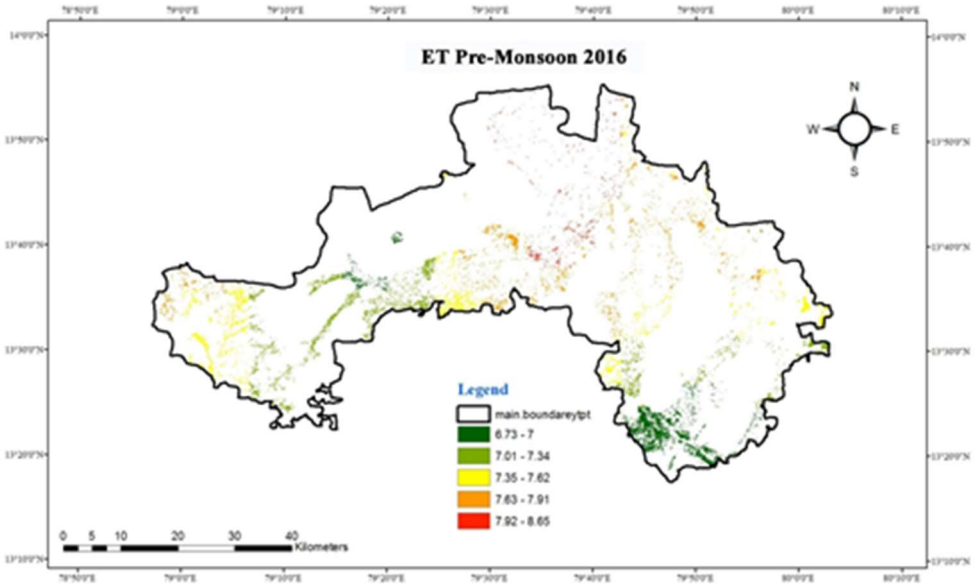


Fig 2. Evaporation in 2016 pre monsoon

The mean values of evapotranspiration (ET) for different crops are as follows: 3.76 mm/day for Groundnut, 5.91 mm/day for Paddy, 1569.14 mm/day for Sugarcane, and 2.76 mm/day for Orchards. The water consumption of the aforementioned crops per hectare, taking into consideration their respective growth periods, is as follows:

S. No	Crop	Growing Period	Average ET (mm/day)	Water requirement (mm/growing period)	Water requirement (cubic meter/ ha)
1.	Groundnut	140	3.76	525.70	5257.00
2.	Paddy	140	5.91	827.40	8274.00
3.	Sugarcane	365	4.30	1569.14	15691.35

4.	Orchards	365	2.76	1006.67	10066.70
5.	Other Crops	90	1.83	164.70	1647.00

Table 4 :Pre-monsoon average ET and water requirement per ha

Sugarcane, a significant agricultural commodity in the nation, necessitates a substantial amount of water over its whole growth cycle, which spans from 12 to 18 months. The specific duration of this cycle is contingent upon the agro-climatic areas, which range from sub-tropical to tropical. According to the Food and Agriculture Organization (FAO), the yearly water demand for this particular crop is within the range of 1500-2500 mm. The estimated yearly water demand for sugarcane in our research region is 1569.14 mm during a period of 12 months.

S. No	Crop	Water requirement (cubic meter/ ha)	Area (Ha) Pre monsoon			Total Water Consumption (Million Cubic meter/Total Cropped Area)		
			1997	2008	2016	1997	2008	2016
1.	Groundnut	5257	21348	419	3326	112.23	2.20	17.48
2.	Paddy	8274	22774	2252	3132	188.43	18.63	25.91
3.	Sugarcane	15691	8653	4475	4992	135.78	70.22	78.33
4.	Orchards	10066.7	7563	8463	10402	76.13	85.19	104.71
5.	Other Crops	1647.	7201	796	1090	11.86	1.31	1.80

Table 5: Pre-Monsoon Water requirement and Consumption for different crops

3.7 Post-Monsoon Water Requirement

The ET reference data has been multiplied by the basal crop coefficient (Kcb). The following information presents the range of evapotranspiration (ET) values for the key crops during the post-monsoon season of 2016.

S.No	Crop	Range (mm/day)
1.	Groundnut	3.42 to 3.76
2.	Paddy	5.538 to 5.914
3.	Sugarcane	3.84 to 4.564
4.	Orchards	2.193 to 3.346
5.	Other Crops	1.21 to 1.896

Table 6: ET ranges post-monsoon

The range of evapotranspiration (ET) values for the aforementioned crops varies from 1.21 to 5.91 mm/day, with the maximum ET being reported by the paddy*:*

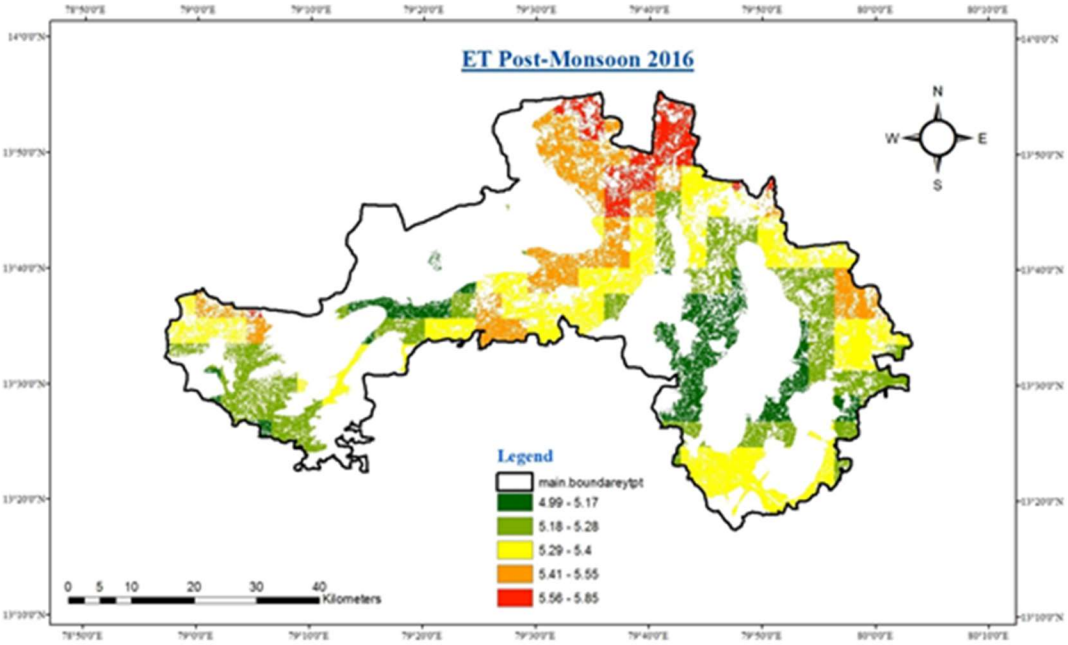


Fig 3. Evapotranspiration in 2016 post monsoon

S.No	Crop	Crop Period	Water Requirement Avg. Value (mm/day)	Water requirement (mm/crop period)	Water requirement (cubic meter/ ha)
1.	Groundnut	140	3.59	502.60	5026.00
2.	Paddy	140	5.73	801.64	8016.40
3.	Sugarcane	365	4.20	1533.73	15337.30
4.	Orchards	365	2.77	1010.87	10108.68
5.	Other Crops	90	1.55	139.77	1397.70

Table 7: Post-monsoon average ET and water requirement per ha

The groundnut crop exhibits an average evapotranspiration of 3.59 in its third position during the post-monsoon season, with a water need of 5026 cubic meters per hectare. The rice crop has the greatest average evapotranspiration (ET) value, whereas sugarcane surpasses it in terms of water

need, with a daily rate of 15331.3 mm/day. This is due to the longer growth time of sugarcane compared to paddy.

S.No	Crop	Water requirement (cubic meter/ ha)	Area (Ha) Pre monsoon			Total Water Consumption (Million Cubic meter / Total Cropped Area)		
			1997	2008	2016	1997	2008	2016
1.	Groundnut	5026.00	26384	20594	20594	132.61	103.51	103.51
2.	Paddy	8016.40	38414	44440	34440	307.94	356.25	276.08
3.	Sugarcane	15337.30	8653	4992	5732	132.71	76.56	87.91
4.	Orchards	10108.68	7563	8463	10402	76.45	85.55	105.15
5.	Other Crops	1397.70	37599	32765	22382	52.55	45.80	31.28

Table 8: Post-Monsoon Water requirement and Consumption for different crops

The water consumption for high water need crops, such as paddy, saw a drop in 2016 as compared to the levels seen in 1997. This occurrence may be attributed to a decline in the overall cultivated land area. Nevertheless, under the provided cropping plan, rice cultivation continued to occupy the top position. The total area under cultivation is mostly allocated to crops other than paddy. However, if the current tendency persists, there is a possibility of further reduction in the cultivated area for paddy, perhaps leading to its replacement by other crops such as orchards, which have shown an increasing trend in cultivated area over the years. Hence, the adoption of System of Rice Intensification (SRI) may be considered for paddy farming, while the implementation of drip irrigation can be recommended for sugarcane production, with the aim of mitigating excessive water consumption in both agricultural practices.

3.8 Other important factors in growth performance of agriculture sector

3.8.1 Fertilizers Consumption

Soil productivity increases with proper fertilizer and manure application. From 2007 to 2016, Tirupati Revenue Division consumed more fertilizers, as seen in Fig. 5.10. Urea, NPK, DAP, and others are used 76, 25, 95, and 200 percent more. Chemical fertilizers have helped farmers grow crops since the 1930s. Chemical fertilizers can cause stream pollution, crop burn, air pollution, soil acidification, and mineral loss. Farmers in these regions should limit fertilizer use and switch to organic farming to naturally increase soil fertility.

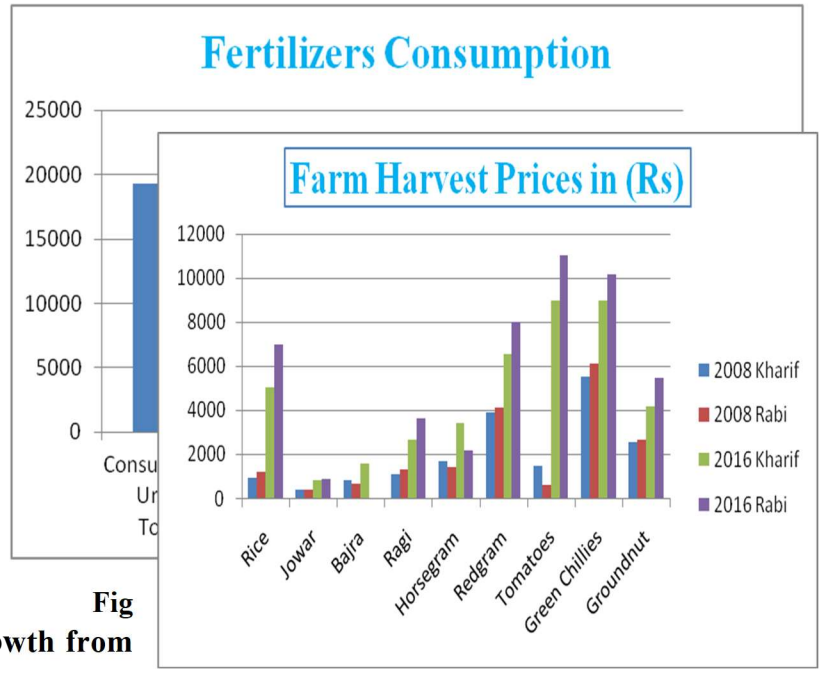


Fig 4. Fertilizers consumption growth from 2007-2016

3.8.2 Farm Harvest Prices

Agricultural harvest prices include product and input prices at various marketing phases. In India, the government's agricultural price strategy tries to ensure growers receive fair prices to stimulate investment and productivity. Annual minimum support prices for main agricultural goods are set after considering Commission on Agricultural Costs and Prices recommendations. In real life, harvesting prices are rising double and triple but minimum support rates are not, so farmers are converting to laborers and losing agricultural land. Fig 5.11 displays agricultural crop harvest prices. Massive increases lead to agricultural deficits. The government will disclose the minimum support price as rates rise.

Fig. 5 Farm harvest prices growth from 2008-2016

3.8.3Agricultural Credit

Each economic sector relies on credit. Farmers need credit for investment and working capital. Poor investment credit hinders HYV seed expansion and optimal input use. Like other sectors, agriculture needs easy, appropriate, and timely credit. Even though India has several Rural Financial Institutions (RFIs), the formal banking industry neglects a substantial percentage of the rural population. However, formal Indian banks have rigid credit flows and security-based lending. Additionally, "Long gestation period, lack of educated technical staff to discover potential activity, inadequate eligibility, and security issues contribute to limited loan flow to agriculture. For agriculture financing to move quickly, it must be fixed.

3.8.4 Irrigation system

The Revenue Division's agriculture and allied operations require irrigation, thus the study area's needs must be met. Modern drip, splenkar, and tube well irrigation increases, as seen in Fig.5.12. It is good, but only 10–15% of the remaining land uses traditional methods, which require more water. The irrigation system in this income division has to be changed.

Fig. 6 Irrigation system growth from 1997-2008-2016

3.8.5 Agricultural literacy

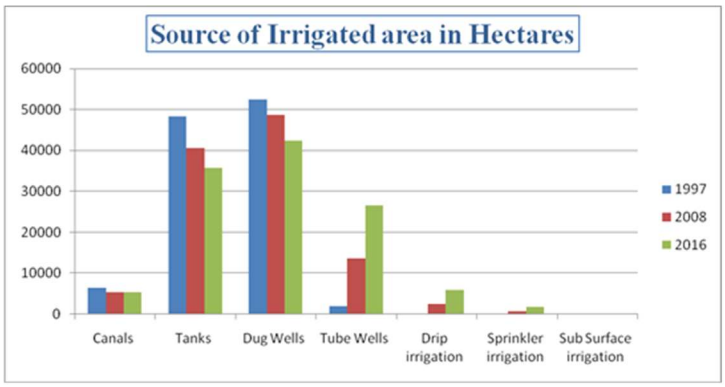
Agricultural literacy involves critical thinking and value judgments regarding agriculture's economic, environmental, and social and political impacts. An agriculturally literate person can assess “trade-offs” to people and society from agricultural activities. Decisions and values shape agricultural content. The ability to discuss and make decisions about societal choices shows agricultural understanding.

However, the Revenue division does not have clear statistics on this, and most of the area is rural, and I have seen little agricultural literacy. Thus, farmers must be educated through street performances, night schools, and other techniques to use technology immediately.

3.8.6 HYV, SRI and Mechanization

Modern methods and technology including high-yielding variety (HYV) seeds, tractors, irrigation infrastructure, herbicides, and fertilizers transformed Indian agriculture into an industrial system during the Green Revolution. Mostly found by M.S. Swaminathan. The Green revolution, started by Norman Borlaug, used agricultural research and technology to boost output. Implementation of high yields variety is not complete in study area.

The System of Rice Intensification SRI maximizes farmers' land, labor, and capital returns by lowering their seed, water, and labor needs. This boosts their incomes and helps the environment. SRI plants are resilient to water stress, storm damage, pests, and diseases, which is needed as climate change threatens. This skill may grow in importance. According to the divisional agriculture officer interview, the revenue division has practiced fewer than 20 to 30 hectors of SRI during the past five years. Thus, ground-level technological deployment is crucial for water and agricultural sustainability.



The income division is improving as mechanization continues, but the percentage is low. According to the district statistical handbook, the improvement from 10 years is only 15 to 20% in all types of mechanization. The research region did not properly implement technological mechanization including harvesting machinery and cultivator’s machinery save for land ploughs and electrical pump sets.

3.8.7 Agricultural research staff and centers

The study region had 1–2 agricultural staff per mandal and little technical staff, who were mostly involved in administrative tasks. Most of the study area lacks time to solve basic difficulties. The Southern Zone headquarters, Regional Agricultural Research Station (RARS), Tirupati, is one of two research stations in the study area. The station is 7 kilometers from Tirupati on the Tirupati–Chittoor route. The station was founded in 1979 to research groundnut and groundnut-based agricultural systems, soil and water management, pulses, biofuels, watershed management, and fodders. By 2011, RARS, Tirupati had established Agricultural Polytechnic College in addition to research. Institute of Frontier Technologies was founded in RARS, Tirupati with modern infrastructure and lab facilities to explore biotechnology, bioinformatics, nanotechnology, bio control, soil and water analysis, and quality analysis. The university and Tirupati's best labs are at this institute. Another research station is Krishi Vigyan Kendra, Vanasthali, in Renigunta mandal near Karakambadi. Has district-level Farm Science Centers created by the Indian Council of Agricultural Research (ICAR), New Delhi to speed up technology transfer to farmers. These centers transfer cutting-edge agricultural technologies to end users to boost production and productivity. It collaborates with other agencies. Farmers are interacting with both research sites and answering their agricultural questions. Research is also being implemented locally.

4. Conclusion

In conclusion, the research emphasizes how urgently the study region requires strategic water resource management, in particular as a reaction to the concentrated distribution of current water bodies in the eastern side and the expected gap in water storage projects. The plan that has been presented places an emphasis on the building of modest projects along the Swarnamuki river area. The goal of the strategy is to strengthen water resources in order to facilitate increased agricultural production.

In addition, a technique that is based on remote sensing is used in the research to estimate the amount of evapotranspiration (ET) that occurs in the Tirupati Region. The use of the METRIC method makes it easier to calculate ET values for a variety of crops throughout the pre-monsoon and post-monsoon seasons in the year 2016. The results highlight the enormous water needs of crops such as sugarcane, calling for novel irrigation techniques such as micro-irrigation, with drip and sprinkler systems displaying significant water consumption savings. The findings also call for innovative irrigation strategies such as micro-irrigation.

According to the findings of the study, there is a possibility that excessive water consumption may be reduced by applying the System of Rice Intensification (SRI) for paddy farming and by boosting drip irrigation for sugarcane. In addition, the research identifies fluctuations in farmed areas across various types of crops, which indicates the need for adaptable agricultural techniques. In general, the study produces useful insights for the management of water resources in a sustainable manner, and it argues for the use of contemporary irrigation practices in order to improve water usage efficiency and agricultural yields in the area.

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Quantifying Crop Water Consumption and Stress Patterns in Bagpath District, Western Uttar Pradesh: A Comprehensive Analysis Using Multidate Resourcesat Satellite Data

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Abstract

This research utilizes remote sensing techniques and incorporates NDVI-based classification methods to estimate crop evapotranspiration (ETc) in the region of Bagpath, located in Western Uttar Pradesh. The approach employs NDVI profiles to accurately map sugarcane-wheat and rice-wheat cropping systems, achieving an accuracy of 86.86% for Kharif crops and 79.72% for Rabi crops. The potential evapotranspiration exhibits seasonal variations, characterized by significant peaks in Kcb values between the months of September and February for both systems. The research examines the variation in ETc, ranging from 3.09 to 6.87 mm day−1, throughout the period of June 2017 to April 2018, with a specific focus on the water requirements for cultivating sugarcane. The dynamics of water stress, as shown by WS_LSWI data, exhibit a correlation with the various phases of crop development, therefore emphasizing the influence of harvesting operations on the levels of water stress.

1. Introduction

Agriculture has significant importance across all economic sectors due to its susceptibility to water constraint. At present, the agricultural sector is responsible for around 70% of the total worldwide freshwater withdrawals. Water has a pivotal role as an essential element in the process of food production. Given the substantial water transpiration demands associated with biomass production, it would not be inaccurate to assert that agriculture serves as both a catalyst and a casualty of water shortage. The exponential increase in population has resulted in significant environmental consequences due to the escalating demands placed on natural resources. The potential effects of climate change on water supplies and water demand, as well as the influence of bioenergy generation on agriculture, are subjects that now lack certainty. Climate change has the potential to modify hydrological patterns and the accessibility of freshwater resources, hence affecting both rain-fed and irrigated agricultural practices (FAO, 2008; FAO, 2011a). There has been seen an augmentation in precipitation levels within temperate regions, along by a decline in precipitation within semi-arid areas. Additionally, there has been noted a heightened variability in the distribution of rainfall, coupled with an overall rise in temperature. The aforementioned factors have a distinct influence on agriculture in tropical and sub-tropical regions. Changes in runoff in rivers and recharging of aquifers have a significant impact on the availability of water, hence exacerbating the strain on water resources caused by human activities.

India has a significant scarcity of water resources, as it accommodates around 16.0 percent of the global population but possesses just 4.0 percent of the available fresh water suitable for use. The irrigation industry is the largest consumer of water resources. Approximately 80% of the global water resources are allocated for the purpose of irrigation. In India, irrigation accounts for almost 80% of the used water resources. The projected water resources of India amount to 4000 cubic kilometers, based on the country's geographical

size of 3.3 million square kilometers and an average annual rainfall of 1170 mm. Approximately half of the water undergoes various processes such as evaporation, percolation, and subterranean flows towards the seas, resulting in a loss. Consequently, only a total of 1953 Billion Cubic Meters (BCM) of water is accessible. According to Phansalker and Verma (2005), the presence of water is subject to temporal and spatial fluctuations, resulting in a further reduction to 1086 BCM. According to estimates, the Annual Water Resource, which measured 2214 cubic meters in 1996, is projected to decrease to 1496 cubic meters by the year 2025. According to Gulati et al. (2005), the Developed Water Resource (DWR) accounts for about 25% of the total accessible water resource.

Low water availability limits plants. Stomata regulate plant water, oxygen, and carbon dioxide flow. Water stress causes stomata to shut to save water, limiting the oxygen, water, and carbon dioxide exchange route and decreasing photosynthesis (Porporato et al., 2001). Thus, water stress affects leaf development more than root growth because roots can adjust. Reduced photosynthesis due to water scarcity reduces crop growth and development. Soil moisture, canopy temperature/evapotranspiration (ET), leaf water content, and LWP affect crop water stress.

Water stress detection helps farmers reduce output losses. Remote sensing and ground-based methods may identify water stress.

Traditional stress assessment methods include predawn leaf water potential (Dixon, 1914), leaf pigment concentration (Lichtenthaler, 1987), leaf chlorophyll fluorescence (Muller, 1874) and ET (Priestley and Taylor, 1972). Predawn leaf water potential estimation employs pressure chamber. This method has measured tree and shrub water relations for 40 years. Manual operation is sluggish and laborious. Leaf water content approach analyzes plant water status by measuring relative leaf water content. Most plant water is in mesophyll cells. The ratio of fresh, dry, and turgid leaf weights determines relative leaf water content. This approach is time-consuming since the water potential difference between stressed and non-stressed plants is largest in the morning. Leaf pigment concentration approach assumes plant pigment concentration changes with species, phenology, and natural and human stress. Chlorophyll levels are higher in healthy plants and lower in stressed ones. Traditional chemical methods involve destructive sample and time-consuming laboratory studies, whereas chlorophyll meters are simple, portable, and fast. Leaf chlorophyll fluorescence is being employed to study photosynthetic equipment. This approach employs a portable optical equipment and fluorescence meter. Photosynthesis is dependent on light, water, and nutrients, which cause plant stress. Thus, this device is a useful diagnostic of plant stress because Chlorophyll fluorescence changes before tissue degradation is noticed in plants, allowing stress to be diagnosed before physical damage. The downside is that this method does not produce commercial instruments. Plant ET is measured with lysimeters.

All ground-based measurements can quantify plant water stress at ground level or local regional level, but not at large geographical scales like remote sensing. Either ground measurement can ground truth remote sensing applications.

Remote sensing for plant and environmental research became popular in the 1980s.Remote sensing provides accurate, quantitative, and timely crop condition data at a lower cost than field approaches (Shen et al., 2009). Remote sensing detects crop growth, stress, and assists agricultural development decisions (Shen et al., 2009). The spectral characteristics of vegetation are determined by leaf internal structure and elements like water, nitrogen, cellulose, and lignin absorption and scattering. Leaves' cellular structure and water content are identified in near and mid-infrared, while their colors are recognized in visible band.

Chlorophyll and water content are key plant stress indicators. Stressed flora has less chlorophyll, which affects leaf pigment light absorption. Therefore, it directly impacts plant spectral signature by lowering

green band reflection and increasing blue and red band reflection, modifying normal plant spectral signature. Thus, Visible, Near Infrared (NIR), SWIR, and TIR bands may detect water stress. Vegetation water stress index (VWSI) and Land Surface Wetness Index (LSWI) are SWIR and NIR indices (Ghulam et al., 2007), while Crop Water Stress Index (CWSI) and Water Stress Index (WSI) are TIR indices.

Precision agriculture depends on irrigation scheduling to avoid water stress and maximize production under restricted water circumstances, hence satellite monitoring of vegetation water stress is crucial. This research used optical data to diagnose sugarcane water stress in Bagpath, western UP.

2. Study Area

The study area includes Bagpath, located in Western Uttar Pradesh. The Western U.P region makes a significant contribution to the overall food grain output, accounting for 34 percent at the state level and 6 percent at the national level. The prevailing agricultural produce in this area is sugarcane.

The research region is situated within the latitudinal range of 28.8 degrees to 29 degrees and the longitudinal range of 77 degrees to 77.5 degrees. The western region is geographically demarcated by the presence of the Yamuna River, which serves as a natural boundary separating it from the neighboring states of Haryana and Delhi. The research was carried out in the Bagpath district located in western Uttar Pradesh.

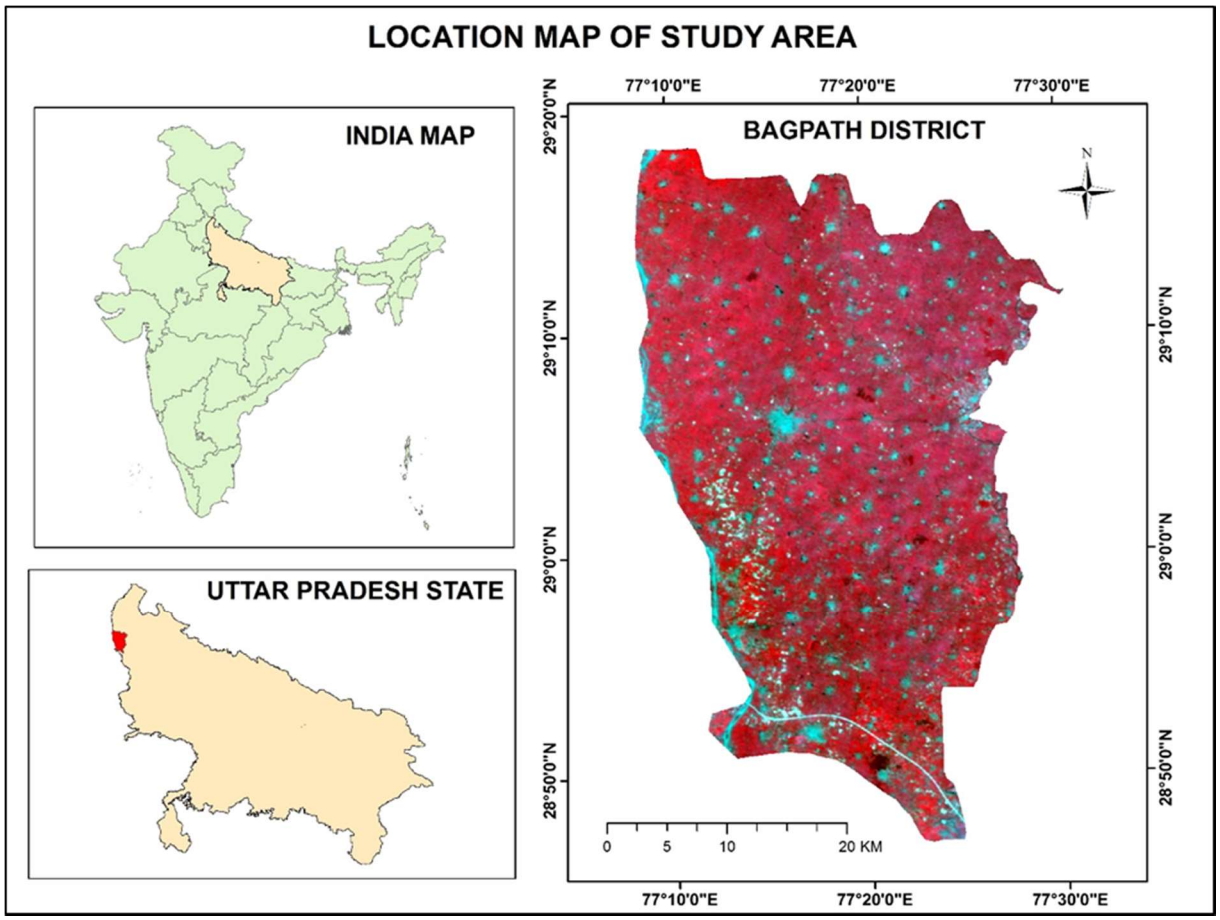


Fig 1. Location Map of the study area

2.1 Soils

Western UP soil is coarse-to-medium alluvium and somewhat alkaline. Their dark gray color indicates considerable organic matter. Loam and silty clay loam cover much of the terrain. 2016 (Nitika et al.)

2.2 Farming Method

Farmers' main business is crop production. This area also farms dairy. Agro-horticulture and agro-forestry are other growing agricultural industries in this area. Sugarcane dominates this region's commercial crop. Due to delayed sugarcane harvesting, wheat field preparation begins in November and lasts until the second week of December. Over 90% of land is irrigated wheat, which receives 4–5 irrigations. 2016 (Nitika et al.)

3. Materials and Methodology

Evapotranspiration of crops ETc provides the foundation for agricultural water needs assessment and irrigation control. This study evaluated ETc using satellite-derived ETo and Kcb. ETc was calculated for the whole research region after satellite image preprocessing. ETo is most often calculated using the FAO-56 technique, which is retrieved daily from MOSDAC. NDVI is used to determine the basal crop coefficient Kcb, as detailed below.

3.1 Data Used

Satellite products, supplementary data, and software were employed to fulfill the study's goal.

3.2 Remote sensing data

Table 3.2 lists the satellite dataset utilized in this investigation.1. AWIFS data was unavailable in February, March, and April 2018, hence Sentinel data was utilized.

S. No	Data Type	Date of Acquisition	Resolution
1	Sentinel-2A	25th April 2018 26th March 2018 14th February2018	10 m (Resampled to 56 m)
2	AWiFS	4thJune 2017 27th September 2017 17th October 2017 20th November 2017 18th December 2017	56 m

		30th January 2018	
3	INSAT-3D (PET_Daily)	8th April 2017 11th May 2017 4th June 2017 27th September 2017 17th October 2017 20th November 2017 18th December 2017 30th January 2018	5 km (Resampled to 56 m)
4	MOD04, 05, 08 Products	For Aerosal Optical Depth, Water Vapour and Ozone	Source Giovanni(Average value data)

Table 3.2 Details of satellite data products used in this Study

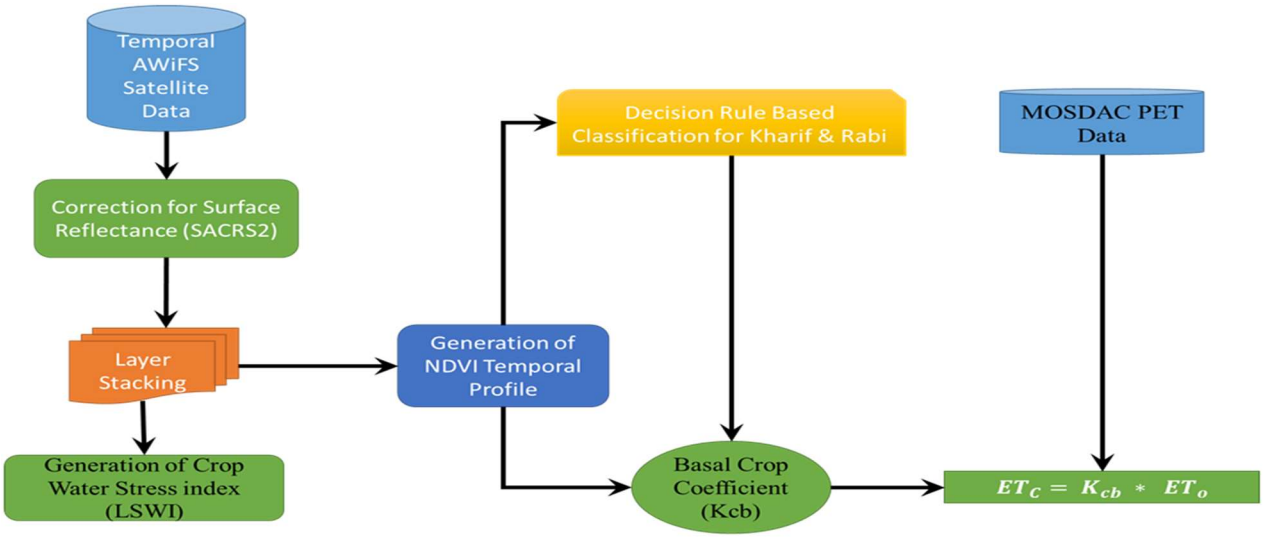


Fig 2. Methodology flowchart

3.3 Basal Crop Efficient

Estimating crop ETc for irrigation scheduling using crop coefficient methods is common. Generalized crop coefficient curves in the literature only estimate ETc for "optimum" crop conditions within a field, which must be modified for local conditions and cultural practices and adjusted for seasonal crop and weather variations. Thus, generalized crop coefficient uncertainties may lead to ETc predictions that are considerably different from real ETc, which might lead to poor irrigation water management. Crop attributes like percent cover and leaf area index may be modeled using vegetation indices (VIs) to quantify real-time crop fluctuations from remotely-sensed VI measurements. VIs can also predict the basal crop coefficient (Kcb) for maize and cotton, according to limited studies. This study estimated Kcb using NDVI measurements.

$$\boldsymbol{K_{cb}} = \boldsymbol{K_{cb\,max}} \frac{(\boldsymbol{NDVI - NDVI_{min}})}{(\boldsymbol{NDVI_{max} - NDVI_{min}})} \qquad (1)$$

Where $\boldsymbol{K_{cb\,max}}$ is Basal crop coefficient and $\boldsymbol{K_{cb\,max}}$ is Basal crop coefficient at effective full ground cover i.e., (Hunsaker, 1994)

3.4 Evapotranspiration potential

INSAT 3D is a geostationary meteorological satellite launched in 2013 as an exclusive INSAT spacecraft. This radiometer has four bands: wide VIS (0.52-0.75), SWIR (1.55-1.70), MIR (3.8-4.0), WV (6.5-7.0), and thermal TIR1(10.2-11.2), TIR2 (11.5-12.5) with 19 sounder channels. VIS and SWIR have 1 km x 1 km spatial resolution, whereas MIR, WV, and two thermal IR bands have 4 km x 4 km. INSAT Meteorological Data Processing System (IMDPS) automates ‘full-globe’ and ‘sector’ data products in all bands at half-hour intervals at 4 km spatial resolution. Daily purchases are limited to 48.

Evapotranspiration (ET) drives the hydrological cycle. ET is unique in its position as a link between the energy and water cycles. Solar radiation, wind speed, air temperature, and vapour pressure deficit affect ETo. Solar radiation is the most sensitive, affecting ETo variability by 60-70%. PET, also known as grass reference ETo, is the quantity of water transferred per unit time to atmosphere from a water-non-limiting surface covered with evenly and actively growing short grass like Alfalfa. ETo is the atmospheric evaporative demand for a given climate. Water stress results from moisture deficiency. Reference Evapo-transpiration is a hydrological and agricultural variable. It is a crucial input in soil water balance models together with precipitation. Many of these models use daily or hourly evapotranspiration data to predict plant water needs. The regional water demand would vary by agroclimatic conditions and agricultural season. Space rainfall and ETo may enable rainfed agriculture monitor water shortfall and excess throughout growing season. PET product accuracy is 80-90% (INSAT-3D Manual, 2015).

3.5 Crop Evaporation Transmission

Crop ETc is the evapotranspiration of a disease-free crop produced in wide fields with plenty of water and fertilizer (Doorenbos and Pruitt, 1977). Calculating soil water balance and irrigation schedule requires ETc estimation. Weather and crop conditions determine ETc. ETc is mathematically represented as $\boldsymbol{ET_C = K_C * ET_O}$ (2)

Kc is the crop coefficient, which varies by crop and growth stage, and ETo is the reference crop evapotranspiration.

3.6 Land Surface Wetness Index

LSWI assesses stress using NIR and SWIR. This measure is sensitive to soil background and total vegetation liquid. LSWI was estimated using this equation:

LSWI=NIR-SWIR/NIR+SWIR (3)

Water stress scalar (Ws) was calculated using estimated LSWI (Xiao et al., 2005).

$$W_S = \frac{1-LSWI}{1+LSWI_{max}} \quad (4)$$

Where LSWI is pixel value and LSWImax is maximum pixel LSWI value for growth season.

4. Results and Discussion

4.1 Crop discrimination

Each crop has a distinct spectral signature, therefore remotely sensed data can distinguish crops. Typical crop spectral reflectance displays pigment absorption in visible area (0.62-0.68 m) and significant near infrared reflection owing to leaf cellular structure. Red absorption and near-infrared reflectance indicate crop health (Navalgund et al., 1991b).

A rule-based classification analysis identified and distinguished rice, sugarcane, and wheat crops from other land use/land cover groupings. Rule-based feature selection using basic mathematical logics is successful. For crop discrimination, AWiFS temporal NDVI was utilized to create rules based on NDVI values of

various seasons, such as September. The transformation NDVI*127.5+127.5 linearized NDVI values between 0-255 (Ray S S et al., 2000).

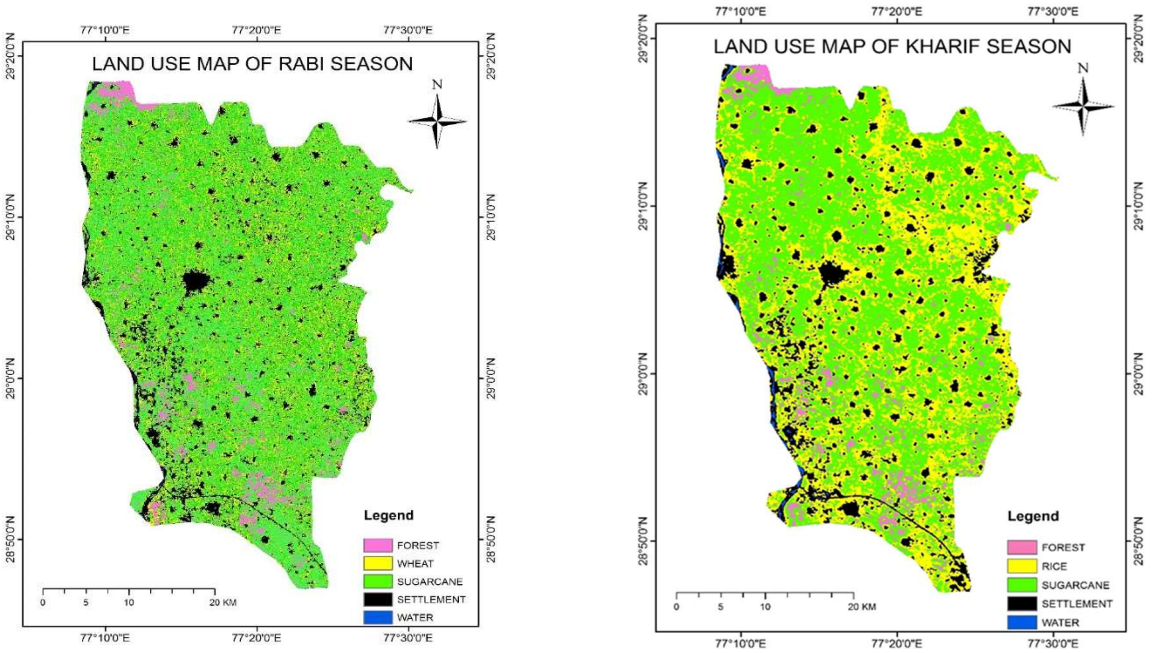
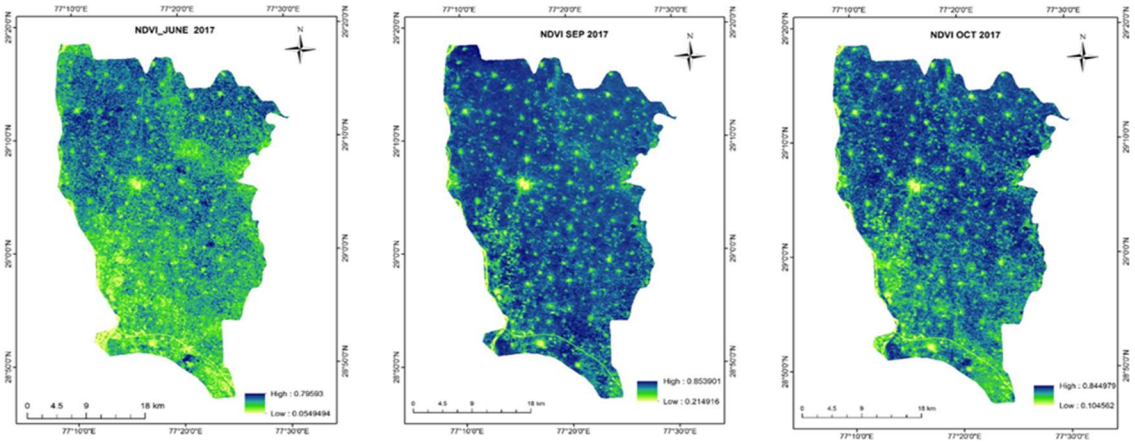


Fig 3. Shows the crop inventory map of Kharif Season & Rabi Season

4.2 NDVI Variation Throughout the Crop Season

A time-series of NDVI was created from all 9 AWiFS dates throughout crop growing seasons. Figure 4 show the 2017–2018 Kharif and Rabi NDVI temporal and geographical variance in the research region. NDVI peaks in November, whereas Rabi season (November–April) peaks in February. The greatest NDVI score indicates crop peak growth in Kharif and Rabi seasons. Kharif season had a higher average NDVI than Rabi season, perhaps owing to factors that accelerated crop growth: Higher rainfall (south-west monsoon), increased photosynthesis due to longer sunny hours, and wider crop area in Kharif season.



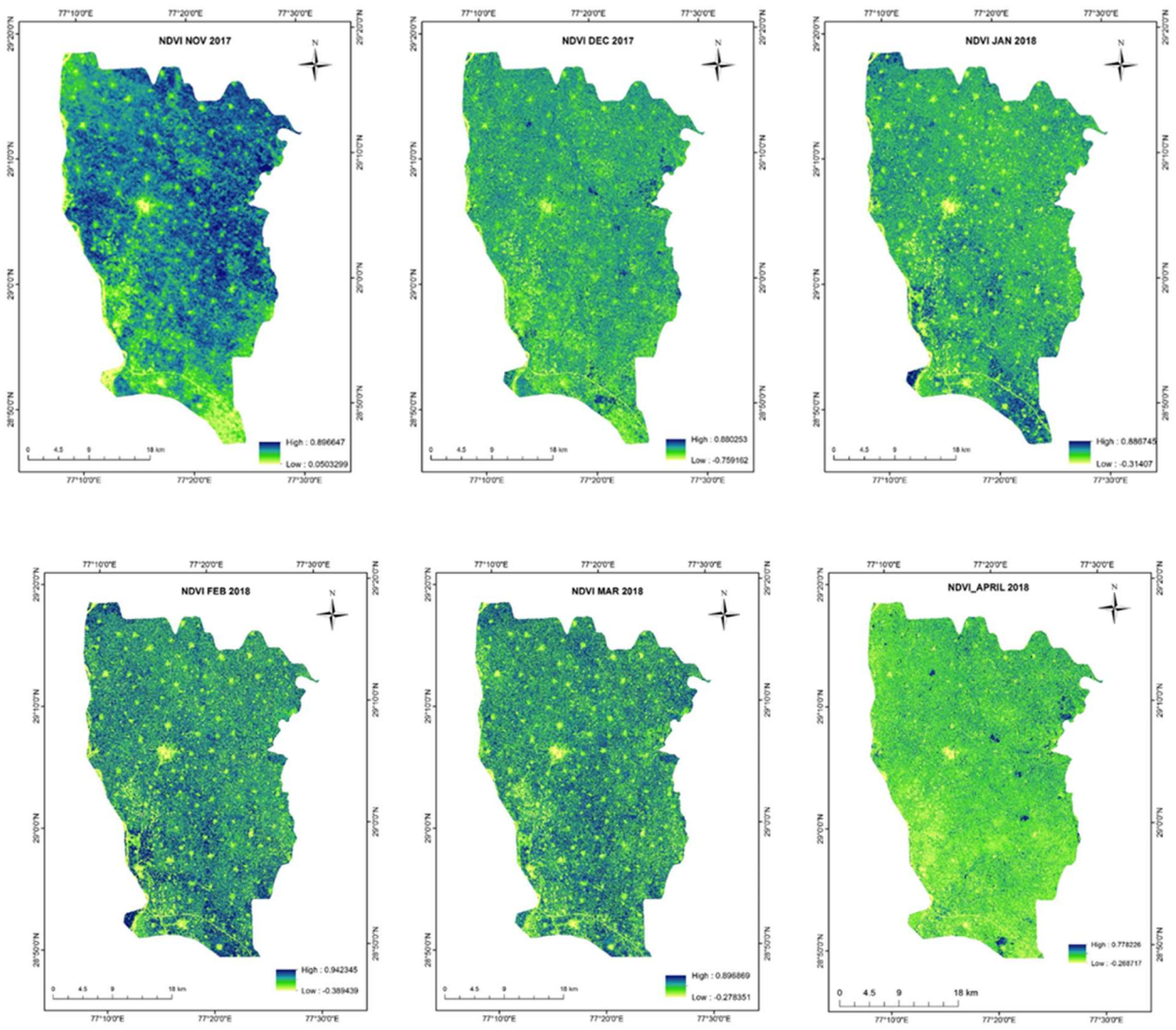


Fig 4. Spatial distribution of NDVI for June 2017 to April 2018

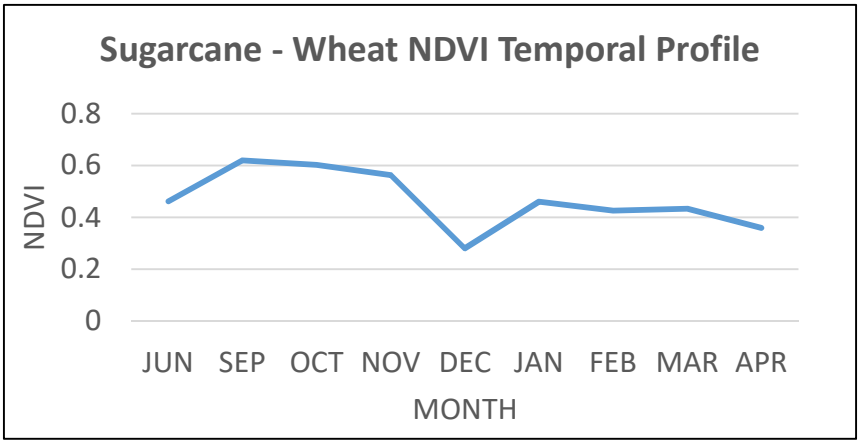


Fig 5. Temporal variation in NDVI for sugarcane–wheat cropping system

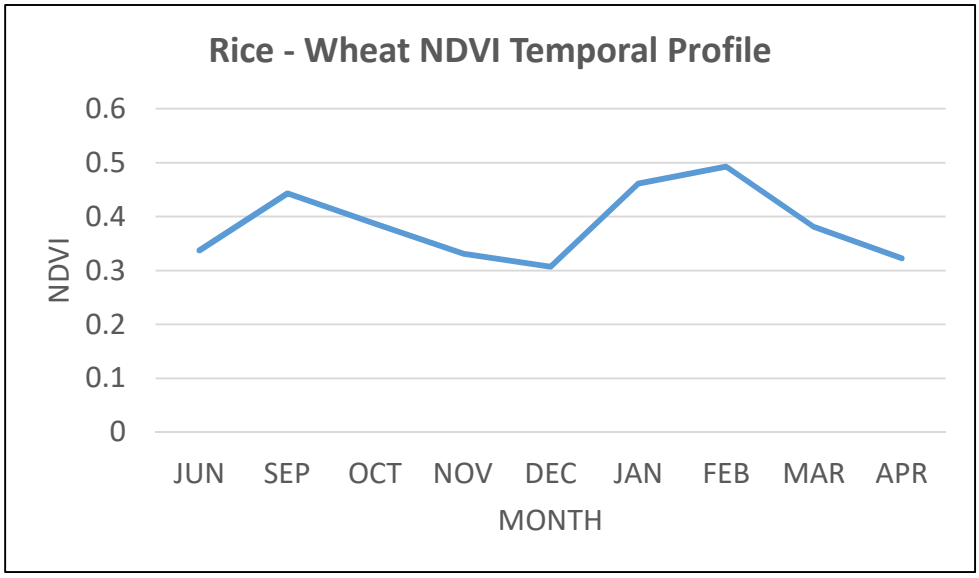


Fig 6. Temporal variation in NDVI for rice–wheat cropping system

The Normalized Difference Vegetation Index (NDVI) exhibited variability in relation to different crops and their phonological progression throughout the course of the growing season. The temporal fluctuations in NDVI for the sugarcane-wheat cropping system and the rice-wheat cropping system are shown in Figure 5 and 6, correspondingly. Figure 5.23 clearly demonstrates a decrease in NDVI values during December 2017. This decline corresponds to the development of wheat throughout the winter season after the harvest of sugarcane, as well as the early vegetative stage of sugarcane. The majority of the sugarcane crop was gathered in the month of December under the sugarcane-wheat agricultural system. Furthermore, a well-defined Normalized Difference Vegetation Index (NDVI) curve was found for the rice-wheat cropping system (refer to Figure 6). This curve clearly illustrates the trend of NDVI values while the rice and wheat crops undergo continuous phonological growth. These fundamental factors have effectively distinguished between the two systems. The observed NDVI patterns in this study exhibit similarities to the NDVI patterns reported by Kumari et al. (2013) in the context of sugarcane-wheat and rice-wheat cropping systems.

4.3 Basal Crop Coefficient

NDVI was used to derive the basal crop coefficient. The spatial representation of maps is below. Kcb and ETc fluctuated with crop and phenological development throughout the season, affecting crop water requirements. Fig.7 shows the temporal change of Kcb in Rice-Wheat and Sugarcane-Wheat cropping systems. Fig.7 show a fall in November and December 2017 owing to rice harvesting from Kharif season and a rise in Rabi season wheat transplanting. Rabi season adopts same profile. When temporal profile peaks, crop plant growth is maximum, hence water requirements are higher. The rice-wheat cropping system peaked in September and February with Kcb values of 1.2 and 1.23. In sugarcane-wheat cropping

system, Kcb temporal profile peaks in September and February with values of 1.24 and 1.03, although wheat peak value is low, perhaps because to mixed pixel combination with immature sugarcane plantings.

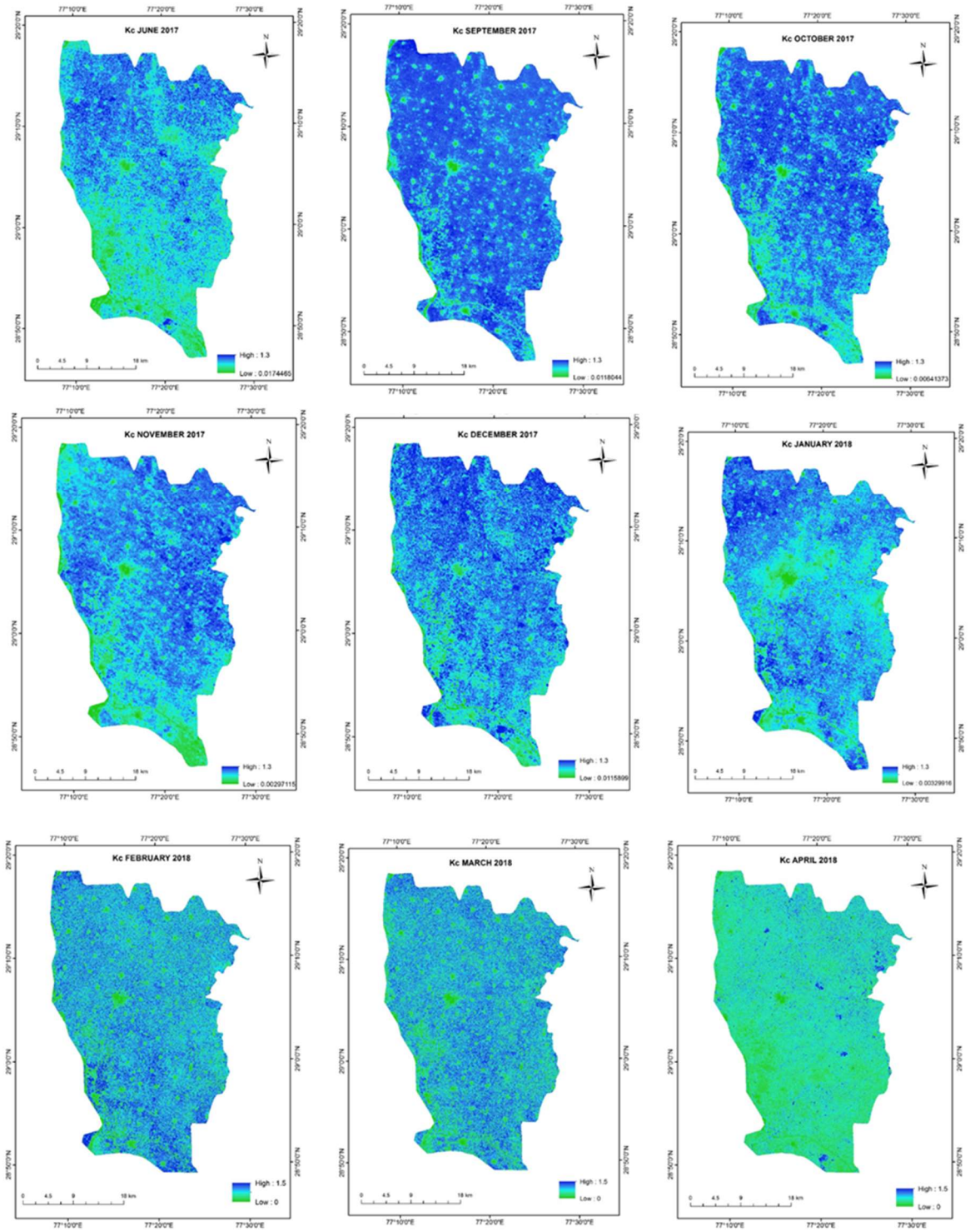


Fig 7. Spatial distribution of Kcb for June 2017 to April 2018

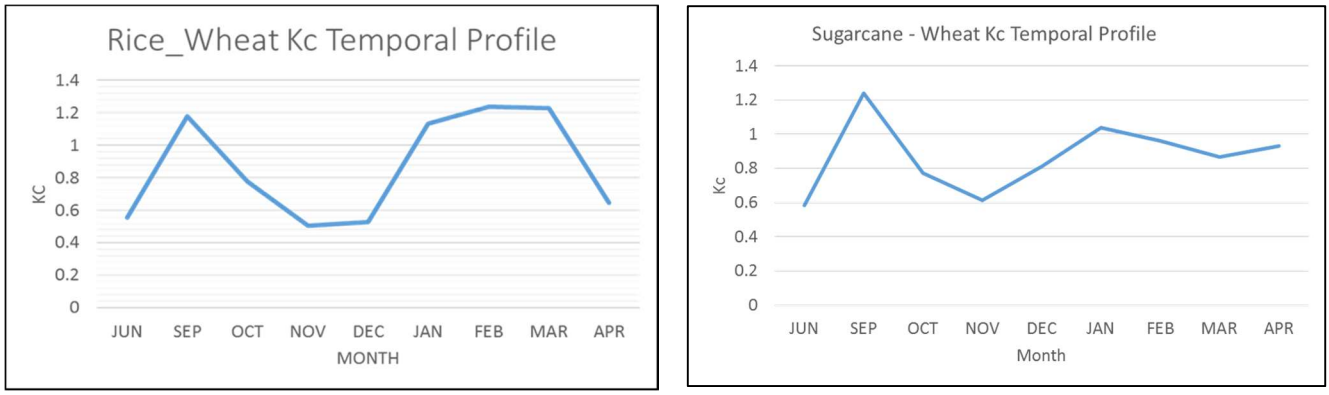
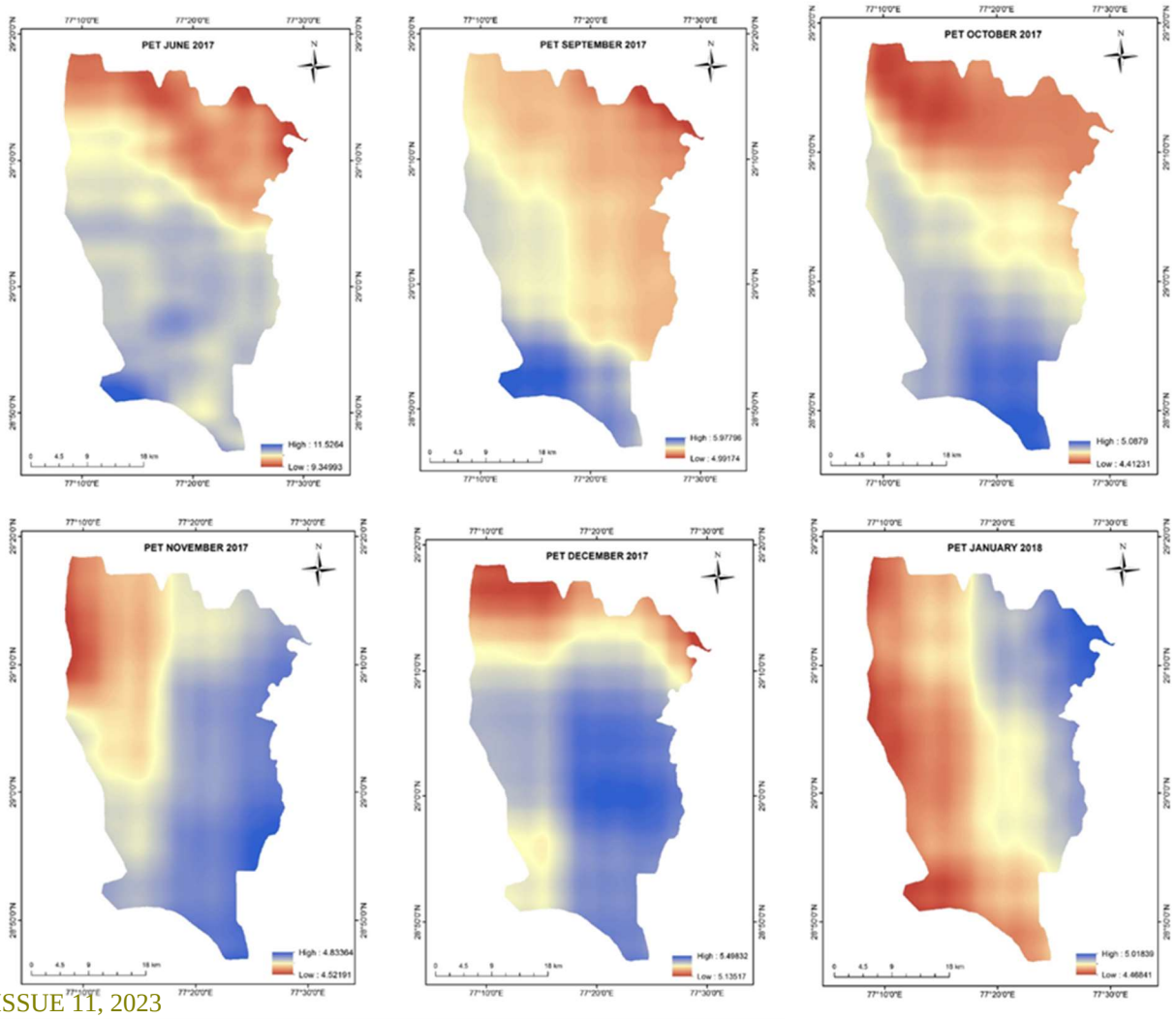


Fig 8 Temporal variation in Kcb for rice–wheat & sugarcane–wheat cropping system

4.4 Potential Evapotranpiration

The daily PET data downloaded from MOSDAC with a resolution of 5 km is resampled to 56 m resolution of AWiFS data. This is a daily average data product and the units of the PET data is in mm/day. The accuracy of the PET product is about 80-90% (INSAT-3D Manual, 2015). The temporal variation of daily PET as shown in figure 9. In Kharif and Rabi season the average value of PET in ranges between 4.41 to 5.91 mm/day and 3.30 to 5.42 mm/day



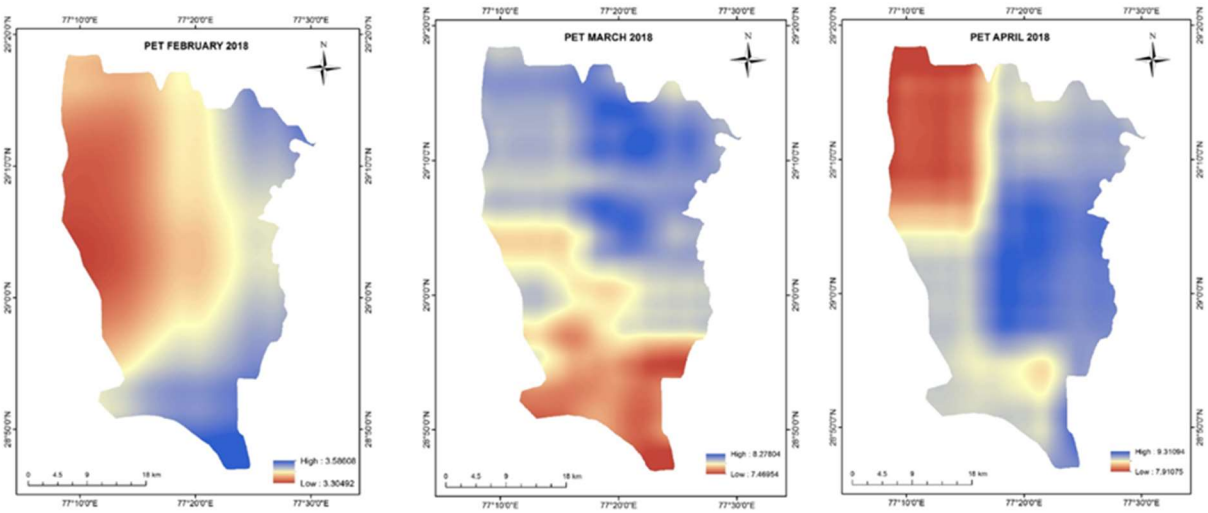


Fig. 9 Spatial distribution of PET (mm/day) for June 2017 to April 2018

4.5 Crop Evapotranspiration

The daily data from the PET (Potential Evapotranspiration) has been multiplied by the base crop coefficient (Kcb). The analysis of actual evapotranspiration (ET) based on the baseline crop coefficient and potential evapotranspiration (PET) reveals a marginal increase in ET during the month of November, followed by a fall in February. This may be attributed to the growth of sugarcane in November, with a significant portion being harvested by December. Lower readings are being recorded in February owing to the early vegetative development of wheat. The monthly photos exhibit a discernible pattern in the geographical distribution of monthly evapotranspiration. The evapotranspiration (ETc) exhibited a range of 3.09 to 6.87 mm day−1 throughout the period from June 2017 to April 2018. It is noteworthy that the mean ET value for sugarcane cultivation was determined to be 4.29 mm day−1. Sugarcane, a significant agricultural commodity in the nation, necessitates a substantial amount of water over its whole growth cycle, which typically spans 12 to 18 months. The specific duration may vary based on the agro-climatic areas, which range from sub-tropical to tropical. The crop's yearly water need in sub-tropical states like as Uttar Pradesh, Punjab, Haryana, and Bihar has been estimated to be 2000 mm (Shukla, S.K, 2017). The Food and Agriculture Organization (FAO) suggests that the range for this requirement falls between 1500-2500 mm. The estimated annual water demand for sugarcane in our research region is 2316.6 mm over a period of 18 months, and 1544.4 mm over a period of 12 months. The graphic shown below illustrates the spatial distribution of evapotranspiration (ET) and its temporal change.

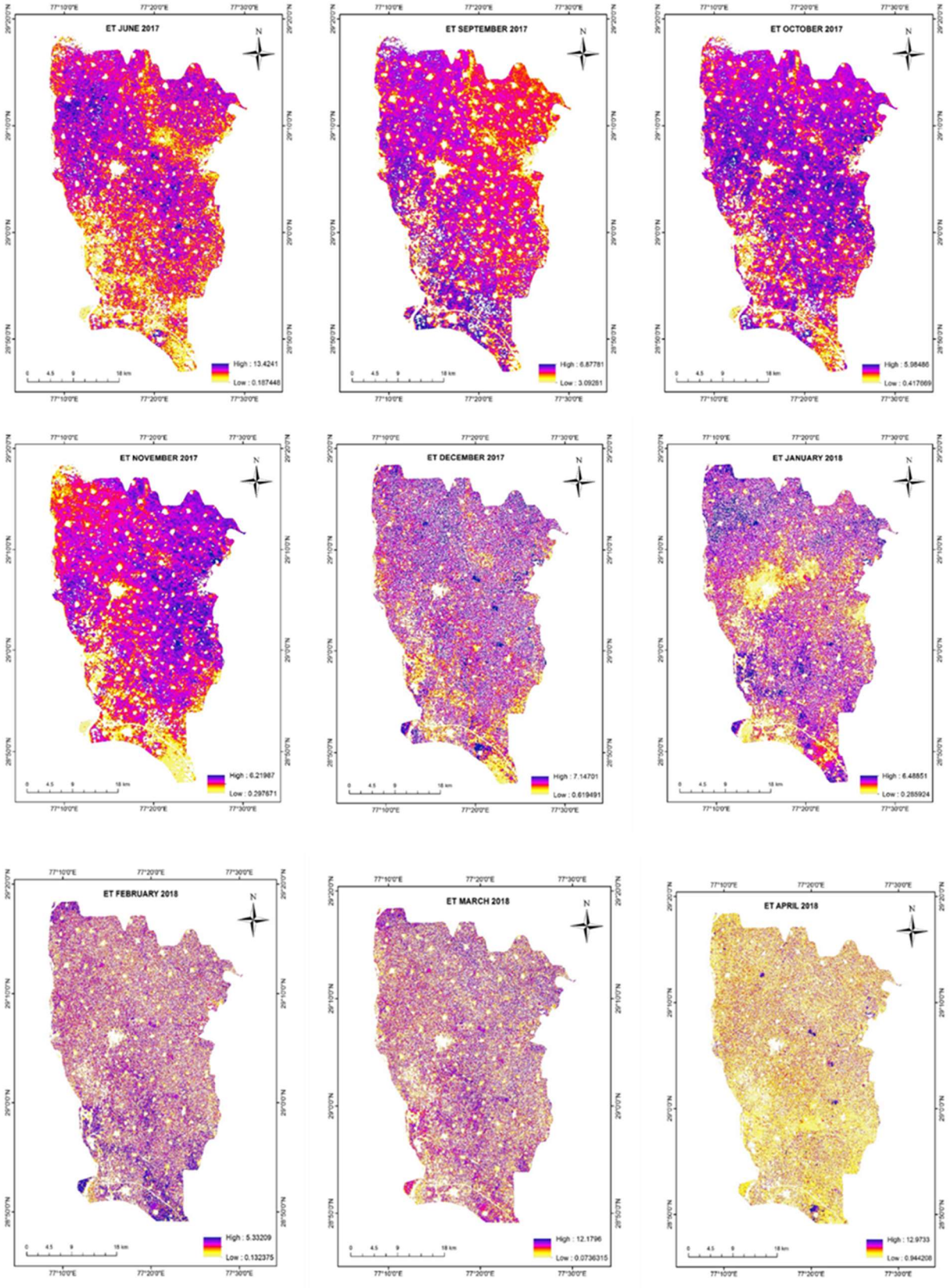


Fig. 10 Spatial distribution of Daily ET (mm/day) for June 2017 to April 2018

4.6 Land Surface Wetness Index (Lswi)

Land surface wetness index is a linear combination of NIR and SWIR bands. LSWI value ranges between -1 to +1 (Xiao et al., 2005).

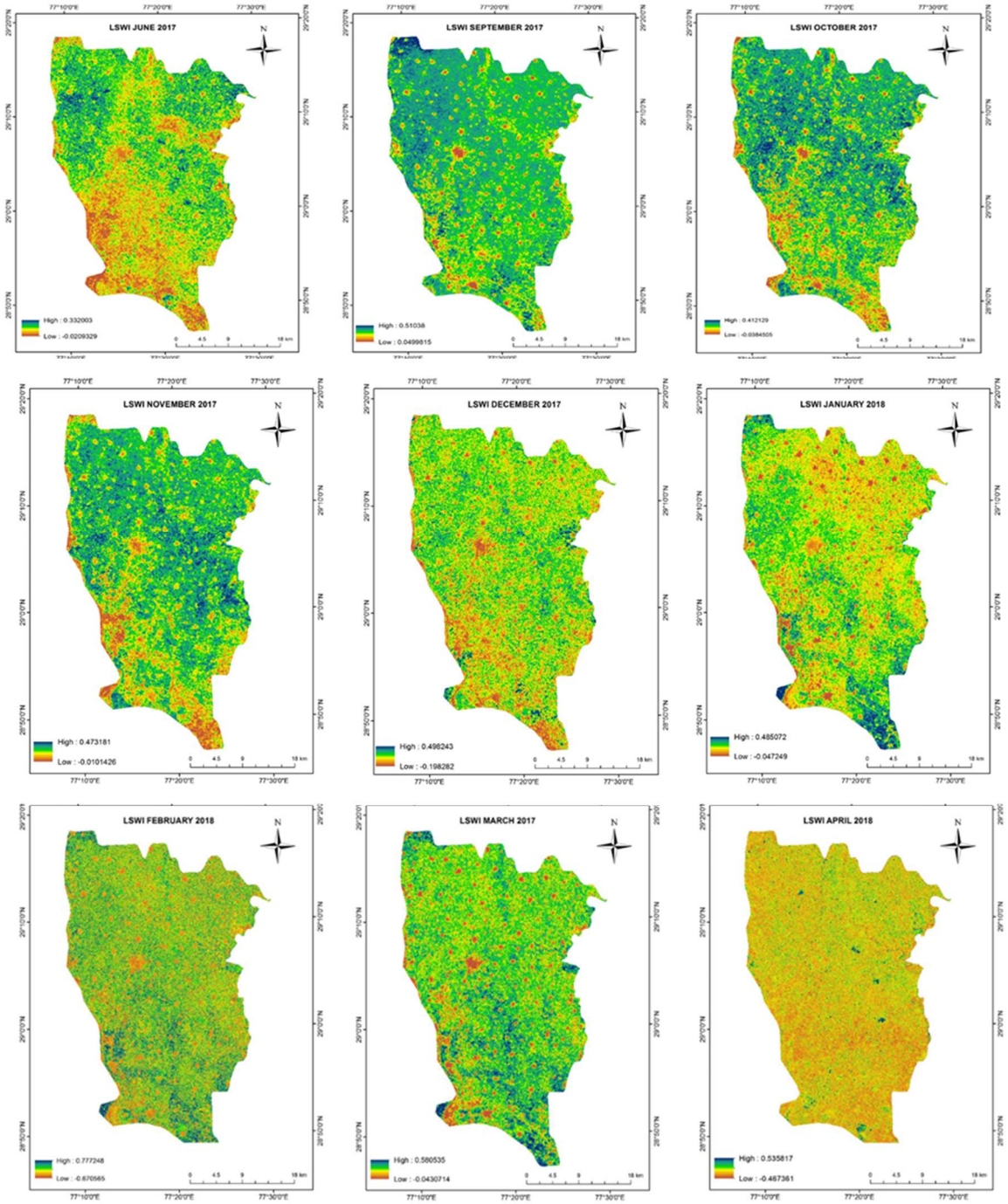


Fig. 11 Spatial distribution of LSWI for November 2017 to April 2018

4.7 Water Scalar Land Surface Wetness Index (Ws_Lswi)

The index is characterized by a numerical scale ranging from 0 to 1, with 0 denoting the absence of stress and 1 representing the presence of severe stress. The time distribution of water scalar may be noticed in Figure 5.71. Based on the findings from the period spanning June 2017 to January 2018, the observed trend may be attributed to the successive cultivation of kharif crops followed by rabi crops, leading to increased strain on the agricultural system. Subsequently, from February to April, the recorded values indicate a decline, which can be attributed to the commencement of crop harvesting during this period. In the month of June, a stress level of 0.56 was detected. However, in the subsequent months of September and October, the stress level exhibited a declining trend due to the increased vegetative development of sugarcane and rice crops. In November, there was a modest rise in the stress level, and by December, the value reached 0.50. This increase in stress may be attributed to the harvesting activities of rice and the presence of older sugarcane farms. The water scaler values show a decline subsequent to December, indicating a decrease in water stress. This trend aligns with the development of wheat crops occurring in January, February, and March. However, in April, a greater level of stress is noticed, as indicated by a value of 0.69, which may be attributed to the harvesting of wheat during this period.

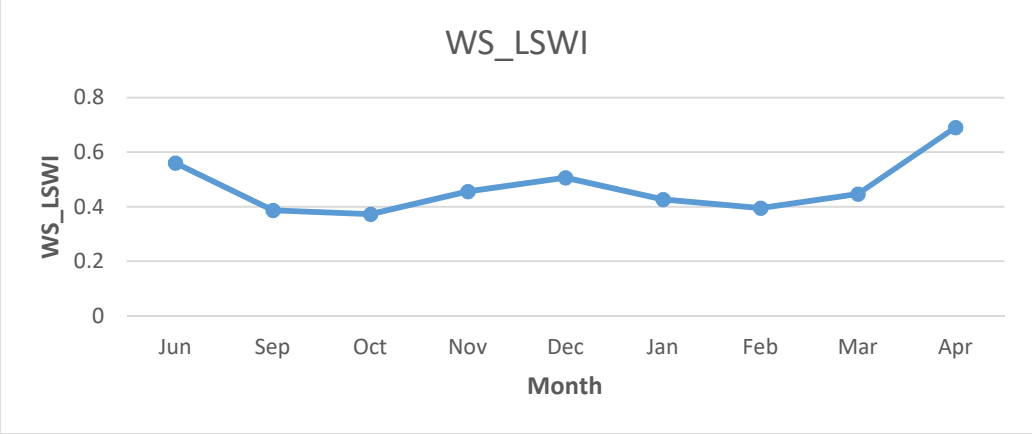


Fig. 12 Temporal variation in WS_LSWI

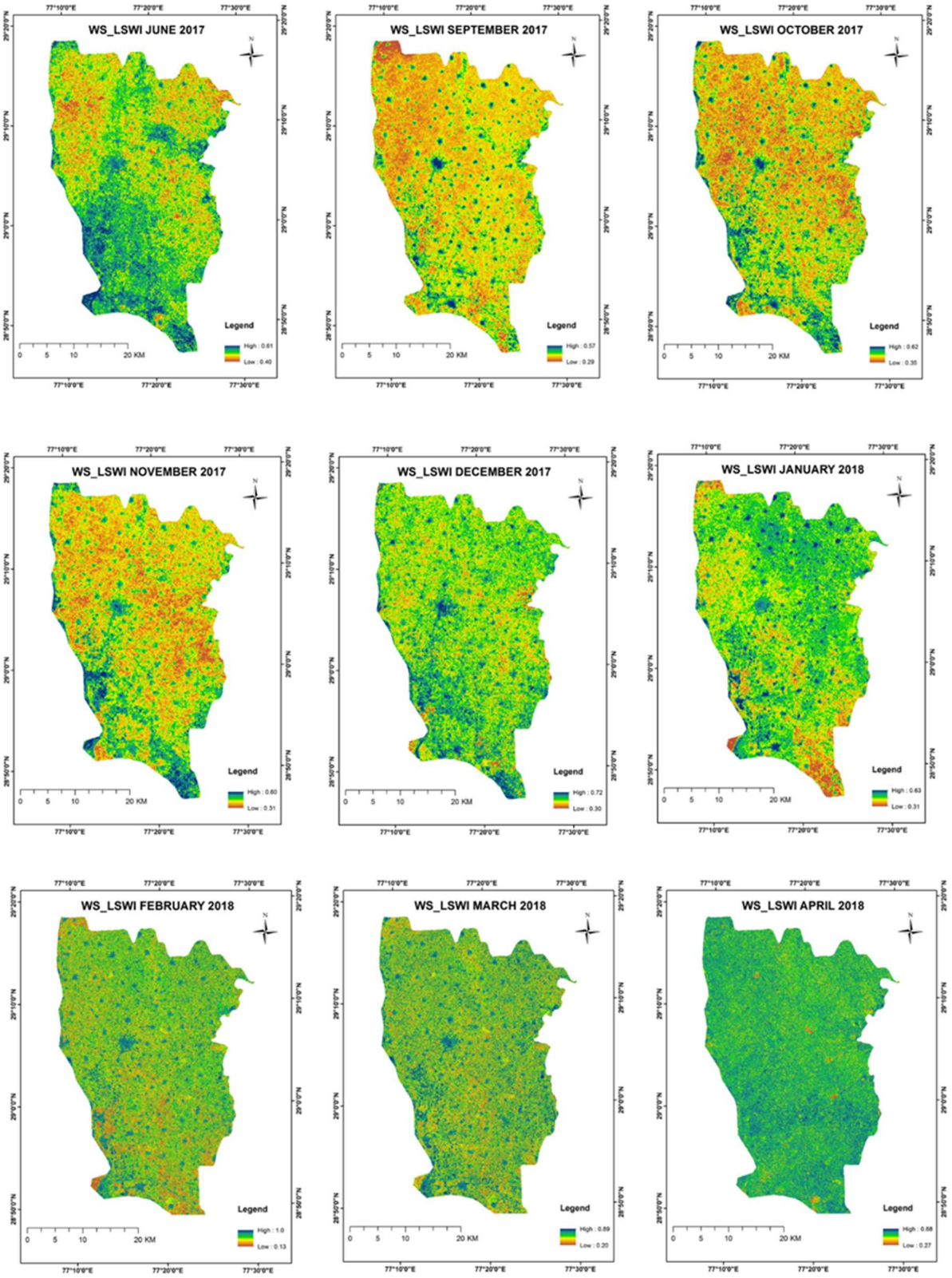


Fig. 13 Spatial distribution of WS_LSWI for June 2017 to April 2018

CONCLUSIONS

The current work used a remote sensing-based technique to estimate crop evapotranspiration (ETc) from Bagpath, located in Western Uttar Pradesh. A rule-based classification using the Normalized Difference Vegetation Index (NDVI) was conducted to classify Kharif and Rabi Seasons. This included establishing thresholds for various classes within the research region. The resulting classification achieved an overall accuracy of 86.86% for Kharif crops and 79.72% for Rabi crops. The kappa coefficients for Kharif and Rabi crops were determined to be 0.81 and 0.712, respectively. The assessment of the NDVI profile effectively covers the growth season of the sugarcane-wheat and rice-wheat cropping system, allowing precise crop mapping within the designated research region. During the Kharif and Rabi seasons, the mean potential evapotranspiration (PET) varies from 4.41 to 5.91 mm/day and 3.30 to 5.42 mm/day, respectively. In the rice-wheat cropping system, a notable surge was seen between the months of September and February, with corresponding Kcb values of 1.2 and 1.23, respectively. The temporal profile of Kcb in the sugarcane-wheat cropping system exhibits peaks in the months of September and February, with corresponding values of 1.24 and 1.03, respectively. However, it is seen that the peak value of wheat is relatively lower, which might perhaps be attributed to the presence of mixed pixels resulting from the mixture of young sugarcane plants. The evapotranspiration (ETc) exhibited a range of 3.09 to 6.87 mm day−1 throughout the period spanning from June 2017 to April 2018. It is worth noting that the average ET value for sugarcane cultivation was determined to be 4.29 mm day−1. The estimated yearly water demand for sugarcane in our research region is 2316.6 mm over a period of 18 months and 1544.4 mm over a period of 12 months. The WS_LSWI data was collected between June 2017 and January 2018. In the month of June, a stress level of 0.56 was recorded. However, in the subsequent months of September and October, the stress level exhibited a downward trend due to the significant rise in vegetative development of sugarcane and rice crops. In November, there was a modest increase in stress levels, which may be attributed to certain factors. Finally, by December, the stress level reached a value of 0.50, likely due to the harvesting activities of rice and the presence of older sugarcane farms. The water scaler readings show a decline subsequent to the month of December, indicating a decrease in water stress. This decline coincides with the growing period of the wheat crop, which occurs mostly in the months of January, February, and March. However, in April, a greater level of water stress is detected, with a recorded value of 0.69. This increase in stress may be attributed to the harvesting of the wheat crop during this period.

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Director/Coordinator (MM-TTC)

Enhancing Urban Resilience: An Innovative Software Model for the Design and Administration of Gully Control Structures in Storm Water Systems

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Abstract

Gully control structures are primarily used for the sake of soil and water conservation, as well as the development of plants. These structures are comprised of dams of many designs that are built with the intention of stabilizing the slope, storing water, and mitigating the speed of runoff. Software models refer to abstract representations or descriptions of software systems, which are used to facilitate understanding, analysis, and design of these systems. Various design options for permanent gully control structures are now available on the market. However, the focus of our work is on evaluating these options. An endeavor was initiated to build software that offers a simplified manner for the design of check dams. Permanent gully management structures are engineered interventions designed to mitigate the erosive effects of gullies in a long-lasting manner. The model was built with the Visual Studio 2013 software. The validation of GCS_Designer was observed in the check dam, resulting in an error of 2.7523%. The highest value for the lowest compressive stress was determined, with an associated error of 0.0681%. The minimum length requirement for the check dam. A total of 25 criteria are taken into consideration. The validation of GCS_Designer for check dam involves assessing the percentage of compliance with the 10 parameters. The error and remaining values indicate a zero % error. The aforementioned figures are subject to an overestimation of 80%. The positive value is seen, whereas the remaining numbers indicate an underestimation. The drop spillway has a length of 28.6 units. The percentage of values that are overestimated is greater than the percentage of values that are underestimated, with 71.4% of values falling into the latter category. In a similar vein, a mistake has been identified. The event took place at a drop inlet spillway, involving a total of eight parameters. It is worth noting that 87.5% of the values examined did not exhibit any errors. the present study, we aim to investigate the impact of social media on adolescent mental health. The design of chute spillways resulted in overestimation and underestimation of values, with 87.5% and 12.5% respectively. Please provide individual estimates for each item. Design considerations may be undertaken for the construction of a check dam, drop spillway, drop inlet spillway, and chute. The GCS_Designer program was used with great effectiveness to design a spillway that is adequate for the local circumstances.

1. Introduction

The issue of soil erosion in India exhibits significant variation in terms of extent, intensity, and characteristics throughout various regions of the nation. These variations are influenced by factors such as climate, terrain, soil composition, land use, and the prevailing agricultural economy. According to the research conducted by Dhruva and Ram in 1983, it was shown that soil erosion occurs at a rate of about 5334 metric tons per year, equivalent to 16.35 metric tons per hectare, alone as a result of agricultural and related activities.

The rivers of the nation transport around 2052 metric tons, equivalent to 6.26 tons per hectare. Approximately 29% of the total eroded soil, amounting to roughly 1572 million metric tons, is transported annually by rivers to the sea. Additionally, around 480 million metric tons of soil are deposited in different reservoirs, leading to a loss of storage capacity ranging from 1 to 2%. India has a total geographical area of 329 million hectares (Mha), with around 167 Mha (51% of the total) being impacted by significant water and wind erosion, as estimated by Das in 1985. Approximately 127 million hectares (Mha) of land are affected by significant soil erosion, while an additional 40 Mha have been degraded due to various factors such as gully formation, ravines, shift cropping, water logging, salinity, alkalinity, changing river courses, and desertification. According to Maji (2007), in India, about 120.72 million hectares of land, out of a total geographical area of 329 million hectares, are impacted by different types of land degradation. Among these, water-induced soil erosion above 10 megagrams per hectare per year accounts for 82.57 million hectares.

1.1 Control Measures for Gullies

Structures are primarily used for the purposes of soil and water conservation, as well as the development of plants. These structures are comprised of dams of different designs that are built with the intention of stabilizing the slope and decreasing the speed of runoff. Temporary and permanent structures may be used in situations where runoff is not severe and may be effectively managed via the presence of well-stabilized vegetation. The user's text is too short to be rewritten in an academic manner. Within gullies, the growth of vegetation is crucial until it becomes firmly entrenched. Temporary constructions are constructed using readily accessible materials found in the surrounding area, such as brush, poles, woven wire, loose gravel, and boards. In cases when runoff is substantial and the implementation of vegetation-based control measures is not viable, the use of permanent gully control structures becomes necessary. Several types of gully control structures include the check dam, drop spillway, drop inlet spillway, and chute spillway.

1.1.1 Check Dam

A check dam is a small-scale structure constructed across a watercourse to control the flow of water and prevent erosion. It is typically A check dam is a diminutive and transitory barrier positioned inside a ditch or watercourse with the intention of impeding erosion by diminishing the speed of fluid motion. The installation of a dam inside a ditch or channel disrupts the natural movement of water, resulting in a decrease in its velocity. While it is true that sedimentation may occur behind a dam, it is important to note that check dams are not primarily designed to catch sediment. Instead, they are often built using loosely distributed erosion stone or rip rap, or by using stone-filled gabions. The drop spillway, also known as a stepped spillway, is a hydraulic structure often used in dam engineering to safely release excess water from a reservoir.

The drop structure under consideration is classified as a weir structure, with a maximum allowable drop of 3 meters. The water passes through a hydraulic structure known as a weir, where it subsequently cascades over an apron, resulting in the dissipation of the water's energy. These structures are strategically positioned at regular intervals along a waterway, with the purpose of stabilizing it by altering its configuration from a consistently steep slope to a sequence of gradually sloping sections. Additionally, they serve as discharge points for tile and surface water located at the upstream terminations of drainage ditches. In the majority of soil conditions, it is feasible to construct drop spillways using commonly available masonry materials such as stone or brick, as well as concrete and concrete blocks, with or without reinforcing. The use of temporary storage to achieve a significant decrease in discharge along the structure is not appropriate.

1.1.3 Drop Inlet Spillway

The drop inlet spillway is a hydraulic structure often used in civil engineering projects to manage the flow of water. It is designed to efficiently divert excess water. A drop inlet or shaft spillway is characterized by the ingress of water by a horizontally oriented riser or inlet, often in the form of a circular or rectangular box. Subsequently, the water proceeds through a circular conduit, which may be either horizontal or nearly horizontal, towards an outlet protection system. The drop inlet spillway is a suitable solution for situations when it is necessary to regulate the flow of the downstream channel by creating a temporary storage area upstream of the structure. The structure comprises of a dam constructed from earthen materials and a spillway designed in the form of a pipe. The dam facilitates the temporary retention of runoff from the contributing watershed, while the spillway allows for the controlled release of the designed flow downstream. The adaptation occurs when the descent exceeds a magnitude of 3.0 meters. The drop inlet structure is comprised of three main components: the inlet, conduit, and outlet. When the form of the intake resembles a funnel, it is sometimes referred to as a Morning Glory or Glory Hole spillway.

1.1.4. The chute spillway

chute spillway is a hydraulic structure often used in dam engineering to safely discharge excess water from a reservoir. A chute spillway, also known as an open channel or trough spillway, is a hydraulic structure designed to transport the discharge of water from the upper portion of a channel or reservoir to the downstream channel level. This is achieved by using an open channel that is positioned next to a dam, abutment, or saddle. Chute structures are often used for the purpose of gully head management, proving to be effective for drops ranging from 5 to 6 meters in height. The chute spillway offers more advantages compared to the drop spillway in situations when there is a need to discharge a significant amount of runoff from a particular location. The flow in a chute spillway occurs at velocities that are classified as super-critical.

1.2 Design Planning

The design of structures necessitates thorough research into the numerous components that impact the characteristics of runoff approaching the structure. These investigations should include unique site circumstances, downstream flow characteristics, and any other special needs. There is a lack of universally applicable answers for the many challenges experienced in the field.

The design should include a comprehensive review of all the pertinent aspects that exert influence on the task. The data necessary for the design of these structures is as follows.

1. The topographic map of the contributing watershed and the adjacent downstream region is being referred to.

2. Soil data refers to information pertaining to the composition, properties, and characteristics of the soil within a certain area or region.

3. Rainfall data and characteristics include the quantitative measurements and qualitative attributes associated with precipitation, including its frequency, intensity, duration, and spatial distribution.

4. The existing land use pattern denotes the current arrangement and use of land within a specific geographic area, including various activities such as agriculture, residential, commercial, industrial, and natural areas.

1.3 Study Scope

The primary objective of a watershed development program is to mitigate the adverse effects of water and soil by enhancing the process of infiltration into the soil. This is achieved via the implementation of measures to regulate and mitigate excessive runoff, effectively manage and harness runoff, and minimize soil erosion in order to safeguard the integrity of the land. The successful design of buildings that are both economically efficient and safe requires a comprehensive understanding of the subject matter, proficiency in engineering principles, and much practical experience in the area. It is important to consider the local design factors, which include the soil texture, rainfall patterns, and agricultural practices of the indigenous population. A significant number of individuals engaged in watershed management lack enough proficiency in design, while existing textbooks on soil and water conservation fail to provide comprehensive design guidance tailored to specific regional contexts. Hence, it is important to develop a complete software solution for the purpose of managing soil and water conservation structures. There are other software models that exist for the creation of permanent gully control systems. However, the focus of our work was to produce software that is characterized by its simplicity.

The method for the design of check dams and permanent gully control systems. The model was constructed with Visual Studio 2013. The model was developed with the purpose of serving as a dam designer for field workers, while also functioning as an instructional tool for students to analyze the impact of modifying input parameters on the design output.

Taking into consideration the aforementioned concerns, the current investigation was conducted with the accompanying aims. The objective is to **1. create software that may be used for the purpose of designing gully control structures. 2. A Comparative Analysis of Various Parameters between Software-generated Output and Manually-generated Output. 3. The statistical analysis is used to compute the error for various parameters of structures.**

2. MATERIAL AND METHODS

Process for Gully Control Structure Design The gully control structure design process has three phases: hydrologic design, which calculates runoff rates and volumes. intended to manage, hydraulic design examines dimensions' needs. structure to withstand high runoff via drop and chute structures and structural design provide components strength and stability. Structural components. It analyses structure-affecting forces.

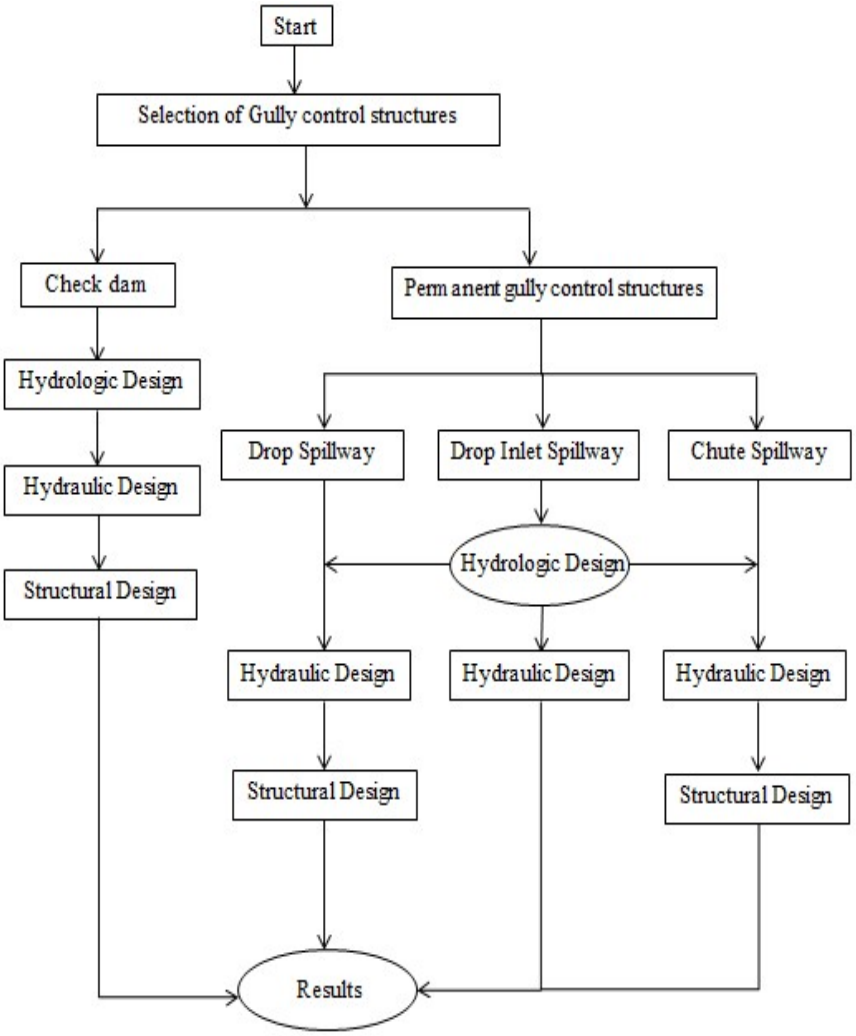


Fig.2.1 Flow chart for software design of gully control structures

2.2 DESIGN PROCEDURE OF CHECK DAM

2.2.1 Hydrologic Design

Structure can be designed for the maximum possible peak runoff rate which may occur within a reasonable frequency of interval (25/30/50 Years).The peak rate of runoff for a catchment is generally estimated for check dam by Dicken's Method.(WALAMTARI)

Computation of maximum flood discharge $\boldsymbol{Q = CA^{3/4}}$, cusecs

Where, **Q** = Maximum flood discharge (Cusecs)

C = Dickens constant (Appendix-I)

A = Catchment Area (square miles)

2.2.2 Hydraulic Design

The step by step procedure of check dam hydraulic design for software development by using the visual basic as described below.(Dhan Foundation, Chittoor)

I. CREST LEVEL OF THE CHECK DAM ($\mathbf{l_C}$)

The apex of the weir body wall where water is at full reservoir level is its crest.

II. HEIGHT OF THE CHECK DAM($\mathbf{H_b}$)

It is the elevation difference between the highest point and lowest point of water flow in the watershed.

III. LENGTH OF CHECK DAM, $\boldsymbol{L = 4.75\sqrt{Q}}$, m

IV. DISCHARGE PER METER RUN, $\boldsymbol{q = \frac{Q}{L}}$, Cumecs

V. APRON LEVEL, $\mathbf{l_A = [\, l_c - H_b]}$, m

VI. TOP LEVEL OF DOWNSTREAM(D/S) SOLID APRON, $\mathbf{l_{DA} = l_A}$, m

VII. DOWNSTREAM TAIL WATER LEVEL (T W L)

Tail water depth, $\mathbf{d_t = [\frac{Q}{1.656L}]^{2/3}}$, m

T W L on D/S, $\mathbf{l_{TW} = l_{DA} + d_t}$, m

VIII. UPSTREAM MAXIMUM FLOOD LEVEL

The depth of water flowing over the crest of the Check Dam is the difference between the Maximum Water Level and Full Reservoir Level.

- Head over crest

$$\mathbf{d_c=[\frac{Q}{1.845L}]^{2/3}}, \text{ m}$$

- Maximum flood level on U/S

$$\mathbf{l_{FU} = l_c + d_c}, \text{ m}$$

Provide 0.3 m thickness of foundation wall below the bottom level of check dam

IX. SCOUR DEPTH CALCULATIONS

- Regime Scour depth **R = 1.346 $[\frac{q^2}{f}]^{1/3}$,** m

  f = Laceys silt factor (Appendix-II)

- D/S bottom level of foundation = **[l_{TW} - 1.5R],** m

  Provide D/S cut-off wall 1.5 m below the body wall of check dam

  - U/S bottom level of foundation = **[(l_{FU}) - R],** m
  - Provide U/S cut-off wall 0.9 m below the foundation bottom level

X. LENGTH OF APRONS , L_A = **$10C_a [(H_b * q)/231]^{0.5}$**, m

XI. LENGTH OF SOLID APRON **(L_{SA})**

L_1= [1.5 + 2*(dc* h)$^{0.5}$], m

Where,**h = [(l_{FU}) - (l_{TW})],** m

L_2= [2*(H_b + d_c)], m

L_3= [4*C_a *(H_b/33)$^{0.5}$], m

L_{SA}= [(L_1+L_2+L_3)/3], m

XII. LENGTH OF TALUS, **L_T = L_A- L_{SA},** m

Provide length of talus at least 2 m

XIII. THICKNESS OF SOLID APRON, **t_{SA} = [0.5 * (d_c + h)$^{0.5}$],** m

Provide solid apron for a thickness of (t_{SA} – 0.1) m with 0.1 m thick wearing coat over it.

2.2.3 Structural Design

The following components are designed to develop software for the structural stability of the structure as given below. (Dhan Foundation, Chittoor)

I. BODY WALL OF THE CHECK DAM

- Top width of the check dam, **Tw = [(3*d_c)/(2*spwc)],** m

  Note: Provide 0.6 m top width if calculated T_W is less than 0.5 m

- Bottom width of the check dam, **Bw = [(H_b + d_c)/(spwc)$^{0.5}$],** m

  Note: Provide B_W as equal to H_b, if calculated B_W is less than H_b

II. THICKNESS OF CUSHION WALL

Solid wall constructed at the downstream end of apron, **t_c = (Tw/2),**m

III. STABILITY CALCULATIONS OF WALL

Stability of the wall can be calculated in two cases namely consider water is up to the crest level and water is discharging at maximum flood level.

Case I: Consider water is up to the crest level

For Calculating stability of wall formulas are considered as shown in the Table3.1

Table: 2.1 Inflow water is up to crest level

Force (1)	Magnitude (t/m) (2)	Lever arm (m) (3)	Moments about A(t) (2)*(3)
W_1	T_W*H_b*spwc	$(T_w/2)$	
W_2	$0.5*(B_w - T_w)*H_b*spwc$	$\{[(B_w - T_w)/3]+T_w\}$	
W_H	$[H_b]^3/6$	-	
Total	$\sum W =$		$\sum M =$

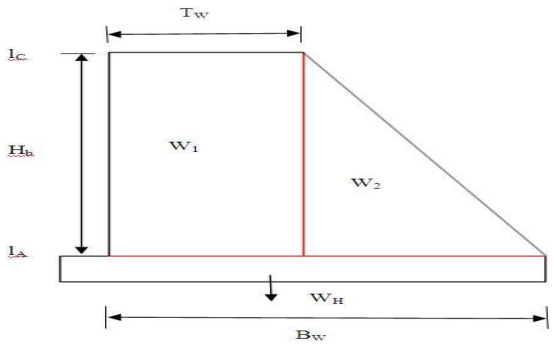


Fig.2.2 Water is up to crest level of the check dam

- Resultant $R_{s1} = \sum M/\sum W$, m

a) Check against tension

The resultant thrust lies in the middle third of the base width {**i.e.** $(B_w/3)$ **to** $[(2*B_w)/3]$m,then the wall is safe against tension at its base.

b) Check against overturning

The resultant thrust is passing within the base then the wall is safe against overturning.

c) Check against compression

- Eccentricity developed $(e) = [(0.5*B_w) - R_{s1}]$, m
- Eccentricity limit $= \{B_w/6\}$, m
- Compressive stress developed

*Maximum compressive stress $=\{(\sum W/B_w)*[1 + \{(6*e)/B_w\}]\}$ t/m^2

*Minimum compressive stress $=\{(\sum W/B_w)*[1 - \{(6*e)/B_w\}]\}$ t/m^2

The stresses developed are within permissible limits then it is safe against compression.

Case II: Water is discharging at maximum flood level

For Calculating Discharge at maximum flood level formulas are considered as shown in the Table 3.2

Table: 2.2 Water is discharging at Maximum flood level (M F L)

Force (1)	Magnitude(t/m) (2)	Lever arm (m) (3)	Moments about A (t) (2)*(3)
W_1	T_W*H_b*spwc	$(T_w/2)$	
W_2	$0.5*(B_w - T_w)*H_b*spwc$	$\{ [(B_w - T_w)/3]+T_w \}$	
W_3	T_w*d_c*spww	$(T_w/2)$	
W_4	$0.5*[(d_t/H_b)*(B_w - T_w)]*d_c*spww$	$\{ [\{(d_t/H_b)* (B_w - T_w)\}/3]+T_w \}$	
W_5	$[(d_t/H_b)*(B_w - T_w)]*(l_c - l_{TW})*spww$	$\{ [(B_w - T_w)/2]+T_w \}$	
W_6	$0.5*[(d_t/H_b)*(B_w - T_w)]*d_t*spww$	$\{ (B_w)- [(d_t/H_b)* (B_w - T_w)] \}$	
W_H	$[H_b]^3/6$	-	
Total	$\sum W =$		$\sum M =$

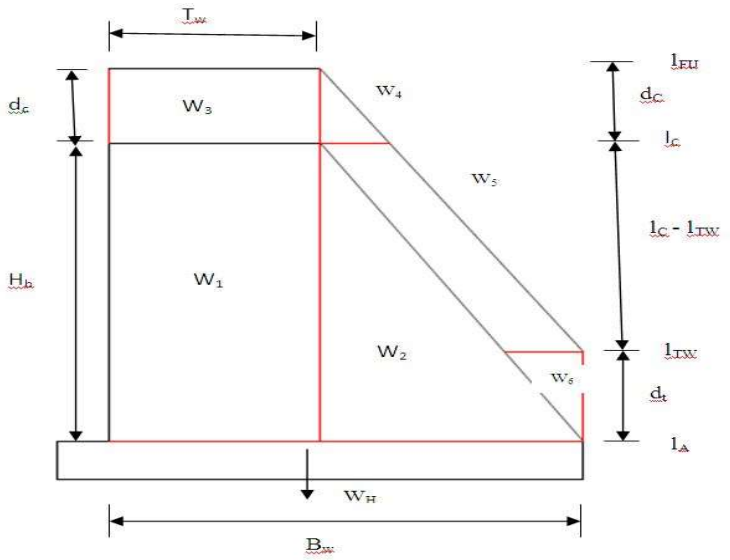


Fig.2.3 Check dam is discharging at maximum flood level

- Resultant $\mathbf{R_{s2}} = \sum \mathbf{M}/\sum \mathbf{W}$, m

a) <u>Check against tension</u>

The resultant thrust lies in the middle third of the base width **{i.e, $(B_w/3)$ to $[(2*B_w)/3]$**m,then the wall is safe against tension at its base.

b) Check against overturning

The resultant thrust is passing within the base then the wall is safe against overturning.

c) Check against compression

- Eccentricity developed **(e) = [(0.5*B_w) – R_{s1}]**, m
- Eccentricity limit = **{B_w/6 },** m
- Compressive stress developed

*Maximum compressive stress=**{ (∑W/B_w)*[1 + {(6*e)/B_w}] }** t/m^2

*Minimum compressive stress=**{ (∑W/B_w)*[1 - {(6*e)/B_w}] }** t/m^2

The stresses developed are within permissible limits then it is safe against compression.

IV. CREEP LENGTH PROVIDED FOR CHECK DAM

- Creep Length required, **C_L = ($C_a$$H_b$),** m
- Creep length provided, **C_{LP} =L_h + L_v** , m

= [2T_W+B_W+L_A+L_T] + [0.3+0.9+t_{SA}+H_b]

If Creep length provided is more than the creep length required hence design is safe against creep otherwise Provide “creep length required”

V. CHECK AGAINST PIPING

- Weighted creep ratio (C_W) = {[∑L_h + 2∑L_v]/(3H_b)}

The calculated C_w is greater than tabulated C_w value (Appendix-III) then the structure is safe against piping.

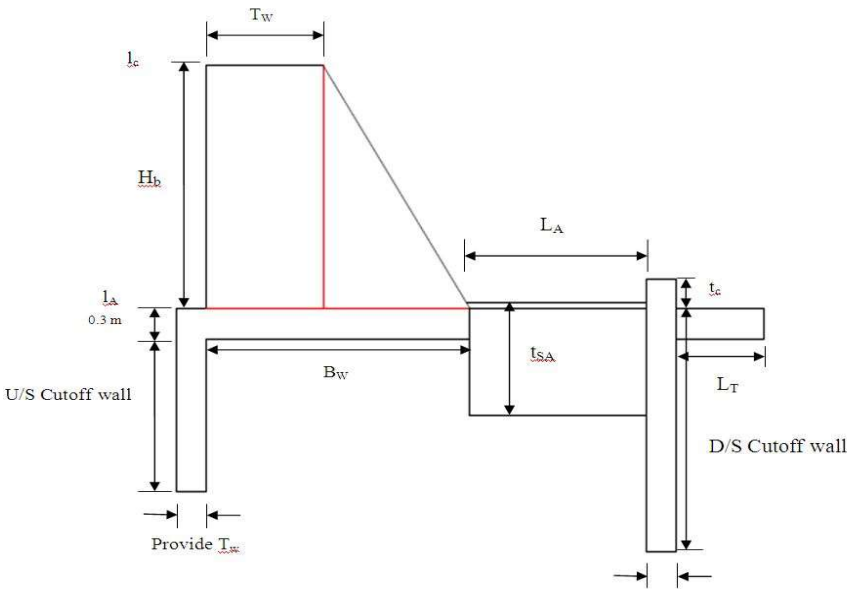


Fig.2.4 Creep path provided for check dam

2.3 DESIGN PROCEDURE OF DROP SPILLWAY

2.3.1 Hydrologic Design

Flood discharge volume calculated by computing the runoff rate for 25/ 30/ 50 years return period. Runoff rate is calculated by Rational method. (Ghanshyam Das, 2012)

Computed discharge value, **Q=CIA/360**

Where, Q= peak runoff rate, cumecs

C= coefficient of runoff (Appendix-IV)

= **(1/A)*(C_1A_1+ C_2A_2+ C_3A_3+……..+ C_nA_n)**

I= Intensity of rainfall, mm/h

2.3.2 Hydraulic Design

The width of gully and depth of gully are known then determining the length of crest, depth of the weir to provide required capacity and maintain free board. (Ghanshyam Das, 2012)

I. LENGTH OF WEIR CREST, **L=Width of gully – 0.5,** m

II. HEIGHT OF WATER AT CREST, **$Q=(2/3)* C_d *(2g)^{1/2}*L*h^{3/2}$,** cumecs

Where C_d = discharge coefficient (0.6)

g = 9.8, m/sec^2

L = length of weir crest, m

h = height of water at crest, m

III. HEIGHT OF THE WEIR, **d = h+0.15**, m

IV. HEIGHT OF WATER DROP FROM THE CREST, **H=depth of gully –d,** m

V. BASIN/APRON LENGTH, $\mathbf{L_B = 0.75(H+d)+H,}$ m

VI. WIDTH OF THE SIDE WALL, **W=H+d+1,** m

VII. HEIGHT OF THE SIDE WALL

a) At the end sill end = at least 1.5d $\geq$H/2, m

b) At the weir end = equal to gully width, m

VIII. LENGTH OF THE WING WALL, $\mathbf{L_W = 2.25h}$, m

IX. DEPTH OF THE TOE WALL, **h +0.1**, m

2.3.3 STRUCTURAL DESIGN

The force analysis of drop spillway can be carried out here. (Ghanshyam Das, 2012)

I. TOTAL UPLIFT PRESSURE, $\mathbf{P_U = H-0.5,}$ m

II. ANALYSIS OF FORCES

Drop spillway structural forces can be calculated, if know the volume of component, material density, lower arm length of the structure as described in the Table 3.2.

Table: 2.3 Analysis of forces of the Drop Structure

Forces on structure	Volume of component per unit length (m^3)	Material density (kg/m^3)	Force per unit length of structure (kg/m) (2)*(3)	Lower arm length (m)	Moment(kg) (4)*(5)	Type of moment
(1)	(2)	(3)	(4)	(5)	(6)	(7)
P_1	(d*H)*1			0.5*H		Over Turning
P_2	$0.5*H^2*1$			(1/3)*H		Over Turning
P_{u1}	$0.5*(L_B+1.5)*1*1$			$(2/3)*(L_B+1.5)$		Over Turning
P_{u2}	$0.5*(L_B+1.5)*1$			$0.5*(L_B+1.5)$		Over Turning
W_1	(H-0.5)*1*1			$((L_B+1.5)-0.5)$		Restoring
W_2	0.5*(H-0.5)*0.5			$L_B+[(2/3)*0.5]$		Restoring
W_3	$0.5*(L_B+1.5)*1$			$0.5*(L_B+1.5)$		Restoring

1- Safety against overturning

Safety against overturning is calculated by following formula

Total restoring moment > Total overturning moment

2- Safety against sliding

For safety against sliding,

$\sum f_h$ should not be greater than $C_f*\sum f_h+C_rA$ i.e. **[$\sum f_h < (C_f*\sum f_v+C_rA)$]**

Where, $\sum f_h = P_1+P_2$ = horizontal forces, m^3

$\sum f_v = W_1+W_2+W_3 - P_{u1} - P_{u2}$ = vertical forces, m^3

$C_f = \tan\emptyset$, ($\emptyset$ = angle of internal friction of soil)

C_r = cohesion resistance of soil (Kg/m^2)

$A = [H*(L_B+1.5)]$=area of plane of sliding , m^2

If it satisfies $\sum f_h < (C_f*\sum f_v+C_rA)$ sliding is safe otherwise redesign

3- Safety against tension

The eccentricity (e) should not be greater than [width (d)/6] then the structure is safe against tension.

$e = Z-[Width(d)/2]$, m

$Z=[\sum moments/(\sum f_v)]$, m

4-Safety against compression

The force should be compressive in nature, so that there is no floatation of the structure. Thus, the resultant force should act downwards,

$$\text{Contact pressure, } P_e = \{(\sum f_v/A)*[1\pm(6e/d)]\}$$

Where the +ve sign will give pressure at the upstream, and the –ve sign will give pressure at the downstream.

5- Safety against piping

The weighted creep ratio (C_W) should be higher than the recommended value then the structure is safe against piping.

$$C_W = \{(\sum L_h+2\sum L_V)/(3H)\}$$

Where, C_W = Weighted creep ratio

$\sum L_h$ = Sum of all horizontal (flat) contact distances, m

$\sum L_V$ = Sum of all vertical r steep contact distances, m

H = Head between the head water and the tail water, m

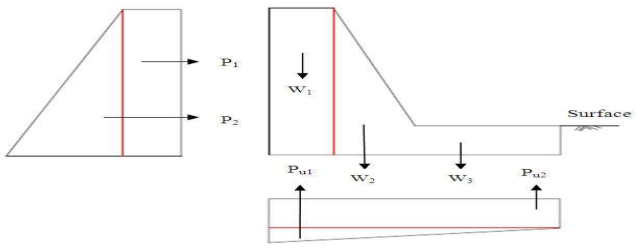


Fig.2.5 Analysis of forces for Drop spillway

2.4 DESIGN PROCEDURE FOR DROP INLET SPILLWAY

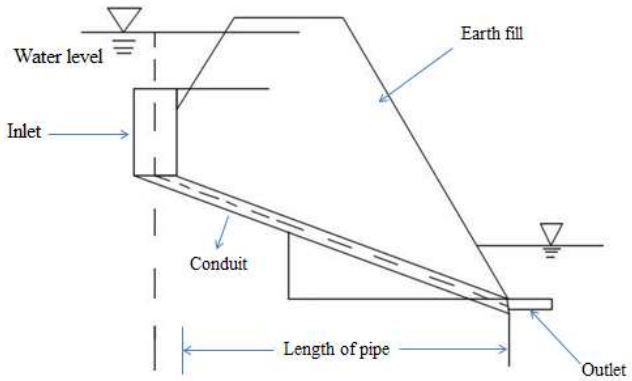


Fig.2.6 Components of Drop inlet spillway

2.4.1 Hydrologic Design of drop inlet spillway

Estimation of flood discharge volume by computing the Runoff rate for 25/ 30/ 50 years return period. Runoff rate is calculated by Rational method.(Ghanshyam Das, 2012)

Computed discharge value, **Q=CIA/360** , cumecs

Where, Q= peak runoff rate, cumecs

C= coefficient of runoff (Appendix-IV)

$= \mathbf{(1/A)*(C_1A_1+ C_2A_2+ C_3A_3+\ldots\ldots\ldots..+ C_nA_n)}$

I= Intensity of rainfall, mm/h

2.4.2 Hydraulic Design for drop inlet spillway

The width of gully and depth of gully are known, the design consists of determining the length of the pipe, velocity of flow, radius of pipe, natural slope. (Ghanshyam Das, 2012)

I. LENGTH OF PIPE,**L**=Base width of the embankment, m

II. VELOCITY OF FLOW IN CULVERT PIPE, $\mathbf{V= (2gH)^{0.5}/(1+K_e+K_cl)^{0.5}}$, m/s

Where, K_e = Coefficient of entrance losses

K_c = Head loss coefficient

g = 9.81, m/s^2

H= water head, m

III. CROSS SECTIONAL AREA OF A PIPE, $\mathbf{A=Q_0/V}$, m^2

Where, Q_0=discharge, cumecs

IV. RADIUS OF A PIPE, $\mathbf{r = (A/\pi)^{0.5}}$, m

V. DIAMETER OF THE PIPE, **d = 2 * r,** m

VI. NATURAL SLOPE, $\mathbf{S_n= (K_cV^2/2g) /(1-(K_cV^2/2g)^2)^{0.5}}$, **%**

VII. PIPE SLOPE=**height of drop/pipe length,%**

2.5 DESIGN PROCEDURE OF CHUTE SPILLWAY

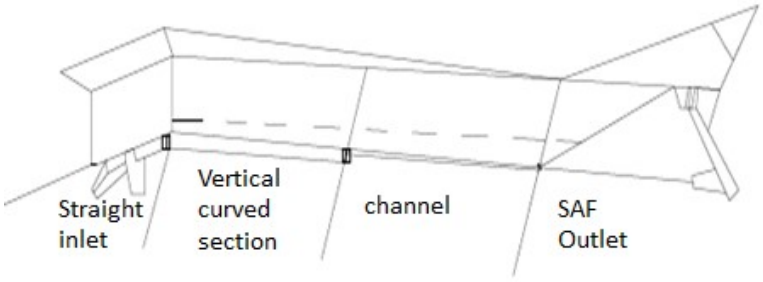


Fig.2.7 Chute spillway

2.5.1 Hydrologic Design of chute spillway

Estimation of flood discharge volume is calculated by computing the runoff rate for 25/ 30/ 50 years return period. Runoff rate is calculated by Rational method. (Ghanshyam Das, 2012)

Computed discharge value,**$Q=CIA/360$**

Where, Q = peak runoff rate, cumecs

C= coefficient of runoff (Appendix-IV)

= **$(1/A)*(C_1A_1+ C_2A_2+ C_3A_3+\ldots\ldots\ldots..+ C_nA_n)$**

I= Intensity of rainfall, mm/h

2.5.2 Hydraulic Design of chute spillway

The design consists of determining the length of weir, head loss, sequent depth, if know the width and depth of gully. (Ghanshyam Das, 2012)

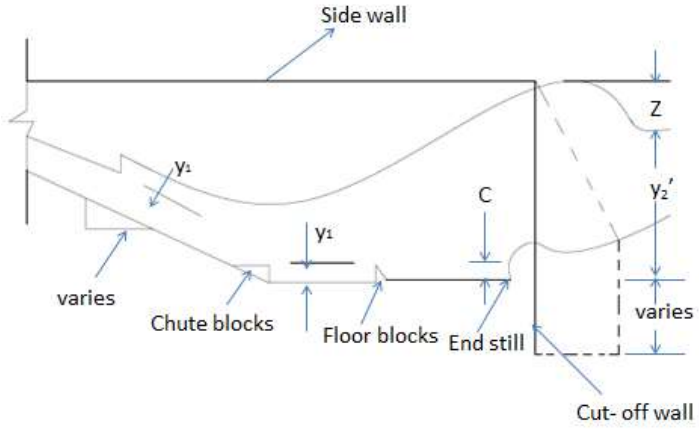


Fig.2.8 Sectional view of chute spillway

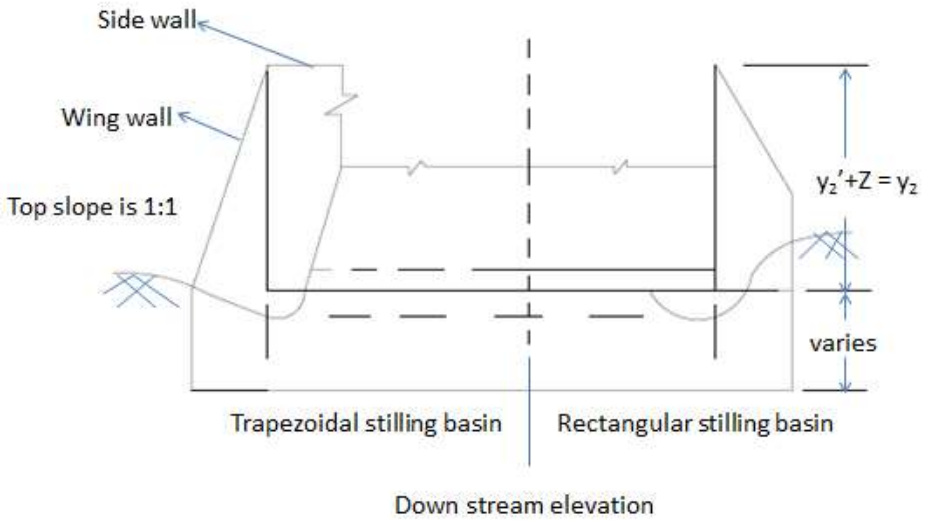


Fig.2.9 SAF stilling basin outlet

I. LENGTH OF STRAIGHT INLET , **$L=Q/1.77*H^{3/}2$,**m

Q=Discharge, cumecs

H=Depth of flow, m

II. HEAD LOSS AT TOE, **h_e=drop in gully head(D)-10% of gully head(D),** m

III. VELOCITY AT STIILING BASIN TOE, **$V=(2gh_e)^{0.5}$,** m/s

Where, g=9.81, m/s^2

IV. INITIAL DEPTH OF THE FLOW, **$y_1=Q/LV$,** m

V. FROUDE NUMBER, **$F_r=V/(g*y_1)^{0.5}$**

VI. SEQUENT DEPTH, **$y_2=y_1*0.5((1+8(F_r)^2)^{0.5}-1)$,** m

VII. FLOOR AND CHUTE BLOCK HEIGHT= **y_1**,m

VIII. SPACING AND WIDTH BETWEEN FLOOR AND CHUTE BLOCKS=**$0.75*y_1$**, m

IX. DISTANCE OF FLOOR BLOCKS FROM THE SIDE WALLS =**$0.375*y_1$**, m

X. TAIL WATER DEPTH OVER THE STILLING BASIN, **$y_2' = 1.4y_1*(F_r)^{0.45}$,** m

XI. STILLING BASIN LENGTH,**$L_B=4.5y_2/(F_r)^{0.38}$,** m

XII. SIDEWALL AND STILLING BASIN HEIGHT = **$(y_2/3)+y_2'$**,m

XIII. TRANSVERSE SILL HEIGHT = **$0.07*y_2$,** m

XIV. SIDE WALL FREE BOARD TO BE PROVIDED ABOVE THE TRAILED WATER DEPTH = **$y_2/3$,** m

XV. WING WALL HEIGHT= **$(y_2/3)+y_2'$**m

2.5.3 STRUCTURAL DESIGN OF THE CHUTE SPILLWAY

I. FORCES ANALYSIS

Forces can be analyze by using head of each section upstream, head of each section downstream, force per horizontal width of the water body as shown in Table 3.4. (Ghanshyam Das, 2012)

Table: 2.4 Force analyses for Chute spillway structure

Pressure diagram section no.	Head of each section up stream (m)	Head of each section downstr eam (m)	Force per horizontal width of the water body (m)	Pressure diagram area (m^2)	Uplift force (Kg)	Cumulative uplift force (Kg)	Weight of each section (Kg)	Cumulative weight of the structure (Kg)	Comments— safe when weight > the uplift force(Safe or Unsafe) (9)>7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	d	P=A-B	x/4	0.5(d+(A-B))*x/4	(5)*W*1000		W_t		
2	A-B	C-D	x/4	0.5*((A-B)+(C-B))*x/4	(5)*W*1000		W_t		
3	C-D	E-F	x/4	0.5*((C-D)+(E-F))*x/4	(5)*W*1000		W_t		
4	E-F	G-H	x/4	0.5*((E-F)+(G-H))*x/4	(5)*W*1000		W_t		
5	G-H	0.01	W_S	0.5*W_S*(G-H)	(5)*W*1000		Wt_s		

$$P=\left\{\frac{D+d}{x+ws}*\left((x+ws)-{}^{x}/_{4}\right)\right\}-\left\{\frac{D}{x}\left(x-{}^{x}/_{4}\right)\right\}$$

$$A=\left\{\frac{D+d}{x+ws}*\left((x+ws)-{}^{x}/_{4}\right)\right\}$$

$$B=\left\{\frac{D}{x}\left(x-{}^{x}/_{4}\right)\right\}$$

$$C=\left\{\frac{A}{(x+ws)-x/4}*\left((x+ws)-2\,{}^{x}/_{4}\right)\right\}$$

$$D=\left\{\frac{B}{(x-x/4)}*\left(x-2\,{}^{x}/_{4}\right)\right\}$$

$$E=\left\{\frac{C}{(x+ws)-2x/4}*\left((x+ws)-3\,{}^{x}/_{4}\right)\right\}$$

$$F=\left\{\frac{D}{(x-2x/4)}*\left(x-3\,{}^{x}/_{4}\right)\right\}$$

$$G=\left\{\frac{E}{(x+w\ )-3x/4}*\left((x+ws)-4\,{}^{x}/_{4}\right)\right\}$$

$$H=\left\{\frac{F}{(x-3x/4)}*\left(x-4\,{}^{x}/_{4}\right)\right\}$$

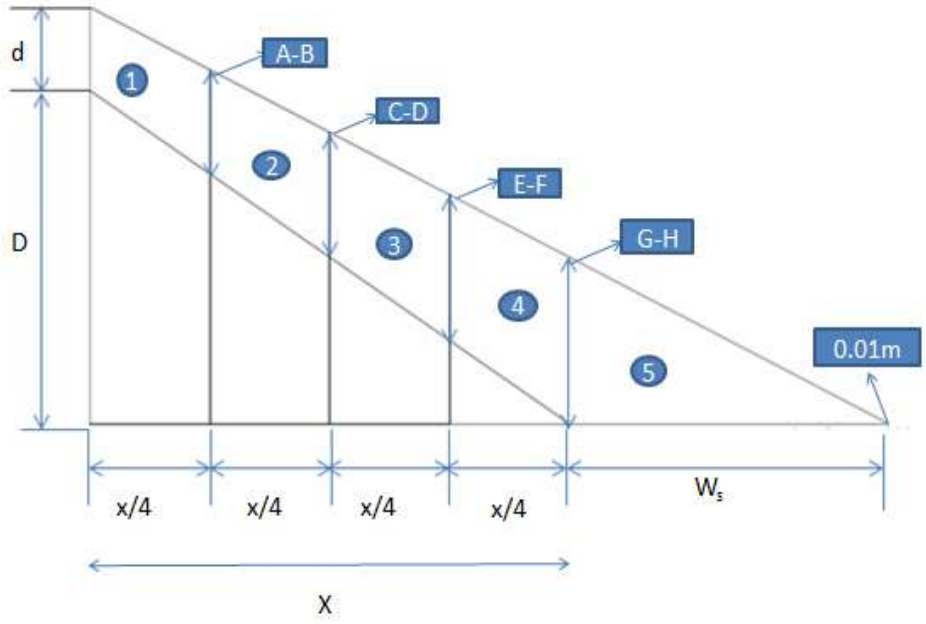


Fig. 2.10 Pressure diagram for chute spillway

II. THE WEIGHT OF THE SECTION OF STRUCTURE

=**Cross-sectional area of a section (L/4*W) *thickness (t)*density,** Kg

III. LENGTH OF THE TOTAL CHANNEL**(L)=(D^2+x^2)$^{0.5}$,** m

IV. LENGTH OF EACH SECTION=**L/4,** m

V. WEIGHT OF THE BASE OF EACH SECTION= **(L/4)*W*t*density,** Kg

VI. WEIGHT OF TWO SIDE WALLS ON EACH SECTION =**2*((L/4)*d*t*density),** Kg

VII. TOTAL WEIGHT OF EACH SECTION

(W_t)=((L/4)*W*t*density)+(2*((L/4)*d*t*density)), Kg

WEIGHT OF THE STILLING BASIN

VIII. WEIGHT OF THE BASE=**W_s*W*t* density,** Kg

IX. SUPPOSE THE HEIGHT OF SIDE WALLS OF THE STILLING BASIN=**0.7,** m

X. WEIGHT OF THE SIDE WALLS=**2*(W_s*0.7*t* density)**, Kg

XI. TOTAL WEIGHT OF THE STILLING BASIN

(Wt_s)=(W_s*W*t* density)+(2*(W_s*0.7*t* density)), Kg

3. RESULTS AND DISCUSSION

Gully control structures, such as check dams, drop spillways, drop inlet spillways, and chute spillways, are developed using hydrologic, hydraulic, and structural stages.

3.1 Check Dam Design Hydrologic design for gully control structures is similar, but check dam design differs. Hydraulic and structural designs vary each structure. Using mathematical formulas from the previous chapter, structures are constructed in Visual Studio 13.3.1 Check Dam Design - Hydrologic design based on numerical formulas - Fig. 3.1 - Hydraulic design procedure - Fig. 3.2 - Structural design - Fig. 3.3 - Check dam discharging at maximum flood level - Fig. 3.4 - Check against

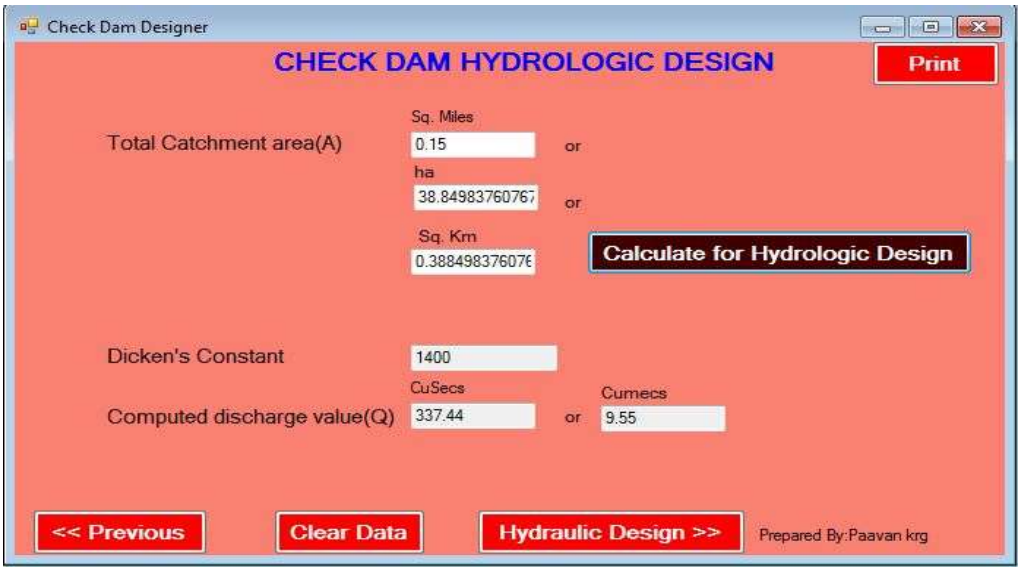
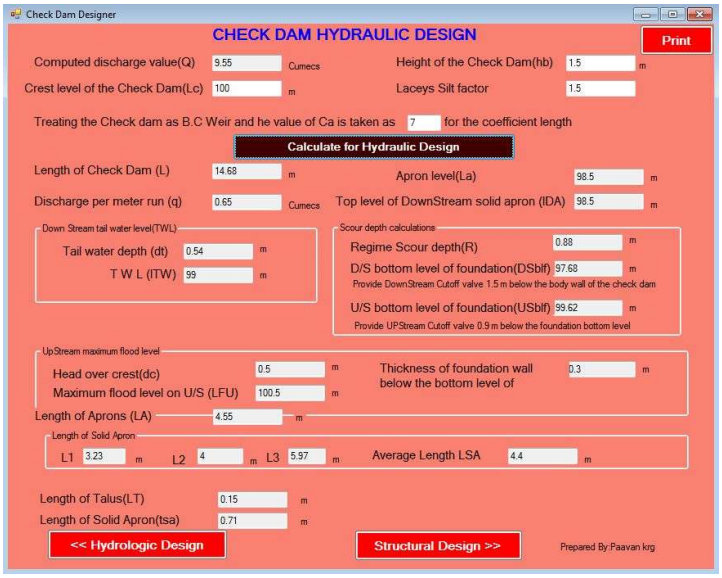


Fig.3.1. Hydrologic design of check dam



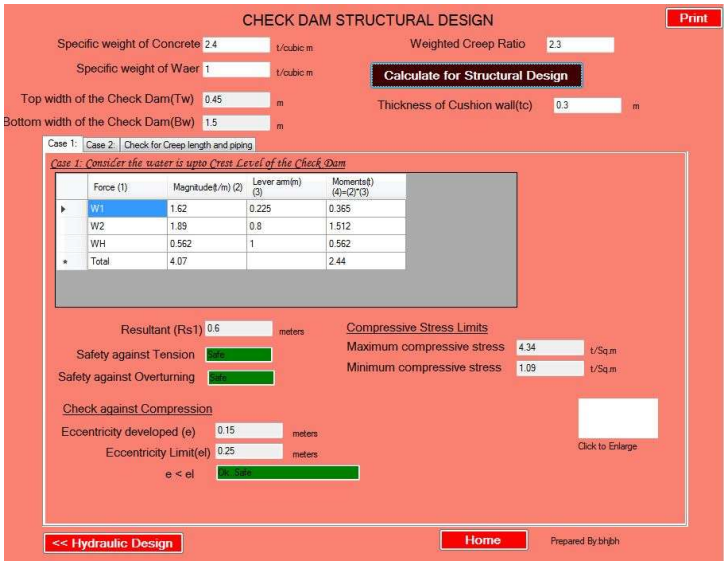


Fig.3.2. Hydraulic design of check dam **Fig.3.3. Water is up to crest level of check dam**



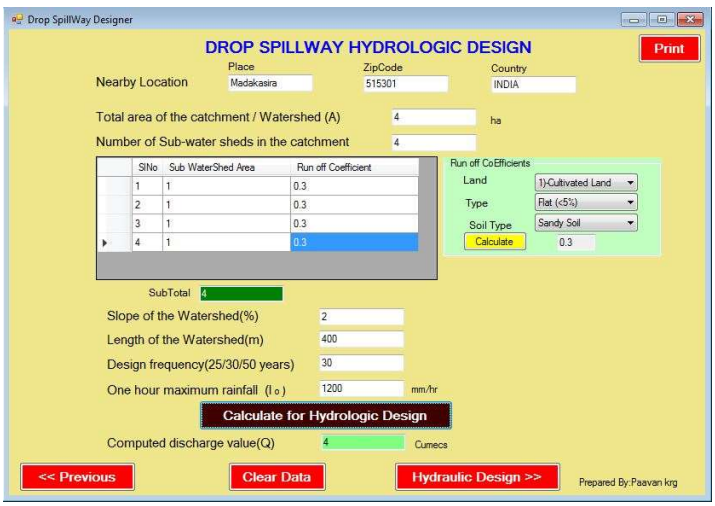


Fig.3.4. Check dam is discharging at maximum flood level

Fig.3.5. Check against creep length and piping

4.2 Drop spillway design

The hydrologic design of a drop spillway is determined by the rational formula, as shown in Figure 3.6. The hydraulic design process for the drop spillway is illustrated in Figure 3.7. Additionally, the structural design of the drop spillway is analyzed by force analysis.



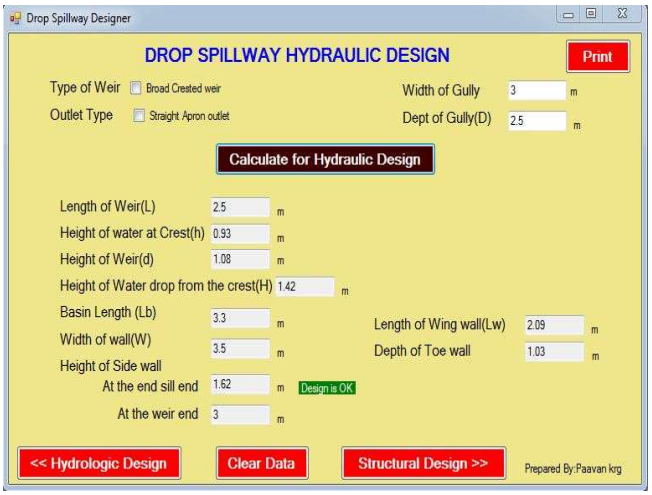
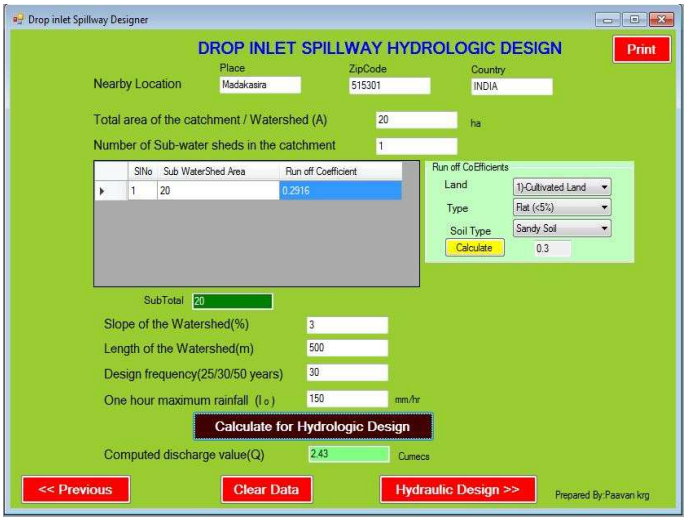


Fig.3.6. Hydrologic design of Drop Spillway **Fig.3.7. Hydraulic design of Drop Spillway**

4.3 Drop Inlet spillway design

The design of the drop intake spillway takes into account the hydrologic design, as shown in Figure 3.8, and the hydraulic design of the pipe spillway, which considers factors such as the percentage of pipe flow, as illustrated in Figure 3.9.



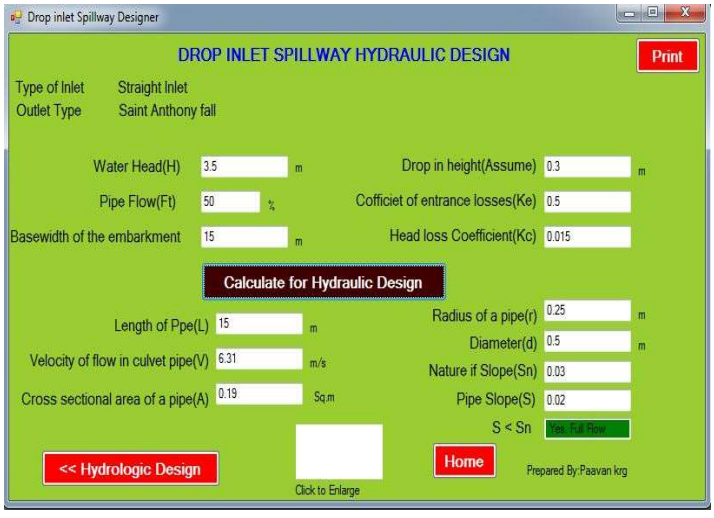


Fig.3.8. Hydrologic design of Drop Inlet Spillway **Fig.3.9. Hydraulic design of Drop Inlet Spillway**

3.4 Chute spillway design

The hydrologic design of a chute spillway is also determined by using the rational method for calculating the maximum flood flow, as seen in Figure 3.9. The dimensions of the chute spillway are determined by the hydraulic design technique, as seen in Figure 3.10. The structural design of the chute spillway involves the performance of strength and stability calculations.

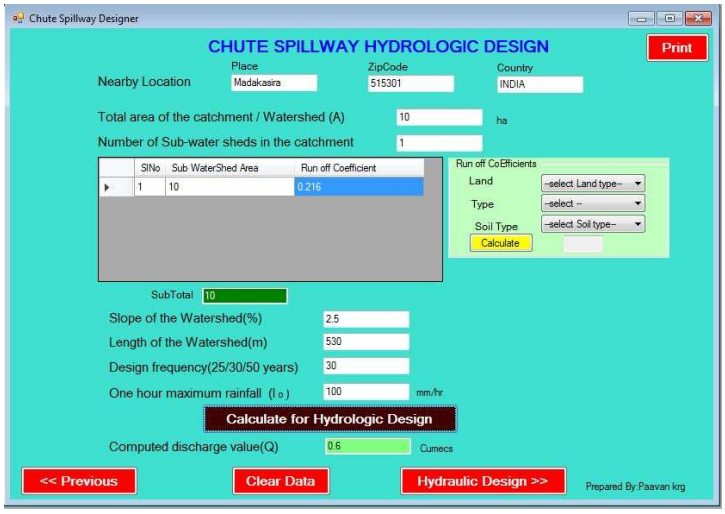


Fig.3.9. Hydrologic design of Chute Spillway

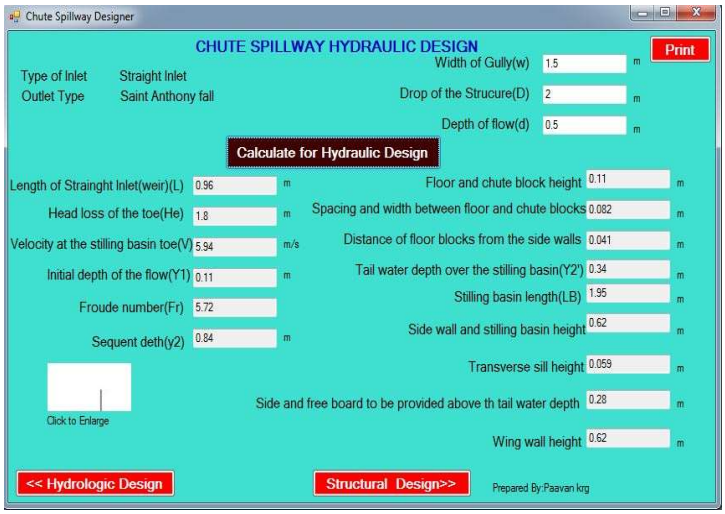


Fig.3.10. Hydraulic design of Chute Spillway

3.5 Validation of GCS_Designer for check dam

Table 3.1 shows the hydrologic, hydraulic, and structural design parameters computed by the program and compared to manual output or human computation for the check dam. GCS_Designer software and hand calculation yielded the same maximum flood discharge of 9.55 m3/s, hence no mistake was discovered.

The manual check dam length was 14.67 m and the GCS_Designer length was 14.68 m, and the truncation error was 0.0681 due to rounding. Except for length of apron 4.54 m and 4.55 m, length of solid apron 4.39 m and 4.40 m, and thickness of solid apron 0.70 m and 0.71 m for manual and GCS_Designer, the remaining hydraulic design parameters have similar values in both outputs and zero percentage error.

In two cases, structural design parameters have split. In circumstance 1 (water up to the check dam crest), manual and GCS_Designer had maximum compressive stress of 4.37 and 4.34 t/m2 and minimum of 1.06 and 1.09 t/m2. Maximum and lowest compressive stresses have -0.6192% and 2.7523% errors.

In case 2 (check dam discharge at maximum flood level), manual and GCS_Designer had maximum compressive stress of 4.93 and 4.90 t/m2 and minimum of 2.25 and 2.31. Maximum and lowest compressive stresses have errors of -0.6122% and 2.5974%.

Manual and GCS_Designer creep lengths were 12.34 m and 12.36, with weighted creep ratios of 4.25 and 4.26. Creep length and weighted creep ratio have 0.1618 and 0.2347 percentage errors. Table 4.1 creep length for structural design was correct.

GCS_Designer validation in check dams yielded 2.7523 % error for minimum compressive stress and 0.0681 % inaccuracy for length. Validating GCS_Designer for check dam involves 25 parameters. 10 parameters have % errors while the rest have zero. The remainder are under estimate (negative) and 80% are above estimate (positive).

Table: 3.1. Validation of GCS_designer for check dam

Design parameter	Manual output	GCS_Designer output	% of Error	Remarks
Hydrologic Design				
Computation of maximum flood discharge (Q),m^3/s	9.55	9.55	0.0000	do
Hydraulic Design				
Length of check dam (l),m	14.67	14.68	0.0681	Truncation
Discharge per meter run (q),m^3/s	0.65	0.65	0.0000	do
Apron level (l_a),m	98.50	98.50	0.0000	do
Top level of downstream solid apron (l_{da}),m	98.50	98.50	0.0000	do
Tail water depth (d_t),m	0.54	0.54	0.0000	do
Head over crest (d_c),m	0.50	0.50	0.0000	do
Scour Depth Calculations				
Regime Scour depth(R), m	0.88	0.88	0.0000	do
Length of aprons (LA),m	4.54	4.55	0.2198	Truncation
Length of solid apron (LSA) ,m	4.39	4.40	0.2273	Truncation
Length of talus(LT),m	0.15	0.15	0.0000	do
Thickness of solid apron($\mathbf{t_{sa}}$),m	0.70	0.71	1.4085	Truncation
Structural Design				
Case-1 (Water is up to crest level of the check dam)				
Resultant (Rs1),m	0.60	0.60	0.0000	do
Maximum Compressive Stress, t/sq.m	4.37	4.34	-0.6912	Truncation

Minimum Compressive Stress, t/sq.m	1.06	1.09	2.7523	Truncation
Eccentricity developed (e), m	0.15	0.15	0.0000	do
Eccentricity limit (el),m	0.25	0.25	0.0000	do
Case-2 (Check dam is discharging at maximum flood level)				
Resultant (Rs2),m	0.66	0.66	0.0000	do
Maximum Compressive Stress, t/sq.m	4.93	4.90	-0.6122	Truncation
Minimum Compressive Stress, t/sq.m	2.25	2.31	2.5974	Truncation
Eccentricity developed (e), m	0.09	0.09	0.0000	do
Eccentricity limit (el),m	0.25	0.25	0.0000	do
Check against creep and piping				
Creep Length required (C_L), m	10.50	10.50	0.0000	do
Creep length provided (CLP), m	12.34	12.36	0.1618	Truncation
Weighted creep ratio (C_W)	4.25	4.26	0.2347	Truncation

3.6 Validation of GCS_designer for drop spillway structure

GCS_Designer software and hand calculation yielded the same maximum flood discharge of 4.00 m3/s, hence no mistake was discovered.The height water at the crest was 0.93 m and 0.96 m (error = -3.2258 %), the weir was 1.08 m and 1.11 m (error = -2.7778 %), the water drop from the crest was 1.42 m and 1.39 m (error = 2.1127 %), the basin apron was 3.30 m and 3.27 m (error = 0.9091%), and the wing wall was 2.09 m and 2.16 m (error = -3.3493%). The weir crest length, side wall width, and side wall height were correct. In structural design of drop spillway, total uplift pressure was 0.92 m in both outputs, therefore no mistake occurred. The findings were in Table 4.2. GCS_Designer validation in drop spillway showed -3.3493 % error for wing wall length and -0.0309 % error for head wall extension at end sill end. Out of 12 parameters analyzed for GCS_Designer drop spillway validation, 7 exhibit % error and the rest show zero. 28.6% of drop spillway values are above estimate and 71.4% are under estimate.

Table: 3.2. Validation of GCS_designer for Drop Spillway Structure

Design parameter	Manual output	GCS_Designer output	% of Error	Remarks
Hydrologic Design				
Computed discharge value (Q),m^3/s	4.00	4.00	0.0000	do
Hydraulic Design				
Length of weir crest (L),m	2.50	2.50	0.0000	do
Height of water at crest (h),m	0.96	0.93	-3.2258	Truncation
Height of the weir (d),m	1.11	1.08	-2.7778	Truncation
Height of water drop from the crest (H),m	1.39	1.42	2.1127	Truncation
Basin apron length (Lb),m	3.27	3.30	0.9091	Truncation
Width of the side wall (W),m	3.50	3.50	0.0000	do
Length of the wing wall(Lw),m	2.16	2.09	-3.3493	Truncation
Depth of the toe wall, m	1.06	1.03	-2.9126	Truncation
At the end sill end, m	1.67	1.62	-0.0309	Truncation
At the weir end, m	3.00	3.00	0.0000	do
Structural Design				
Total Uplift Pressure (P_u),m	0.92	0.92	0.0000	do

3.7 Validation of GCS_designer for Drop Inlet spillway

The discharge value of 2.43 m3/s was determined for both the manual calculation and the output from the GCS_Designer program. The velocity of the flow in the culvert pipe was measured to be 6.31 m/s and 6.30 m/s (with an error of 0.0016%) for the GCS_Designer software output and manual output, respectively. However, no error was observed in the measurements of the pipe's length (15 m), cross-sectional area (0.19 m2), radius (0.25 m), natural slope (0.03%), and pipe slope (0.02%), as indicated in Table3.3. The user's text is incomplete and does not provide any information. The validation of GCS_Designer was seen in the drop inlet spillway, resulting in a velocity of flow in the culvert pipe with an inaccuracy of 0.0016%.

The validation of GCS_Designer for drop inlet spillway involves the consideration of a total of 8 parameters. Among these parameters, one parameter exhibits a percentage of error, while the rest

parameters exhibit zero % error. A mistake has been observed in the drop inlet spillway among a total of 8 parameters, while the remaining 87.5% of values do not exhibit any errors.

Table: 3.3. Validation of GCS_designer for Drop Inlet Spillway

3.8 Validation of GCS_designer for Chute spillway

The discharge value of 0.60 m3/s was determined using the GCS_designer program, and no errors were detected throughout the hydrologic design process. The Froude numbers were determined to be 5.72 and 5.85, with an error of -2.2727%. The sequent depths were measured to be 0.84 m and 0.82 m, with an error of 2.3810%. The spacing and width between the floor and chute blocks were found to be 0.082 m and 0.08 m, with an error of 2.4390%. The distance of the floor blocks from the side walls were measured to be 0.041 m and 0.04 m, with an error of 2.4390%. The tail water depth over the stilling basin was determined to be 0.34 m and 0.33 m, with an error of 2.9412%. The length of the stilling basin was measured to be 1.95 m and 1.85 m, with an error of 3.0769%. The height of the sidewall and stilling basin was found to be 0.62 m and 0.60 m, with an error of 3.2258%. The transverse sill height was measured to be 0.059 m and 0.06 m, with an error of -1.6949%. The side wall free board above the trailed water depth was determined to be 0.28 m and 0.27 m, with an error of 3.5714%. The wing wall height was measured to be 0.62 m and 0.60 m, with an error of 3.2258%. The GCS_Designer software output and manual output yielded these results, with no errors found in the remaining parameters of the hydraulic design of the chute spillway, as presented in Table 3.4.

Design parameter	Manual output	GCS_Designer output	% of Error	Remarks
Hydrologic Design				
Computed discharge value (Q),m3/s	2.43	2.43	0.0000	do
Hydraulic Design				
Length of pipe (L),m	15.00	15.00	0.0000	do
Velocity of flow in culvert pipe (v), m/s	6.30	6.31	0.0016	Truncation
Cross sectional area of a pipe (A), sq.m	0.19	0.19	0.0000	do
Radius of a pip(R),m	0.25	0.25	0.0000	do
Diameter of a pipe(d),m	0.50	0.50	0.0000	do
Natural slope (Sn), %	0.03	0.03	0.0000	do
Pipe slope(S), %	0.02	0.02	0.0000	do

Table: 3.4. Validation of GCS_designer for Chute Spillway

The chute spillway's structural design parameters were length of the total channel 3.61 m and 3.6 m

Design parameter	Manual output	GCS_Designer output	% of Error	Remarks
Hydrologic Design				
Computed discharge value (Q),m^3/s	0.60	0.60	0.0000	do
Hydraulic Design				
Length of the straight inlet(L),m	0.96	0.96	0.0000	do
Head loss at toe (H_e),m	1.80	1.80	0.0000	do
Velocity at stiiling basin toe (V), m/s	5.94	5.94	0.0000	do
Initial depth of the flow (Y1),m	0.11	0.11	0.0000	do
Froude number (Fr)	5.85	5.72	-2.2727	Truncation
Sequent depth (Y2),m	0.82	0.84	2.3810	Truncation
Floor and chute block height, m	0.11	0.11	0.0000	do
Spacing and width between floor and chute blocks, m	0.08	0.082	2.4390	Truncation
Distance of floor blocks from the side walls, m	0.04	0.041	2.4390	Truncation
Tail water depth over the stilling basin(Y2'),m	0.33	0.34	2.9412	Truncation
Stilling basin length(LB),m	1.89	1.95	3.0769	Truncation
Sidewall and Stilling basin height, m	0.60	0.62	3.2258	Truncation
Transverse sill height, m	0.06	0.059	-1.6949	Truncation
Side wall free board to be provided above the trailed water depth, m	0.27	0.28	3.5714	Truncation
Wing wall height, m	0.60	0.62	3.2258	Truncation
Structural Design				
Horizontal length of spillway(x),m	3.00	3.00	0.0000	do
Length of the total channel(L),m	3.60	3.61	0.2770	Truncation
Length of each section, m	0.90	0.90	0.0000	do
Weight of the base of each section, kg	466.70	466.75	0.0107	Truncation
Weight of two side walls on each section, kg	310.20	310.50	0.0966	Truncation
Total weight of each section(W_t), kg	778.35	778.41	0.0077	Truncation
Weight of the stilling basin				
Weight of the base, kg	1035.00	1035.00	0.0000	do
Weight of the side walls, kg	965.00	966.00	0.1035	Truncation
Total weight of the stilling basin(Wts), kg	2000.00	2001.00	0.0500	Truncation

(error = 0.2770%), weight of each section's base 466.75 kg and 466.70 kg (error = 0.0107%), weight of two side walls 310.50 kg and 310.20 kg (error = 0.0966%), total weight of each section 778.41 kg and 778.35 kg (error = 0.0077%), and weight of the stilling basin side walls 966 kg and 965 kg (error = 0.1035%). For GCS_Designer software output and manual output, chute spillway structural design was error-free. Horizontal length was 3.0 m, section length was 0.9 m, and stilling basin base weight

was 1035 kg. GCS_Designer proved valid in chute spillway with 3.5714 % error for side wall free board above tail water depth and 0.0077 % error for total section weight. 16 of the 25 parameters analyzed for GCS_Designer chute spillway validation exhibit percentage of error, while the rest show zero percentage error. 87.5 % and 12.5% values were over estimate and under estimate, respectively.

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CROP REGIONS IN DISTRICT KURNOOL OF ANDHRA PRADESH

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ABSTRACT

Agricultural regionalization is a process of Delineating on area in to territorial units of complexes of uniformities on the basis of physical factors like climate, soils, vegetation, and availability of water, farm size and socio-economic parameter. It has a significant bearing on the development of agricultural and regional planning in developing countries. It is needed to understand Agricultural types, variations, challenges, forecast productivity, feature plans for agricultural developments, suggest optimal land utilization patterns, and make an inter-regional comparison in different aspects and so on. Agriculture is one of the leading occupations in India. It is back bone of Indian economy. In India nearly about 64 % of the total population and 90 % of rural population is engaged in agriculture. India being a country of Intensive subsistence farming activities are observed all-round the year in various intensities. Understating the importance of regionalization, specifically crop regions; an attempt is made in the present study, to demarcate the crop regions of Kurnool district for two time periods i.e., 2007-08 & 2018-19.

Keywords : *Primary crop region, Secondary crop region, Tertiary crop region Ranking Method, and Change of crop regions***.**

INTRODUCTION

Agriculture is an important occupation which is considered as a part and parcel

of human life and which runs through a definite process. It is carried under the control of natural environment. Agriculture is an important source of food. In spite of growing industrialization and urbanization in the world. In developing countries agriculture sector has been a major source of employed and income. Agriculture is a backbone of Indian economy. In India near about 64 % of the Total population and 90 % of rural population is engaged in agriculture. In spite of technological development, environmental factors play key role in the Development of agriculture in the region. Socio-economic factors also support for the growth of agriculture. This it is necessary to focus on the physical and Socio-economic Factors of the study region to understand the agricultural scenario of the region.

Agricultural regionalization is one of the oldest concepts in Agricultural classification and has a significant bearing on regional planning and development of agriculture in developing countries. It is regarded as a device for clustering both visible and non-visible Agricultural phenomena on the earth surface. Such device enables geographers to divide an area in to several regions in terms of diversity present in agricultural system. It gives us the relative position of crops on regional scale (Dayalan N.2018). The analysis of general land use, agricultural regionalization and cropping pattern helps to denote the intensity and status of farming in an area and also helps in the formulation of Agricultural plans which may go a long way in reducing the regional disparities and inequalities.

Systematic study of crop regions is of great significance for a comprehensive and clear understanding of the agricultural mosaic of an agro-climatic region and the planning and development of its agriculture, in recent years the concept of crop regions has engaged the attention of geographers and agricultural land use planners.

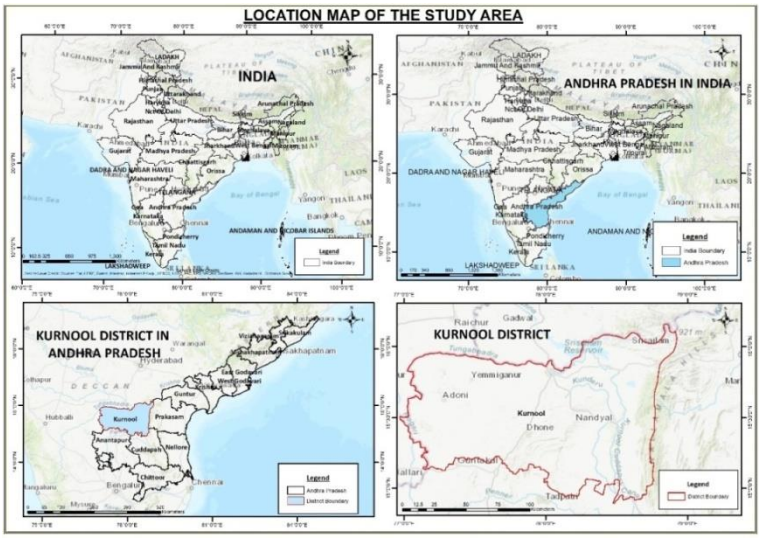
The first attempt of agricultural regionalization of Europe was made by *Jonsson* (1926) in his work Agricultural regions of Europe. Baker (1926), one of the Leading American Geographers, published Agricultural regions of North America, and Jones (1928) produced his book Agricultural regions of South America. Similarly, Taylor (1930) Delineated agricultural regions of Australia and Valkenberg (1931) divided Asia into Agricultural Regions. The first attempt to classify types of agricultural land use the world over, in terms of agricultural element – complexes, was in the form of the empirical system developed by Jones and Whittlesey (1932). A few of Russian authors who have put forwarded their views regarding Agricultural regionalization, Marshall (1787), Arsenev (1818), (Raktinika, 1959, 1971, 1973, 1975, 1979). Others have attempted to demarcate regions by aggregation of basic areal units based on agriculture with the help of quantitative taxonomic methods (Hartshorne and Dicken 1935, Nordgard 1974).

In India, geographers richly contributed to the studies of agricultural geography on various aspects including cropping intensity, crop combinations, crop concentration, crop diversification, agricultural efficiency, agricultural classification, agricultural regionalization, agricultural typology of which brought about lot of changes in the subject matter, approaches and methodology of agricultural geography. Deshpande (1942, 1964), Mukherjee (1942), Dayal (1950) etc. made regional studies in agricultural geography. Chatterjee (1952, 1956), Shafi (1960), Singh (1962), Bhatia (1967), Mishra (1969), Raifullah, Jasbir Singh (1972) etc. are among the notable agricultural geographers in India.

LOCATIONAL SETTING OF KURNOOL DISTRICT

Kurnool district is the south-western district of Andhra Pradesh and lies approximately between 14º54' to 16º18' North Latitudes and 76º58' 79º34' East Longitudes. The altitude of the district varies from 100 ft above the mean sea

level. This district is bounded on the north by Tungabhadra and Krishna River as well as Mahbubnagar district, on the south by Kadapa and Anantapur district, on the west by Bellary district of Karnataka state and on the east by Prakasam District. The district ranks 10 in population with 40, 53,463 people accounting for 4.63 % of the total population of the state as per 2011 Population census. While in area it occupies the 3rd place 17658 sq.km. which account for 6.41% of the total area of the state. The Nallamala and Earramalla are two important mountain ranges in the district running in parallel from North to south. Earramla divided the district into two well defined tracks from east to west in terms of soils. The Kurnool District is a combination of Red, Block and sandy soils. It has facility of Irrigation through canals (K. C. Canal, Tungabadra project low level canal and hundri neva sujalasravanthi project), tanks, wells, and river sources. The district has typically geographical aspects and climatic variation comparatively from other districts of Rayalaseema region of Andhra Pradesh. The district is well connected with road and rail transportation with national highways to farmer capital city of Andhra Pradesh.



OBJECTIVES

To identify and demarcate the crop regions such as primary, secondary and tertiary crop regions of Kurnool district for the years 2007-08 and 2018-19.

To study the changes in crop regions during 12 years period.

DATA AND METHODOLOGY

In the present study, secondary data pertaining to general cropping pattern for two time periods i.e., 2007-08 and 2018-19 have been collected from the Government records and reports from the Chief Planning Officer, Handbook of Statistics, Agricultural Department of Kurnool district taking 'Mandal' as Unit. Simple statistical techniques such as percentages and averages have been used to analyze the data. The spatial patterns of various crops that ranked from first to third in percentage of total cropped area is attempted here for the study of Primary, Secondary and Tertiary crop regions. The task of the first order crop regions (or) first ranking crop regions is accomplished by considering the crops which account for the maximum percentage of the total cropped area in each of the component areal units, no matter what percentage it occupies in the total cropped area. In the same way, the second-order crop regions and third-order crop regions have been demarcated on the basis of their percentage in order. To fulfill the set objectives, percentages of different crops that are growing in the district have been calculated and arranged in descending order, to demarcate the crop regions.

PRIMARY CROP REGIONS (2007-2008)

During the study period, out of 10 crops, only four crops namely Pulses (22 mandals), Ground nut (13 Mandals), Sunflower (10 mandals) and Paddy (8 Mandals) were registered as primary crops in different mandals with different concentration and one mandal srisailam which is in north eastern part of the district is 100 % covered with forest. Pulses occupied first place in the Maximum no of mandals and paddy crop in the minimum no of mandals in the district.

PULSES REGION

Pulses crop is dominant primary crop region in the study period occupying in

the district. It formed the largest region as primary crop. Pulses are one of the important food crops globally due to their higher protein content. Pulses are an important group of crops in India which is also responsible for yielding large financial gains by amounting to many exports. Pulses form an integral part of the Indian diet provides much needed protein to the carbohydrate –rich diet. India is largest producer of pulses in the world. In India the main regions with high productivity are Punjab, Haryana, western UP, West Bengal Delta region, Coastal A.P, Tamil Nadu, Kerala, Coastal and eastern Karnataka, and some parts of Maharashtra. In Kurnool it occupied about 269832 Hectares. In about 22 mandals of the district spread over in most of the south western, south-eastern, north-eastern part of the district. (Table 1 & Fig. 1).

GROUNDNUT REGION

Groundnut crop is the second –largest crop region in the study period occupying 13 mandals of the district. Groundnut is a leguminous plant that is widely cultivated in the tropics and subtropics. It is valued for its high oil edible seeds and as such, it is the fourth most important source of edible oil and a third most important source of vegetable protein and an important agricultural export commodity. In India, after Gujarat, Andhra Pradesh occupies 2nd place in groundnut production. In the actual area, it occupied about **236972** hectares. In About 13 Mandals of The district, Namely C.Belagal, Dhone, Bethamcherla, Veldurthy, Krishna Giri, Peapully, Kosigi, Pedda Kadubur, Yemmiganur, Pattikonda, Devanakonda, Tuggali, Gonegandla, mostly confined to the central, south and north western part of the district (Table 1 & Fig. 1).

SUNFLOWER REGION

Another important primary crop region in Kurnool District is sunflower spreading over 10 mandals. In the actual area, it occupied about *157104* hectares. The mandals where the sunflower region is dominant as the primary

crop region are Kallur, Kodumur, Atmakur, Kothapalle Gadivemula, Adoni, kowthalam, Nandavaram, mantralayam, Holagunda mandals, which are located in western, north, north eastern part of the district. (Table 1 & Fig. 1)

PADDY REGION

As primary crop region, paddy crop spreading over 8 Mandals, namely Velogode, Pamulapadu, Nandayala, Mahanandi, B. Atmakur, Rudra varam, sirvella, Gospadu which are distinctly seen in the eastern part of the district in Andhra Pradesh, it is mainly cultivated in the Krishna, Guntur, Kurnool, Nellore Prakasham, and twin Godavari district Kurnool sonamasoori rice is popularly fine rice variety being cultivated in Rayalaseema, especially in Kurnool due conductive atmosphere. (Table 1 & Fig. 1).

PRIMARY CROP REGIONS (2018-2019)

During the year 2018-19, 5 crops have been noticed under primary crop region in Kurnool District. They are cotton (17 Mandals), Pulses (15 Mandals), paddy (9 Mandals), millets (8mandals), Ground nut (4 mandals).

COTTON REGION

In 2018-19 cotton crop is dominant primary crop region. Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fiber) to cotton textile industry. Cotton in India provides direct livelihood to 6 million farmers and about 40 - 50 million people are employed in cotton trade and its processing. In India, there are ten major cotton growing states namely Punjab, Haryana, Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu.

Cotton region is newly formed primary crop region during the period 2018-19 replacing the sunflower, ground nut and pulses crops. The actual area it occupied in this district about 259498 hectares and spread over 17 mandals especially located in Western and northern part of the district. It is emerged as the largest crop region in the study is during 2018-19. (Table 1 & Fig. 1)

PULSES REGION

This is 2nd largest crop regions occupying the 15 mandals during the study period, confined mostly to the north, south, south eastern part of the district. (Table 1 & Fig. 1)

PADDY REGION

As a primary crop region, paddy crop is reported 9 mandals of the district, especially located in eastern part of the district. (Table 1 & Fig. 1)

MILLETS REGION

Eight mandals namely Pagidayala, Jupadubunglow, Atmakur, Pamulapadu, kothapalle, Gadivemula, Allagada, Chagalamari are reported as primary crop regions with millets in the Study period (Table 1 & Fig. 1).

GROUND NUT REGION

Ground nut as a primary crop region has been noticed in only four mandals namely Dhone, Krishna giri, Devanakonda, Tuggali located in central part of the district. (Table 1 & Fig. 1)

CHANGE IN PRIMARY CROP REGIONS (2007-08 & 2018-2019)

Noticeable changes have occurred in primary crop regions of the district during 12 years' period. Among the 4 primary crop regions which are registered in 2007-08, namely pulses, groundnut, sunflower, and paddy have been noticed.

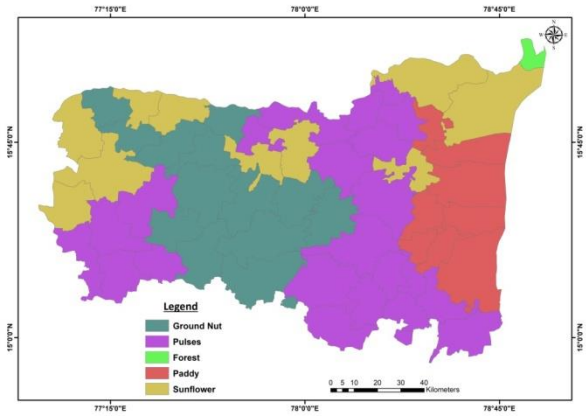
After 12 years' period, new crops Cotton and millets were registered. The other changes are, increase in the number of mandals regarding paddy crop region (+ 1 mandals). A decrease in the number of mandals has been seen in the pulse's region (-7mandals) and ground nut region (-9 mandal) and sunflower crop remarkably decrease and not registered in 2018-19. New regions i.e., the Cotton and Millets regions have emerged with 17 and 8 mandals that previously belonged to the sunflower, groundnut and pulses region (Fig. 1 & Table 1).

Table – 1

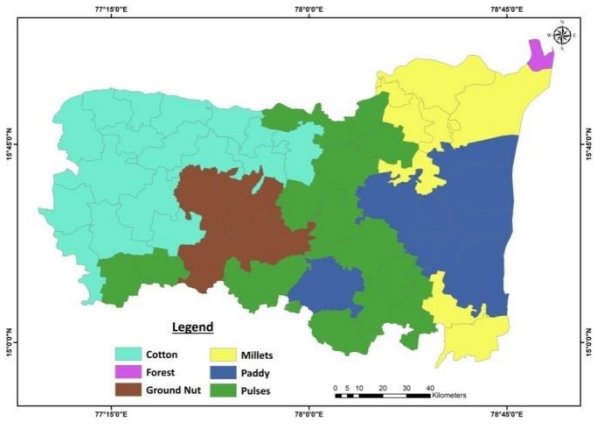
Primary crop regions in Kurnool District 2007-08 & 2018-19

S. No.	Crops in Primary Crop Region	No of Mandals in each Individual Crop Region		Decrease / Increase in the Number of Mandals during 12 Years Period
		2007-2008	2018-2019	
1	Pulses	22	15	-7
2	Ground Nut	13	4	-9
3	Sunflower	10	0	-10
4	Paddy	8	9	1
5	Cotton	-	17	17
6	Millets	-	8	8
7	**Total**	**53**	**53**	-

Fig. 1



Kurnool District Primary crop Regions 2007-2008



Kurnool District Primary crop Regions 2018-19

SECONDARY CROP REGIONS (2007-08)

Seven crops have been reported in secondary crop regions during the year 2007-08. The maximum number of mandals is in sunflower region found (15 mandals) fallowed by millets region (9 mandals), Pulses (8 mandals), Ground nut (8 mandals), Paddy (6 mandals), Fruits and vegetables (6 mandals) and cotton (1mandal). (Table-2 & Fig. 2)

SECONDARY CROP REGION (2018-19)

During 2018-19, about seven crops gained ground under secondary crop regions. Among these seven crops, Pulses region dominated with 22 mandals fallowed by millets region (10 mandals), cotton (8 mandals), Ground nut (6 mandals), Paddy (4mandals), Fruits and vegetables (2 mandals) and Condiments and spices (1 mandal). Sunflower has lost its place in the secondary crop regions during the study period. Condiments and spices came up as a new crop in the secondary crop region (Table 2 & Fig. 2).

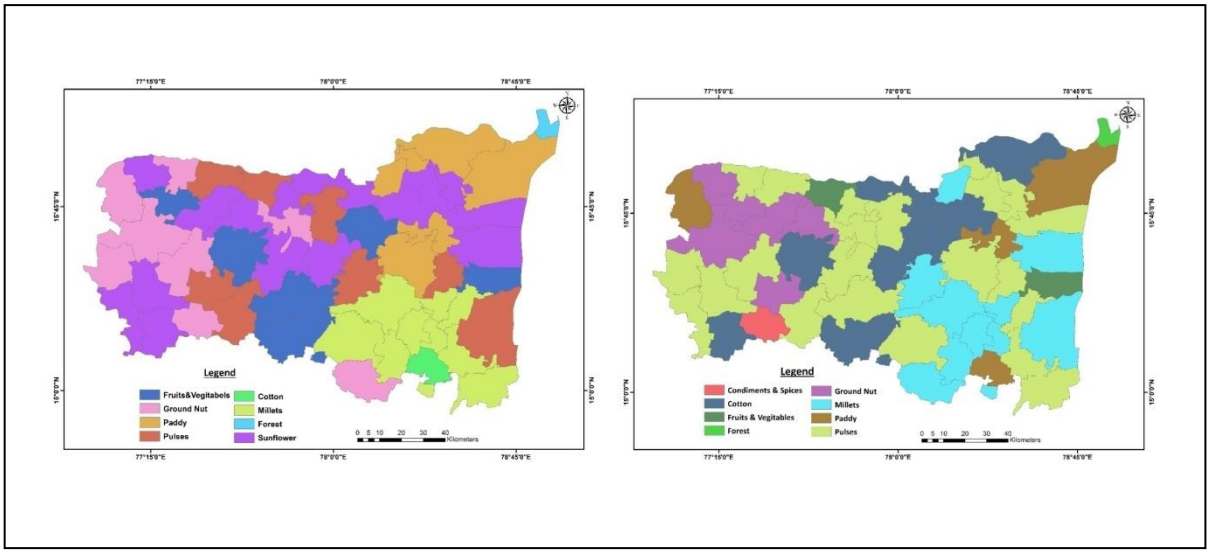
CHANGES IN THE SECONDARY CROP REGION (2007-08 TO 2018-19)

Table -2

Secondary crop regions in Kurnool District 2007-08 & 2018-19

S. No.	Crops in Primary Crop Region	No of Mandals in each Individual Crop Region		Decrease / Increase in the Number of Mandals during 12 Years Period
		2007-2008	2018-2019	
1	Pulses	8	22	14
2	Ground Nut	8	6	-2
3	Sunflower	15	-	-15
4	Paddy	6	4	-2
5	Cotton	1	8	7
6	Millets	9	10	1
7	Fruits & Vegetables	6	2	-4
8	Condiments & Spices	-	1	1
	Total	53	53	-

Fig. 2



Kurnool District secondary crop regions 2007-08

Kurnool District secondary crop regions 2018-19

During 2007-08, seven crops have been recorded under secondary crop regions and the year 2018-19 also seven crops formed secondary crop regions. An increase in the areal spread has been observed in pulses (14 mandals), cotton (7 mandals), Millets (1 mandal) and condiments and spices (1 mandal). Decrease in the number of mandals has been found in fruits and vegetables (4 mandals), Ground nut (2 mandals) and paddy (2 mandals). Sunflower has lost its place in the secondary crop regions. Condiments and spices crop region is the new secondary crop region reported in 2018-19.

TERTIARY CROP REGIONS (2007-08)

In 2007-08, as many as 8 crops have emerged as the third ranking crops in the district, among which pulses (11 mandals) fallowed by sunflower (10 mandals), paddy (10 mandals), millets (9 mandals), Ground nut (7 mandals), Fruits and vegetables (3 mandals), condiments and spices (2 mandals) and cotton (1 mandal). (Table 3 & Fig. 3).

TERTIARY CROP REGIONS (2018-19)

During the year 2018-19, 9 crops have been noticed under tertiary crop regions with varied intensity. Paddy crop region is emerged as the largest tertiary crop region with 15 mandals fallowed by Millets (14 mandals), pulses (7 mandals), cotton (5 mandals) fruits and vegetables (4mandals), Ground nut (3 mandals), condiments and spices (3mandals), onions (1 mandal) and castor (1 mandals). sunflower has lost its place in the secondary crop regions. Onions and castor crop regions are the new secondary crop regions reported in 2018-19. (Table 3 & Fig. 3)

Table - 3

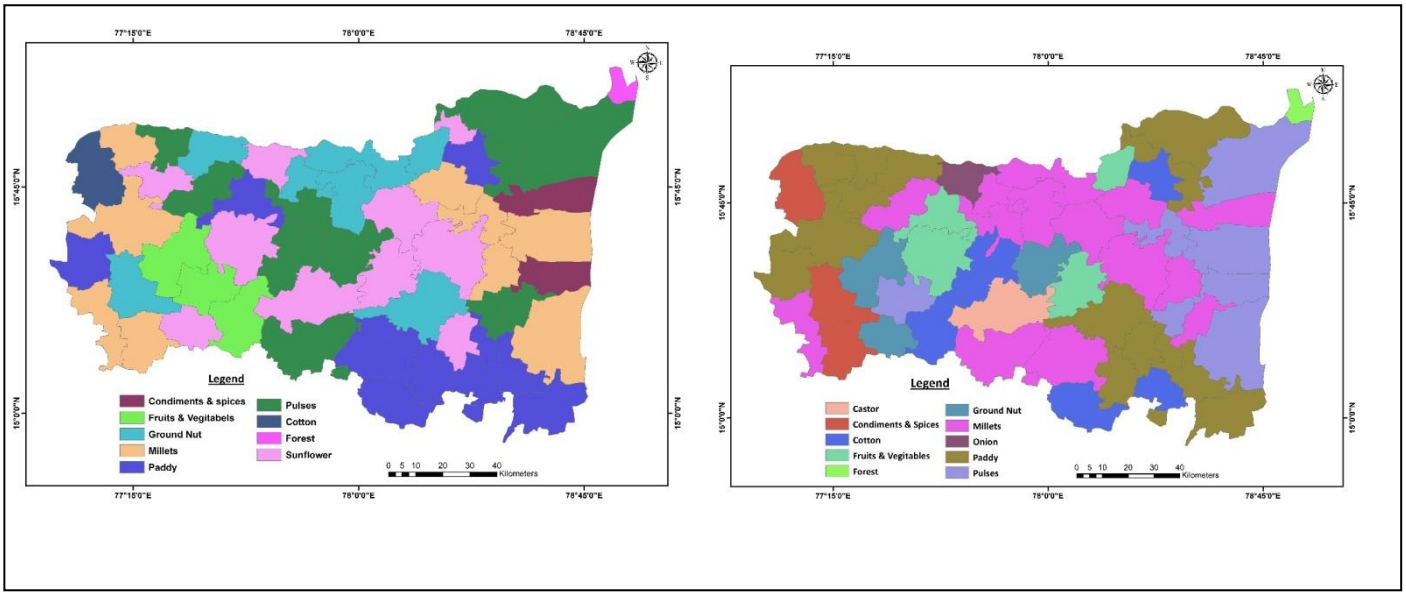
Tertiary crop regions in Kurnool District 2007-08 & 2018-19

S. No.	Crops In Primary Crop Region	No Of Mandals In Each Individual Crop Region		Decrease /Increase In The Number Of Mandals During 12 Years Period
		2007-2008	**2018-2019**	
1	Pulses	11	7	-4
2	Ground Nut	7	3	-4
3	Sunflower	10	-	-10
4	Paddy	10	15	5
5	Cotton	1	5	4
6	Millets	9	14	5
7	Fruits &Vegitables	3	4	1
8	Condiments &Spices	2	3	1
9	Onions	-	1	1
10	Castor	-	1	1
		53	53	-

Totally about 10 crops have been reported in the study period under tertiary crop regions. They are pulses, Groundnut, sunflower, paddy, cotton, Millets, fruits and vegetables, condiments and spices, Onions and castor. A decrease in the number of mandals each tertiary region during the 12 years is observed in pulses (-4 mandals) and Ground nut (-4 mandals). Increase in the number of mandals under each tertiary crop region during the 12 years of study period is noticed paddy (5mandals), millets (5 mandals) cotton (4 mandals), Fruits and

vegetables (1 mandals) and condiments and spices (1 mandals). Onions and castor crop regions are the new secondary crop regions reported in 2018-19. Sunflower tertiary crop region is absent during the 2018-19.

Fig. 3



Kurnool district Tertiary crop regions 2007-08

Kurnool district Tertiary crop regions 2018-19

CONCLUSION

During the agricultural year 2007-08, Kurnool District in India exhibited four primary crop regions, which included Pulses, Groundnut, Sunflower, and Paddy. However, in the subsequent agricultural year of 2018-19, there was a significant decline in the Sunflower crop region, and it was no longer registered in the district's agricultural landscape. In addition to the existing primary crop regions, Cotton and Millet crop regions emerged previously encompassed within the regions of Sunflower, Groundnut, and Pulses. Regarding the secondary crop regions, the year 2007-08 saw a total of seven crop regions. Unfortunately, in 2018-19, Sunflower lost its place among the secondary crop

regions, and a new crop region, namely Condiments and Spices, emerged, resulting in a total of seven secondary crop Regions.

In both years, 2007-08 and 2018-19, the district reported eight different crop regions at the tertiary level. However, in 2018-19, the Sunflower tertiary crop region was absent, and instead, Castor and Onion regions emerged, replacing one of the tertiary crop regions from 2007-08, namely sunflower. The agricultural landscape of Kurnool District underwent notable changes between 2007-08 and 2018-19. Sunflower experienced a significant decrease and was no longer present in both secondary and tertiary crop regions. Meanwhile, new crop regions like Cotton, Millet, Condiments, and Spices emerged, showcasing the dynamic nature of agriculture in the region over the year.

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IDENTIFYING THE TRUE COST OF NITRATE CONTAMINATION IN THE MID-GANGETIC PLAIN, BIHAR (INDIA): WHO'S PAYING FOR THOSE COSTS AND WHO'S RECEIVING THE BENEFITS

Narender Singh

Abstract

The Mid-Gangetic Plain (MGP) covers an area of 99,058 km^2 & is a lifeline for millions of people who rely heavily on groundwater. Although this is a region rich in rivers, more than 80% of the irrigation needs of the Bihar plains are met by groundwater, mainly due to easy access, unpredictability and poor irrigation networks. This has led to a rapid decline in water quality and quantity in shallow aquifers. This research aims to understand how nitrate contamination in the groundwater of the MGB has developed over time & comprehend the specific impacts on the rural communities of India particularly those facing socio-economic challenges. Given that a substantial 80% of India's populace resides in these rural regions, understanding & addressing these implications is of paramount importance. The weighted average water quality index (WAWQI) shows that 20.2% of groundwater is unfit for drinking. Surface water irrigation in the 19th century, the introduction of nitrogen-intensive crops (i.e. wheat, rice & sugarcane etc.) & pesticide at higher rate in the 20th century, urban development and groundwater irrigation intensified agricultural activity in the Indo-Gangetic Plain. Furthermore, the districts of South Bihar, compared to North Bihar, naturally receive a disproportionate amount of irrigation water from the Ganga and its tributaries. Additionally, during the non-monsoon season (November to June with little rainfall), groundwater is most often used for irrigation, especially for growing wheat & during the monsoon season (July to October with abundant rainfall), the demand for rice is met by the combination of monsoon rains and groundwater that transfers excess nitrate to shallow aquifers through vertical connections. This can cause secondary reactions in aquifer minerals, leading to the mobilization of toxic pollutants, thereby affecting human health. Other sources of groundwater contamination include unrestricted discharge of partially or untreated sewage and industrial wastewater into surface waters, which eventually percolate underground and contaminate surface aquifers.

Introduction

Nitrate contamination is an escalating concern in India, endangering groundwater safety and public health. Groundwater serves as the primary drinking water source for 85 % of India's rural population and fulfills 60 % of its agricultural water demands. The Ganga alluvial plain hosts a significant population, around 10% of the global populace, with agriculture serving as the primary livelihood in the Mid-Gangetic Plain. (World Bank, 2011) Due to over-exploitation of groundwater for irrigation and instability over time, groundwater levels are currently decreasing, especially in southern Bihar districts (i.e. Buxar, Bhojpur, Rohtas, Kaimur, Aurangabad, Gaya, Arwal, Nawada, Jamui, Banka, Sheikhpura and Lakhisarai). Furthermore, the main factor influencing changes in groundwater storage in the Mid-Gangetic Plain is pumping rather than differences in rainfall. Similar alluvial aquifer systems worldwide have faced water table declines due to unchecked groundwater extraction (Konikow, Kendy et al., 2005; Gautam et al., 2020). Furthermore, the swift pace of urbanization and industrialization poses a major threat, deteriorating both the quantity and quality of groundwater (Nijesh et al., 2021; Pant et al., 2021).

High levels of groundwater nitrate primarily stem from extensive nitrogen fertilizer usage, yet other contributing factors include intrinsic elements like geology, hydrogeology, hydro-geochemistry, biogeochemical processes, as well as external human-driven influences such as land use. These aspects collectively affect the leaching and distribution of nitrate in groundwater. In the last 30 years, northern India has experienced declining water tables due to shifting rainfall patterns and extensive groundwater extraction. While this issue receives considerable attention, the deterioration of groundwater quality from significant pollutants like nitrate, arsenic, heavy metals and organic contaminants is equally concerning, albeit less highlighted. (MacDonald et al., 2016). To solve this problem, the Indian government has proposed to increase the efficiency of groundwater use for irrigation by 20% (MOWR, 2014). A recent study supports this suggestion, showing that different watering methods (sprinkler, drip, and alternating wet/dry systems) can increase efficiency by 23 to 49% without reduces productivity (Bouman et al., 2001) but currently, the impact of this proposed improvement on water levels in the area has not yet been quantitatively assessed. Therefore, consistent and methodical monitoring of groundwater quality is crucial to track contamination factors and develop sustainable aquifer management strategies. (Bonsor et al., 2017). Hence, it's crucial to pay particular attention to shallow groundwater extensively used for household needs.

Objectives

(1) To determine the groundwater quality in the Mid-Gangetic Plain and assessing its adequacy for municipal water supply requirements using the WAWQI (Water Quality Index); and

(2) Moreover, to examine the true costs associated with nitrate pollution in the research region in order to determine which organizations bear these costs and who benefits from this circumstance.

Study Region

The current research area is 99,058 square kilometers, including the latitudes of 24°00′N to 28°40′N and the longitudes of 78°40′E to 86°10′E. It is located in India's Middle Ganga Basin includes 29 districts in the state of Uttar Pradesh. This area is located in an active tectonic zone in the Ganga Plain. The majority of the sediments in this basin are from the Himalayas, which are periodically subject to tectonic movements and climate changes. (Shukla, Raju et al. 2008). Over 30% of India's groundwater supplies are unsuitable for human consumption (Cronin, Prakash et al. 2014). It could be a difficult and nerve-wracking effort to provide drinking water to approximately 700 million rural Indians who live in 15 different ecological regions. Additionally, water-related chronic diseases impact the economy and cost the country approximately 180 million working days annually. (Water Aid, 2007). According to the Agency for Toxic Substances and Disease Registry (ATSDR) of 2011, the toxicity ranking nitrate is 220 but this groundwater contamination challenge impact socioeconomically deprived rural inhabitants in India, where about 80% of the population resides. The concentrations of nitrate in drinking water, primarily induced by agricultural activities, exceeded the Bureau of Indian Standards (BIS) of 45mg/L in 11 states of India. The first reported case of high concentrations of nitrate was in the southern district Rohtas of Bihar. (Ray, et al., 2000) Later, groundwater nitrate contamination greater than the BIS standard was reported in a total of 266 and 503 blocks (out of 534) in 9 districts (out of 38) respectively. (Mishra, Shaw et al. 2009). In the consecutive years numerous habitations were found contaminated with nitrate levels greater than the World Health Organization (WHO) standard of 50mg/L. Elevated levels of nitrate in the soil and in the food chain, and health risks associated with the consumption of nitrate through water and foods were also reported in the state. (Singh, Ghosh et al. 2014)

Database and Methodology

Groundwater samples were collected from across the Gangetic plain during the post-monsoon period of 2015 by the Central Ground Water Board (CGWB). They mainly collected samples from hand pumps that draw water from the aquifer. Various factors influencing the chemical composition of water have been extensively studied worldwide using statistical techniques such as hydro chemical scatter plots, simple linear regression, analytical multivariate trilinear regression, multivariate statistical analysis (MSA), remote sensing and geospatial methods. Multivariate statistical analysis (MSA) was used for sedimentary rock aquifers in Canada to understand hydrogeochemical evolution (Cloutier et al. 2008), similar method for assessing aquifer connectivity and sediment flux in Australia (King et al. 2014). In the Ganga basin, researchers have successfully studied the geochemical processes in aquifer evolution and hydro geochemistry using MSA, various graphs and correlation matrices (Pant et al., 2021; Kumar et al., 2021). Geospatial techniques are valuable for spatial visualization and temporary and have been used worldwide to identify potential groundwater areas, understand seasonal variations in contaminants in different hydro geological environments and more. (Nitesh et al., 2021) Maps created with Adobe Photoshop 7.0 taking into account the ATSDR (2011) toxicity level of the contaminant, based on district-level groundwater pollution data for nitrate, fluoride and any other contaminant which we obtained from the official website of Ministry of Drinking Water and Sanitation, Government of India.

Results and Discussion

In Bihar, out of 532 community blocks, roughly 13% of the blocks had nitrate contamination; no district had 100% nitrate contamination. Of the districts in the state, only 4 had nitrate contamination levels of ≥50%, while eleven were completely free of nitrate pollution. A total of 180 community blocks (out of 532) had only one contaminant, according to several groundwater contamination analyses. That is, nitrate contamination affected 8 neighborhood blocks across 6 districts. There were 13 blocks containing iron and nitrate in 8 districts; 5 blocks containing nitrate and arsenic in 4 districts; and 1 block containing fecal coliform and nitrate in just one district (**Fig. 1**). Thus, it determined that four districts are at the extreme end of the pollution prevention scale, and nine districts are at the high priority level, requiring rapid attention to water management. Most of the districts that border the Ganges River are classified as either high priority areas or extreme areas. Groundwater mitigation strategies and interventions should be given top attention in the

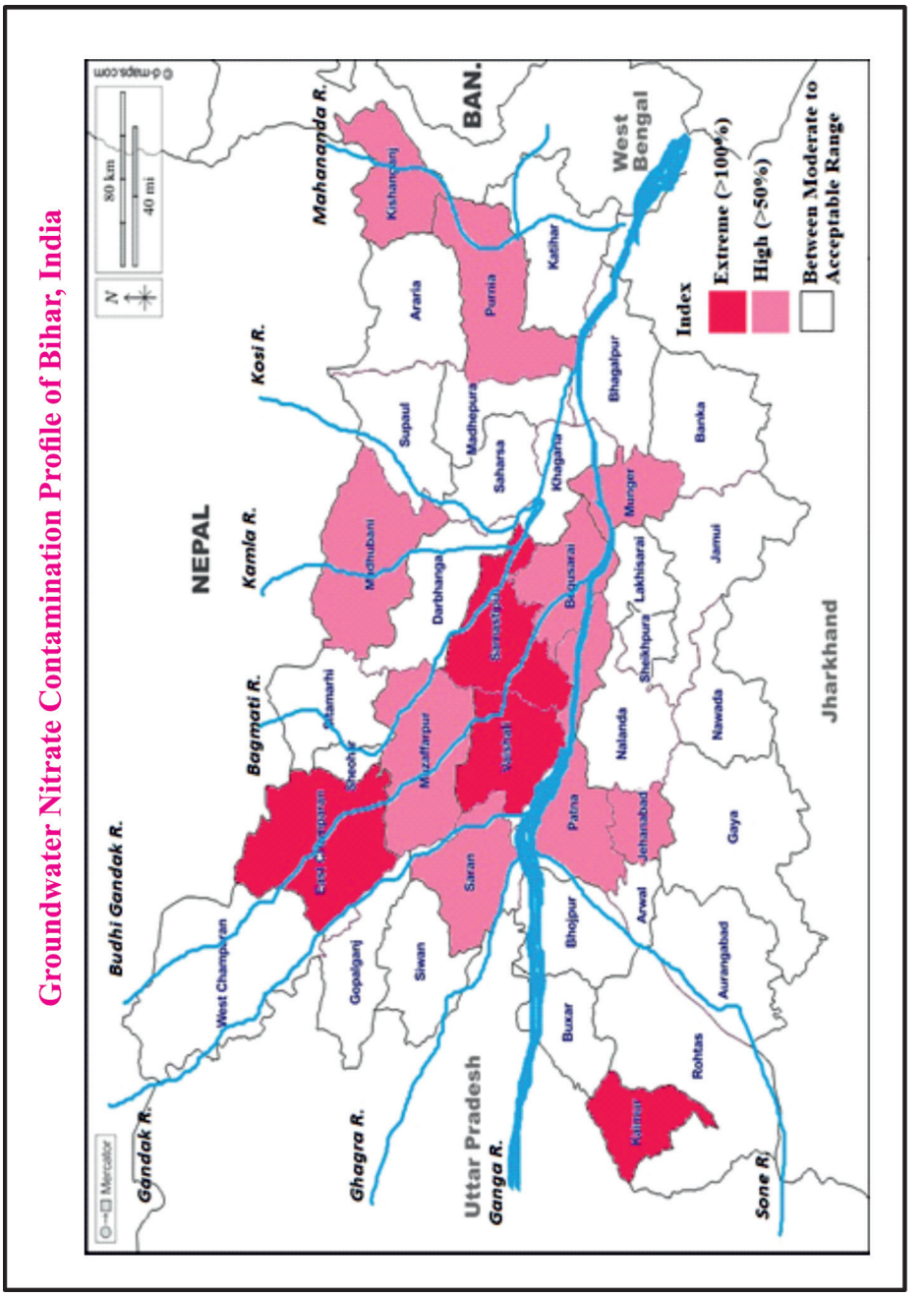

Groundwater Nitrate Contamination Profile of Bihar, India
NEPAL
BAN.
Uttar Pradesh
Jharkhand
West Bengal
Budhi Gandak R.
Gandak R.
Bagmati R.
Kamla R.
Kosi R.
Mahananda R.
Ghagra R.
Ganga R.
Sone R.
Index
Extreme (>100%)
High (>50%)
Between Moderate to Acceptable Range
Mercator
N
80 km
40 mi
© d-maps.com
West Champaran
Gopalganj
Siwan
Saran
Buxar
Bhojpur
Rohtas
Kaimur
Aurangabad
Arwal
Jehanabad
Gaya
Patna
Nalanda
Nawada
Sheikhpura
Lakhisarai
Jamui
Banka
Bhagalpur
Munger
Begusarai
Khagaria
Saharsa
Madhepura
Supaul
Araria
Purnia
Kishanganj
Katihar
Darbhanga
Madhubani
Sitamarhi
Sheohar
Muzaffarpur
Vaishali
Samastipur
Darbhanga

Fig. 1

districts of E. Champaran, Samastipur, Vaishali, and Kaimur. The current study examined the following research gaps and insights in light of the findings:

(1) Lack of guidelines for the minimum number of drinking water sources (sampling density) in a community and inaccurate data on the pollutants that are specific to a community's water quality.

(2) The inability to prioritize mitigation plans due to a lack of instruments for decision-making resulted in the failure of water management programs.

(3) The monitoring of water quality and mitigation strategies is increased when sampling density criteria, or the minimum number of samples to be evaluated per square mile, are not followed.

(4) Many water filters were created and tested on a national and regional level in the areas affected by multiple contamination; however, the majority of the time the filters failed.

Magic Limit of Nitrate in Drinking Water

What is the safe limit for nitrate contamination to protect public health? The simple answer is that we do not know and can agree with people, who say that the 10 ppm may not be the right number, and that's a completely different discussion as what is the allowable level of nitrate in our water supply, and should we be looking at just the isolation of nitrate alone or should web looking at nitrate in with other compounds such as uranium, fluoride, arsenic or others around?. Another important thing for people to understand that to go based on that 10-ppm number because that's what's legal. It's important to kind of layout where that number comes from (Blue baby syndrome based) decade's worth of health studies and showing the difference between what is legal and what is safe? So presumably that is a good place to start not trying to debate what the magic number is or what should be legal? We do know there is a growing awareness that nitrate contamination is probably associated with a number of public health conditions at levels much lower than the BIS (Bureau of Indian Standards) ISI 201245mg/LNO3-. Conditions are, namely, Colorectal cancer [from0.87 mg/LNO3-N], Abortion [from5.5 mg/L], Premature babies &/or short-term gestation [from5.5 mg/L], Thyroid cancers [from2.5 mg/L], ladder cancer and Spinal bifida, brain tumors and spinal cord defects of babies. (**Fig.** 2)

The Indian Government was and still been failing to put public health before GDP. This is underscored by a "risk analysis" commissioned by CGWB who are

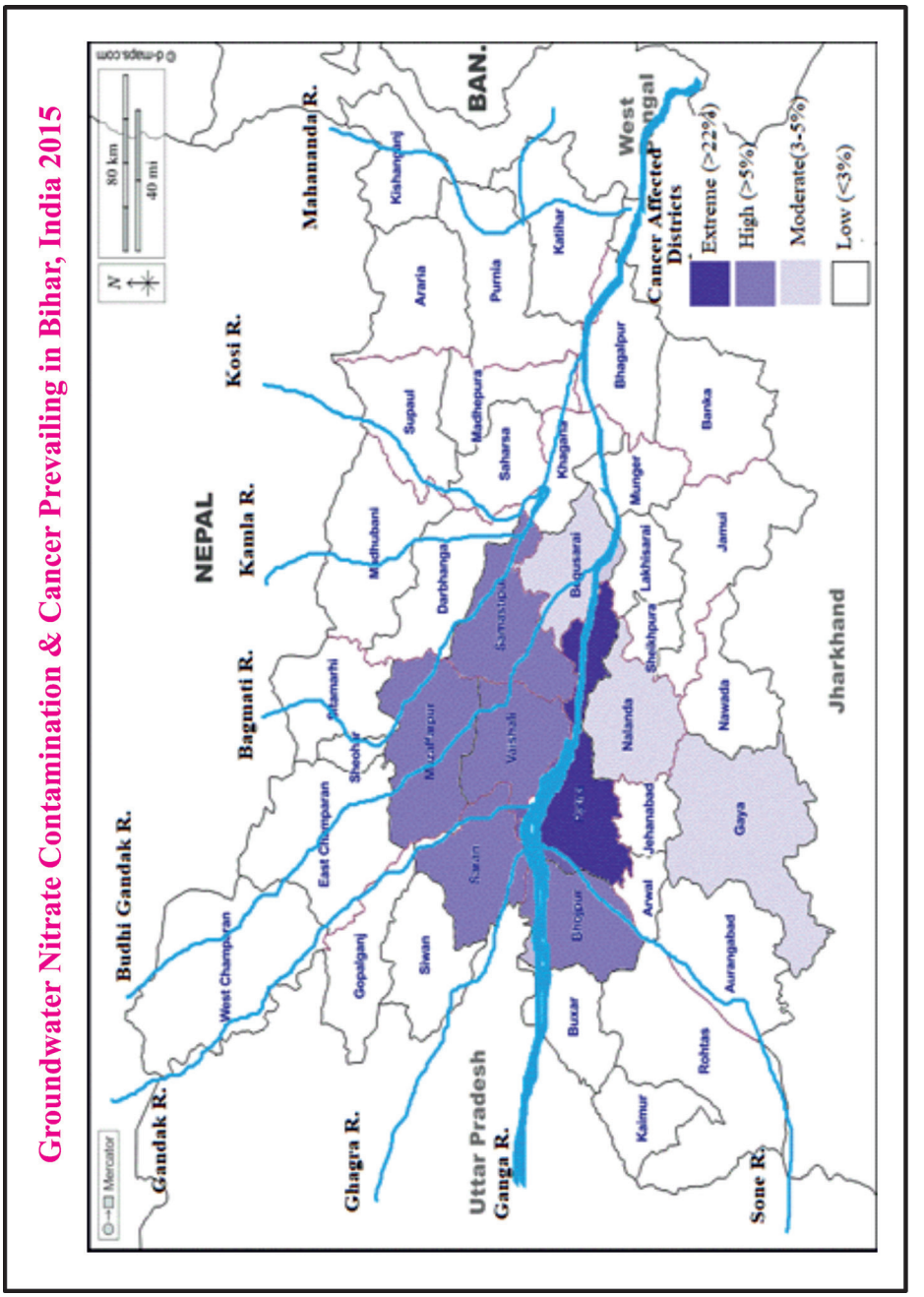

Groundwater Nitrate Contamination & Cancer Prevailing in Bihar, India 2015
Mercator
N
80 km
40 mi
© d-maps.com
NEPAL
BAN.
Budhi Gandak R.
Gandak R.
Bagmati R.
Kamla R.
Kosi R.
Mahananda R.
Ghagra R.
Uttar Pradesh
Ganga R.
Sone R.
West Bengal
Jharkhand
West Champaran
East Champaran
Gopalganj
Siwan
Saran
Buxar
Bhojpur
Rohtas
Kaimur
Sitamarhi
Sheohar
Muzaffarpur
Vaishali
Arwal
Jehanabad
Aurangabad
Gaya
Nalanda
Nawada
Sheikhpura
Lakhisarai
Begusarai
Samastipur
Darbhanga
Madhubani
Supaul
Madhepura
Saharsa
Khagaria
Munger
Jamui
Banka
Bhagalpur
Araria
Purnia
Katihar
Kishanganj
Cancer Affected Districts
Extreme (>22%)
High (>5%)
Moderate(3-5%)
Low (<3%)

Fig. 2

in an illusion that high levels of nitrate contamination in drinking water does not pose a risk to human health so long as yours green. (Anti-oxidants in the diet should provide adequate protection). In the absence of not too many Indian research studies, it is useful to look to first world countries prepared to spend money on much needed research.

Who is Receiving the Benefits for Nitrate Contamination?

The question of who benefits from purifying the water quickly becomes a delicate question when you consider who benefits from using the nitrates that need to be purified. Obviously, it's the producers/farming community in the area, but it's not just the producers, it's the whole chain that makes money from this grain, whether it's cooperatives, selling seeds or selling chemical ointments. This causes the money chain to spread rapidly. In India, the amount of money paid out by the medical system for nitrogen-related cancers or other water contamination-related health concerns is in the millions of INR, as are the health care costs. Who else stands to gain if we successfully address these issues? The quality healthcare that we provide to the rural population is not just for Bihar, but anything that is designed in this state can be applied to other Indian states as well, where we need to take care of the rural population. You can move to another state. Since the main activity is agriculture, we have developed a system to address these issues. How to effectively care for this population could benefit us and, frankly, other places around the world (**Fig.** 2).

Who is Paying Costs for Nitrate Contamination?

In terms of health impacts, obviously the person who is dealing with the disease, the toxicities that comes with the therapy for it. It also then impacts the rest of their life because even though the person who survived the disease, 75% of them will go on to have long term impacts of the care that they received that will require medical attention for the rest of their life. According to a 2015 research report by Gahlot & Kumar, patient registration data comes from Mahavir Cancer Sansthan Hospital in Patna (Bihar) India, shows that the annual registered new patients from all cancers were 20,746 and 50% of the patients belong to 6 districts (Bhojpur, Saran, Muzaffapur, Samastipur, Vaishali & Patna) which fall in Gangetic belt. The study found that 95% of patients were of low socio-economic status and 54% of patients had never attended school. Furthermore, groundwater contamination, poverty, and disease literacy were identified as key important factors for the high incidence of cervical cancer. Who else pays that cost? The family in many different

ways, first of all, obviously the horror of dealing with a child/person who has cancer or others health issues, but in that bill logistics terms, we know that there are many, many costs that are passed on to the family. Whether that is the idea of can they stay employed because it takes so much time off to care for their child both in land outside of the hospital, travel costs that can be impacted more on rural areas for people have to travel such a great distance. So if we say that water quality is having a hand in diseases like cancer or birth defects, the cost is going on to the family Source: MCS (Mahavir Cancer Sansthan), Registration Data 2015, Patna (Bihar). Besides that; when it comes to discussing contamination or setting regulations or policies, or even just changing the practices. The discussion always comes down to cost benefit, and it's much easier to come up with figures for additional treatment at a water treatment plan to or cost too businesses or farms for prevention measures, but feel like downstream cost of the health impacts, which is always missed out, because it is harder to quantify it spreads across many individuals instead of just impacting one entity with financial records even and those impacts are harder to relate directly back to the water contamination. So try and bridge that gap between what we know academically from research about health risks, and then what we can do to advance policy discussions and paint those fuller fair pictures of the costs overall, because it's not just treatment plant or cost to businesses, cost of farms, there is also health impacts and all of those other peripheral impacts really needs to be taken into account.

Conclusion

India's food security is largely dependent on its groundwater system in the Indo-Gangetic Basin (India), hence the current over exploitation of this groundwater resource is a serious worry. The presence of higher groundwater nitrate concentrations in predominantly agricultural parts of alluvial IGB basin aquifers, is of grave concern to the region's vast groundwater-dependent population. The groundwater in most parts of Bihar is getting increasingly contaminated with either nitrate or other forms of dangerous pollutants, as demonstrated by early inquiry and data analysis. This is not a legacy issue, but a worsening situation. The majority of the districts bordering the Ganges and its tributaries are classified as either extreme or high priority zones. Because the exposed communities are socio-economically deprived, water filters capable of filtering numerous contaminants should be produced and delivered at a discounted rate to the affected communities. Furthermore, we must emphasis the importance of long-term monitoring research, including modelling approaches, to aid in the development of more detailed quantification of groundwater nitrate

problems and appropriate groundwater management policies, not only in Bihar but across India. We all benefit if we can increase their (farmers') efficiency, reduce their input costs, and keep nitrogen out of the water. This escalating pollution trend requires immediate and drastic solutions to prevent further degradation of natural water bodies, particularly in developing countries like India, where water shortages exacerbate the issue. Urgent actions are essential to avert the complete deterioration of these vital water resources.

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IMPACT OF TROPICAL CYCLONE DISASTER ON LIVESTOCK RESOURCES OF ODISHA

Dr. Damodar Panda, Dr. Rashmi Rani Anand and Dr. Maya Devi

Abstract

Odisha located on the eastern coast of India is being frequently affected by cyclonic storms. Life and property are generally affected by storms and floods. The economy of the coastal Odisha is agrarian, people grow crops, keep livestock to utilize crop residues as fodder, utilize natural fertilizer in agriculture, and augment family income. Economically and socially weaker sections of the society exclusively depend on livestock for their livelihood. Most of the people in the coastal Odisha live in traditional temporary houses made up of locally available construction materials not resilient to cyclonic storms and floods. They keep the domesticated animals mostly milching animals, drought animals, goat, sheep, pig and poultry birds in temporary houses. As part of the disaster management policy adopted by the state govt. evacuation of population could minimize human casualty, but no such policy adopted for a long time for livestock, which results injury and death of large number of livestock and poultry birds. Realizing the importance of livestock for the rural economy in the disaster-prone area, state govt. has initiated measures for evacuation of livestock and their care during disaster. In spite of this recent measure still large number of livestock and poultry birds are killed due to the impact of cyclonic disasters. The only solution is the construction of permanent livestock sheds in the coastal villages, awareness generation among the livestock farmers, post disaster care and insurance of the livestock.

Introduction

Disasters affect animals and human beings with more impact on animals. Animals are more vulnerable to disasters than human beings. In the developing countries the impact of disasters on animals is higher and more long lasting than in developed countries (Heath et al 1999).In developing countries livestock employs more people than developed countries (Schwabe 1984). In India, 70% of all livestock

are owned by 67% small and marginal farmers, who depend on animal husbandry for their livelihood. The contribution of animal husbandry to the GDP of India has grown up significantly over the years. Disasters that affect animals can, therefore, reduce an important source of employment, revenue and wealth particularly affecting small, marginal farmers and landless livestock keepers who often solely depend on livestock for their livelihood. In spite of serious implications of natural disasters on livestock and livestock owners, disaster management of livestock has yet to receive attention in India as also many other developing countries of the world (Sen and Chander 2003).The Livestock sector plays a central role in nature resource based livelihood of the vast majority of population and often considered as the poor people's ATM. Apart from providing a subsidiary income, rearing of livestock is a source of nutrition in the form of milk, egg and meat. They are kept as a unit of production and provide an important source of revenue, employment and wealth. This sector is facing problem due to the natural disasters like cyclone and flood. Lack of well-developed disaster management plans results in a severe loss of human life, animal life and property, which could be saved if necessary, mechanisms were evolved. The preparedness, response and rehabilitation mechanisms were primarily focused on human beings, whereas, inadequate attention to livestock management led to heavy losses and delayed recovery from livestock related damages. Whenever any region, country or a place is struck by any natural calamity be it cyclone, flood, earthquake, volcanoes etc. the livestock is first to be affected, the reason being the government's relief and rehabilitation measures are focused primarily on population and therefore the sector gets least importance.

Study Region

Odisha is located on the east coast of India with a coast line of 480 km along the Bay of Bengal. The state has an area of 15,5707 sqkm. and consists of 30 districts. Physiographically the state has been divided in to (i)-the northern plateau, (ii)-the central river basin, (iii)-the eastern hills, and (iv)-the coastal plain. The climate is tropical monsoon. The coastal plain of Odisha is agriculturally developed with high population density. The coastal districts are economically developed in comparison to other parts of the state. The state is vulnerable to multiple disasters. Due to its subtropical coastal location, the state is prone to tropical cyclones, floods, tidal surges and tsunamis. The state accounts for 4.05 % population of livestock in the country. According to 2012 livestock census, total livestock was 207.33 lakh Cattle and buffaloes-59.56%, goat and sheep-38.56%, pigs-1.35%.

Objectives

(1) To study the impact of cyclonic disasters on the livestock resources.

(2) To analyze various measures taken by the govt. and the community to reduce the loss and injury of the livestock.

(3) To analyze the livestock affected and loss in the districts.

(4) Suggestion for various measures to be taken to reduce the impact of cyclonic disasters on livestock resources.

Database and Methodology

Data were collected from memorandum on Cyclones from the Special Relief Commissioner, Govt. of Odisha. Disaster management plan of livestock, Animal Resource Development Sector, Govt. of Odisha, Economic survey of Odisha, review of literature, electronic and print media. Data has been analyzed at district level and presented as graphs to understand the trend of cyclonic disasters affecting livestock and loss. Also analyzed the spatial vulnerability of livestock by composite index.

Impact of Cyclone Disaster on livestock Resources of Odisha

Super Cyclone, 1999

The Super Cyclone of 1999 was the most destructive Cyclonic storm of the century. The most severe Super Cyclonic Storm hit the coast of Odisha near Paradeep on 29th October 1999. It affected severely 12 coastal and adjoining districts with wind speed of 270-300kmph and tidal surge of 5-7 m. height. The disaster management policy of the government was rescue and relief operation. The Cyclone prediction was not accurate in its intensity, wind speed, direction and timing. Warning was received three days before the Super Cyclone. People did not take the warning seriously, thus Resulted heavy human and livestock casualty. Lack of adequate cyclone/flood shelters and the shelters constructed by the red cross society was in damaged condition and few in numbers. Numbers measures were taken for evacuation of livestock to safer places before Super Cyclone. The livestock farmers received the warning through various sources well before (24 h to 12 h) the onset of the Super cyclone but, majority of them could not shift their animals to safe places. Non availability of sufficient safe shelters was the most important problem of shifting livestock, non availability of shifting arrangement, delay in decision making and ambiguity of warning. As a result, the majority of the livestock farmers

only untethered their animals before leaving home to save their own lives. They did not put much value to the warning due to their own judgment about the possible impact of the cyclone since they underestimated the impact. The warning messages could not provide information on the possible magnitude of the damage that the cyclone may cause and that might be the reason, why many of them did not think of an early evacuation. Livestock farmers had to suffer a lot for carcass disposal. Since most of the study area remained flooded by the sea water for about a week or more the farmers could not bury or burn the animal bodies. Later, Non-Governmental Organization (NGO) and Amy personnel took the responsibility but it was after 10 to 15 days of the Super Cyclone. The Veterinary personnel were not involved in the carcass disposal as they had no skills and experience. Marginal and small farmers suffered the most due to loss of livestock in the cyclone since they owned large number of livestock. The loss of farmers could have been reduced significantly had insured their animals. The Super cyclone. brought about major decline in the numbers of cattle, buffalo, sheep and ducks, while goat, pig and poultry only made up the loss quickly but also made impressive gains in their numbers by the year 2001(Kurup 2003).It was also reported that the affected areas were the major producer of milk, meat and eggs (Bhanja etal1999) and severe scarcity of milk and milk products were noticed in the coastal districts of Odisha even after 2 years of the Super cyclone(Das 2002).Government paid compensation of Rs.2420.48 lakh for loss of animals and birds, supply of chicks for immediate recovery programme Rs.322.50lakh,establishment of poultry units for the poor families Rs.938.00 lakh, community fodder cultivation Rs.190.00lakh,growing of perennial trees for fodder Rs.186.00lakh and development of fodder nurseries Rs.13.89lakh.Govt spent Rs.4070.871lakh for livestock due to Super Cyclone impact.

Phailin

The very severe cyclonic storm (VSCS) Phailin hit the southern coast of Odisha at Gopalpur on 12th October 2013 with wind speed of 205-220kmph and tidal surge of 3-3.5 m. height ravaged 14 coastal and adjoining districts of the state. On getting the information from the IMD on 8th October, the state govt. intimated to all the collectors, the print and electronic media. On the 10 of October 2013, the IMD reported that the deep depression had intensified in to a Very Severe Cyclonic Storm named as Phailin, indicating the threat to Odisha coast along with the track and intensity of the system. Accordingly, the collectors of the 14 coastal and adjoining cyclone prone districts were alerted through mailman and telephone. As part of the preparedness measures steps were taken for cattle health and supply of cattle feed

for the affected cattle population. Steps were taken to shift 31,062 livestock to safer places.283 veterinary teams were deployed, 89840 livestock treated, 230400 cattle vaccinated, 849.25 MT of cattle feed distributed among 29248 livestock in 1284 cattle camps. They were directed to take all precautionary/preparatory measures to meet the cyclone threat. Total livestock affected were 4689838 with 3250810 Large livestock and 1439028 small livestock. Poultry bird affected were 2368865. Maximum 1995500 livestock and poultry affected in Ganjam district. Total 4502 livestock lost and maximum 3704 livestock lost in Ganjam district.99159 cow sheds were damaged with maximum 65371 damaged in Ganjam district. As per the relief code provision for the replacement of the animals killed due to Phailin subject to ceiling of 1 large milch animal @Rs.16400 or 4 small milch animal @ Rs.1650 or 1 large drought animal @ Rs.15000 or 2 small drought animals @ Rs.10000 per household. For the reparation of the damaged cowshed @Rs1200 paid. Government spent is Rs.3277.15lakh for the livestock affected by Phailin (**Table-**1and 2, **Fig. 1** and 2).

Hudhud

The Very Severe Cyclonic Storm Hudhud crossed close to the Visakhapatnam coast of Andhra Pradesh on 12 the October 2014 with wind speed of 80-100 kmph. and passed through southern Odisha. IMD, Pune disseminated alert of the affected districts of Odisha from 9thOctober on wards. The state govt. circulated the IMD forecast to the Collectors of 16 coastal and adjoining districts likely to be affected, with instructions to remain in full preparedness to meet any eventuality. Collectors of 8 southern districts were cautioned about the flash flood and instructions were issued to start evacuation of livestock and domesticated animals to safer places before the occurrence of the disaster. Advance arrangements were made for the cattle health care and supply of cattle feed in the affected districts. As preventive measure 22 297 animals were shifted to safer place,106 veterinary doctors and 680 para- veterinary teams were deployed,3140 livestock treated,26950 cattle vaccinated and 159 MT of cattle feed distributed. Large areas were inundated in Kendra pada and Puri districts due to storm surge.15 districts affected due to the disaster. Due to its impact 39350 livestock and poultry affected. 670 livestock killed in 4 districts, Gajapati, Koraput, Malkangiri and Rayagada. Maximum 614 livestock killed in Koraput district.670 big animals,198 small animals and 472 poultry birds killed. About 57 cattle sheds damaged. As part of the compensation and related expenditure, the state govt. spent Rs.5.35lakh for the disposal of caracasses, Rs.41.78 lakh for the replacement of livestock, Rs.30.41 lakh for the distribution of

fodder and Rs.85,500 for the reparation of cattle shed. Government spent Rs.78.67 lakh. For the livestock affected by Hudhud.

Titli

The Very Severe Cyclonic Storm Titli crossed the coast near Palasa of Andhra Pradesh, south west of Gopalpur with wind speed of 140-150 kmph. and tidal surge of 1meter on 11th October 2018. The Indian Meteorological Department (IMD) reported on 7th October 2018 about formation of a low-pressure area over south east of Bay of Bengal and adjoining North Adaman Sea. It was predicted that the depression very likely to move towards Odisha during the next 72 hours. After getting the information from the IMD, the state govt. started closely monitoring the situation and intimated all the Collectors, print and electronic media. In the preparedness measures, all Collectors of likely affected districts were instructed for the evacuation of livestock and domestic animals to safer places and to ensure that no cattle should be left tied in kutcha (temporary)house. All cyclone bulletins and warnings shared by the IMD disseminated through DD, AIR, other electronic media for information of the public. 711 MT cattle feed supplied,208462 animal vaccinated,129637 animal treated,158 veterinary team deployed,1798 veterinary camp opened and 48858 carcasses disposed. Livestock were affected in six districts, Cuttack, Gajapati, Ganjam, Puri, Kandhamal and Rayagad. Total 481068 livestock affected with large animal 299795 and small animal 181273.Total poultry affected were 481068.Maximum number of 190349 livestock affected in Ganjam and Gajapati districts of south Odisha. Government spent Rs.623.58lakh.for livestock affected by Titli.

Fani

Extremely Severe Cyclonic Storm Fani crossed the Odisha Coast between Satapada and Puri on 3rd May 2019 with wind speed of 175-185kmph. and tidal surge of 1.5-meter height. On 28th April, IMD Indicated that cyclonic storm Fani moved northwards and would very likely to intensify in to a very severe cyclonic storm. There was also forecast and warnings for Odisha that light to heavy rainfall likely to occur at one or two places in southern Odisha on 2nd May and heavy rainfall from 3rd May over coastal Odisha. Though there was no warning issued by IMD for the Odisha coast, the state government started closely monitoring the situation. On 30th April IMD reported that the Very Severe Cyclonic Storm Fani very likely to cross Odisha coast between Gopalpur and Chandbali to the south of Puri on 3rd May afternoon. Massive preparedness measures were undertaken by

the government soon after receipt of warning from IMD. The districts were alerted based on the probable cyclone track and impact area.14 coastal and adjoining districts were affected due to the impact of Fani. Severely affected districts are Puri, Khurdah, Ganjam, Kendrapara, Cuttack and Jajpur. The cattle population shifted to safer places and cattle feed /fodder arrangement was made. Instructions were issued to field veterinarians to aware dairy farmers and small animal owners to take immediate measures by shifting their animals to safe places to avoid livestock loss.635 animal shelters in school premises and multipurpose cyclone shelters were identified. Over 40,000 large animals like cow, buffalo, bullock etc. were shifted to such shelters.300MT cattle feed stored to meet the requirement. About 80,000 livestock farmers of such districts were made aware about safeguarding of animals and severity of the cyclone through sending of mobile voice messages under mobile advisory programme. Steps were taken for health care services and carcass disposal. Total livestock affected were 3439282,large animal affected were 2443329 and small animal affected were 996053.Poultry bird affected were 5371373.Maximum livestock and poultry affected in Puri, Cuttack and Khurdah districts. Total 6281 livestock lost, maximum loss in Khurdah, Puri and Cuttack districts.119694 cowshed damaged. 2006.5 MT of cattle feed were supplied and steps were taken for the supply of two thousand quintals of green fodder to the severely affected districts. Mobile veterinary units and 115 rapid response teams were used for conducting veterinary camps,4105 animal health camps organized and 5.08 lakh animals treated. Compensation given for the loss of livestock for the replacement of drought/milch animals Rs.950.92lakh,provision of fodder and cattle health care Rs.2432.85 lakh, disposal of carcass RS.437.56 lakh and reparation of cowshed Rs. 2513.574 lakh. Govt. spent Rs6334. 904.lakh for livestock affected by Cyclone Fani.

Bulbul

Very Severe Cyclonic Storm Bulbul crossed Sunderban delta on 9th November 2019 with wind speed of 110-120 kmph. and tidal surge of 0.5-1.0 m. height. On 5th November IMD informed that the depression would very likely to intensify in to a deep depression and cyclonic storm. It would very likely to move towards Odisha-West Bengal coast. Soon after receiving the meteorological warning, the state govt. started closely monitoring the situation. As per the special bulletin of IMD on 7th November the cyclonic storm Bulbul very likely to intensify in to severe cyclonic storm and move towards West Bengal–Bangladesh Coast. Soon after receipt of warning from IMD, the state govt. took all required preparedness

measures to combat the possible situation. It affected 6 coastal and adjoining districts of north Odisha. Due to its impact 31238 livestock affected with 27344 large animal and 3894 small animal. 6125 poultry affected. Only two districts, Bhadrak and Kendrapara livestock were affected and maximum affected in Kendrapara district. Total 19 livestock killed, 1464 cowshed damaged and maximum damage in Kendrapara district. 312 animal health camps at every affected GPs organized. Compensation given for replacement of milch/drought animal of Rs.4.00 lakh, animal health camps Rs15.60 lakh, reparation of cowshed Rs30.74 lank. Govt. spent Rs.50.34lakh for livestock affected.

Amphan

The Extremely Severe Cyclonic Storm Amphan crossed West Bengal coast of Sundarbans on 20th May 2020 with wind speed of 155-165kmph. and tidal surge of 4-5 m height. On 16th May, the IMD informed that the low pressure area would very likely to intensify in to severe cyclonic storm likely to move towards West Bengal Coast during 18th to 19th May 2020. The coastal Odisha would likely to experience light to heavy rainfall from 18th to 20th May.IMD informed that It was associated with high wind speed and heavy rainfall. As part of the preparedness measure, the government alerted the collectors of the 12 coastal and adjoining districts to effectively handle the disaster. Awareness campaign on protection of animal resources from possible cyclone situation was launched in electronic as well as print media. People were advised to shelter the cattle and domestic animals at safe places. They were advised to evacuate their cattle to the ground floor of the Multipurpose Cyclone Selter/Multipurpose Flood Shelter (MCS/MFS) and other suitable buildings in case of necessity. It affected 10 coastal and adjoining districts. Total 1903 livestock affected with 1249 large animal and 654 small animals. 18875 poultry affected. Livestock affected in 6 districts with maximum in Jajpur district.38 livestock killed with maximum in Keonjhar district.393 cowshed damaged. As part of the compensation Rs.8.20 lakh spent for replacement of drought and milch animal and reparation of cow shed Rs.8. 25 lakhs. Government spend Rs.16.45 lakh for livestock affected by Amphan.

Yaas

Very Severe Cyclonic Storm Yaas crossed north Odisha coast south of Balasore with wind speed of 130-140 kmph. and tidal surge of 2-3m.height on 26th May 2021.Indian Meteorological department (IMD) reported on 20th may 2021 that a low pressure area would very likely to form over north Andaman sea and adjacent

east central Bay of Bengal around 22nd May 2021.it would very likely to intensify in to a cyclonic storm and reach Odisha-West Bengal coasts around 26th May morning. Soon after receiving the meteorological warning, the state government started closely monitoring the situation. As part of the preparedness measure IMD weather bulletin and cyclone warnings were disseminated to Collectors, departments and other stake holders at regular intervals. The livestock and domesticated animals of vulnerable area were shifted to safer places. No cattle let tied in kutcha house. People were advised to shelter the cattle and domestic animals at safe places. They were advised to evacuate their cattle to the ground floor of the MCS/MFS and other suitable buildings in case of necessity. Required vaccines, essential medicines were prepositioned at veterinary hospitals/dispensary and 1500 MT of cattle feed was kept ready by OMFED. Due to its impact 11 districts were affected. Total 1358578 livestock affected with 1022361 large animals and 336217 small animals. 1115810 poultry affected. 72 livestock killed.3024 cowshed damaged with maximum damage in Bhadrak District.75 mobile veterinary teams deployed, 37 animal health camps organized, 1617 animals treated and 5100 animals vaccinated. Compensation paid for replacement of milch/ drought animals Rs.16.684 lakh and cattle feed Rs.148.760 lakhs. Government spent Rs.165.444 lakh for livestock affected by Yaas.

Livestock Affected and Loss in Districts

On the basis of the recent past cyclonic disasters affected Odisha from 1999 to 2021, total livestock and poultry affected in the state was 191,64, 505.Livestock affected was 100,01,907 and poultry affected 91,62, 598. Large animal affected were 70,44,888 and small animal 29,57,119. Maximum livestock 46,89,838 affected by Phailin followed by Fani and Yaas. Least affected by Amphan 1903.Maximum poultry 53,71,373 affected by Fani followed by Phailin (Table.1 &**Fig. 1** & 3). The most vulnerable district is Puri with maximum 3618558 livestock affected and lowest vulnerable district is Dhenkanal with 3011 livestock affected. On the basis of the composite index, very high vulnerable districts are Cuttack, Ganjam and Puri, high vulnerable are Bhadrak, Jagatsinghpur, Jajpur, Nayagarh and Kendrapara, medium vulnerable are Balasore, Mayurabhanj Khurdah, Keonjhar and Gajapati low vulnerable are Dhenkanal, Kandhamal and Rayagada. The vulnerability depends on the number of livestock farmers, intensity and track of the cyclone over the state. The vulnerability of the livestock is gradually declining as the people are more aware, construction of more permanent cowsheds and alternate shelters for the livestock during cyclones (**Table-**1 and **Fig. 1** and **Table-**2)

Livestock loss

Loss of livestock and poultry are due to the impact of very high wind speed coupled with flood and damage of temporary structures. Total livestock lost was 456110 with maximum livestock lost due to Super Cyclone 1999 was 621377. Lowest number of livestock lost was 19 by Bulbul. After Super Cyclone of 1999, loss of livestock drastically reduced to maximum 6281 by Fani in 2019.After Super Cyclone loss of livestock reduced to only 16388 from 2013 to 2021 by six cyclonic storms. Maximum livestock lost 110742 in Jagatsinghpur district, the landfall point of Super cyclone and minimum 10 in Rayagada district of southern Odisha. The composite index shows very high loss of livestock in Cuttack, Jagatsinghpur and Kendrapara districts, High loss of livestock in Balasore, Bhadrak, Jajpur, Dhenkanal, Puri and Khurdha districts.

Table-1: Livestock Affected by Cyclone Disasters in Odisha

Sl. No.	Districts	Cyclone						Total
		Phailin	Titli	Fani	Bulbul	Amphan	Yaas	
1	Balasore	446320	0	62268	0	1015	558855	1068458
2	Bhadrak	283835	0	6233	1417	14	1167787	1459286
3	Cuttack	1150000	519	1673790	0	3730	2	2828041
4	Dhenkanal	3011	0	0	0	0	0	3011
5	Gajapati	50000	530361	0	0	0	0	580361
6	Ganjam	1995500	190349	173709	0	0	0	2359558
7	Jagatsinghpur	589617	0	859282	0	886	0	1449785
8	Jajpur	892995	0	901816	0	17002	104336	1916149
9	Kendrapara	55982	0	550200	35946	34	622396	1264558
10	Keonjhar	79519	0	5803	0	0	8069	93391
11	Khurdha	3347	0	1126976	0	0	0	1130323
12	Mayurabhanj	206474	0	1324	0	0	12944	220742
13	Nayagarh	671342	0	466767	0	0	0	1138109
14	Puri	630761	5222	2982575	0	0	0	3618558
15	Kandhamal	0	17893	0	0	0	0	17893
16	Rayagada	0	16282	0	0	0	0	16282
	Total	7058703	760626	8810755	37,363	22681	2474396	19164505

Source: SRC, Bhubaneswar

Table-2: Livestock Lost by Cyclone Disasters in Odisha

Sl. No.	Districts	Cyclone							Total
		Super Cyclone	Phailin	Hudhud	Fani	Bulbul	Amphan	Yaas	
1	Balasore	38778	0	0	17	0	5	13	38813
2	Bhadrak	9766	10	0	28	8	7	24	9843
3	Cuttack	62114	46	0	1100	0	0	0	63260
4	Dhenkanal	11027	0	0	15	0	0	0	11042
5	Gajapati	0	40	17	0	0	0	0	57
6	Ganjam	0	3704	0	58	0	0	0	3762
7	Jagatsinghpur	110682	18	0	34	0	8	0	110742
8	Jajpur	19082	2	0	26	0	1	6	19117
9	Kendrapara	77453	7	0	70	11	0	21	77562
10	Keonjhar	8606	37	0	0	0	17	5	8665
11	Khurdha	53704	35	0	1214	0	0	0	54953
12	Mayurabhanj	555	23	0	1	0	0	3	579
13	Nayagarh	0	85	0	13	0	0	0	98
14	Puri	52764	495	0	3705	0	0	0	56964
15	Kandhamal	0	0	2	0	0	0	0	2
16	Koraput	0	0	614	0	0	0	0	614
17	Malkangiri	0	0	27	0	0	0	0	27
18	Rayagada	0	0	10	0	0	0	0	10
	Total	444531	4502	670	6281	19	38	72	456110

Source: SRC, Bhubaneswar

Management of the impact of cyclone disaster on livestock population

The new disaster management plan incorporates provision for evacuation of livestock and provision of fodder, drinking water and medicine. As preventive measures mobile veterinary team deployed, animal health camps organized, affected animals treated and vaccinated. In Super Cyclone of 1999, the number of livestock evacuated is still very low in comparison to the number of livestock in highly vulnerable areas. Evacuated livestock were kept in flood/cyclone shelters and school premises identified by the district administration for the purpose. People are also asked to take the animals to safer places and don't tide them in cowshed. Developed cyclone prediction, early warning and awareness of the people could able to reduce the loss of livestock. Large number of large and small livestock are affected

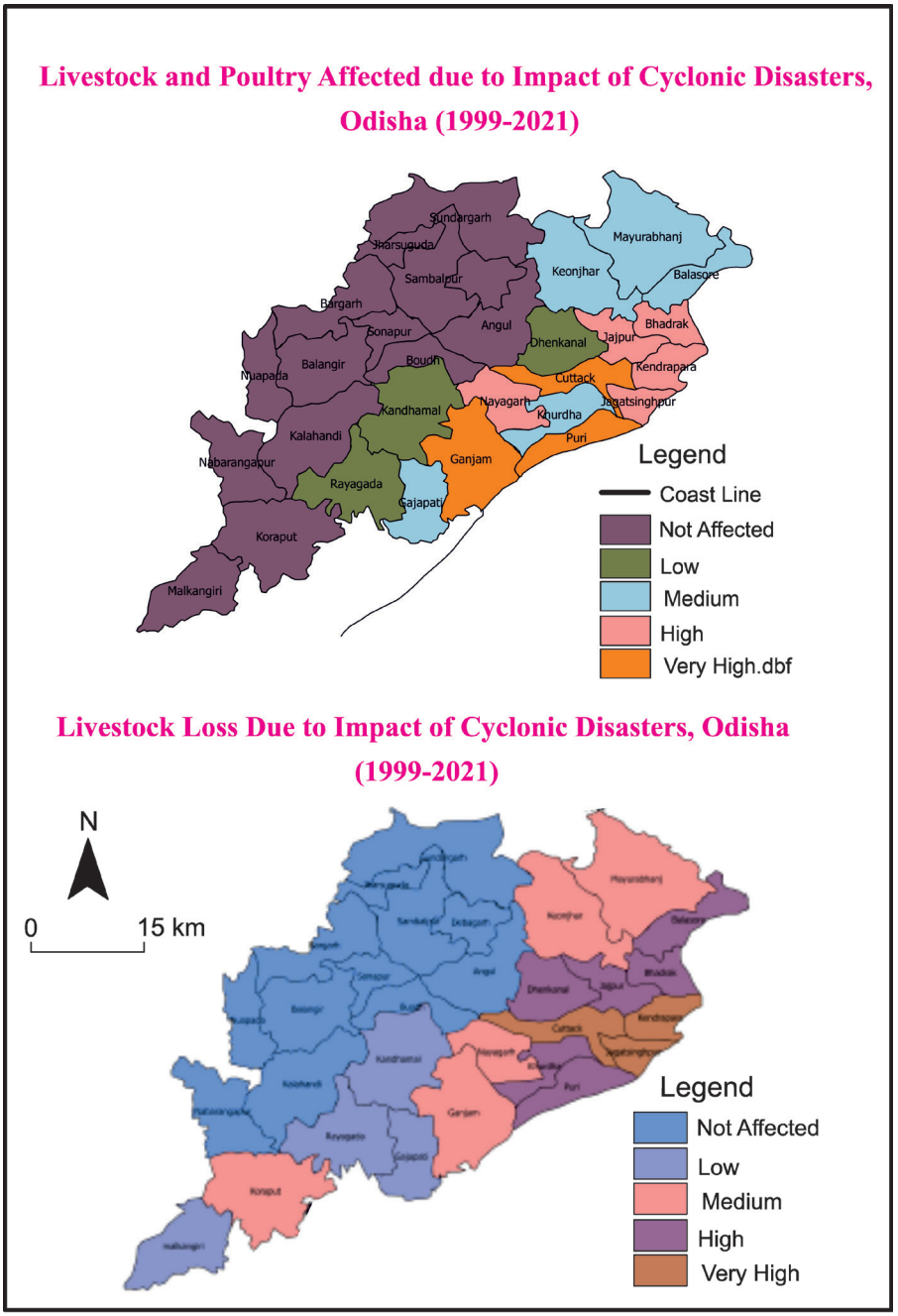

Livestock and Poultry Affected due to Impact of Cyclonic Disasters, Odisha (1999-2021)
Sundargarh
Jharsuguda
Sambalpur
Bargarh
Mayurabhanj
Keonjhar
Balasore
Bhadrak
Jajpur
Dhenkanal
Angul
Sonapur
Boudh
Balangir
Nuapada
Kendrapara
Cuttack
Nayagarh
Jagatsinghpur
Khurdha
Puri
Kandhamal
Kalahandi
Nabarangapur
Ganjam
Rayagada
Gajapati
Koraput
Malkangiri
Legend
Coast Line
Not Affected
Low
Medium
High
Very High.dbf
Livestock Loss Due to Impact of Cyclonic Disasters, Odisha (1999-2021)
N
0
15 km
Legend
Not Affected
Low
Medium
High
Very High

Fig. 1

due to the temporary cowsheds damage by wind and flood water. Loss of livestock is gradually decreasing where as number of livestock affected are increasing. Death of poultry bird is always high due to high wind speed; adequate protection needs to be taken. Post cyclone storm care of the livestock taken including immunization and fodder supply. Community based organizations lacked the necessary trained manpower, resources and know-how to cope with the challenges. In the aftermath of the cyclone, feed and fodder were scarce and consequently many animals starved and the productivity of animals decreased. The various steps to be taken prior, during and after disaster in relation to livestock management includes: Prevention: a) construction of shelter for animals in cyclone and flood prone areas and in case of shifting animals to safer places preference should be given to bullocks, milk cows, breeding bulls as their loss can cause immense damage to economy. b) Untethering the animals when shelter is not available c) Efforts should be made to collect feed, fodder, medicine etc and they should be kept at safer places d) Proper training should be given to farmers for evacuating their animals. Relief: a) Proper care should be taken to protect the animals against prey, poisonous snakes and reptiles b) proper arrangement for quick movement of veterinary personals to reach animals for treatment, vaccination and deworming. Rehabilitation: a) Livestock owners should be provided with compensation in case of livestock loss or diseased condition b) Working bullocks and milch animals should be provided from other unaffected regions that are surplus in these animals c) Reconstruction of veterinary and A.I centers that are damaged due to floods d) A permanent feed security system should be set up in flood prone areas) Livestock owners must insure their livestock. The scarcity of feed and fodder after any disaster poses a serious and indirect threat to the livestock. The use of urea treated straw as a feeding option that has the potential of meeting up the challenge to some extent. The straw feeding during the disasters can reduce the burden on the already scarce feed resources without compromising the production performance and also suggested use of Urea Molasses Mineral Block (UMMB) as a viable feeding option during disasters. Further, by products of sugarcane like bagasse, molasses, sugarcane tops etc., should be fed to animals during scarcity period. They also reported that urea when used for treatment of bagasse enhances its nutritional quality and steam treatment can also be used to increase its digestibility.

Conclusion

Exposure to cyclonic disasters and their consequences play a significant role to the socio-economy of the coastal Odisha. Livestock support the livelihood of

majority of the people of this region. Livestock are the easy victim of the cyclonic disasters as people keep them in highly vulnerable temporary cowshed. Protection of livestock resources should be given top priority for livelihood support of the poor people of the coastal villages. The number of livestock loss has been reduced due to preventive measures taken by the government but adverse impact on livestock is increasing. After disaster fodder problem becomes critical as dodder damaged by flooding water. Steps must be taken for availability of cheap fodder for the livestock. The number of poultry loss is increasing as the birds are sensitive to high wind speed. Number of livestock affected due to temporary cow sheds are increasing though the loss is reducing. Inadequate shelters for the livestock increase vulnerability. Steps must be taken to reduce death of livestock by construction of permanent cowshed. Compensation given for the loss of livestock and poultry ceiling must be removed by fully compensation by alternate agency. All livestock owners must insure their livestock for their benefit. Livestock farmers severely affected by loss of livestock should be provided alternate livelihood support.

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SPATIO-TEMPORAL VARIATIONS OF AGRICULTURAL LABOR WAGES IN INDIA

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Abstract

The paper analyzed variations in agricultural labors' real wage in 19 states of India from 2005-06 to 2020-21using statistical methods. For a comprehensive study and analysis of the changes in agricultural labour wages across the country, the paper attempted three statistical methods viz comparative analysis of agricultural wages' means across the time period; measuring fluctuations in the change in wages via coefficient of variance; and compound annual growth rate of agricultural wages. Mean real wages of Indian states across the years shows that, Southern and North Western states have higher wages as compared to states in Great Northern Plains, North East India and Central Uplands. Some states have deviated from general trend of increase in wages with the increase in economic growth and development. This decline in wages occurred both in states observing high and low agricultural wages. This anomaly emerged as a national concern because of its spatial diversity across the country and raising frequency in recent years. Fluctuations in the real wages of agricultural labor of different states across the years have no relation with actual real agricultural labor wages of the state. Both states with high and low wage rates experienced high as well as low fluctuations also. Growth rate of agricultural labor wages showed an inverse relationship with the past's real wage rates, that is, states which had high wage rates in past have showed relatively slower growth as compared to those states that had low wage rates. Agricultural labor real wages' increment requires special attention by the policy makers and administrator as it plays major role in boosting rural economy by raising demand of goods and services that too by masses, increasing production process conferring more diverse employment opportunities to disguised unemployed individuals, adding family income and improving standard of living by boosting education and health.

Introduction

A person is treated as an agricultural labor, if he/she follows one or more of the following agricultural occupations in the capacity of a labor on hire, whether paid in cash or kind or partly in cash and partly in kind: farming including cultivation, growing and harvesting of any agricultural commodity; production, cultivation, growing and harvesting of any horticultural commodity; dairy farming; raising of livestock, bee-keeping or poultry farming; and any practice performed on a farm as incidental to or in conjunction with the farm operations (including any forestry or timbering operations and the preparation for market and delivery to storage or to market or to carriage for transportation of farm products). Most deprived section of rural India is landless families who either migrate toward cities or work as agricultural labor. Agricultural workers constitute the most neglected class in Indian rural structure. Agricultural laborer's households constitute the historically deprived social groups, displaced handicraftsmen and dispossessed peasantry. Since, they possess no skill or training, they have no alternative employment opportunities either. Agricultural labors are socially and economically poorest section of the society. They are the poorest of the poor in rural India. The reason for their poverty is their easy exploitation because they remain largely unorganized, therefore their level of income, standard of living and the rate of wages have remained abnormally low. Demand of agricultural labor has declined due to improved farming methods and mechanization of middle and rich farmer's fields, decline in demand and abundance of supply pulled down the wages of the laborers making them economically further more weak. Agriculture laborer wages are function of demand supply of labor, irrigation and cropping intensity of region, fixed minimum wages, price of farm output in the market determining the paying ability of the employer, cost of living etc. Therefore, agriculture laborer wages are different in different states.

Study Region

The study is based over 19 states of the country including Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, and West Bengal. Data of CPI-AL base year 1986-87 is in continuity and gives data of parent and child state data on the name of the parent state to sustain continuity in the data, For example, Chhattisgarh from Madhya Pradesh, Jharkhand from Bihar, Uttarakhand from Uttar Pradesh, and Telangana from Andhra Pradesh. Therefore, these states are not studied separately rather they are clubbed with the parent states.

Objectives

The objective the paper is to analyze spatio-temporal variation of agriculture labor real wages across different states of India, finding out fluctuations in trend of increase in agricultural wages and evaluating growth rate of increase in agricultural wages in India.

Database and Methodology

Secondary data of nominal wages of agricultural laborers of different states used in the paper is extracted from Labor Bureau Shimla, Ministry of Labor and Employment, Government of India for 2005-06 to 2020-21. Consumer Price Index Agricultural Labor data for the same time period is taken from Handbook of Statistics on Indian States, RBI and Labor Bureau Shimla. State Indices:

$$I_n = \frac{\sum P_n Q_0}{\sum P_0 Q_0}$$

Whereas: I_n= Index Numbers

P_n= Price of current period

P_o = Price of base

Q_o = Quantity of base year

All-India Index: The all-India index is worked out as a weighted average of the indices of 20 States, weights being the estimated consumption expenditure of all rural and agricultural labor households in each State as a proportion of corresponding expenditure for all-India. All-India group indices are also compiled by using the State weights in the particular group, derived as a proportion of corresponding expenditure at all-India level. Base year of CPI is adjusted to 2014-15 for whole data set using following formula:

$$\frac{x}{CPI(214-15)} \times 100$$

x = CPI (2005-06 to 2020-21)

In the study real wages are used instead of nominal wages which is calculated using following formula:

$$Rw = \frac{Nw}{CPI} \times 100$$

Whereas: Rw = Real wage

Nw = Nominal Wage

CPI = Consumer price Index (Agricultural laborers)

Coefficient of Variance is used to measure the fluctuations in the wages of different states. Following formula is used in the study to find out growth rate of agricultural wages along with compound annual growth rate:

$$GR = \frac{PRw \quad CRw}{PRw} \times 100$$

Whereas: GR = Growth Rate

PRw = Previous Year Wages (average of 2005-06 to 2007-08)

CRw = Current Year Wages (average of 2018-19 to 2020-21)

Result and Discussion

Spatio-temporal Variation in Agricultural L labourer Real Wages

Average of 16 years (2005-06 to 2020-21) real agricultural labor real wages in India shows that 8 out of 19 states (Kerala, Jammu and Kashmir, Haryana, Himachal Pradesh, Punjab, Tamil Nadu, Tripura and Rajasthan) showed higher wages than national average with exceptionally high wages in Kerala followed by Jammu and Kashmir while the minimum wages are being paid in Madhya Pradesh followed by Maharashtra, Odisha, and Gujarat. Kerala labors are paid high wages due to high demand and low supply of labors. Kerala labors tends to migrate to foreign countries for grasping better opportunities in the form of high wages, better and safe working conditions facilitated by premigration established linkages. Cost of living in Kerala is also high therefore labor wage is highest among all states. Demand of labors in Jammu and Kashmir is not fulfilled as migrants avoid to migrate there because of volatile law and order conditions along with harsh climate and topography. Thus, leaving only local labors in the market for work that too for shorter period of time allowed by climate for cultivation. Himachal Pradesh is known for out migration. Many villages in Himachal Pradesh had turned into ghost villages because of migration by nearly all families out of their village. This trend of migration by youth causes lack of labors in the state. Demand of labors had increased due to rise in horticulture, evolution of modern technology to practice farming at mountains, and improved marketing facility in the form of better roads, and enhanced communication facility. High demand and low supply of labor made

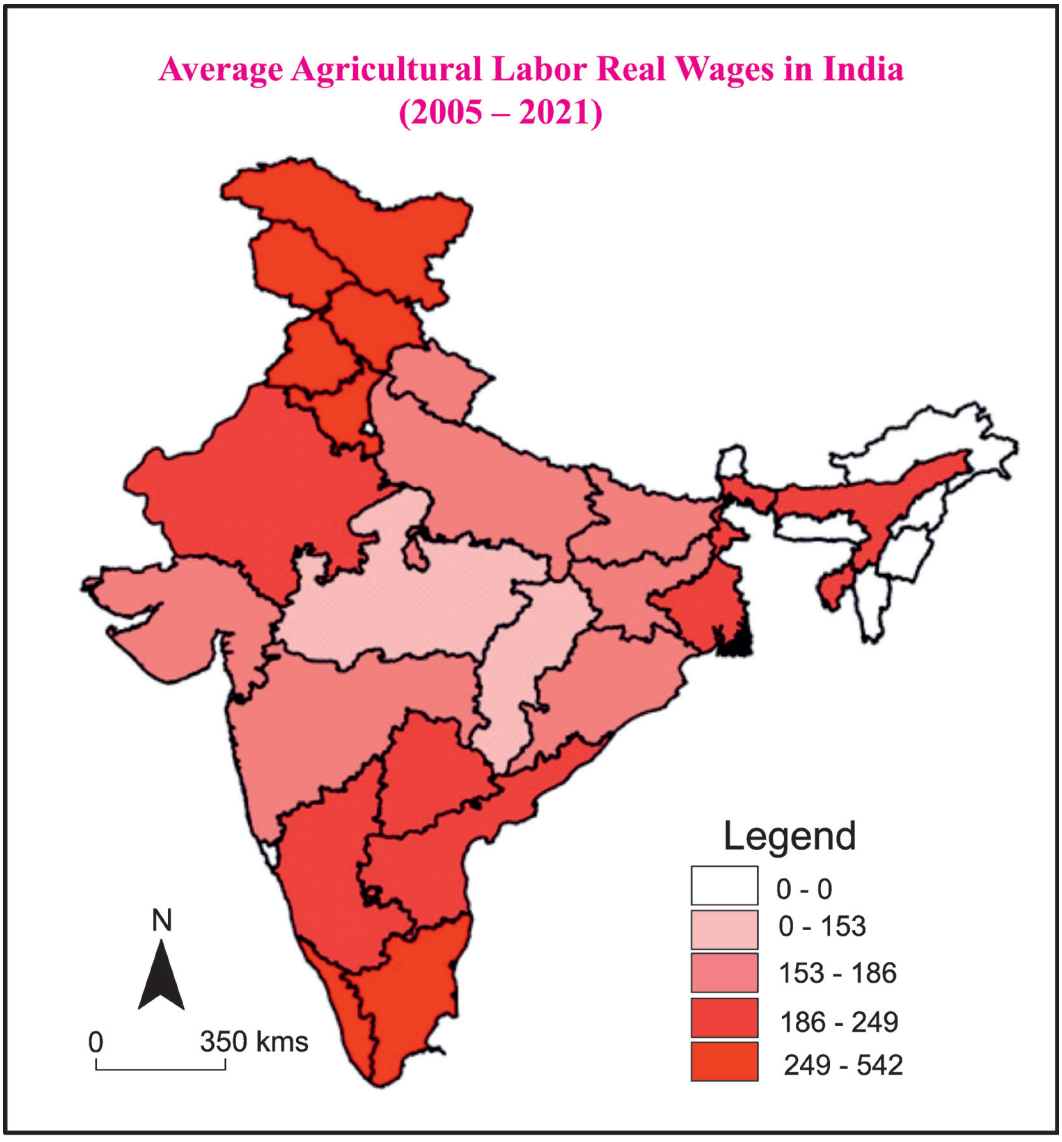

Average Agricultural Labor Real Wages in India
(2005 – 2021)
Legend
0 - 0
0 - 153
153 - 186
186 - 249
249 - 542
N
0
350 kms

Fig. 1

the agricultural wages of Himachal Pradesh high. Haryana and Punjab are hub of highly intensive agriculture which needs capital, technology and labors in large quantity. States themselves are not capable to fulfilled labor demand therefore in-migration of agricultural labors from low wages states like Uttar Pradesh and Bihar is observed in Punjab and Haryana. Only significantly high wages could attract labors to work far from their local area, thus they are offered higher wages. Along with agriculture, Haryana and Punjab have good level of industrialization which creates parallel demand of semi-skilled and non-skilled labors benefiting labors in the form of high wages at both places. Haryana is bordered with national capital which offers huge employment opportunities in tertiary sector, offering opportunities of wages in agriculture sector. Madhya Pradesh and Odisha have high tribal population that migrate and to labors to shift towards tertiary sector. This again push towards increment work as agricultural labor at a very low cost. Their bargaining power is low and their migration also results into adequate supply of labor in the market. Per capita income of farmers is also very low in these states and farmers practicing commercial agriculture are very less, thus these state experience low wage rates. Odisha is one the major rice producing states of India with limited mechanization of agriculture thus leaving large scope for labors to get engaged. Despite state's large share of rice production very meagre amount is cultivated for commercial purpose and mostly done for domestic or self-consumption which don not allow farmer to hire labor on high wages. Family members themselves cultivate in spite of hiring labor. Maharashtra and Gujarat are also among those states that receive maximum number of in-migrants thus they ensure supply in the market. Maharashtra is the state with very high farmers in distress making the state topper in farmer's suicide. The farmers of the state use minimum inputs for the agricultural production. Labor being a factor of production is avoided by the farmers up to possible limits. Uttar Pradesh and Bihar have huge human resource having low per capita income with suitable geographical conditions for cultivation and irrigation source in the form of rivers, canals and underground water. Bihar lags behind in development of other sectors of economy viz secondary and tertiary, which leaves little room for workers to find employment elsewhere, thus there is excessive supply of labors in the market with demand at fewer location causing fall of their wages. Due to high population in both of the states, agricultural land suffered from fragmentation in large scale, making the land unsuitable for commercial crop and fit only for subsistence agriculture which do not support high agricultural labor wages (**Fig. 1**)

Generally, it has been observed that with the economic growth, wages of employees of every sector (including agriculture) increase, but this is not universally applicable. For example, in Gujarat agricultural real wages had declined in 2017-21 period as compared to 2005-09. In many other states also during same time frame, agricultural real wages have seen decline instead of rise. For example, in Himachal Pradesh, Kerala and West Bengal wages declined in 2009-13 from 2005-09. Andhra Pradesh, Punjab and Tripura have seen higher wages in 2009-13 period as compared to 2013-17. Mean data shows that 7 states have witnessed decline in real wages in 2017- 21 as compared to 2013-17 viz Assam, Haryana, Jammu and Kashmir, Meghalaya, Punjab, Rajasthan and Tamil Nadu. Further analysis used 2017-18 as watershed and taking average of 3 year before and after that time period to find out the recent trend of the change in wages of agricultural labor in the country. Out of 19 states, 11 shows that a declining trend of real agricultural wages. They include Assam, Gujarat, Haryana, Jammu and Kashmir, Kerala, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan and Tamil Nadu. Although pan India data shows increase in real agricultural wages but that is very minute. State irrespective of the actual wages showed declining trend for example, Kerala, the highest paying state and Gujarat second lowest agricultural wages both showed decline in wages. Most significant decline is showed by Tamil Nadu (5.21%), Meghalaya (11.48%), Jammu and Kashmir (5.06%) and Rajasthan (-6.31%). All the states are located at four corners of the country which indicates that the decline in wages in not a regional issue rather a matter of national concern. Making 2014-15 as the divide line for comparison of previous and current agricultural wage we found that most of the states have improved their agricultural wages except for Gujarat and Tripura. Looking at the comparison of before and after 2014-15 collectively with the average of 2015-16 to 2017-18 and 2018-19 to 2020-21 reveals that the initially wages in most of the states were growing but decline of wages witnessed is a problem originated in very recent times that is after 2017.

Fluctuations in Real Agricultural Wages

Fluctuations in wages means abnormal rise and fall of wages. Fluctuation of wages are unsuitable for agricultural labors' sustained growth in a planned way. High fluctuations in wages demotivates labor to continue with the profession and seeks to engage in another alternative work for stable income. Fluctuation of wages may be caused by natural disaster, interference by administration in wage related issue, MSP hike in any specific crop etc. Coefficient of variance used to find the

fluctuations showed that maximum fluctuation of wages is in Odisha, Maharashtra, Tamil Nadu, and Himachal Pradesh whereas Jammu and Kashmir, Kerala, Gujarat, and Meghalaya are states with minimum fluctuation that is have high stability in wages of agricultural labors. Fluctuations in agricultural wages are independent of the level of wages in the states. States with high wages, shows both high fluctuations and low fluctuations in wages, for example Kerala and Jammu and Kashmir, are low fluctuating states whereas Himachal Pradesh is high fluctuating state. Similarly states with low wage rates also lies in both high and low fluctuating category. For example, Gujarat is low fluctuating state and Odisha is highest wage fluctuating state whereas both have low agricultural wage rates.

Growth Rate of Agricultural Wages in India.

Growth rate of agricultural wages is calculated between 2005-06 and 2020-21 using three years average (2005-06 to 2007-08) as previous data and three years recent data for current entry. Highest growth rate is observed by Odisha followed by Tamil Nadu, Bihar, and Uttar Pradesh whereas lowest is observed by Gujarat followed by Meghalaya, Tripura, and Jammu and Kashmir. These four states have showed negative growth rate, that is the wages in the 2005-06 were more than the 2020-21. This is because of sudden decline in agricultural wages due to economic impact of COVID-19. Despite fall in wages in current year due to COVID-19, 15 showed positive growth rate, indicating the overall growth in the wages. Compound annual growth rate for analysis of successive hike in wages over the years showed that Tripura and Gujarat experienced negative growth rate and very small positive growth rate is experienced by Meghalaya and Jammu and Kashmir. Highest growth rate is experienced by Himachal Pradesh, Odisha, Rajasthan and Bihar. A general trend observed in the growth rate is that states with high wage rate shows slow or negative growth rate for example Jammu and Kashmir and Kerala whereas the states with low wage rate shows high growth rate like Odisha, Bihar and Uttar Pradesh. Coefficient of correlation between compound annual growth rate of agricultural labor real wages and average agricultural real wages of states is negative which again indicates that states having high real wages showed lesser growth whereas as states having low wages rates experienced higher growth rate. This is because development of connectivity, transport and communication technology allowing free and unrestricted movement of labors loaded with required information and knowledge. This eventually is leading towards creating an equilibrium of wages across the country by filling the demand and supply gap.

Conclusion

Agricultural labors are among the most deprived section (economically, socially, politically) of rural society having meagre resources to sustain a meaningful, dignified life. Major and sometimes the only source of their income is the wages they derive by working in fields of others and other related allied activities. Decline in their wage or relatively slow growth as compared to inflation would have harsh impact on their development. Decline in agricultural laborer's wages would lead to reduction in purchasing power and demand of products and services thus slowdown in production process that would again hit the consumption as reduced production would cause increased unemployment, decline in capacity to spend for education, health, skill development. Agricultural labor wages depend upon demand and supply of labors thus in order to increase their wages their supply need to be cut short by engaging them in other sector of economy like decentralized micro, small, medium manufacturing enterprises, food processing industry, providing them with skill training for making them ready for semi-skilled jobs and increasing their demand by promoting farming practices that are more convention, integrated, labor intensive, and natural farming. Community farming or cooperative supported animal husbandry could support their household income and reduce vulnerability. Efforts are needed at central and state policy making level, by demotivating farm mechanization especially at those states that are labor surplus by introduction of seeds and techniques that engulfs more labor and support farmers financially to incur the increased cost of production thus tackling the problem of unemployment, reducing wages of agricultural labors and excessive rural to urban migration in one go.

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INCLUSIVE GROWTH: ROLE OF MIGRATION

Dr. Geeta Devi

Abstract

Migration has an intimate association with the development and inclusive growth. While development causes migration the converse is also true. No doubt migration depri ves the society of origin of its young energetic creative manpower, but the remittances sent by them give rise to not only a number of developmental activities but also creates opportunities for all the section of the society in one way or the other. Remittances are most important to development though this depend on a variety of factors as the propensity to remit differs from person to person. Nevertheless, remittances helped in generating employment through the investments made by the migrant households thus helped the migrants and non-migrants equally. Remittances also helped in improving the standard of living of people through enhancing their consumption levels, thus having a multiplier effect on the economy. As the policymakers have shifted the focus away from the quantity of growth to the quality of growth, this paper is an attempt to highlight the key issues regarding the inclusive growth and how migration can impact inclusive growth. Therefore, the main objective of the present research is to know the role of migration in helping for an inclusive growth. To properly understand the relationship between remittance, migration and inclusive growth we need to look beyond household income effects and consider wider social impacts. In the present study the discussion is based on migration and inflow and use of remittances leading to poverty alleviation, migration and inequality, migration and changes in social institutions, and migration and change in role of women.

Introduction

Increasing migration flows in recent decades have been an important element of economic integration at both the global and regional levels, notably in Asia. The main drivers of migration in Asia, as elsewhere, are the wage gap between origin and destination countries, which remains wide, and the lack of employment

opportunities in origin countries, especially less-educated workers. These factors explain much of intra-regional migration by the low-educated (ADBI, 2013). In recent years, many policymakers have shifted their focus away from a narrow concern with GDP growth towards a broader target of 'inclusive growth.' This concept is understood to encompass both a lasting reduction in absolute poverty and a more equitable distribution of the gains from growth (UN, 2010). Since 2011, the Asian Development Bank Institute (ADBI), together with the Organisation for Economic Co-operation and Development (OECD), have organized an annual Roundtable on Labor Migration in Asia as part of its thematic priority in capacity building to promote regional integration and international cooperation and inclusive growth. The main theme of the second Roundtable, held in January 2012, was Managing Migration to Support Inclusive and Sustainable Growth. (ADBI, 2013). During the Roundtable, participating country-of-origin governments expressed the view that outmigration by educated citizens was largely positive. Governments raising this topic expressed confidence that it provides greater returns to education, and these countries hope to benefit from higher per capita remittance levels, the inclusive growth approach takes a longer term perspective. The emphasis on improving the productive capacity of individuals and creating conducive environment for employment, rather than on income redistribution as a means of increasing incomes for excluded groups. Due to this longer term perspective, there is an explicit focus on structural transformation and internal migration in the inclusive growth analytics framework. In developing countries a significant part of growth is generated through reallocation of labor from low productivity to high-productivity sectors.

Objectives

This paper is an attempt to highlight the key issues regarding the inclusive growth and how migration can impact inclusive growth. Therefore the main objective of the present research work is to know how migration weather internal or international work as a key for an inclusive growth.

Database and Methodology

In order to achieve the objectives of the present study, secondary data/ information have been used. The approach adopted for the research work is a systematic literature review strategy. Secondary data was collected from books, reports, journals, research articles having a direct bearing on the subject.

How Migration can help in Impacting an Inclusive Growth

Migration particularly rural to urban migration is one of the most conspicuous processes of the present day. The process can be comprehended in terms of the cause and consequences of migration in relation to the communities of the origin and destination of the migrants. The community structure generates situations which compel the people to make a move on the one hand and, on the other, the process of migration brings about changes in the community structure itself. Migration is a two way process, as it is a cause of development and as well as a consequence of development. The consequences of migration are numerous. These however are difficult to analyze as it involves a number of units and depends also on various factors at the place of origin and place of destination. The rapid growth of cities in the developing world is the major impact of migration. In the 20th century, rural-urban migration was viewed favorably in the economic development literature (Todaro, 1977). Internal migration was thought to be a natural process in which surplus labor was gradually withdrawn from the rural sector to provide needed manpower for urban industrial growth. The process was deemed socially beneficial since human resources were being shifted to locations where their social marginal products were not only positive but also rapidly growing as a result of capital accumulation and technological process. During the growth process, migration has a role to play in bringing about structural changes in the economy.

The consequences of migration are numerous. These however, are difficult to analyze because of the involvement of a number of units such as individuals, families, communities, regions and countries as well as intermediating variables like the socio-economic, political, environmental and cultural background and prevailing conditions at the place of origin and place of destination. Further, quite often, migration has more indirect than direct effects at the places of origin and destination and that too of variable temporal dimensions (U.N., 1984). Impacts of migration depend on the contexts, such as seasonality of movement, educational level of migrants, the length of time spent away, assets and social structures and institutions allowing women and others to pursue activities previously reserved for men and household heads (de Haan, 2000). Therefore to properly understand the relationship between remittance, migration and inclusive growth we need to look beyond household income effects and consider wider social impacts. Migrants impact both the place of origin and destination. And as the links between migration and growth is quite complex as the different aspects of it interacts,

making the quantitative assessments problematic. Therefore, it can observe from the following discussions that how migration impacts economy and society as well leading to an inclusive growth:

Migration and Poverty Reduction

The relationship between migration and poverty is a complex one. Migration can help to reduce poverty and poverty itself is also a cause of migration. But both are deeply interlinked. Researchers on migration have long grappled with the question of whether migration increases or reduces poverty. A consensus has not been achieved partly because of paucity of information and partly because of the tremendous variation across contexts and ethnic groups. The poverty reduction impact depends on a variety of factors like the availability of surplus labour with in the household and village and whether migration increases labour scarcity. Due to a tightening of domestic labor market (both agriculture and non-agriculture); however, that the wage increased in a higher rate in the agricultural sector shows an increase in employment opportunities and alternative particularly for low-income groups. An increase in wage rates can be a pivotal element for rural growth dynamics (Brown et al, 2013; Housen et al, 2012).

A research in Kenya showed even though poor households have less access to opportunities, income from migration may form a more important part of their income than that of the better-off (Knowles and Anker, 1981). Although most international remittances do not flow directly to the poorest people, remittances often make upon important share of the income of the poor people and poor communities as poor people might be affected indirectly through the economy wide effects of remittances expenditure on wages, prices and employment in migrant sending countries (Taylor et. al.1996). Taking the example of Nepal it has been observed that despite the political upheavals, there is a dramatic fall in poverty level and maintaining a stable level of growth over the past two decades, averaging around 4% annually. This sustained growth and reduction in poverty rate is a contribution of outmigration and remittances and this recent growth is termed as an inclusive growth (Maskay and Adhikari, 2013). Teto (2001) estimated that 1.7 million (out of 30 million) Moroccans would fall back into absolute poverty without international remittances and the proportion living below the poverty line would increase from 19 to 23.2 per cent. Another analysis of Egyptian and Ghanian survey data equally indicates that migration enables poor people to move out of poverty. Afsar (2003) also argues that migration has reduced poverty directly and indirectly in Bangladesh as remittances have expanded the area under cultivation and rural labour markets

by making land available for tenancy. Morina, D., Gashi, P. and Morina K., 2015 had observed in their study on Kosovo, that migration is a selective process that affects the growth potential and the welfare of non-migrants as well.

Anh's (2003) conclusions based on data from China, Vietnam, Phillipines and Bangladesh identifies migration as a driver of growth and important route out of poverty with significant positive impacts on people's livelihood and wellbeing. Research by the World Bank and other institutions points to a positive correlation between migration and poverty reduction. A study of 74 low and middle income developing countries reveal that on average a10 per cent increase in the number of international migration in a country's population can lead to a 1.2 per cent decline in poverty (Page and Adams,2004). Therefore, it seems to be of little doubt that migration can reduce poverty and stimulate economic growth (Deshingkar and Gramm, 2004). Migration may have direct and indirect effects on poverty. It can directly reduce poverty by reducing the number of people that a poor household must support. If the potential migrant was not working before leaving, this effect is particularly beneficial. Migration helps stabilize the household income and prevent the household from plunging further into poverty. Migration and migrant can have indirect effects on poverty in the migrant's home community. Migrants leave the local labour force making local labour force more scarce and pressuring the wages upwards, while remittances adds liquidity to local market, potentially stimulating economic activity (de Brauw, 2007).

Migration and Inequality

A commonly held view is that migration increases inequality. The effects of rural out migration on economic welfare in sending areas depends critically on how emigration effects the local capital-labour ratio among non-migrants, that is, on the distributional effects of migration. Moreover, an important concern of the literature on migration is that the poorest are rarely found the major beneficiaries of remittances, at least directly. This is due to the inability to finance expansive moves such as those overseas or those requiring some degree of education. Thus, the impact of migration and remittances on income distribution and in source regions remains a matter of interest in the literature but also of some dispute. The effects of remittances on income distribution and other aspects of wealth is primarily a function of migration selectivity. If migrants mainly originate from relatively wealthy households, migration is more likely to imply greater inequality in the community of origin, while the reverse seems likely if migrants come from relatively poor households, as in the case of Indian rural to urban migration, it has been emphasized

that better off migrants are "pulled" towards better job prospects while the poor are "pushed". "Push" and "pull" migration are twin children of inequality in the same sort of village; but they are also sources of new inequality (Lipton, 1980). It is more correct to say that the impact of migration on income inequality on migrant sending communities vary for different types of migration and for different periods in a community's migration history (see for instance, Stark et.al, 1988). Through the development of social networks between migrants and people staying behind which diminish the risk and costs of migration (Bauer and Zimmermann, 1988), and the flow back of international (Kornar, 1992) less wealthy households initially tend to gain increasingly easy access to international migration. As a consequence of this diffusion process, the initially negative effect of remittances on income inequality might, therefore, be dampened or even reversed in the long term. One might conclude that migration has contributed to increasing household income inequality within a certain community or region however, when comparing this migrant sending region as a whole with other more wealth and centrally located region in the same country (or between countries), one may find that inequality between the region has actually decreased as a consequence of developmental effects of migration (Taylor et. al, 1996). Inequality clearly influences and is in turn, influenced by migration (Waddington, 2003). The search for a better and more secure livelihood drives many migratory movements, and according to Nyberg-Sorensen et. al. (2003), is most common where survival is at stake. Not only does inequality influences who can migrate where, when and how, but it may also be a primary cause of migration. For example, Salemink (2002) shows how internal migration in Vietnam relates to a lack of land rights is customary law for certain excluded social groups. Gaps and access to water and land resource are also documented as causing migration in South Africa (Rwelamira et.al, 2000), Cameroon (Schrider and Knerr, 2000), West Bengal (Ragaly, 2003) and tribal Western India (Mosse et. al, 2002). Here, however the concern is more with how migration influences inequality. Although inequality increasing effects, have been found in various studies at the regional (Adams, 1989) and national (Mishra, 2007) levels, this mechanism is not inevitable.

Migration and changes in Social Institutions

Several historical and empirical studies of immigration have recognized and confirmed that the concentration of particular nationality and ethnic groups in certain cities facilitated the migration of the same groups to these cities (Levy and Wadycki, 1973). Networks play an important role in migration. Kinship ties, friendship and shared community origins are hypothesized to increase migration flows because

they reduce the psychic and risk costs of immigration. These networks connection constitute a valuable social capital that migrants can drop on to gain access to foreign employment and better wages and working conditions (Boyd, 1989).

Massy (1989) has made a case for networks under the assumptions of a risk-diversification model. According to this model families allocate member labour within the constraint of their own needs and aspirations in a cost-efficient and risk minimizing way. Moreover, modernization and development create social and economic dislocations that intensify the unstable and unpredictable economic environment created by the usual risks of drought, crop failure and natural disasters, for rural as well as urban areas. In the absence of other ways to ensure against such risks, diversifications of family members location minimize overall family income risk (Massey, 1989). Networks promote the independence migratory flows for two reasons. First, once network connections reach some threshold level, they amount to an autonomous social structure that supports immigration. This support arises from the reduced social and economic and emotional costs of immigration that network permit. That is, network supported migrants have important help in arranging transportation, finding housing and jobs in their place of destination and in effecting a satisfactory personal and emotional adjustment to what is often a difficult situation of cultural marginality.

These benefits make migration easier, thus encouraging people to migrate who would otherwise have stayed at home unless migrants are uprooted. Education appears to be a major factor in who benefits from and is able to undertake migration with in a community, even if this is only in relative terms (Skeledon, 1997). As stated by the Tilak (2007) also "education is the most critical ele¬ment in empowering people with skills and knowledge and giv¬ing them access to productive employment in the future". Therefore, education is an important sphere of wellbeing that can be affected by migration and a livelihood outcome in its own right. Through migration, individuals may be educated or skilled (i.e. it may be a motive to migrate itself) assuring migration is an accumulated strategy thus future generation may benefit through investment in their education (Waddington, 2003). Expenditure in areas such as education, health, food, medicines and investment in housing as well as community projects for education, health and recreational facilities can enhance people's wellbeing and ability to lead the lives they have reason to value. De Haan (2000) reviews literature from parts of India. Zimbabwe and Kenya finding on balance. That migrants are more educated as education can assist the development of critical consciousness and expose individuals to different values and norms.

Where women are educated they are able to participate in transnational migration and entrepreneurship, sending remittances that help to sustain social networks and participating in migrant organization (Nyberg-Sorenson, 2002).

Work in different parts of India by Parry (2003), De Neve (2003) and de Haan (2003) documents how networks are important even, crucial assets to enable migration. This may be through kinship or other kinds of social affiliation and identities such as caste solidarity. In the former, dependency patronage and other kinds of support (e.g. business partnership) can lead to upward mobility. For the later, the village community can be a good source of information and help with alternatives. In west Bengal, Rogaly (2003) reports how migrants establish long term relations with individual employers, which are crucial for survival. De Haan (2003) reports that caste identity plays a role in the personal networks that mediate migration of migrants to Calcutta. Migration can reinforce the structures, ideologies and support networks for development works and also influence positively institutions such as family, school, social norms and traditions and religious organizations by bringing in new progressive ideas into the development of social institutions and also migrants invest in strengthening these local institutions (Haque, 2006).

Women Migration and Empowerment

The most striking example of the social changes in Nepal resulting from out migration has been the empowerment of women in the rural areas. As men have moved abroad to work, women left behind in Nepal have gained increasing autonomy and discretion over household budgets. In a nationally representative survey of married women, more than half of currently married women who earn cash said that they themselves mainly decide on how their cash earnings are used; two in five indicated that the decision is made jointly with their husbands and only 5% said that the decision is made mainly by their husbands. Similarly, the proportion of surveyed married women who earned cash for their work and who solely decided on the use of their cash earnings has increased from 31% in 2006 to 53% in 2011. It is now recognized that gender equality and female empowerment are central to improvements in standards of living and wellbeing (World Development Report, 2011). Further, the empowerment of women in the rural economy has led to drastic changes such as increasing access to information, offering new choices, and providing demonstration effects. Thus, an unforeseen consequence of foreign labor employment to Nepalese labor is that it has spurred societal changes, namely the empowerment of women in rural areas. It has been argued that female migrants show a deeper commitment than male migrants to providing more economic support to

households that are left behind (Osaki, 1999; Carling, 2005; Boyd, 1989). Several studies indicate that until recently migration was dominated by single men (De Haan, 2000), but things are now changing and feminization of migration is now occurring. In India, regional differences in women's mobility have been noted by Singh (1984 cited in De haan,2000), where migration among women in South India is higher than their northern sisters who live in a cultural milieu that is similar to West Asian and North African Arab countries. Bremen (1996) observed that migrant women in Gujarat, India carrying out equivalent tasks to migrant men earned lower wages. It is sometimes assumed that the migration of men encourages the emancipation of women who stay behind since behind since in their husband's absence, women's responsibilities, autonomy and power would increase (see, for instance, Fadloullah et. al, 2001), while remittances enable these women to assert this newly acquired independence. The pattern in China is still largely male-dominated as a number of studies have established (Zhao, 2001, 2003) both due to cultural reasons restricting female mobility and the nature of the demand for manual workers in urban areas. But more women are migrating to labour intensive industries in areas such as Guangdong. Regional comparisons show that women's migration is very high in South America and South East Asia (Guest, 2003). For example, a study of the cities of Ho Noi and Ho Chi Minh estimates that 40-45 per cent migrants are female (Grace, 2002).

There is micro evidence from several countries in South East Asia that the levels of female migration have increased over recent decades. The employment of women is greatest in the five major export-oriented, labour intensive industries, which are electrical machinary, electronics and computer parts; textiles and readymade garments; frozen and canned foods; precious stones and jewellery and footwears (Clawn,2002). The majority of female rural-urban migrants in East and South East Asia are young and unmarried and the concentration of this group in urban areas is partially in the mega cities (Guest, 2003). This form of migration has increased and become more socially acceptable in South Asia (Siddiqui, 2003). In some areas cultural barriers are breaking down because of the huge opportunities offered by migratory work. Migration thus offers many prospects for helping women to exit from poverty (Deshingkar and Grimm, 2004). It is now recognized that, international migration is positively associated with the status of a women and the opportunities for women to go abroad for employment draws from changes of role of women in areas such as household's decision making, division of labour, gender roles and community perception. Gammage (2004) found that, through migration

and remittances, Haitian women have been able to change the political landscape of Haiti and have challenged traditional gender roles. The so called, "autonomous female migration", has increased because of a greater demand for female labour in certain services and industries and not just as accompanying spouses.

The feminization of migration is one of the principal recent changes of population movement. Today women account for about half of the migrant population (Haque, 2006). Both Courbage (1996) and Fargues (2006) hypothesized that besides factors such as older age of marriage, increased female labour participation and improved education migration from North America to European countries has contributed to the diffusion and adoption of European marriage patterns and small family norms and so has played an accelerating role in the demographic transition. Blue (2004) found that females were positively associated with remittances behaviour among Cuban emigrants. The changes in the family and social norms brought by the female migrants are insignificant and potentially beneficial for the society (Haque, 2006).

Conclusion

Inclusive growth is regarded as the new mantra of development. This paper looks at the approach to the building up of a relationship between inclusive growth and migration and how migration is impacting it. Though many have argued that migration deprives poor countries of its valuable human resources, but studies also have proved that migrants are a potential source of development to their origin as they bring with them the new skills, advanced technology and also potential sources of finance in the form of remittances sent by them. Therefore, it can be concluded that migration does not always lead to brain drain but also to brain gain. Therefore, migration weather internal or international promotes the welfare of the economies and help in bringing an inclusive growth and development directly or indirectly, through the helps provided by the migrants to the area of destination or origin, such as construction of houses and cattle sheds, purchase of land and livestock economy, introduction of new farm technology, education etc. To continue the process of economic growth and social transformation to which remittances are contributing, the economies should foster an economic environment conducive to the productive use of remittances. Therefore, migration weather internal or international promotes the welfare of the economies and help in bringing an inclusive growth and developmental process directly or indirectly. To continue the process of economic growth and social transformation to which remittances are contributing, the economies should foster an economic environment conducive to the productive use of remittances. In particular it should maintain a reasonable level

of economic stability through building consensus among the political parties on minimum common economic agenda for development and growth.

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PROSPECTS AND CHALLENGES OF SUSTAINABLE TOURISM IN ANDAMAN AND NICOBAR ISLANDS

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Abstract

The paper discussed the status, prospects, and challenges of sustainable tourism in Andaman and Nicobar Islands. It has been found that there is huge potentiality of sustainable tourism in the islands. Unexplored geographical features, diversified biodiversity, rich cultural heritage, rich tribal culture, evergreen forests, wild life sanctuaries, and river tributes, are prominent factors for the potential growth of the tourism sector. Travellers can enjoy the village life of the local tribes. The islands have plenty of marine wildlife, and amphibian. Cellular Jail National Memorial, Chatham Saw Mil, Samudrika Naval Museum, Anthropological Museum, Corbyn's Cove, Sound and Light Show are the popular places. But, there are also challenges before the tourism industry. Therefore, government should implement policies for mitigating such challenges.

Introduction

The term tourism was introduced in the 19th century and it is associated with the term "sustainable tourism". Tourism industry is important for any country, because it surge growth and demand of products/services of industries in the country. Tourism has the cultural, and economic phenomenon, where people move from one place to another for multiple purposes. It is the short period or temporally movement from the native place. Duration of the visit may be just one night, or up to one year. It always includes the domestic tourism, inbound tourism, and outbound tourism. Tourism industry is considered as a bigger industry in terms of employment and foreign earnings. It improving the communications among the peoples and solving various social disputes. It has many benefits, such as introduction of new technologies, boost in economic activities, infrastructure development, increase global connectivity, source of foreign exchange earnings, improve nations brand image, improvement of living standards, cultural growth etc. Sustainable tourism involved in development of both the present and future generation. It means movement of people outside own houses and visit various

places without harming the natural environment. Sustainable ecotourism benefits both the visitors and the local peoples. It is useful for swelling conservation and economic growth. Travellers can witness the beauty of the natural environment and also learn about the culture of the ethnic peoples. Ecotourism is natural based activities that increases the interest of people about certain places. Such activities will be economically, ecologically, and socially sustainable and helpful for the wellbeing and conservation of the areas. Local people will be benefited through such tourism without affecting their culture and customs.

Objectives

The main objective of this study is to investigate the prospects of sustainable tourism in Andaman and Nicobar Islands, and to study the challenges before the tourism sector.

Study Region

Andaman and Nicobar Islands is a union territory of India. It contains two island groups, Nicobar Islands, and Andaman Islands. The total land area of the islands is nearly 8,249 km^2. There are 572 islands. Port Blair is the capital of the union territory. It is situated 1,255 km from Kolkata, 1,200 km from Visakhapatnam, and 1,190 km from Chennai. Hindi, and English are the official languages of the islands. (**Fig.** 1)

Database and Methodology

(1) Design and approach: The present study is based on the secondary data. The data has been collected from reports of Andaman and Nicobar Tourism, and India Tourism Statistics. Various journals and books have also been referred in the present study.

(2) Method of analysis: To reveal the growth of tourism industry of Andaman and Nicobar Islands in general and the sustainable perspectives of the industry in particular, different methods of qualitative analysis comprising of tabulation and text analysis were performed.

(3) Hypothesis: Data analyses have been done on the following hypotheses:

H0: There are no impact of corona pandemic on the Tourism Industry in Andaman and Nicobar Islands.

H1: There are impact of corona pandemic on the Tourism Industry in Andaman and Nicobar Islands.

Results and Discussion

Tourism industry in Andaman and Nicobar Islands are increasing due to the beautiful beaches, and adventure sports like sea-walking, and snorkelling. Its tropical rain forest is rich with a diversity of animal life. Kalpong River, Alexandra River, Galathea River, and Dagmar River are the popular rivers. Kalpong river situated in Andaman District, are originated from Saddle Peak. The remaining three rivers situated in Great Nicobar. Hydroelectric dam is constructed on the Kalpong River. The top tourist visited places are Port Blair, Havelock Island, Neil Island, Ross Island, Diglipur, Long Island, Cinque Island, Mayabunder, and Little Andaman. Port Blair is the capital and headquarter of Andaman and Nicobar Islands. It is the gateway for the others incredible islands. Veer Savarkar International Airport is the only airport in the islands. It is well connected with the mainland by air from Visakhapatnam, Chennai, and Kolkata. Cellular Jail National Memorial, Chatham Saw Mil, Samudrika Naval Museum, Anthropological Museum, Corbyn's Cove, Sound and Light Show are the popular places of the city. Cellular Jail is a British colonial prison. Today it is a national memorial monument. Wandoor Beach is situated 25 km south-west of Port Blair. It is located near the Mahatma Gandhi Marine National Park. There are plenty of marine wildlife, and amphibian. Saltwater crocodiles are often found on the coasts. Wandoor is also recognized for its Mangroov forest, lagoons, and backwater. Travellers can enjoy the village life of the local people. Agriculture crops (coconut, and paddy) and fishing are the main sources of income of villagers. Travellers can see the rural life of the diversified tribes. It will enhance the rural tourism in the islands.

Table-1 discussed the populations and areas in Andaman and Nicobar Islands. It has been found that south Andaman district have the largest number of population, followed by the North. and Middle Andaman districts. It is the largest district followed by the South Andaman district. Mahatma Gandhi Marine National Park was established in 24th May 1983 under the Wildlife Protection Act of 1972 for the protection of nesting sea turtles, and corals. Twin Islands and Labyrinth Islands are the two major island groups in the park. Majority of the coral reefs are fringing reefs. There are nearly some 20 islands and rocks in the park. Many islands are covered with thick mangrove vegetation, sheet rocks, uprooted trees, and sand covered beaches. There is scope of ecotourism in Red Skin and Jolly Buoy islands. Havelock island is a popular eco-tourism spot. Water sports like as scuba diving, banana boat ride, and sea walking are popular among the tourist.

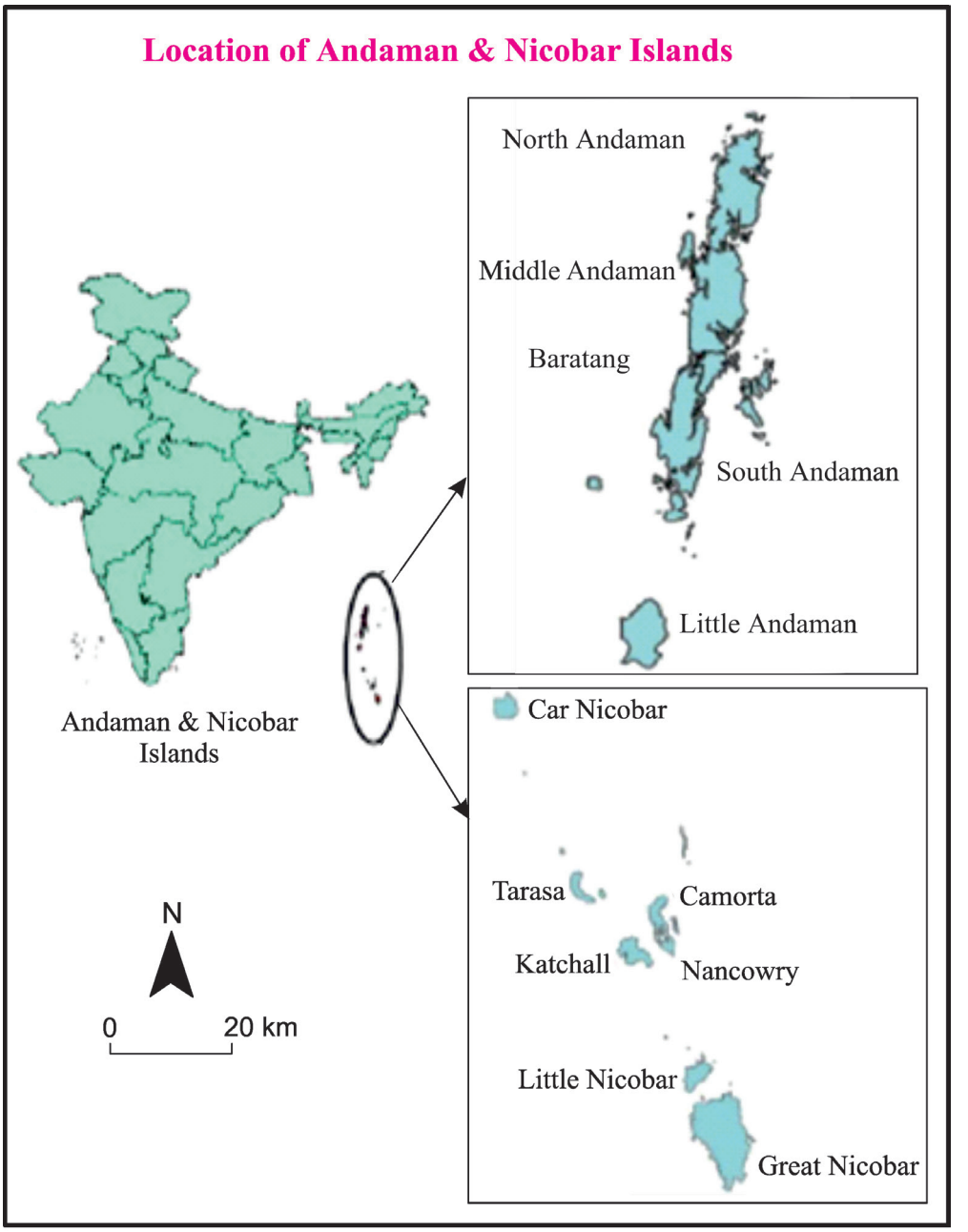

Location of Andaman & Nicobar Islands
North Andaman
Middle Andaman
Baratang
South Andaman
Little Andaman
Andaman & Nicobar Islands
Car Nicobar
Tarasa
Camorta
Katchall
Nancowry
Little Nicobar
Great Nicobar
N
0
20 km

Fig. 1

Elephant beach, Kala Patthar beach, and Radhanagar beach are the popular beaches. Tourist can also enjoy the mangrove safari, fishing, trekking, scuba diving etc. Neil Island is situated 40 Km. away from Port Blair. Sitapur beach, Laxmanpur beach, and Bharatpur beach are popular beaches of Neil Island. Travellers can witnessing the unexplored coral reefs. Ross Island is an uninhabited island. The ruins and a small museum of Indian Navy is the main attraction of the island. Ross Island is located three km. east from central Port Blair. There are many lighthouse towers. Peacocks and spotted deer are easily available in the island. Palm and coconut trees are the native trees of the island. Travellers can see the amazing landscapes and sunset views in the evening. (**Table-**1 and 2)

Table-1: The Populations and Areas in Andaman and Nicobar Islands

District	Capital	Population (2001)	Population (2011)	Area (km.)
South Andaman	Port Blair	208,471	238,142	2,640
N. and M. Andaman	Mayabunder	105,613	105,597	3,536
Nicobar	Car Nicobar	42,068	36,842	1,765
Totals		356,152	380,581	7,950

Source: Office of Registrar General & Census Commissioner of India.

Table-2: Historical Population Growth in Andaman and Nicobar Islands

Year	Population	Growth	Year	Population	Growth
1901	24,649	-	1961	63,548	+105.2%
1911	26,459	+7.3%	1971	115,133	+81.2%
1921	27,086	+2.4%	1981	188,741	+63.9%
1931	29,463	+8.8%	1991	280,661	+48.7%
1941	33,768	+14.6%	2001	356,152	+26.9%
1951	30,971	−8.3%	2011	380,581	+6.9%

Source: Census of India.

Table-2 discussed the historical population growth in Andaman and Nicobar Islands. It has been found that except 1041-1951 period, in other periods population was increased. Viper Island lies four kilometres west of Port Blair. It is popular among the tourist because for its mesmeric picnic spots, and having historical

importance. Nali, Mud Spitting Volcano, and Kalipur beach are the popular places of the island. Saddle Peak National Park, Orange gardens, paddy fields, Saddle Peak, and expansive greenery and marine life are other tourist attractions. Trekking, scuba diving, and snorkeling are the common activities. Long island has the beautiful eco-huts headed by Blue Planet. Merk Bay, and Lalaji Bay are the popular sports. Clinque Island is a human inhabited island. Tourist can enjoy the wildlife, greenery, and marine life of the island. The Mahatma Gandhi Marine National Park, salt water crocodile, starfish, sea weeds, varieties of coral reefs, fishes, shells, turtles, and sprawling marine life are the major tourist attractions. Mayabunder situated in middle Andamans. It is cultural hub of 71 villages where majority of people are immigrated from Pakistan and Bangladesh. Karmatang beach, and Karmatang Beach have the turtle nesting spots. Little Andaman is paradise for the natural lovers. Travellers can involve in coral watching, fishing, diving, snorkeling, surfing etc. Beautiful beaches, Red Oil Palm Plantation, evergreen rain forests, and waterfalls adds additional satisfactions to the tourist. (**Table-**3)

Table-3: Year-wise Arrivals of Tourist in Andaman and Nicobar Islands.

Years	Tourist Visits			Percentage Share		Rank	
	Domestic	Foreign	Total	Domestic	Foreign	Domestic	Foreign
2008	123914	12512	136426	0.00	0.10	31	23
2009	142042	13684	155726	0.00	0.10	31	23
2010	180781	14615	195396	0.00	0.10	31	25
2011	202221	15814	218035	0.02	0.08	31	25
2012	238699	17538	256237	0.02	0.08	31	25
2013	243703	14742	258445	0.02	0.07	30	25
2014	285146	17235	302381	0.02	0.08	31	27
2015	296684	14674	311358	0.02	0.06	32	27
2016	384552	15466	400018	0.02	0.06	31	26
2017	471919	15313	487232	0.03	0.06	30	27
2018	498279	15242	513521	0.03	0.05	31	28
2019	505398	16206	521604	0.02	0.05	31	29
2020	191207	5412	196619	0.03	0.08	28	25
2021	126238	1687	127925	0.02	0.16	32	21

Source: India Tourism Statistics.

The above **Table-**3 discussed the arrivals of tourist in Andaman and Nicobar Islands. It has been found that number of tourist are increasing continuously since 2010, but declined in 2020, due to the corona pandemic. Domestic tourist arrival was more than 50 thousand in 2019, but it was dropped to only 126238 in 2021. On the other hand, foreign tourist arrivals were 16206 in 2019, and it was just 1687 in 2021. Lockdowns, and travelling restriction due to the corona pandemic is main factors behind the sudden drop of the tourist arrivals. Therefore, the null hypothesis is rejected and alternative hypothesis is accepted, i.e. there is impact of corona pandemic on the Tourism Industry in Andaman and Nicobar Islands. There are three districts in Andaman and Nicobar Islands. They are Nicobar, South Andaman, and North and Middle Andaman. Malacca is the capital of Nicobar district. It is situated in Car Nicobar tehsil. Car Nicobar is located in the northernmost of Nicobar Islands. It is popular for the silvery beach. It is flat island with clusters of coconut palms, and areca nut. It is a small island (only 126.9 km^2). There are 21 villages. It has tropical monsoon climate. Bird watching is popular among the tourist. Green imperial pigeons, Andaman boobooks, White-headed starlings, Andaman cuckoo-doves, Andaman wood pigeons, and Nicobar serpent-eagles are the prominent birds. Car Nicobar is 260 kilometers, far away from Port Blair.

Ship service is available between the two towns, and travellers can collect ticket from the office of the Director, Shipping services, Port Blair. Indian Air Force operating the charter services between Car Nicobar Air Force Base, and Port Blair's Veer Savarkar International Airport, Campbell Bay. Regular service of Pawan Hans helicopter is also available. Mount Thullier is the highest point of Nicobar Island. It is 642 meter above the sea level. Dak Tayal, Dak Aniang, Amrit Kaur, Jubilee, and Galathea are the popular rivers of the island originated from Mount Thullier. Among the rivers, Galathea River is the longest river. Indian passport holders can travel the island, but the foreign passport holder's needs Landing Permits from the Office of the Deputy Commissioner, Andaman District. Indira Point is the most southern point of Great Nicobar Island. Great Nicobar Island is declared as World Network of Biosphere Reserves by the UNESCO. The island is comprising three distinct groups- Northern Group, Central Group, and Southern Group. Nicobarese, Shompen, and Mainland Indians are the ethnic tribes. Galathea National Park, and Campbell Bay National Park of Great Nicobar are protected areas. The island has the tropical climate. Mayabunder is the headquarter of North -Middle Andaman district. It is connected with Port Blair by the Andaman Trunk Road. It is the major highway. This highway connected Diglipur and Port Blair, via Mayabunder,

Nimbudera, Billy Ground, Rangat, Kadamtala, Baratang, and Ferrargunj. The distance between the two places are 242 km. Ferry service also available between them. It is a waystation for several tourist attractions, like as Karamatang Beach (13 km), beach at Aves Island (30 minutes by boat), and mangrove lined tidal creeks. Majority of the population of union territory lives in this district. Port Blair is the headquarter of South Andaman district. It is also the capital of Union territory. It is connected with the main land of the country by sea, and air. Other towns are Garacharma, Prothrapur, and Bambooflat. Bambooflat is located nearly 13 Kilometers from Port Blair. (**Table-**4)

Table-4: District-wise Popular Tourist Places in Andaman and Nicobar Islands.

District	Popular Tourist Places
South Andaman	Jolly Bouy, Swaraj Dweep (Radha Nagar Beach), Netaji Subhash Chandra Bose Island, Chatham Island, Cinque Island, Corbyn's Cove Beach, Cellular Jail, Mount Harriet, Gandhi Park, and Shaheed Dweep.
North- Middle Andaman	Lamiya Bay Beach, Karmatang Beach, Ramnagar Beach, Mud Volcano at Shyam nagar, Kalpong Hydro Electricity, Limestone Caves in Diglipur, Twin Islands - Ross & Smith Islands, Saddle Peak, Kalipur Beach and Turtle Nesting Ground.
Nicobar	Little Nicobar, Great Nicobar, and Car Nicobar.

Source: Official website of the districts.

Table-4 exhibits the popular tourist places in districts of Andaman and Nicobar Islands. It has been found that tourist places are scattered in the districts. Lamiya bay beach is situated in the foothill of Saddle Peak. It is near the Kalipur beach. Karmatang beach is perfect place for the snorkelling and scuba diving. Travellers can observe the olive ridley turtles, hawksbill turtles, green ocean turtles, and leatherback turtle. Ramnagar beach located 35 kilometers from Diglipu. It is more suitable for suitable for swimming. turtle nest is easily available. The beach has the eco-friendly beach facilities, like as seating arrangements, and eco-huts. Mud Volcano located near Hathilevel. The chain of Mud volcanoes can observe in the green jungle of Shyamnagar. Seating facilities along with information boards are available for the tourists. Kalpong dam is constructed on the across Kalpong river at Nabagram. It is only dam in the Union Territory. Turtle Nesting takes place at

Ramanagar beach and Kalipur beach are popular among the tourist. It is the home to thousands of turtles during their nesting period. Alfred caves is located near the Ramnagar beach. Ross & Smith islands are popular among the tourists. There is a marine sanctuary. It is enclosed by tropical forests. It is the perfect place of trekking and trail hiking. Diglipur is popular for eco-friendly tourists. It is a beautiful place having the orange garden paddy field, forest, and marine life. Andaman and Nicobar Islands are enriched in culture & heritage. Folklore is narrated and folk songs are the part of the festivals. There are many indigenous peoples in the islands. Andamanese are a listed as scheduled tribe as per India's constitution. Traditionally they lived a hunter-gatherer lifestyle, Great Andamanese and Jarawas are the major tribes. Jarawasve lives in Middle and South Andaman Islands. According 2011 Indian census, their population is 380. They are hesitated interaction with outsiders. Tourism department of the Andaman and Nicobar administration issued warning for attempting photographing them, or contact with Jarawas. They are protected under the under the Protection of Aboriginal Tribes Regulation, 1956. Onge is the another tribe. They live in Little Andaman. Their belief system is a form of animism. They are still maintaining their cultural and biological identity. Their population is declining due to their food habits brought about by their contact with the outside world. Therefore, there are huge potentiality of sustainable tourism in the islands. Unexplored geographical features, diversified biodiversity, rich cultural heritage, rich tribal culture, evergreen forests, wild life sanctuaries, and river tributes, are prominent factor for the potential growth of the tourism sector. But, there are also challenges before the tourism industry. Lack of media coverage, ethnic conflicts, lack of alternatives means of transport, boundary issues, poor connectivity, and abysmal infrastructure are the major challenges before the sector.

Conclusion

There is enormous potentiality of sustainable tourism in Andaman and Nicobar Islands. Port Blair is the capital, and the largest city. It is well connected with mainland by air and sea. Cellular Jail National Memorial, Chatham Saw Mil, Anthropological Museum, Corbyn's Cove, Sound and Light Show are the popular places of the city. The top tourist visited places in the islands are Port Blair, Havelock Island, Neil Island, Ross Island, Diglipur, Long Island, Cinque island, Mayabunder, and Little Andaman. Havelock island is a popular eco-tourism spot. Water sports like as scuba diving, banana boat ride, and sea walking are popular among the tourist. Elephant beach, Kala Patthar beach, and Radhanagar beach are the popular beaches. Diglipur is popular among the tourist because for its mesmeric picnic

spots, and historical importance. It is a beautiful place having the orange garden paddy field, forest, and marine life. Travellers can observe the olive ridley turtles, hawksbill turtles, green ocean turtles, and leatherback turtle. Great Nicobar Island is declared as World Network of Biosphere Reserves by the UNESCO. Andaman and Nicobar Islands are enriched in culture & heritage. There are many indigenous peoples in the islands. So, there are huge potentiality of sustainable tourism in the Union-Territory. But certain factors, like as ethnic conflicts, poor connectivity, lack of media coverage, lack of alternatives means of transport, boundary issues, and abysmal infrastructure are the major challenges before the sector.

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HISTOGENESIS AND GROWTH OF PATNA METROPOLITAN CITY

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Abstract

"Every place is a history of a life" (Tuan, 1977). Studying the histogenesis and growth of a historical city is not merely an exercise in understanding the past but it is an exploration of the transformative power of human civilization in crafting the urban environment as well. Examination of historical evolution of a city "illuminates the hidden relationships between power and space, revealing a deeply rooted interplay of social and spatial transformations" (Soja, 2010). This research paper delves into the histogenesis and growth of Patna settlement, a city of profound historical significance in India. Through an in-depth examination of historical records, maps and demographic data, this study traces the city's growth, from its ancient origin as Patliputra to its current status as a bustling metropolitan area. The research scrutinizes spatial expansion, population dynamics and key socio-political events that have shaped Patna's trajectory over millennia. The study reveals the pivotal role of strategic location along the Ganga river (Prasad, 2008), successive dynasties (Thapar, 2013) and colonial influence (Rai, 2010) in shaping the Patna's urban landscape. The analysis further delves into post-independence challenges, including economic decline and administrative restructuring, particularly following the separation of Jharkhand from Bihar in 2000. Despite these challenges, Patna's resilience is evident in its population growth which has multiplied tenfold since the early 20th century. This study projects a population of over 4 million by 2051, underlining the city's continued vitality and potential for further expansion. This comprehensive historical account contributes to a better understanding of the city's urban development processes and provides a foundation for urban planning and development in the future.

Introduction

To ensure a better future, it is vital to learn from the past. In order to comprehend the processes and patterns of urban development, it is essential to study the origin, evolution, and growth of cities. An examination of the histogenesis of a city is

necessary to properly comprehend the process of urbanization. The origin of ancient cities is often linked to myths, legends and divine interventions. The discipline of urban geography is concerned with the precise study of a city's location, site and situation in a temporal context. Recent advancements in underground exploration surveying technology have provided a gateway to search for 'city seeds' (Bosker, 2022). The development of cities is intricately tied to the progress of humanity and civilization. While traces of human civilization have been found worldwide, the civilization of the Indian sub-continent has an antecedence of urban nature. The Harappan civilization provides evidence of urban infrastructure such as proper drains, planned housing, lanes, and roads. Furthermore, several cities in mainland India are assumed to have divine origins dating back thousands of years, including Varanasi, Mathura, and Dwarika. Patna city has a history dating back to the 6th century BCE or even earlier. Apart from the Kumhrar excavation, there is no significant evidence of infrastructural traces to date. Historical and religious texts have always made appropriate mentions of Patna's expansion up to the pre-historical Mahabharat period. The travel accounts of foreigners during the ancient period also mention Patna under different names such as Pataliputra, Palibotra (Greek), and so on. The city has been given many names during the rule of different dynasties in the ancient history of the Indian sub-continent. As with other ancient cities, Patna's origin has evinced conflicting claims.

Study Region

Patna, the capital of Bihar, holds a prominent place in the historical and geographical landscape of India. This city, located in the west-central region of the Bihar state, lies in the midst of the fertile Ganga plain. The city falls within the coordinates of latitude 25°30' to 25°40' North and longitude 85°0' to 85°15' East. The city is surrounded on three sides by the Ganga, Sone, and Punpun rivers, and it boasts a unique convergence of four rivers with the Gandak river to the north. The Ganga's southern embankment forms the city's northern boundary, while the Punpun river flows approximately 5 kilometres to the south and the Son river more than 10 kilometres to the west. The city's elevation, averaging 55 meters above mean sea level, encounters lower areas to the southeast that are susceptible to prolonged waterlogging after floods. Most of the metropolitan area is part of the older floodplain, with the western region along the Ganga's embankment classified as an active floodplain. The city's population grew substantially between 1991 and 2011 with a significant "floating" population commuting daily. As of the 2011 census, Patna is home to a population of 2,046,652. The city extends for

about 24 kilometres from east to west, with an average width of 2.5 kilometres and encompasses an area of approximately 142 square kilometres.

Objective

The main objective of this study is to reveal the origin and evolution of the city including its evaluation of its spatial and demographic growth.

Database and Methodology

The study is solely based on secondary sources of data as it delves in to histogenesis and growth of the city. Accessible literature, historical maps, Survey of India Topo-sheets, Census data and other related government reports have been used as secondary data. ArcMap 10.8 has been used to prepare different relevant thematic maps such as extent of urban growth and settlement of urban landscape. MS Excel has been used for data analysis, presentation and interpretation.

Origin

The ancient origins of Patna are steeped in legend, with a multitude of stories surrounding the city's name and foundation. Over the course of its long and illustrious history, Patna has gone by a variety of monikers, from Patligram - a small village named after the patli flower that still grows in the city to this day - to pushpapuri and kusumpura, both of which mean 'city of flowers' and evoke an image of a tranquil city surrounded by blooming gardens. Patliputra is perhaps mostly well-known of these names, a testament to the city's rich cultural and historical heritage as the site of the ancient kingdom of Magadha and the Mauryan empire's flourishing capital. By the time of Sher Shah Suri in the 16th century, Patliputra had evolved into Patna, a name that phonetically resembled the Sanskrit word for 'port', paatan. However, the city underwent another name change when it became known as Azimabad during the Mughal era, named after the Mughal prince Azim-uh-shan, who established a court here. With the fall of the Mughal empire, the people of the city returned to calling it Patna, a name that has endured to this day and is synonymous with images of grand empires, scientific advancement and a rich cultural legacy that remains an integral part of India's history.

Tales and Anecdotes

The narrative from an ancient Hindi manuscript, translated from the Sanskrit Brihatkatha, provides a captivating account of the foundation of Patna. It chronicles the journey of a Brahmin Bhumideva and his sons, Kusa and Bikusa,

along with their wives Pramati and Sumati, who sought their fortune overseas. The intervention of deities Mahadeva and Parvati, prophesizing the birth of a child named Putra with a unique ability to generate a thousand gold coins. Putra, in a gesture of love and identity, established and named Pataliputra after his wife and himself. Following his reign, son Kusuma ascended to the throne, and under his rule, the city was renamed Kusumapur. This narrative intertwines folklore, divine intervention, and urban genesis, offering a rich tapestry of Patna's origin.

Evolution

The city of Patna owes much of its prominence to its strategic location, situated as it is amidst the rivers Ganga, Son, Gandhak, and Punpun. This unique position didn't only ensure its political pre-eminence but also allowed the city to thrive as a hub for riverine trade. Over the centuries, Patna has served as the capital of various powerful dynasties, from the Shishunaga and Nanda to the Maurya, Shunga, Kushana, and Gupta. Each of these dynasties has contributed to the city's cultural and historical heritage, leaving an indelible imprint on its identity. The city has also attracted travellers who found Patna inspiring and wrote vividly about its vibrant personality and historical journey. Patna played a critical role in India's struggle for independence, further cementing its place in the annals of Indian history.

Ancient Period (5th Century BCE to 12th Century CE)

In the 5th century BCE, Ajatashatru of the Haryanka dynasty of Magadh, son of Bimbisara, emerged as a significant ruling figure in Indian history. He was a contemporary of the great souls namely Mahavir and Gautam Buddha. Despite a tumultuous ascent to power, in which he forcefully overtook the kingdom from his father and imprisoned him, Ajatashatru emerged as a successful conqueror. By capturing Vaishali, fortifying a village to form the city of Patliputra, and capturing Kashi and other smaller kingdoms, Ajatashatru secured his position as the ruler of the most powerful kingdom in North India. Between 491 and 961 BCE, Ajatashatru moved the capital of Magadha kingdom from Rajgriha to Patliputra, and his son Udayabhadra succeeded him, leading to the city's growth into the largest city in the region. Although Gautam Buddha visited Patliputra during the last years of his life and prophesied a successful future, he also predicted the city's ruin from Flood, Fire and Feud. In the 4th century BCE, Chandragupta captured Patliputra and established the Mauryan dynasty, which lasted from 321 to 185 BCE. With the rise of the Mauryan dynasty, Patliputra became the centre of power. The city was constructed using wooden structures during this time, with multi-story buildings

and palaces surrounded by ponds and parks. The drainage system was another notable feature of Patliputra. The streets' water route drained into a moat , which functioned as both a defence system and drainage system. In 303 BCE, Greek ambassador Megasthenes visited the royal court of Chandragupta and described Patliputra as an important and fortified city with wooden walls, crowned with 517 towers and 64 gates, all surrounded by a protective ditch. The main gate of the city was protected by a special armed contingent under the kiledar . Megasthenes noted that visitors had to show their identity to the gatekeeper while entering the city. He described Patliputra as a splendid city and compared it to the contemporary Persian sites (Waddell, 1903). In the 3rd century BCE, King Ashoka, the grandson of Chandragupta, extended the Mauryan empire as far as Madras and renovated the wooden capital into a stone construction in 273 BCE. During this time, education and learning received immense state support, leading to Patliputra becoming home to several eminent world-class scholars, including Aryabhata, Ashvaghosha, Chanakya or Kautilya and Vatsyayana. Patliputra was considered the largest city during 300-195 BCE.

Emperor Ashoka's reign marked a significant period of cultural, social, and religious transformation, with his emphasis on Buddhism and his rock and pillar edicts promoting social justice, religious harmony, and non-violence. In 232 BCE, the Mauryan dynasty came to an end with the death of king Ashoka, and the Shungas took control over the kingdom. India then reverted to a group of unfederated kingdoms with the Shungas controlling most of the core territories of Magadha. In the 2nd century BCE, Magadh entered a period of political decline. Although most of the powerful kingdoms were located in the south and west, the north remained culturally active, with Buddhism spreading throughout the region. During the 4th century CE, Patliputra regained prominence under the Gupta dynasty, especially during the reign of Chandragupta I (320-335). He revitalized Magadh by conquering the territory, setting up Patna as the capital and consolidating a kingdom in the eastern region of northern India. Chandragupta I revived some of the principles of king Ashoka's government. However, it was his grandson, Chandragupta II (376-415), who established a vast empire in the north and western Deccan. In the 5th century CE during the reign of Chandragupta II, the Chinese pilgrim Fa Hein visited Patliputra (Po-lien-fu) and recorded the flourishing state of Magadh, as well as the impressive architecture of the city, describing the walls, gates, palaces, and buildings as being constructed in a manner that could not have been accomplished by human hands (**Fig.** 1 and **Fig.** 2). The wooden outer wall that Megasthenes

previously mentioned was still standing in the early 5th century. Patliputra was also home to many stone buildings and a great palace erected by Chandragupta's grandson, Ashok, who had converted to Buddhism. Hiuen Tsang, who travelled through the silk route, visited Patliputra in 1637 CE and found it to be a deserted and crumbling land, as fire, flood, and internal dissension had all left their mark on the city, as predicted by the Buddha. Following the collapse of the Gupta Empire and continuous annexation by the Hunas, Patna experienced a period of uncertainty similar to the rest of India. The territory eventually came under the growing empire of Harshvardhana Samrat, who defeated the Hunsa and took control of the northwest region of India. However, during the 7th century CE, another Chinese pilgrim named Hiuen Tsang visited India and found Patliputra in ruins.

Medieval Period (13th Century to 17th Century)

In the 13th century, with the Turkish conquest of India and the establishment of the Delhi Sultanate, urbanization and cultural development began in Patna. The first Muslim invasion of Bihar occurred in the late 1190s under the rule of Bakhtiyar Khilji, which led to the expansion of Turkish rule in Bihar. From 1206 to 1526, Patna remained a secondary settlement that was subordinate to the town of Bihar. During the Mughal period, provincial administration reached its zenith. Patna re-emerged as a major centre of trade, but not as a capital city. One of its most remarkable periods was under the rule of Sher Shah Suri, who hailed from Sasaram and revived Patna in the mid-16th century. On his return from Bengal in 1541, Sher Shah arrived in Patna, and while standing on the bank of the river Ganga, he had a revelation that if a fort were built in that location, the water of the Ganges could not flow too far away from it, and Patna would become one of the great towns of the country. Sher Shah's words were put into action when he founded a fort in Patna, which enabled Patna to regain its identity as a hub of power and trade. However, the fort did not last, but the mosque built by him in 1545 survived, and it was built in Afghan architectural elegance with numerous tombs inside.

The earliest mosque in Patna dates back to 1489, built by one of the rulers of Bengal, Alauddin Hussani Shah. The locals call it Begu Hajjam's mosque in honour of a barber who repaired it in 1646. In 1574, the great Mughal emperor Akbar came to Patna to defeat Daud Khan, an Afghan chief. Akbar's secretary described Patna as a flourishing centre for paper, stone, and glass industries. He also mentioned the good quality of various strains of rice grown in Patna. In 1704, Patna was renamed Azimabad, after the grandson of Mughal emperor Aurangzeb, Azim, at the time when he was subedar of Patna (Boyk 2015). Other than the name, very little change

took place during that period. After the decline of the Mughal period, Patna was in the hands of the Nawabs of Bengal. At that time, the city was taken over by Jagirdars who claimed themselves as Nawabs. The Nawabs of Bengal imposed heavy taxes on people but allowed them to flourish commercially. During the 17th century, Patna became the hub of international trade. Much of the lost glory of Patna was revived during the medieval period, giving it a new identity as a medieval city in terms of function and structure under the Afghans and Mughals. The city almost emerged in the same area where it existed in ancient times.

British Period

Patna attracted the next generation of travellers, including Englishman Thomas Roe, who visited in the 17th century and spoke of the four rivers surrounding Patna, each of which served as a valuable waterway for trade. Ralph Fitch, a merchant, reached Patna in the 16th century via one of these riverine routes and observed a flourishing cotton and sugar trade, as well as the infamous opium business. Jean Baptiste Tavernier, a French traveller, visited in 1620 and described Patna as the largest town in Bengal and the most famous for trade, particularly for the exquisitely crafted coral and amber bracelets available in the city's market. By the 17th century, Patna had become a favourite port town for the Dutch, the British East India Company, and merchants from Central Asia, Armenia, and Portugal. In the 1620s, the British established a factory in Patna for the purpose of buying and storing cotton and silk, which soon became a bustling market for saltpetre (Hashmi, 2018). The French, Danes, Dutch, and Portuguese were all drawn to this attractive business, leading to the establishment of several European factories and godowns in Patna, which earned the reputation of being a lucrative location for merchants. In 1632, Peter Mundy declared Patna as the greatest mart in the eastern region. On October 6th, 1763, Nawab Mir Qasim was imprisoned and that led to killings of 45 members of the East India Company (Martin, 1838). Although they had been trading in Patna since 1620, when they established a factory for saltpetre, the British gained control of the city in 1765. After the Battle of Buxar, which took place 115 km west of Patna, the British East India Company was established in East India. Patna soon developed into a strategic centre for trade and regained its lost glory under British rule. Following the Delhi Darbar of 1911, the province of Awadh was divided, creating a separate province of Bihar, with Patna selected as its centre of power and capital city. No matter when, why, or for how long one visited, it was impossible to leave this city without a souvenir, be it a precious commodity from its market or an experience worth immortalizing in writing. After the partition of Bengal presidency

in 1912 (Ahmad, 1988), the city boundaries were extended westwards to include the administrative base and township of Bankipore, known as the New Capital Region. This era also saw the construction of two prominent landmarks, the Patna secretariate and the Patna High Court, designed by architect J.F. Munnings. Many buildings, reflecting either Indo-Saracenic influence or manifesting a Renaissance imprint, were completed by 1916-17. Pseudo-renaissance is expressed in the design of buildings like the General Post Office and the old secretariate. The British also built numerous educational institutions, including Patna College, Science College Patna, Bihar College of Engineering, and Prince Wales Medical College. Patna played a significant role in the Indian struggle for freedom, with notable contributions such as the Champaran Movement against Indigo plantation and the Quit India Movement of 1942.

Post-independence Period

Following India's independence, Patna's economic standing witnessed a sharp decline, particularly in the domain of trade and commerce. The region was predominantly ruled by Congress government from 1947 until the declaration of a state of emergency in 1975. The Bihar movement, led by students such as Jayaprakash Narayan, against the existing maladministration and corruption was initiated in 1974-75, and came to be known as the Sampoorna Kranti, or Total Revolution, and the JP movement. In the year 2000, Bihar faced a severe blow when Jharkhand, a state known for its abundant mineral deposits, was separated from Bihar. This led to a substantial loss in the revenue earned through mining and industrial activities. According to Bhattacharya (2000), while the state has been exploited and left destitute in the past, it could perhaps make up for the loss of mineral deposits by curbing the issue of rampant corruption within its governance structure. In effect, the Freight Equalisation Policy, which involved the transportation of mineral deposits to other states, has resulted in Bihar being underdeveloped. Despite a few challenges encountered during the post-independence, the economy of Patna remained relatively steady until the separation of Jharkhand from Bihar. The present scenario has led to an attempt at rejuvenation and the revitalisation of the region.

Growth

Throughout its history, Patna has experienced growth in various aspects despite its declining status. The earliest known map of the city dates back to 1776, a product of James Rennel for the British-controlled Bihar and Bengal province.

At the time, the city's settlement area was approximately 52 square kilometres. As of 1924, however, the administrative area had expanded by more than double, reaching a total of 142.46 square kilometres. Patna's population has grown more than tenfold since 1901. According to the Statistical Account of Bengal for Patna district in 1877, the city was situated between latitudes 24˚ 58' to 25˚ 42' north and longitudes 84˚ 44' to 86˚ 05' east. The district encompassed an area of 2101 square miles according to the Boundary Commission of 1875. The Census Report of 1872 indicated a population of 15,59,638 for the district (**Fig.** 2).

Spatial Growth

It is challenging task to track the absolute spatial growth of cities in developing nations due to a lack of adequate documentation. During the British period, Azimabad was the main town of Patna, as it was commonly called by the locals. The district of Patna was bounded by the Ganga river in the north, separating it from Tirhut and Saran; Shahabad district lay on the west, separated by the Son river; Monghyr (Munger) lay on the east, and Gaya lay on the south. The settlement and administrative area of Patna has been slowly but steadily expanding. According to toposheet data of Patna from 1924, the settlement covered an area of approximately 52 square kilometres. As per census records in 1961, the administrative area increased to 79.87 sq km (Table-1). The map of the province of Bihar and Bengal (**Fig.** 1) prepared by Major Rennel in 1776 indicates that Patna was an important riverine port city at that time (**Fig.** 3).

Due to this reason, the British colonizers gradually built their separate settlement to the west of the existing settlement. They strategically created military cantonment to protect their interests in trade and power. Britishers had always exploited the resources of Patna without considering the welfare of the city. Buchanan (1812), O'Malley (1907), and Forster (1924) had been critical of the city and its view from a distance was often termed as "mean," "disgusting," "disappointing," and other such derogatory terms. The series of maps for the years 1885, 1924, 1976, and 2009 show the spatial extent of Patna. The map of Patna from 1885 (**Fig.** 1) was prepared by Else Reclus and published in Nations and Nationalities of the World. Although Major Rennel's map does not align with the current system of latitudes and longitudes in modern map-making, it depicts the schematic settlements of Patna at that time. The native settlements mostly confined to the middle of eastern part of the city, between the southern bank of the Ganga in the north and the railway track in the south. Bankipur evolved as the settlement for Britishers, while Danapur cantonment can be seen in the north-western part of the city map.

He Survey of India has performed an outstanding task in mapping the Indian subcontinent's entire terrain in great detail since the British period. These topographical sheets have been invaluable for both military and civilian development purposes. In archives, three distinct toposheets of Patna have been discovered for the years 1924, 1976, and 2009. In 1924, the settlement area was primarily situated along the river Ganga (**Fig.** 2), and the railway line acted as an unofficial southern boundary of the city. Vegetation and water bodies were visibly present in the north-western and central regions, respectively. By 1976, the city had gradually expanded towards the south and south-west (**Fig.** 2), leading to the depletion of vegetation and water bodies during the mentioned period. The nalas of the central zone were severely impacted by the construction of government buildings in that area. The city rapidly expanded towards the west and north-west after 2001, as reflected in the settlement map of 2009 (**Fig.** 2). By this time, the spread of settlements had surpassed the official city limits, providing ample scope for urban sprawl.

Population Growth

Urban studies rely heavily on analysing population growth as a key determinant of the area's land use, infrastructure, and urban amenities. Patna has been a significant urban centre since the British era, as evident from **table-**1. In 1901, the population of the city was 1.8 lakh, which increased to over 2 million in the 2011 census and is expected to exceed 4 million by 2051. However, the rate of population growth has not been constant over time. The 1881 population enumeration recorded a population of 1,70,654, indicating a 7.4% increase of 1,58,900 in nine years. The increase was due to both natural growth and under-enumeration in 1872. In 1901, the population of Patna was 1,80,025. The city experienced stagnant or negative growth during 1911-1921 due to the Bengal famine. The census of 1911 was the last within the state of Bengal, while the 1921 census was the first as the capital city of Bihar and Odisha. Around 12.5 lakh people migrated from Bihar to Bengal in 1911, while around 1.65 lakh people immigrated (**Table-**1).

Post-1921, Patna's population growth fluctuated between 20-40%, indicating steady growth. However, it became a bumpy ride with rapid population growth from 1971-2001. **Table-**1 highlights that the Patna metropolitan city experienced tremendous growth rates in population during 1971-81 and 1991-2001 due to official expansion of the city boundary in adjoining areas. During 1971-81, the PRDA was formed, and three colonies were founded. The outgrowths and adjoining areas of Phulwarisharif, Digha-mainpura, and Danapur cantonment were included in this

Patna in 1776: (a) Clipping from Provinces of Bengal, Bihar and Co. by Major Rennel



Fig. 1

Patna in 1885: (b) Extracted from Universal Geography, Vol-VIII by Elisee

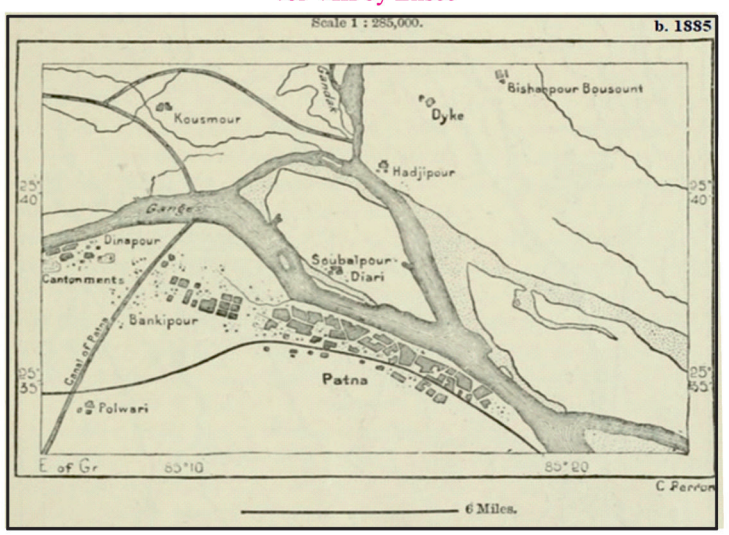


Fig. 2

Table-1: Population Growth in Patna (1901-2011)

Census Year	Persons	Growth Rate (%)	Area (sq km)	Population density (Person/sq km)
1901	1,80,025		-	
1911	1,76,688	-1.85	-	
1921	1,58,048	-10.55	-	
1931	2,01,540	27.52	-	
1941	2,45,267	21.70	-	
1951	3,41,911	39.40	-	
1961	4,35,360	27.33	79.87	5,451
1971	5,75,476	32.18	97.01	5,932
1981	9,53,064	65.61	112.24	8,491
1991	11,40,100	19.62	132.27	8,619
2001	16,97,976	48.93	135.19	12,560
2011	20,49,156	20.68	142.46	14,384

Source: Based on A-4 Table, Census of India, 2011

agglomeration. During 1981-91, new colonies in Patna gradually expanded in open space within the city limits, which were included in previous official boundary expansion. Prior to the 2001 census, the city boundary was further extended. This time, the expansion was from Didarganj to Sherpur and Bailey road to Saguna more and Danapur junction. Apartment culture was on a boom during 1991-2001. Post-2001, the city boundary has remained unchanged, but the status of towns/outgrowths has been modified, and administrative units have been freshly demarcated during the census of 2011. The adoption of the concept of urban agglomeration dates back to the 1971 census, when it replaced the "town group" category. In the interest of developing plans and changing policies, the Government of Bihar has designated the Patna urban agglomeration as the Patna metropolitan city. Despite this, it was not until 1991, when the population exceeded 1.1 million, that Patna attained the status of a metropolitan area. In the 2001 census, Badalpura was identified as an outgrowth, while Patliputra housing colony and Saidpura were classified as census towns in the 2011 census. Previously, both of these towns had been considered as outgrowths. The expected population of Patna in 2051 is estimated to be around 4.3 million. However, due to its relative power status identity and strategic location,

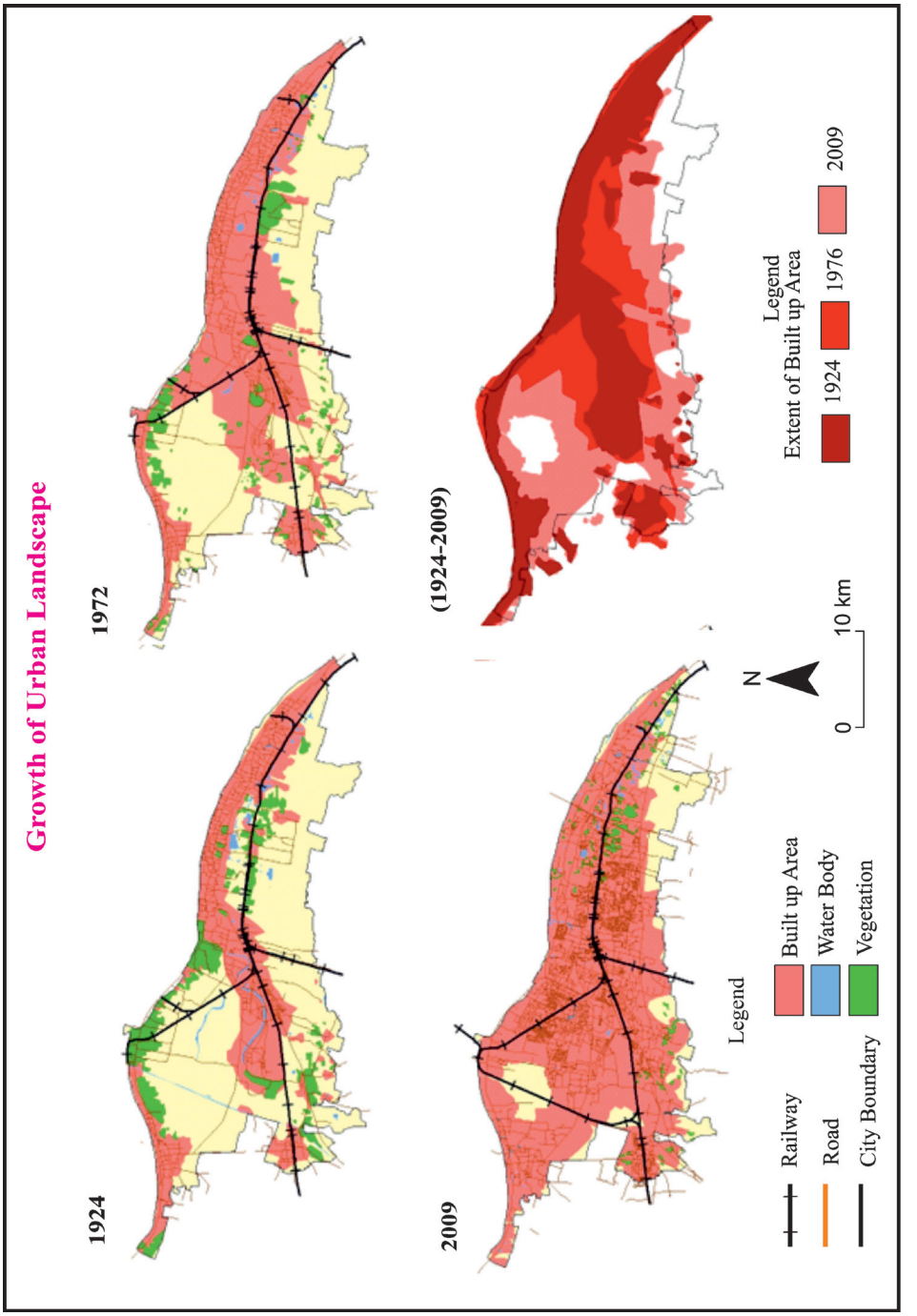

Growth of Urban Landscape
1924
1972
2009
(1924-2009)
Legend
Built up Area
Water Body
Vegetation
Railway
Road
City Boundary
N
0
10 km
Legend
Extent of Built up Area
1924
1976
2009

Fig. 2

the city may even exceed 5 million in the near future, largely due to the rapid influx of migrants. Survey results indicate that a significant number of Patna residents have migrated to the city over the past three decades.

Conclusion

The history and evolution of Patna, the capital of Bihar, is a captivating narrative that spans millennia, reflecting the city's deep-rooted cultural, historical, and geographical significance. Its origins are steeped in legend, with various names and tales that narrate its evolution from a small village named after the patli flower to the flourishing capital of the Mauryan Empire. This historical tapestry weaves folklore, divine intervention, and urban genesis into the fabric of Patna's identity. Megasthenes described the city as being located on the southern bank of the Ganges, at the confluence of the Son river which once joined the Ganges below present-day Patna. Memories of this junction still exist amongst the villagers to the southwest of Patna, where an old channel named the Mara Son flows. As time progressed, the city underwent significant changes, from the Mauryan period to the Shershah Suri era, ultimately becoming an essential strategic and trade centre for the British. The modern Patna has expanded exponentially since British times. Post-independence, the city faced economic challenges, and the separation of Jharkhand in 2000 led to a decline in revenue from mining and industrial activities. With the exponential growth in population and physical expansion of the city, the local administration is tasked with the challenge of providing basic urban amenities and maintaining the city's infrastructure. As the city continues to receive migrants from other areas, there is a shift in the land-use and land-cover patterns, resulting in urban sprawl beyond the city limits.

Between 1924 and 2022, the Patna metropolis has undergone a nearly threefold expansion, specifically from 51.46 to 142 square kilometres. Correspondingly, the demographic landscape has witnessed significant growth, with the city's population escalating substantially from 1.8 lakh in 1901 to 20.5 lakh in 2011. However, notwithstanding these pronounced spatial and demographic advancements, the city exhibits a deficiency in terms of fundamental industrialization. As Patna looks towards the future, it is poised for further growth and development, with its strategic location and historical significance continuing to shape its trajectory. The city's journey from ancient legends to a modern metropolis underscores its resilience, adaptability, and enduring importance in the cultural and historical landscape of India.

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BIOLOGIC EFFECTS OF INGESTION OF NITRATE IN DRINKING WATER AN OVERVIEW OF INDIA

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Abstract

Nitrate pollution in surface or subterranean water is a pervasive global issue, particularly prevalent in agrarian nations. Undoubtedly, regions most susceptible to climatic shifts face heightened vulnerability owing to their geographical disposition. Unfavorable topographic features and uncertainties in hydro-meteorological conditions amplify the extent of contamination. Given that nitrate pollution in our potable water sources is pandemic and the costs linked to purifying these water sources are exorbitant, exposure to elevated nitrate levels significantly contributes to deleterious health consequences that necessitate attention. This manuscript delves into the biological ramifications of surplus nitrate in our drinking water and the diverse array of human health concerns in India and various pivotal parts of the globe. In a bid to forestall methemoglobinemia, an acute toxic response to nitrite exposure impeding oxygen transport via the bloodstream, the US EPA (Environmental Protection Agency) has designated the maximum admissible nitrate level in drinking water at 10 mg nitrate-N/L. However, it's a common occurrence for surface and subterranean water in agricultural regions to surpass this standard periodically and/or over extended durations. While a definitive correlation between nitrate consumption and cancer remains elusive, some indications suggest a potential linkage. The magnitude of health risks posed by nitrate contamination in drinking water remains a subject of debate. Groundwater stands as a vital water source for both domestic and agricultural usage on a global scale. It serves as the primary domestic water source for 50% of the world's populace and nearly 90% of rural inhabitants. A substantial 75-80% of water used for agricultural irrigation originates from groundwater. Safeguarding groundwater against nitrate pollution presents a multifaceted managerial challenge necessitating effective policy alignment at federal, state, and local echelons, particularly due to the inherent complexity of groundwater purification. Moreover, these challenges are compounded by varying levels of awareness, socio-economic development, low literacy rates, high poverty, and the inclusion of cultural practices and rituals, all of which exacerbate the intricacies of the endeavor.

Introduction

Ensuring safe drinking water remains crucial for public health, a fundamental human entitlement. Regrettably, this right falls short of people's expectations. Water, an essential element, faces an impending challenge as research indicates an upward trajectory in nitrate levels. This concern extends beyond rural communities, impacting major urban centers reliant on bore water. The solubility and biodegradability of nitrates contribute significantly to their increased presence in water bodies. The consequential decline in both quality and quantity of water bodies persists due to the heavy reliance on synthetic fertilizers, sewage, industrial waste, and livestock manure. Guidelines from the US EPA's nutrient data policy reveal the distinct markers of nitrate presence. While nitrates occur naturally at very low levels (<1mg/L NO3-N), levels exceeding 1mg/L NO3-N are indicative of human activities. Concentrations surpassing 3mg/L NO3-N generally signal groundwater contamination. In India, the Bureau of Indian Standard (BIS) stipulates the Maximum Contaminant Level (MCL) for nitrate in public drinking water supplies at 45 mg/L as nitrate (NO3-), nearly akin to the WHO guideline of 50 mg/L as NO3- or 11.3 mg/L NO3-N (derived by multiplying NO3 mg/L by 0.2258).

Interestingly, this MCL, initially set in 1962 by the US EPA to prevent infant Methemoglobinemia, lacks considerations for other potential health impacts. A crucial issue with the current MCL for nitrate in drinking water is its obsolescence, particularly its lack of association with colorectal cancer, thyroid ailments, or neural tube defects. Consequently, a more lenient limit of less than 10mg/L NO3-N was established as a generalized threshold for nitrate contamination, offering a lax aspiration level within this range. This distinction between actual safety and mere cleanliness holds immense significance. It delineates a fine line between life and death, between improved health and the burden of costly medical bills for young families, and between mere survival and flourishing for entire communities. Nitrate, prevalent in various foods, peaks in green leafy vegetables like spinach and celery, as well as root vegetables such as beetroot. Daily intakes from food range from 30-130 mg/day as NO3- (7–29 mg/day NO3-N) (ICAR, 2020). Once consumed, most of the ingested nitrate travels through the body and is absorbed into the bloodstream via the small intestine. Approximately 25% of the nitrate in the blood is transformed into nitrite through a reduction process in saliva. While most nitrite is absorbed into the blood and converted into beneficial compounds, a fraction may form potentially harmful N-nitroso compounds.

Study Region

Indeed, nitrate pollution stands as one of the oldest and most financially burden some environmental issues, both regionally (India) and globally. Several contributing factors underline this reality: A notable surge in population, from 5.3 billion to 7.7 billion between 1990 and 2020, with projections foreseeing a rise to 9.7 billion by 2050 (UN, 2020). The onset of increased industrial activities since the mid-19th century has significantly amplified pollution and deterioration of water resources (Bond et al., 2018). Climate change exacerbates water stress globally, particularly in arid regions, through diminished rainfall, leading to severe droughts and erratic rainfall patterns during the rainy seasons (Lorite et al., 2018; WHO, 2012). In recent years, ensuring access to clean drinking water for communities has become increasingly challenging due to the emergence of new water quality issues. Groundwater sources, vital for global agri-businesses, industries, and drinking water needs, face mounting pressure amid growing scarcity concerns and fears of microbial contamination. Nitrate contamination, prevalent in agricultural and densely populated regions, notably affects the Indo-Gangetic Plain (IGP), recognized as one of the world's largest alluvial aquifer systems (MacDonald et al., 2016). Spanning approximately 52 million hectares, it supports a population of 500 million across Delhi, Haryana, Punjab, Bihar, Uttar Pradesh, and West Bengal according to the 2011 Census.

The northwestern segment, marked by intensive agricultural practices and widespread nitrogen-based fertilizer use, exhibits significant groundwater contamination hotspots. India grapples with 20 identified nitrate hotspot areas, each displaying varying average nitrate levels. Some regions indicate averages below 50 ppm, while others range between 59 and 215 mg/L, showcasing considerable data variability (Devaraj et al., 2020; Pant et al., 2020). Notably, values surpassing four times the WHO-recommended standard are reported in certain areas, such as Birbum in West Bengal (44 & 45), Solapur in Maharashtra (66 & 71), and Bareilly in Uttar Pradesh (31 & 51), with reported average values spanning from 7 to 47 mg/L. Even within these regions, over a quarter of samples exhibit nitrate concentrations exceeding 50 mg/L (Hossain & Patra, 2020; Mazhar & Ahmad, 2020; Mukate et al., 2019). The causes of pollution in the country are attributed to various factors, including inadequate maintenance of septic tanks, boreholes, sanitation, and fertilizer use, as highlighted by several authors (Barbieri et al., 2019; Devaraj et al., 2020; Roy et al., 2020).

Objectives

(1) This study aims to conduct a health risk assessment of nitrate in distributed drinking water in India and across significant global regions.

(2) Assessing what needs to be done to ensure an adequate drinking water supply throughout the country & what can be done in managing land & water to limit nitrate pollution.

Database and Methodology

The interest in studying groundwater health, particularly concerning nitrates, has seen a significant surge since the early 1980s. From an average of 100 articles per year globally in the 1970s and 1980s, the scientific community published 2742 articles in 2020 on this subject. In India, the Integrated Management Information System (IMIS) was established in 2009 alongside the National Rural Drinking Water Programme (NRDWP), creating a web-based platform for annual online monitoring of water supply projects and rural coverage. Sarkar et al. (2021) investigated the spatial variation of nitrate content in Indian groundwater using data from the NRDWP database. Various studies nationwide have sampled groundwater from wells, boreholes, and springs primarily used for irrigation or domestic purposes (Devaraj et al., 2020; Hossain and Patra, 2020; Mazhar and Ahmad, 2020; Mukate et al., 2019). However, several nitrate-contaminated areas, particularly within the Indo-Gangetic Plain, were not adequately covered in individual studies, posing a significant limitation. Larger-scale or national studies are necessary to comprehend the extent, spatial distribution, sources, and health impacts of groundwater nitrate contamination, mandating efficient local governance and management. Yet, a comprehensive detailed interpretation required for this remains lacking. Despite numerous articles published until December 2021 detailing groundwater quality parameters, a comprehensive understanding of nitrate pollution and its health impacts at the local level remains elusive. Conducting a comprehensive research and assessment of the health effects of groundwater nitrate contamination at the local level is a novel undertaking. This review delves into nitrate sources in groundwater, its health implications, and focuses on human health risk assessment. Such a study is pivotal in understanding the challenges India faces in achieving Sustainable Development Goals (SDGs) 6.3 outlined by the United Nations in 2015.

Result and Discussion

Methemoglobinemia

Methemoglobinemia, linked to elevated nitrate levels in drinking water used for infant formula preparation, was initially documented in 1945 (Comly H.H. et al., 1945). When ingested, bacteria in the mouth and the less acidic infant stomach convert nitrate to nitrite. Nitrite, in turn, binds with hemoglobin, forming methemoglobin, which disrupts the blood's capacity to carry oxygen. Methemoglobinemia is a severe condition, posing a life-threatening risk when methemoglobin levels exceed approximately >10 mg/L NO3-N. Risk factors for infant methemoglobinemia encompass formula prepared with water containing high nitrate levels, along with foods, medications, and enteric infections that exhibit high nitrate levels. non-existent in these areas.

Adverse reproductive outcomes: (spontaneous abortions)

There have been several studies examining spontaneous abortions, linking high maternal methemoglobin levels caused by elevated nitrate ingestion to miscarriages in laboratory animals and livestock. An intriguing 1996 Center for Disease Control (CDC) of Morbidity and Mortality Weekly Report (MMWR) report documented a cluster of spontaneous abortions among women using private wells in rural Indiana, where nitrate levels exceeded twice the Maximum Contaminant Level (MCL) of 20 mg/L NO3-N. When these women switched to low-nitrate water sources, they experienced healthy live births. While this wasn't a formal study, the evidence was compelling, suggesting the involvement of high-nitrate water in the miscarriages. Interestingly, a separate study in Massachusetts found no association between spontaneous abortion and lower nitrate levels below 5.5 mg/L NO3-N, indicating divergent findings in different settings Indeed, there's been documentation of a heightened incidence of infant methemoglobinemia in Eastern Europe, as noted previously (Ayebo A. et al., 1997). A 2002 WHO report on water and health highlighted significant cases in the region: 41 cases annually in Hungary, 2913 cases in Romania spanning 1985–1996, and 46 cases in Albania in 1996. Generally, nitrate levels surpassing >10 mg/L NO3-N were often linked to increased methemoglobin levels, though clinical methemoglobinemia wasn't consistently present (Fig-1). In India, methemoglobinemia is relatively uncommon, possibly owing to limited awareness or a scarcity of epidemiological studies on the disease. It's intriguing that in a country where agriculture is a predominant livelihood and where sanitation remains inadequate in numerous regions, reported instances of methemoglobinemia are rare (**Fig.** 1).

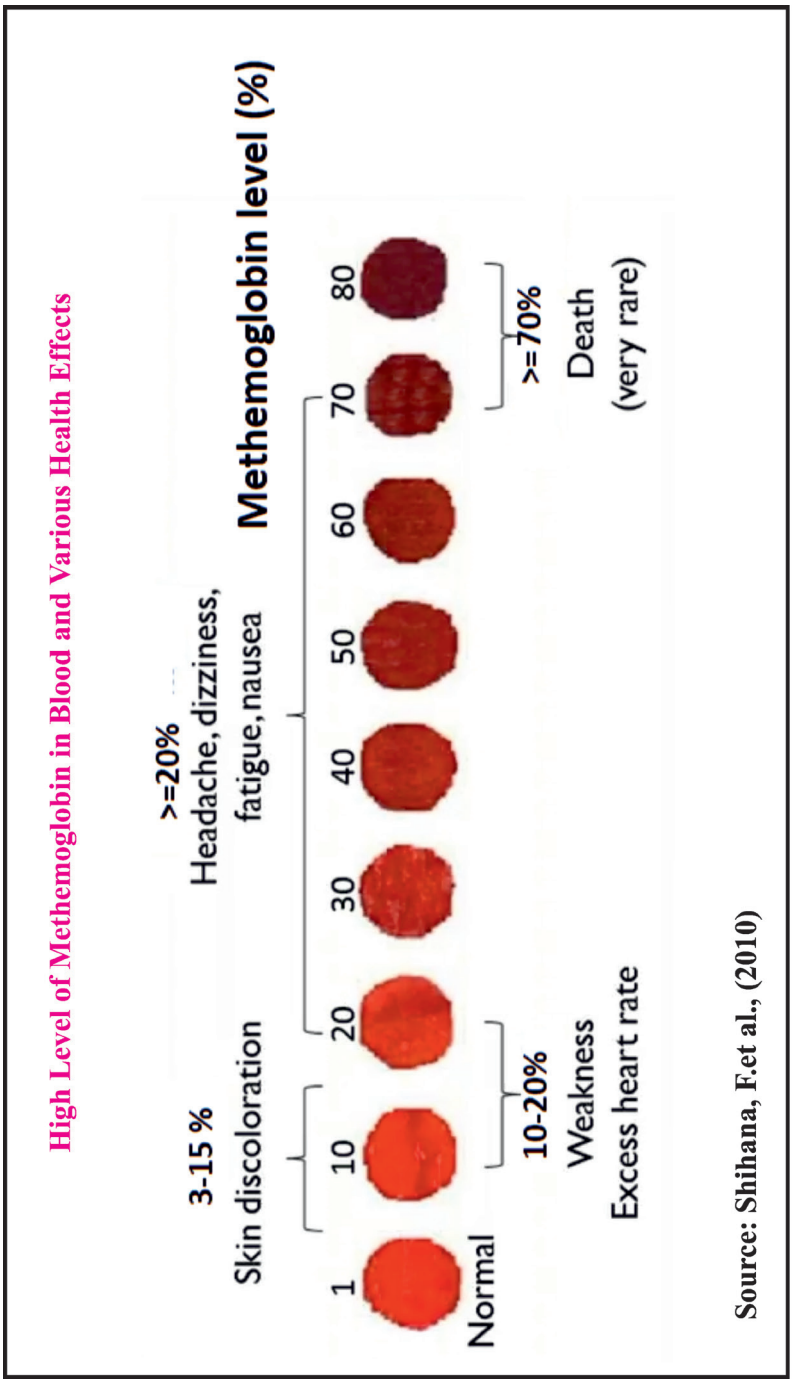

High Level of Methemoglobin in Blood and Various Health Effects
Methemoglobin level (%)
1
10
20
30
40
50
60
70
80
Normal
3-15 %
Skin discoloration
10-20%
Weakness
Excess heart rate
>=20%
Headache, dizziness,
fatigue, nausea
>=70%
Death
(very rare)
Source: Shihana, F.et al., (2010)

Fig. 1

Birth Defects and Cancers

According to a 1995 IARC report, over 300 nitroso compounds were tested in animals, with about 90% found to be carcinogenic. These compounds showed carcinogenicity across various animal species, including non-human primates, suggesting a likelihood of impact on humans. These nitroso compounds have the potential to induce tumors in multiple organs such as the lungs, digestive tract, urinary tract, and some reproductive organs. Exposure during pregnancy can lead to congenital malformations, particularly affecting the Central Nervous System, especially during the critical phase of organ development in the first trimester. Shifting focus to cancer, in 2006, an IARC working group assessed the evidence for the carcinogenicity of ingested nitrate and nitrite. Their conclusion stated that under conditions conducive to the formation of N-nitroso compounds or endogenous nitrosation, nitrate and nitrite were deemed probably carcinogenic to humans. The evaluation drew from compelling evidence obtained through animal studies, where carcinogenicity was consistently observed across all species tested in laboratory settings. Additionally, human mechanistic studies provided further support. These studies indicated that exposure to nitrosamine compounds increased with nitrate ingestion, either through drinking water or controlled intake experiments. It was demonstrated that nitrate ingestion led to heightened exposure to nitroso compounds, measured by their excretion in urine. This correlation between nitrate intake and increased presence of these compounds provided robust evidence supporting the evaluation's conclusions.

Case-control or Cohort Studies of Drinking Water Nitrate and Cancer Studies

(1) Colorectal:5 studies (4 Positives)
(2) Brain(Children/young adults):3 studies (3 Positives)
(3) Bladder:4 studies (2 Positives)
(4) Kidney: 2 studies (2 Positives)
(5) Non–Hodgkinlymphoma:3 studies (1 Positives)
(6) Pancreas: 2 studies (0 Positives)
(7) Brain (adults): 2 studies (0 Positives)

In terms of epidemiological studies, investigations into dietary nitrate consumption didn't yield any association with an increased risk of cancer. However, when it comes to drinking water, the evidence was deemed inadequate due to the limited number of studies available.

Presently, the strongest evidence from epidemiological research suggests a positive association between nitrate exposure and colorectal cancer, with four out of five studies demonstrating such a link. Similarly, concerning childhood brain tumors (including young adults in one study), all three available studies indicate a positive association, with two of these studies conducted or published within the past year. However, for other cancer sites, there's notably less evidence available.

Nitrate in Drinking Water and Hypothyroidism:

In terms of biological plausibility, the concern doesn't solely revolve around nitroso compounds, but also involves nitrate's potential to impede iodine uptake by the thyroid. Three studies showed positive associations between higher water nitrate ingestion and related health issues: A study conducted on school-age children in Slovakia revealed an increased prevalence of subclinical hypothyroidism in areas with high water nitrate levels (ranging from 51 to 274 mg/L NO3-) compared to areas with nitrate levels at or below 50 mg/L (11 mg/L NO3-N) in water supplies (Tajtakova M. et al., 2006). A cohort study of post-menopausal women in Iowa found that higher nitrate intake, both through diet and drinking water from Public Water Supplies, was linked to an increased prevalence of hypothyroidism (Ward M.H. et al., 2010). An Amish cohort study in Pennsylvania discovered that among women, but not men, higher water nitrate levels (>6 mg/L NO3-N) were associated with elevated thyroid stimulating hormone (TSH) levels and a greater prevalence of subclinical hypothyroidism (Aschebrook-Kilfoy B. et al., 2012).

The primary human-caused sources of nitrate contamination fall into five categories: septic tanks, sewage, agriculture, landfills, and industrial activities. Often, nitrate pollution occurs alongside contamination by fluorine, sulphates, potash, phosphates, and heavy metals like zinc, cadmium, or arsenic. This pollution is frequently concentrated in areas reliant on agriculture for income or where sanitation infrastructure is lacking. Beyond these sources, various catastrophic events in recent decades have altered nitrate levels in groundwater in affected regions. For instance: The groundwater near the Union Carbide factory in Bhopal has faced excessive nitrate, chloride, and heavy metal contamination. ("Water Contamination Crisis - Bhopal's Second Disaster - The Bhopal medical appeal", 2021) The Beirut explosion in 2020, caused by inadequate storage of 2750 tons of ammonium nitrate, released a substantial amount of pollutants into the environment. Following the Chernobyl accident, two regions in Belarus reported similar radiation levels, yet the incidence of pediatric thyroid cancer differed significantly due to variations in nitrate contamination in drinking water, measuring 40 vs. 185 ppm (Drozd et al., 2018).

This escalating pollution trend requires immediate and drastic solutions to prevent further degradation of natural water bodies, particularly in developing countries like India, where water shortages exacerbate the issue. Urgent actions are essential to avert the complete deterioration of these vital water resources.

Conclusion

This review examines the water quality of various groundwater bodies throughout the country in terms of nitrate concentrations, discusses various health issues for both this compound and other important pollutants. On the basis of which some general conclusions can be drawn.(1) The occurrence of nitrates in groundwater continues to increase and urgent measures are therefore required to prevent nitrates from breaking down into water particles. (2) Levels exceeding the WHO standard (50 ppm) exist in various parts throughout the country. (3) Nitrate pollution from agriculture, especially the use of fertilizers and pesticides, is common across the nation. (4) In India, large fluctuations in NO3- concentration are observed due to the strong influence of the rainy season and insufficient treatment of septic tanks. (5) In addition to pollution from fertilizers, wastewater discharged without proper treatment & industrial activities contribute significantly to the occurrence of nitrates in groundwater. (6) Apart from the various reasons summarized above, environmental pollution is mainly due to poor health conditions in many parts of India (e.g. the presence of untreated septic tanks). Currently, there are many surface water treatment facilities, but the number of groundwater treatment facilities is still very limited and further research is needed into different treatments for nitrate removal. Recent studies on cancer and birth defects have started identifying population subsets prone to internal nitrosation, but direct methods for identifying these individuals are necessary. New approaches in epidemiological research, such as detecting nitrate-reducing bacteria in the oral micro biome and studying genetic variations in nitroso compound metabolism, hold promise in identifying high-risk individuals. However, a lack of comprehensive studies on individual health impacts hampers definitive conclusions about the risks of consuming nitrates through drinking water. Further investigation is crucial, especially in refining exposure assessment for users of public water systems, understanding exposure levels among those using private wells, quantifying nitrate-reducing bacteria, and assessing various factors influencing nitrosation. Focusing on conditions like colorectal cancer, thyroid disease, and central nervous system birth disorders, consistently associated with nitrate ingestion from water, will significantly contribute to clarifying these concerns.

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A GEOGRAPHICAL ANALYSIS OF CROP CONCENTRATION IN PRAYAGRAJ DISTRICT

Neha Yadav and Dr. Sangeeta Chauhan

Abstract

This study focuses on analyzing crop concentration in Prayagraj District, encompassing all 20 blocks. Secondary data from the year 2020-21 was utilized for this research. Crop concentration is crucial in understanding the suitability of specific areas for particular crops, particularly considering changes in agricultural land use and shifts in crop proportions. Crop concentration has been determined using the Bhatia's location quotient technique. This technique identifies changes in agricultural land use by examining shifts in the proportion of land allocated to various crops. The study calculated the amount of area involved in these changes, highlighting the crops with the most significant increases and decreases. The data obtained is used to create thematic maps, providing a spatial representation of crop concentration in the district. Crop concentration is categorized into four sections: High, Medium High, Medium and low. These categories help depict the intensity of land utilization and identify areas suitable for specific crops. One significant determinant of cropping patterns is irrigation, which generally has a positive influence on the intensity of cropping. The study observed substantial variations in land use and cropping patterns across the study area. Wheat and Rice emerged as the dominant crop throughout the district, in terms of total agricultural production. This research sheds light on the changing cropping patterns and land utilization in Prayagraj District, providing valuable insights into the suitability of different areas for various crops. The findings can inform agricultural planning and land-use policies in the region, helping optimize crop production and land utilization.

Introduction

Crop concentration, as defined by TS Chauhan in 1987, pertains to the spatial distribution of individual crops within a specific area. It serves as an indicator, revealing the variability in crop density within a given region at a particular moment in time.

The delineation of crop concentration assumes paramount importance in the realm of agricultural planning and development. The cropping pattern observed in any region is intricately woven with a tapestry of influences, including geo-climatic, socio-economic, historical, and political factors, as noted by M. Hussain in 1996. Moreover, technological factors have emerged as influential forces shaping these patterns. Terrain, topography, slope, soil composition, and the presence of irrigation facilities all contribute to the diversity of cropping patterns. The use of pesticides, fertilizers, and mechanization further compounds these complexities. Understanding the myriad factors that influence cropping patterns, from natural elements to human interventions, is fundamental for effective agricultural planning and development. The various geographers applied location quotient methods to work out the degree of Crop Concentration in a specific region. The geographers pioneer work of Chisholm (1962), Bhatia (1965), Jasbir Singh (1976) are the contributors to make the agricultural region with the help of quotient method. In this research work, Bhatia's method has been adopted to measure the index of Crop Concentration in Prayagraj District.

Study Region

Latitudinal and longitudinal extent of Prayagraj District is 24°47' N to 25°45'N and 81°31'E to 82°21'E in the south of Uttar Pradesh State at an elevation of 98 meter (322 Ft) and is situated at the confluence of Ganga and Yamuna. To its south and southeast is the Baghelkhand region, to its east is middle Ganges valley of North India, to its southwest is the Bundelkhand region, to its north and northeast is the Awadh region and to its west along with Kaushambi it forms the part of doab i.e. the lower doab region. Prayagraj has a humid subtropical climate. It experiences three seasons in a year. The summer lasts from April to June, monsoon begins in in early July and lasts till September, and the winter season lasts from December to February. The Ganga and Yamuna are the main rivers of the district. The plain area of the district is situated in between Ganga and Yamuna so these rivers play a very pivotal role in the agriculture of the district. The main staple crop of Prayagraj is wheat and rice. According to 2011 census, population of the study area is 5,954,391 of which male and female were 3,13,807 and 2,822,584 respectively. Population growth rate was 20.63% compared to 2001 census. The headquarter of the district is Allahabad City. The district is divided into blocks and tehsils. As of 2011 census there are 20 blocks in 8 tehsils. The total area of the district is 5,482 sq. km. The number of villages is 3003 according to Prayagraj statistical bulletin.

Objectives

(1) To analyze the crop concentration and its variation in Prayagraj District.

(2) To identify the areas of crop concentration in the basis of Bhatia's method.

Database and Methodology

The research work is based on the secondary data obtained from UP statistical Bulletin, Prayagraj (2020-21). Various thematic maps related to cropping patterns are prepared with the help of GIS. In order to determine block wise crop concentration Bhatia's method has been used.

Crop Concentration Index: = (a/b)/(A/B)

Whereas:

a= area of crop 'a' in the component areal unit

b= area of all the crops in the component areal unit

A= area of crop 'a' in the entire region

B= area of all crops in the entire region

Here, the higher index values represent a high level of crop concentration and low values show the low concentration of crop

Crop Concentration Pattern

Rice: It is a staple crop that serves as a primary food source for more than half of the world's population. Paddy is the second most important food grain in Prayagraj district it is cultivated in the kharif season. Moderate temperature and high rainfall is required for its cultivation. Rice cultivation supports the livelihoods of millions of farmers worldwide, it is a source of income and employment for rural communities. Rice is a major agricultural commodity in international trade, contributing significantly to the economies of exporting countries. In 2020- 21, total area under paddy cultivation was 155655 hectares. Paddy is cultivated in all the blocks of Prayagraj district. The blocks having medium high concentration of paddy are Jasra, Shankargarh, Meja, Manda, Holagarh, Mauaima, Soraon, Phulpur Pratappur and Dhanupur. Rest of the blocks have medium concentration of rice. Medium high concentration is in the northern and southern regions of the study area except Koraon and medium concentration is in the centre of the district.

Wheat: Wheat is the most important crop in Prayagraj. It is a Rabi crop it requires cool temperature and moderate rainfall, wheat is harvested in the summer

Table-1: Crop Concentration Index of Rabi Crops in Prayagraj District

Blocks	Crop Concentration Index 2020-21									
	Wheat	Barley	Red Lenti l	Split Chickpe as	Split Peas	Mustard	Flaxseed	Potato	Vegetables	Fodder
Kaudihar	0.91	1.11	0	1.2	0.96	2.52	0	2.03	1.60	3.45
Holagarh	0.86	0.25	0	0.07	1.03	0.14	0	3.92	2.23	1.25
Mauaima	0.83	0.19	0	0.11	1.03	0.48	0	4.02	2.50	1.24
Soraon	0.78	0.84	0	0.25	0.90	0.59	0	4.41	2.87	0.90
Baharia	0.98	0.50	0	0.08	0.96	0.33	0	1.75	1.91	1.26
Phulpur	1.06	0.34	0	0.07	1.15	0.14	0	0.85	1.38	0.80
Bahadurpur	0.89	2.76	0	2.77	1.37	0.56	0	0.69	2.13	0.87
Pratappur	1.03	0.84	0	0.19	1.53	0.66	0	0.76	1.69	2.10
Saidabad	0.98	1.28	0	0.93	1.24	0.30	0	1.23	1.53	0.98
Dhanupur	1.00	0.95	0	0.27	2.45	0.42	0	0.90	1.84	0.65
Handia	1.01	1.11	0	0.83	1.16	0.46	0	0.39	1.95	1.38
Jasra	1.16	0	0	0.49	0	0.62	0	0.05	0.11	0.10
Shankargah	1.00	0.61	5.07	1.89	0	0.38	1.46	0	0.09	0
Chaka	0.95	3.49	0.67	0.89	1.72	1.87	1.12	0.92	1.51	1.55
Karchhana	0.93	2.93	1.18	3.03	1.21	5.04	1.04	0.70	0.57	0.62
Kaundhiyara	1.07	1.46	0.17	1.06	1.48	0.54	2.69	0.50	0.17	0.69
Uruwa	1.04	2.44	0	1.63	0.95	1.12	0.77	0.60	0.30	0.84
Meja	1.10	0.66	2.01	0.58	1.05	0.63	0.71	0.10	0.05	0.12
Koraon	1.09	0.55	1.48	1.18	0.53	1.55	2.44	0.04	0.04	1.11
Manda	0.87	2.02	6.85	2.88	1.12	0.51	6.70	0.28	0.11	0

Source: Calculated and compiled by Authors.

when the grains have fully developed and turned golden brown, modern machinery such as combine harvesters is used for efficient harvesting. Wheat is a primary source of carbohydrates for a significant portion of the world's population. It is a staple food in many countries and is used to make a wide variety of products, including bread, pasta etc (**Table-**1). Wheat is a fundamental component of the world's food

supply. Reliable wheat harvests help stabilize food prices and ensure a consistent food supply enhancing global food security, therefore good concentration of wheat is very crucial for famer and other people. The total area under wheat cultivation in 2020-21 was 249902 hectares. Blocks having medium high concentration are Phulpur, Pratappur, Handia, Jasra, kaundhiyara, Meja and rest of the blocks have medium concentration. Medium high concentration is in the south and north east in Prayagraj District and medium concentration is in the northwest of the study area (Fig-1).

Barley: Barley holds significant importance due to its various uses and nutritional benefits, it is rich in dietary fiber, vitamins and minerals and has low glycemic index. Farmers often cultivate barley for both human consumption and livestock feed, enhancing agricultural productivity. In Prayagraj barley is grown in winter season. In Prayagraj total area under Barley is 2062 hectares (2020-21). In the district blocks having high concentration are Bahadurpur, Chaka Karchhana, Uruwa and Manda the block having medium high concentration are Kaudihar, Saidabad, Handia and blocks having medium concentration are Soraon, Pratappur, Dhanupur, Shankargarh, Meja and Koraon. Rest of the blocks have low concentration.

Vegetables: The vegetables grown in Rabi season are tomato, potato, onion, cauliflower spinach, radish green peas etc. The blocks having high concentration of these vegetables are Holagarh, Mauaima, Kaudihar, Baharia, Soraon, Pratappur, Saidabad, Dhanupur, Handia, Chaka and the block having medium high concentration of Rabi vegetables is Bahadurpur. Rest of the blocks have low concentration. The vegetables grown in Kharif season are bitter gourd, bottle gourd, brinjal, green beans, sponge gourd etc. Blocks having high concentration are Kandahar, Holograph, Bahrain, Manama, and Soprano. The blocks having Medium High concentration are Philpot, Pratappur, Bahadurpur, and Handia. Blocks having medium concentration are Dhanupur, Chaka. Rest of the blocks have low concentration.

Sorghum: Sorghum, also known as jowar in India, is a versatile cereal crop that holds significant importance in the country. Sorghum is drought- resistant, making it crucial crop in regions prone to water scarcity. It can withstand harsh weather conditions, ensuring food security in arid and semi-arid regions. This is a kharif crop, the blocks having high concentration are Shankargarh, Meja, Uruwa, Chaka, Karaon and Meja, the block having medium high concentration is Handia. Mauaima and soraon have zero concentration of Sorghum. Bahadurpur, Pratappur, Saidabad, Dhanupur, Jasra, Kaundhiyara and Manda have medium concentration, rest of the blocks of low concentration (**Table-**2).

Table-2: Crop Concentration Index of Kharif Crops in Prayagraj District

Blocks	Crop Concentration Index 2020-21									
	Rice	Sorghum	Pearl Millet	Maize	Urad	Pigeon Pea	Sugarcane	Sesame	Vegetables	Fodder
Kaudihar	0.90	0.49	1.51	0	2.04	0.86	0	0.08	2.18	1.40
Holagarh	1.23	0.03	0.19	1.14	0.08	0.07	0.07	0.22	2.55	0.88
Mauaima	1.25	0	0.11	0	0	0.02	1.74	0.33	2.58	0.88
Soraon	1.18	0	2.18	0	0.11	0.14	1.13	0.19	3.46	1.27
Baharia	0.94	0.10	1.76	0.88	0	0.30	0.56	1.11	1.56	0.94
Phulpur	1.18	0.11	0.44	0.88	0.13	0.14	1.05	1.45	1.27	1.10
Bahadurpur	0.60	0.79	2.97	0	0.41	1.15	0	1.87	1.47	1.84
Pratappur	1.12	0.88	0.48	3.62	1.07	0.30	2.39	2.07	1.31	1.10
Saidabad	0.89	0.67	1.58	1.56	0.85	0.85	0.98	2.09	0.95	1.36
Dhanupur	1.13	0.51	0.50	2.28	0.49	0.38	4.70	1.74	0.76	1.30
Handia	0.89	1.25	1.38	1.82	0.47	0.84	1.31	0.92	1.06	2.03
Jasra	1.02	0.83	0.84	0	3.30	1.07	0	1.00	0.23	0.40
Shankargah	1.08	1.55	0.46	0	5.65	0.79	0	0.39	0.29	0
Chaka	0.74	2.32	1.47	0	0.40	2.27	0	0.26	0.72	1.37
Karchhana	0.57	0.48	2.44	0	2.24	2.72	4.72	0.07	0.30	1.00
Kaundhiyara	1.16	0.70	0.26	0	0.63	0.73	0.90	2.68	0.30	0.49
Uruwa	0.56	1.75	3.11	0	0.93	1.36	0.34	1.22	0.28	0.89
Meja	1.07	1.54	0.65	0.46	1.07	0.77	0.21	1.83	0.19	0.37
Koraon	0.99	2.77	0.07	2.55	0.96	2.25	0.44	0.07	0.09	0.63
Manda	1.09	0.59	0.53	0.97	0.17	0.91	0.54	1.99	0.26	1.07

Source: Computed by Authors

Pearl Millet: Pearl millet is known as Bajra in India. Bajra is rich in protein, fiber, vitamins, and minerals, making it a valuable dietary staple, especially in regions with poor soil quality and limited access to other nutritious food. This is also a drought resistant crop, many small scale farmers rely on bajra cultivation for their subsistence, providing a source of income and sustenance for their families. This is grown in kharif season the blocks having high concentration are Soraon,

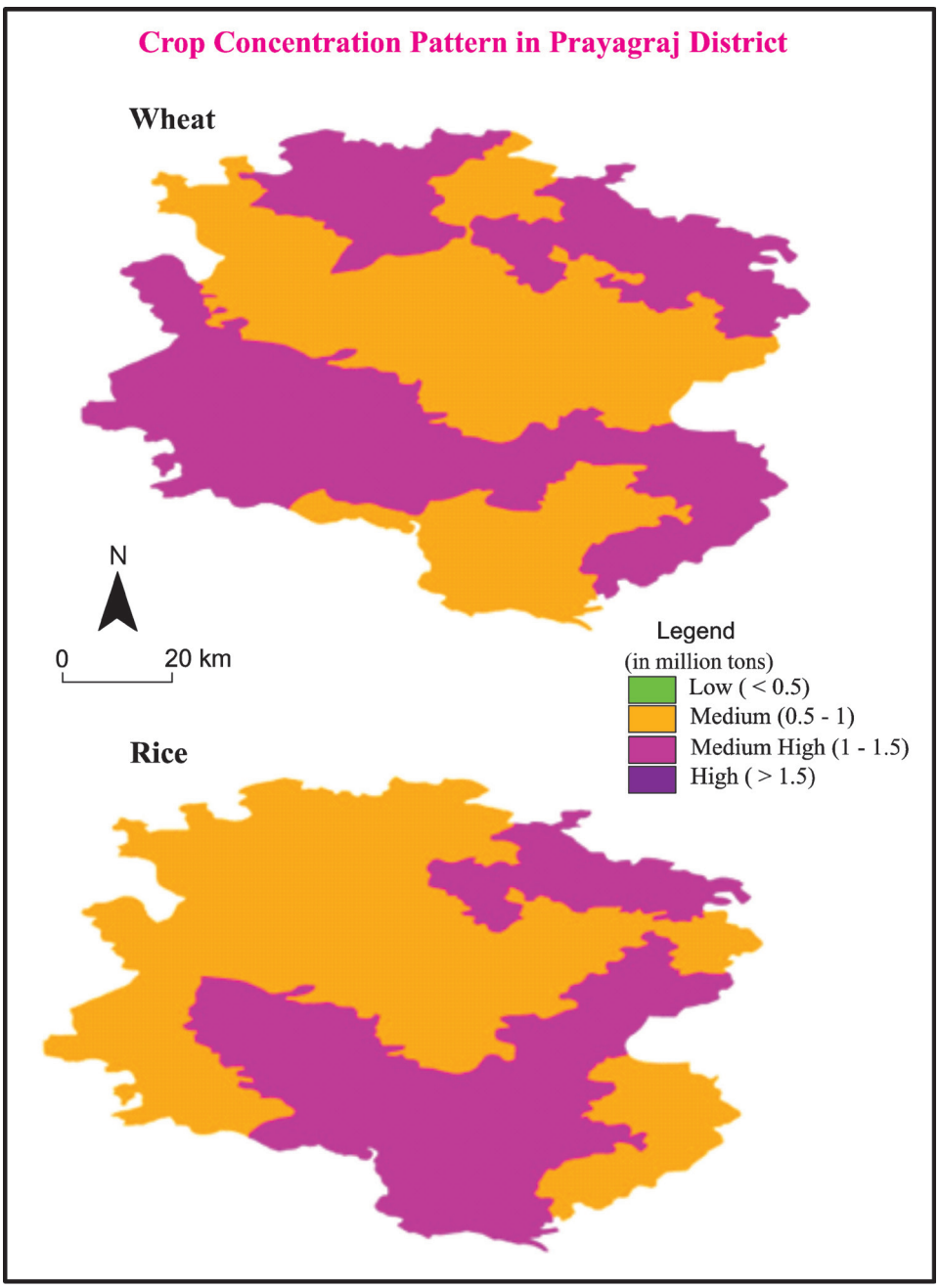

Crop Concentration Pattern in Prayagraj District
Wheat
N
0
20 km
Legend
(in million tons)
Low (< 0.5)
Medium (0.5 - 1)
Medium High (1 - 1.5)
High (> 1.5)
Rice

Fig. 1

Bahadurpur, Karchhana, Saidabad, Kaudihar, Baharia and Uruwa. The blocks having medium high concentration are Handia and Chaka. Meja has medium concentration of Pearl millet, rest of the blocks have low concentration.

Maize: Maize is a staple food for millions of people in India. It is consumed in various forms, such as corn on the cob, popcorn, and makki di roti. This is a droght resistant crop making it suitable for cultivation in regions with irregular rainfall patterns. Maize crop yields a high quantity of grains per hectare, contributing to agricultural productivity. It is grown by both small scale farmers and commercial agricultural enterprises. In Prayagraj, Maize is grown in kharif season, this is rainfed crop, Pratappur, Saidabad, Dhanupur, Handia and Koraon have high concentration of maize. Holagarh has medium high concentration. Baharia, Phoolpur and Manda have medium concentration.

Pulses: Pulses are a primary source of protein for millions of vegetarians in India. They are essential for fulfilling the protein requirements of a predominantly vegetarian population. The pulse industry creates employment opportunities in rural areas, including processing, trading, and transportation, contributing to the rural economy. Pulses cultivated in Prayagraj are Urad, Arhar, Masoor and Chana, the most important among them is Arhar or Pigeon Pea. Arhar dal requires a warm and tropical climate, moderate and well distributed rainfall, well-drained soil, abundant sunlight, and careful management of pests and diseases. The total area under arhar is 14639 hectares (2020-21). Chaka, Karchana and Koraon have high concentration. The blocks Jasra and Uruwa have medium high concentration. Kaudihar, Handia, Saidabad Shankargarh, Kaundhiyara, Meja and Manda have medium concentration. Rest of the blocks have low concentration. Out of 20, 7 blocks have medium concentration of Arhar in Prayagraj District.

Sugarcane: Sugarcane is the primary source of sugar production in India. Sugarcane cultivation and the sugar industry contribute significantly to the Indian economy. India is one of the largest producers of sugarcane and sugar in the world. Sugarcane farming provides employment to millions of farmers and labourers, especially in rural areas. Sugarcane is a long duration crop and requires 10 to 14 months to mature depending upon the geo- climatic conditions, it require 75 to 150 cm rainfall and in average 21 degree to 27° C temperature for better growth in 2020-21 total area under sugarcane cultivation was 666 hectares, the blocks Karchhana, Dhanupur, Pratappur and Mauaima have high concentration. Soraon, Phulpur, Handia have medium high concentration. There is no cultivation of sugarcane in Shankargarh, Chaka and Jasra. Baharia, Kaundhiyara and

Manda have medium concentration. Rest of the blocks have low concentration index of sugarcane in Prayagraj District.

Oilseeds: The most important oil seed in Prayagraj district is mustard. This is usually sown in the winter season from October to December, mustard prefers cool and dry weather during its growth period. Moderately drought resistant but requires adequate moisture during its early stages. The blocks having high crop concentration are Karchhana, Chaka and Koraon. The block having medium high concentration are Bahadurpur, Jasra and Meja. Rest of the blocks have low concentration of mustard crop. Other oilseeds grown in the district are Sesame and Flaxseeds. Sesame is cultivated in all the blocks of the district while flaxseed is cultivated only in 8 blocks of the district.

Fodder: The choice of fodder crop depends upon climate soil type and livestock requirements. For any region fodder plays a crucial role in supporting the livestock population. Fodder is crucial for dairy farming. Well-nourished dairy animals produce higher quantities of milk, supporting the dairy industry and ensuring a regular supply of milk and dairy products for consumers. In the district most of the fodder is grown in kharif season covering 2753 hectares (2020-21) of the total crop area. Two blocks have high concentration, they are Bahadurpur and Handia. The blocks having medium high concentration are Kaudihar, Soraon, Phulpur, Pratappur, Saidabad, Dhanupur, Shankargarh and Manda. The blocks Holagarh, Baharia, Karchhana, Uruwa and Koraon have medium concentration, rest of the blocks have low concentration. Crop concentration index of fodder in the blocks are mostly in medium high and medium range.

Conclusion

The variations in the concentration of Crop cultivation across the study region can be attributed to a complex interplay of factors, including geographical features, climate, water resources, socio-economic conditions and technological influences. These factors collectively contribute to the special distribution pattern of crops in the area. According to research analysis there is not much difference in crop concentration pattern of rice and wheat in the blocks of Prayagraj, this can be attributed to almost similar physical features across the district. High concentration of Barley can be seen in the centre of Prayagraj, only the 25% of the total production of Barley is irrigated. High and medium high concentration of vegetation of both Rabi season and Kharif season is in the Northern portion of the district. Medium high concentration of Sorghum is in the southern portion of the district,

it is a completely rainfed crop. High concentration of sugarcane is observed in east of the district and in Mauaima block which is in northern region of Prayagraj. High concentration of mustard is observed in the centre of the district in northwest and in southern block (Koraon). We can observe that crops like wheat and rice have almost even concentration and the other crops like barley, sorghum, pearl millet, maize, pulses, sugarcane and oilseeds have uneven distribution. This is because wheat and rice is the staple crop of Prayagraj which supports them financially and provides sustenance and other crops are cultivated by the choice of farmers where they have favorable conditions.

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SOCIO-ECONOMIC STATUS OF THE VANTANGIYA COMMUNITY: A CASE STUDY OF VANTANGIYA VILLAGES IN MITHAURA BLOCK OF MAHARAJGANJ DISTRICT

Ruchika Singh and Vaibhav Tripathi

Abstract

The Vantangiya community is a community based on economic activities, which the Britishers settled between the 1920s and 1930s to plant and protect Sal and Teak trees in the Terai areas of the states of Uttar Pradesh and Uttarakhand to meet their economic and infrastructural needs. Since the beginning, the people of this community have been living a displaced life; they were displaced from one place to another in an interval of about five years to plant and protect trees like bonded labours. More or less, this situation remained the same even after the country got independence. The Vantangiya community has been a victim of socio-economic deprivation for many years, and they have struggled a lot to get their rights. The current study examines the socio-economic status of the Vantangiya community in the Mithaura block of Maharajganj district. Socio-economic status of the different villages of the Vantangiya community was identified using the Socio-Economic Index which was constructed by the composition of various socio-economic factors like health, demographic characteristics, education, income-expenditure ratio, land ownership, etc. Variables of all these socio-economic factors and their values are pre-assumed and the value of Standard Socio-Economic Index (SEI) has been calculated on the basis of standard values of all these variables. Based on the value of the Standard Socio-Economic Index, a comparative analysis of the socio-economic status of the five villages of the Vantangiya community is analysed in this study.

Introduction

"Socio-economic development is a process of quantitative, qualitative and structural changes that are a result of actions of subjects taken within social(economic) practice. These changes influence life conditions in the following fields: material conditions (possibility to satisfy needs associated with consumption

of goods and services; it is related with the phenomena of economic growth), economic structure and entrepreneurship, access to public goods and services (that results in changes of education level, a way of taking care of someone's health etc.), relation within social system (integration between individuals, trust, security, social conflicts), environment condition and life satisfaction." Its goal is to maintain the region and its people's social and material well-being in order to achieve the optimal level of human development. Development, in the socio-economic context, refers to the improvement of people's standard of living through better employment, income, skills, and development opportunities. Thus, socio-economic development is the process by which a society develops both socially and economically. Health care facilities, sanitization, the availability of clean water, literacy, the income-to-expenditure ratio, and land ownership are some indicators used to measure it. A person's or group's socio-economic status is a combined economic and social measure of their position about others based on their health, education, and occupation. Socio-Economic status consistently and accurately predicts a wide range of outcomes throughout a person's life. A community is a social group that shares common things like area, traditions, beliefs, values, and identity. Communities may share a sense of place in a specific geographic area (like a country, hamlet, town, or neighbourhood) or virtual space through many communication platforms. According to the given definition of community, a community developed based on economic activities in the state of Uttar Pradesh and Uttarakhand of India in the first half of the 20th century is called the Vantangiya Community. Natural forests were extensively cleared for railway tracks some 100 years ago in this region when India was ruled by the British. Based on the Tangiya technique, a farming strategy used in the mountains of Myanmar, the British chose to create a forested area in its place. Many labourers were brought to the forest for this purpose from the villages of the Gorakhpur division. As a result, they were given the name "Vantangiyas"; "Van" signifies forest, and "Tangiya" comes from the words "tongya" where "tong" means mountain and "ya" belongs to the agricultural area. In Uttar Pradesh and Uttarakhand, the Tangiya system was implemented between 1920 and 1923. More than 5,000 Vantangiya families live in 23 forest villages in Gorakhpur and Maharajganj districts. Since the beginning, the people of this community have been living a displaced life; they were displaced from one place to another in an interval of about five years to plant and protect trees like bonded laborers. More or less, this situation remained the same even after the country got independence. The Vantangiya community has been a victim

of socio-economic deprivation for many years, and they have struggled a lot to get their rights. Due to the prohibition on their primary economic activities for the past several decades, they were forced to lead a displaced life, but for some years, through governmental and non-governmental efforts.

Study Region

Maharajganj district is situated north-eastern Tarai part of Uttar Pradesh in India. Its boundaries touch Nepal Estate in the north, Gorakhpur district in the south, Kushinagar district in the east, and Siddharth Nagar and Sant Kabir Nagar districts in the west. The total area of this district is 2952 square kilometers. Based on the census of 2011, the total population of this district is 26,85,292. Maharajganj was a tahsil of Gorakhpur and became a district on 2 October 1989. Maharajganj district consists of 12 Vikas khand blocks- Partawal, Paniwara, Pharenda, Dhani, Brijmanganj, Nautanwa, Lakshmipur, Mithaura, Nichlaul, Siswa Bazar, Ghughuli & Maharajganj Sadar. Vantangiya community lives in different blocks of the district in which Mithaura block takes prominent place where 5 Vantangiya villages are located: Baluahiya, Hathiahwa, 24 Nursery, 27 Nursery and 28 Nursery. The current study deals with the socio-economic status of these villages.

Objective

The main objective of the current study is to analyse the socio-economic status of the Vantangiya community in the Vantangiya villages of Mithaura block of Maharajganj district through the Socio-Economic Index (SEI).

Data Sources and Methodology

The current study is based on quantitative data analysis, and data are collected from primary as well as secondary data sources. This study used questionnaires, interview schedules, focused group discussions, and observation methods in primary sources, whereas in secondary sources, it considered data and documents related to village officials. This study analyzed 100 respondents and selected purposively 20 respondents from each Vantangiya village, Baluahiya, Hathiyhwa, Nursery 24, Nursery 27 and Nursery 28. After collecting the data, the socio-economic status of the Vantangiya community of Vantangiya villages in Mithaura block of Maharajganj district analyzed through the socio-economic index. For this, the current study used the method to calculate the socio-economic index as follows:

Socio-economic Index = {1/2 Social Index} + {1/2 Economic Index}

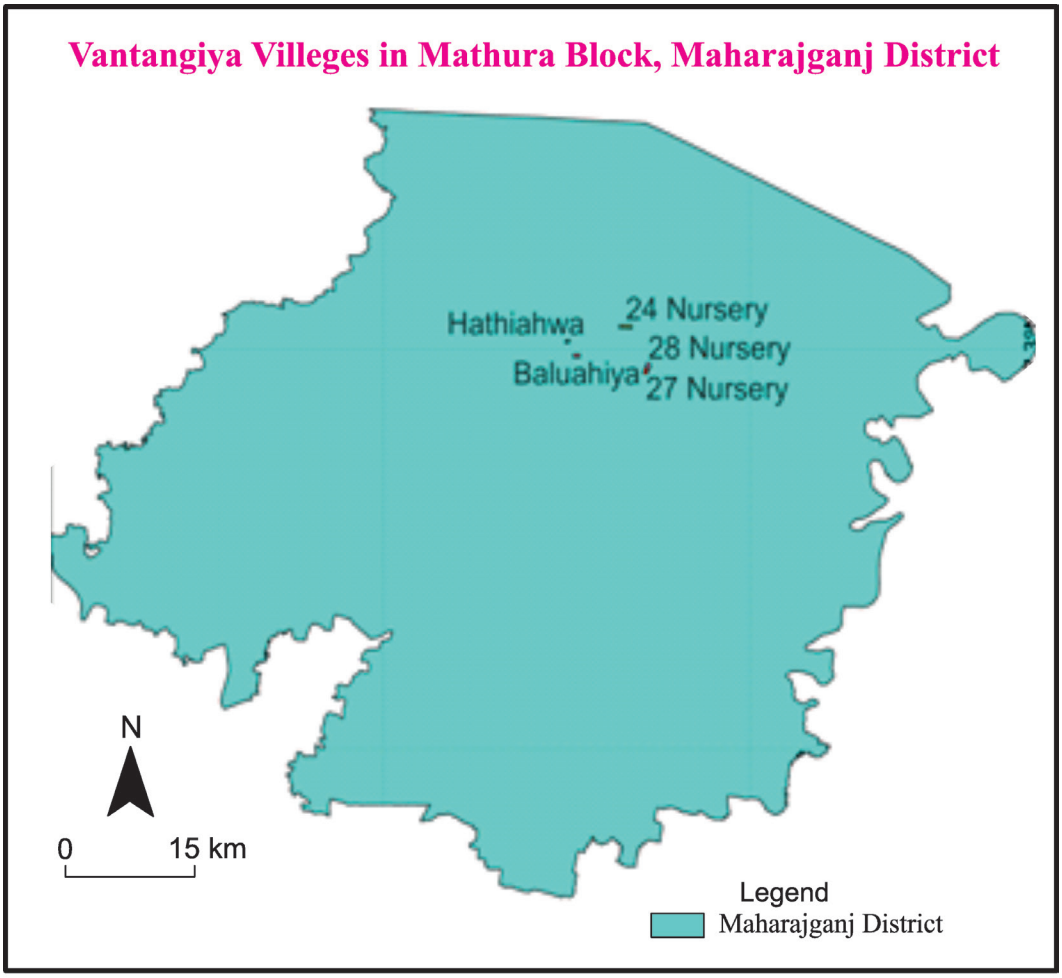

Vantangiya Villeges in Mathura Block, Maharajganj District
Hathiahwa
24 Nursery
28 Nursery
Baluahiya
27 Nursery
N
0
15 km
Legend
Maharajganj District

Fig. 1

Socie-Economic Index– The social index is measured by many indicators like health, demographic, and educational factors that impact a person's family or social position. The sum of the health, demographic, and educational indices is thus the social index.

Social Index = (1/3 Health Index) + (1/3 Demographic Index) + (1/3 Educational Index)

Health Index: Health is a major component of social index which affects society directly or indirectly. In this paper access of health and maternal facilities, standard toilet facilities, availability of safe drinking water and electric facilities are included as health indicators (**Table-**1).

Health Index = Actual Value – Minimum value/ Maximum Value – Minimum Value

Table-1: Health-related Variables and Value

Variables	Values
Access Health/ Maternal Care	No = 1, Yes = 2
Standard Toilet Facilities	No Facility/field = 1
Public Toilet = 2	
Pit/ Flush Toilet = 3	
Safe Drinking Water	No Facilitity = 1
Surface Water = 2	
Tube well/ Handpump = 3	
Basic Electric Facility	No = 1, Have = 2

Source: Computed by Authors

Demographic Index: Demography directly affects development of any society. People's marital status and family size are playing a key role to decide their level of socio-economic development (**Table-**2).

Demographic Index = Actual Value–Minimum value/Maximum Value–Minimum Value

Table-2: Demographic Variables and Code

Variables	Values
Age of Marriage	Less than 21(Male) 18 (Female) = 1, 21-25 (Male) 18-21 (Female) =2, Above 25(Male) 21 (Female) = 3
Size of Family	Above 5 members = 1 5 members = 2 4 members = 3 3 members = 4 Less than 3 members = 5

Source: Computed by Authors

Individual Educational Index = Actual Value/ Maximum Value

Education occupies a prominent role in the social index. An educated society achieves new dimensions of socio-economic development (**Table-**3).

Table-3: Educational Category and Code

Category	Code/Values
No Education/ Illiterate	1
Primary Incomplete/ Literate	3
Primary Complete	5
Junior High School	8
High School	10
Secondary	12
Graduation	15
Post Graduation	17
Ph.D/Other Advanced Study	18

Source: Computed by Authors

Economic Index: The aspects that affect a person's or family's financial situation, such as income, spending, involvement in community events, occupation, and land ownership, have an impact on the economic index (**Table-**4). With the use of the Socio-Economic Index (SEI) measuring formula, the following tables are constructed for the SEI of respondents of the different villages of Vantangiya community in Mithaura Block of Maharajganj district (**Table-**4 and 5).

Economic Index = Actual Value–Minimum Value/ Maximum Value–Minimum Value

Table-4: Economic Variables with their Category and Value Category

Variables	Values
Monthly Income (Expected)	Up to 10000=1
10000-20000 = 2	
Above 20000 = 3	
Expenditure Less than Income	Yes =2, No =1
Participation in Community Events	Yes =2, No =1
Occupation	No Job = 1
Day Labour/ Farmer/Housewife = 2	
Government/ Private Job = 3	
Land Ownership	
(Household)	Up to 1 Bigha = 1
1-3 Bigha = 2	
Above 3 Bigha = 3	

Source: Computed by Authors

Table-5: Socio-Economic Index for Baluahiya Village

Respondents	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	0.834	0.334	0.056	0.408	0.125	0.267
2	0.834	0.334	0.556	0.575	0.625	0.6
3	0.667	0.167	0.556	0.463	0.278	0.371
4	0.667	0	0.056	0.241	0.500	0.371
5	0.667	0	0.056	0.241	0.125	0.183

Contd...

6	0.834	0	0.056	0.297	0.750	0.524
7	0.834	0.167	0.444	0.482	0.625	0.554
8	0.667	0	0.056	0.241	0.250	0.245
9	0.5	0.5	0.056	0.352	0.167	0.260
10	0.5	0	0.278	0.259	0.250	0.255
11	0.5	0.5	0.056	0.352	0.375	0.364
12	0.834	0.334	0.056	0.408	0.5	0.454
13	0.834	0.667	0.056	0.519	0.25	0.384
14	0.834	0.5	0.056	0.463	0.5	0.482
15	0.834	0.334	0.444	0.537	0.375	0.456
16	0.834	0.334	0.667	0.612	0.5	0.556
17	0.834	0.834	0.444	0.704	0.5	0.602
18	0.667	0.5	0.056	0.408	0.375	0.392
19	0.834	0.167	0.167	0.389	0.75	0.569
20	0.834	0.167	0.278	0.426	0.375	0.400
Mean SEI = 0.414						

Source: Computed by Authors

Table-6: Socio-Economic Index for Hathiahwa Village

Respondent	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	0.834	0.167	0.167	0.389	0.625	0.482
2	0.834	0.667	0.834	0.778	0.5	0.639
3	0.667	0.167	0.056	0.297	0.5	0.398
4	0.834	0	0.056	0.297	0.375	0.336
5	0.667	0.167	0.056	0.297	0.25	0.274
6	0.667	0.167	0.278	0.371	0.25	0.311
7	0.834	0.167	0.056	0.352	0.75	0.551
8	0.834	0.667	0.667	0.723	0.625	0.674
9	0.834	0	0.056	0.297	0.5	0.398
10	0.667	0.167	0.056	0.297	0.5	0.274
11	0.667	0.5	0.056	0.408	0.375	0.396
12	0.834	0.5	0.056	0.463	0.5	0.482
13	0.834	0.834	0.125	0.598	0.5	0.549
14	0.667	0.167	0.056	0.297	0.5	0.297

Contd...

15	0.5	0.5	0.444	0.481	0.75	0.616
16	0.667	0.834	0.278	0.593	0.375	0.484
17	0.667	0.334	0.056	0.352	0.375	0.364
18	0.667	0.667	0.278	0.537	0.375	0.456
19	0.834	0	0.556	0.463	0.75	0.607
20	0.834	0.834	0.278	0.649	0.375	0.512
Mean SEI = 0.455						

Source: Computed by Authors

Table-7: Socio-Economic Index for 24-Nursery Village

Respondent	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	0.667	0	0.056	0.241	0.5	0.371
2	0.5	0	0.056	0.186	0.25	0.218
3	0.5	0.167	0.444	0.370	0.125	0.248
4	0.334	0.167	0.056	0.186	0.375	0.281
5	0.334	0.667	0.278	0.426	0.25	0.338
6	0.667	0.5	0.056	0.408	0.375	0.392
7	0.667	0.334	0.056	0.352	0.375	0.363
8	0.834	0,167	0.056	0.352	0.625	0.486
9	0.667	0	0.056	0.241	0.625	0.433
10	0.5	0.167	0.167	0.278	0.25	0.264
11	0.667	0.167	0.056	0.297	0.5	0.398
12	0.667	0.167	0.278	0.371	0.5	0.435
13	0.667	0.834	0.167	0.556	0.875	0.716
14	0.667	0.167	0.056	0.297	0.25	0.274
15	0.667	0.167	0.278	0.371	0.375	0.373
16	0.5	0.5	0.056	0.352	0.5	0.426
17	0.667	0.167	0.056	0.297	0.375	0.336
18	0.667	0.5	0.278	0.482	0.375	0.429
19	0.667	0.334	0.167	0.389	0.625	0.507
20	0.667	0.167	0.278	0.371	0.375	0.373
Mean SEI = 0.383						

Source: Computed by Authors

Table-8: Socio-Economic Index for 27-Nursery Village

Respondent	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	0.834	0.334	0.056	0.408	0.375	0.392
2	0.834	0	0.056	0.297	0.375	0.336
3	1	0.334	0.167	0.5	0.875	0.686
4	1	0.167	0.167	0.445	0.375	0.401
5	1	0.167	0.167	0.445	0.75	0.598
6	0.834	0.167	0.167	0.389	0.5	0.445
7	0.834	0.334	0.056	0.408	0.375	0.392
8	1	0.334	0.167	0.501	0.5	0.5
9	0.834	0.5	0.056	0.463	0.375	0.419
10	1	0.334	0.444	0.593	0.625	0.609
11	1	0.167	0.056	0.408	0.5	0.454
12	1	0	0.056	0.352	0.625	0.486
13	0.834	0.334	0.278	0.482	0.375	0.426
14	1	0.167	0.167	0.445	0.75	0.598
15	1	0.334	0.167	0.5	0.625	0.563
16	1	0	0.056	0.352	0.75	0.551
17	1	0.334	0.278	0.537	0.875	0.706
18	0.834	0.167	0.167	0.389	0.375	0.382
19	1	0.334	0.167	0.501	0.625	0.563
20	1	0.5	0.167	0.556	0.875	0.716
Mean SEI = 0.511						

Source: Computed by Authors

Table-9: Socio-Economic Index for 28-Nursery Village

Respondent	Social Index				Economic Index	Socio-Economic Index (SEI)
	Health Index	Demographic Index	Educational Index	Social Index		
1	1	0.334	0.444	0.592	0.75	0.671
2	1	0.167	0.278	0.482	0.75	0.615
3	1	0.167	0.167	0.445	0.625	0.535
4	1	0.167	0.278	0.482	0.625	0.554
5	1	0.334	0.444	0.593	0.875	0.734

Contd...

6	0.834	0.167	0.056	0.352	0.375	0.364
7	1	0.167	0.167	0.445	0.75	0.598
8	1	0.334	0.167	0.5	0.625	0.563
9	1	0.667	0.444	0.704	0.667	0.686
10	1	0.5	0.056	0.519	0.5	0.505
11	1	0.167	0.056	0.408	0.375	0.392
12	1	0.334	0.167	0.5	0.75	0.625
13	1	0.334	0.056	0.463	0.875	0.670
14	1	0.167	0.056	0.408	0.625	0.517
15	0.834	0.334	0.056	0.408	0.25	0.329
16	1	0.334	0.167	0.5	0.625	0.563
17	1	0	0.167	0.389	0.625	0.501
18	1	0.167	0.056	0.408	0.5	0.454
19	1	0.167	0.167	0.445	0.5	0.413
20	1	0.334	0.167	0.5	0.25	0.375
Mean SEI = 0.533						

Source: Computed by Authors

Determining Standard Value for Socio-Economic Index

For analysis and comparison, there is a need for a standard value of the Socio-Economic Index (SEI). To do so, I have assumed a standard value for each variable. For example, the values for the "Age of Marriage" variable are 1,2 and 3 representing ages below 21(male) & 18(female), age between 21-25(male) and 18-21(female), and age above 25(male) & 21(female) respectively. Here the standard value for this variable is 2 or the age of marriage between 21-25(male) & 18-21(female). The list of variables and their standard value (**Table-**10) are tabulated below:

Table-10: Variables and Their Standard Value

Variables	Values	Standard Values
Access Health Care/Maternal Care	No = 1, Yes = 2	Yes = 2
Standard Toilet Facilities	No facility/field = 1 Public Toilet = 2 Pit/flush Toilet = 3	Pit/flush Toilet =3

Contd...

Safe Drinking Water	No facilities = 1 Surface water = 2 Tube well/Handpump = 3	Tube well/ Handpump = 3
Basic Electric Facilities	No=1, Yes=2	2
Age of Marriage	Less than 21 years(male) & 18 years(female) = 1 21-25 years(male) & 18-21 years(female) = 2 Above 25 years(male) & 21 years(female) = 3	21-25 years(male) & 18-21 years(female) = 2
Size of Family	Above 5 members = 1 5 members = 2 4 members = 3 3 members = 4 Less than 3 members = 5	4 Members = 3
No Education/Illiterate	1	Secondary = 12
Primary Incomplete /Literate	3	
Primary Complete	5	
Junior High School	8	
High School	10	
Secondary	12	
Graduation	15	
Post Graduation	17	
PhD/Other Advanced studies	18	
Monthly Income (Expected)	Up to 10000=1 10000-20000=2 Above 20000=3	10000-20000 = 2
Expenditure less than income	No =1, Yes = 2	Yes = 2
Participation in Community Events	No =1, Yes = 2	Yes = 2

Contd...

Occupation	No Job = 1 Day Labour/Farmer /Housewife = 2 Government/Private Job=3	Day Labour/ Farmer /Housewife = 2
Land Ownership (Household)	Up to 1 Bigha=1 1-3 Bigha=2 Above 3 Bigha=3	1-3 Bigha = 2

Source: Computed by Authors

By putting the standard values in the Socio-Economic Index (SEI) measuring formula,

I get the standard value for Socio-Economic index (SEI) = ½ (Social Index + Economic Index) = ½ (0.722 + 0.625)

Socio-Economic Index (SEI) = ½ (Social Index + Economic Index)

Standard Value for SEI = 0.674

Determining Mean Value for Socio-Economic Index (SEI) for different Vantangiya Villages of Mithaura block.

With the help of statistical techniques:

(1) Mean value of SEI for Baluahiya village = 0.414
(2) Mean value of SEI for Hathiahwa village = 0.455
(3) Mean value of SEI for 24-Nursery villages = 0.383
(4) Mean value of SEI for 27-Nursery villages = 0.511
(5) Mean value of SEI for 28-Nursery villages = 0.533
(6) Mean value of SEI for all these 5 villages = 0.459

Socio-economic Status of the Baluahiya Villages

The socio-economic status of the Baluahiya village covering the social and economic indicators is not better at all as none (0%) of the respondents reported standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and only 35% of respondents of this village whose SEI are 0.459 or above. It can easily be predicted that the

maximum of the respondents of the vantangiya community in Baluahiya village are not have better socio-economic status. The basic social and economic facilities and infrastructure are not available in this village.

Socio-economic status of the Hathiahwa Villages

The socio-economic status of the Hathiahwa village covering the social and economic indicators is not good as only 5% of the respondents have standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and 50% of respondents whose SEI are 0.459 or above. So the socio-economic status of the Hathiahwa village is not as good as required and the basic social and economic facilities and infrastructure are not available.

Socio-economic status of the 24-Nursery Villages

The socio-economic status of the 24-Nursery village covering the social and economic indicators is not good as only 5% of the respondents have standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and only 15% of respondents whose SEI are 0.459 or above. So the socio-economic status of the 24-Nursery village is not good and the difference between the mean SEI of this village and the individual SEI of the respondents shows the inequality in their socio-economic status.

Socio-economic status of the 27-Nursey Villages

The socio-economic status of the 27-Nursery village covering the social and economic indicators is good as 15% of the respondents have standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and 50% of respondents whose SEI are 0.459 or above. So the socio-economic status of the 27-Nursery village is comparatively good among vantangiya villages.

Socio-economic status of the 28-Nursery Villages

The socio-economic status of the 28-Nursery village covering the social and economic indicators is good as 10% of the respondents have standard socio-economic status. The mean SEI value for respondents of the Vantangiya community in Mithaura block is 0.459 and 55% of respondents whose SEI are 0.459 or above. So the socio-economic status of the 28-Nursery village is comparatively better among vantangiya villages. The homogeneity in the mean SEI of this village and the individual SEI of the respondents shows equality in their socio-economic status.

Comparison of socio-economic status among Vantangiya villages of Mithaura block

The mean SEI value is 0.459 for the 100 respondents from different villages of the Vantangiya community in the Mithaura block of Maharajganj district. The mean SEI value for respondents of Baluahiya (0.414), Hathiahwa (0.455), 24-Nursery (0.383), 27-Nursery (0.511), and 28-Nursery (0.533) villages is different and this difference in the SEI level indicates that 27-Nursery and 28-Nursery are maintaining better socio-economic status than the other three Vantangiya villages. Comparing with the standard value of SEI (0.674), none of the respondents in the Baluahiya village have standard socio-economic status; only 5% of the respondents in the Hathiahwa and 24-Nursery village have standard socio-economic status; and 15% and 10% of the 27-Nursery and 28-Nursery, respectively.

Conclusion

This comprehensive and comparative study discussed the socio-economic status of the five Vantangiya villages in the Mithaura block of Maharajganj district. A multidimensional socio-economic index is used to measure the socio-economic status of the Vantangiya community. The Socio-Economic index is the aggregate result of the social index and the economic index. The social index is also subdivided into the Health Index, Demographic Index and Educational Index. The study analyzed 100 respondents from different villages of the Vantangiya community and indicates that 27-Nursery and 28-Nursery villages are in better socio-economic condition than the other three. This study also indicates that there is a huge need for basic socio-economic and infrastructural facilities in these Vantangiya villages to uplift the socio-economic status of the people of the Vantangiya community.

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ASSESSMENT OF WILDLIFE HABITAT MANAGEMENT IN MUKUNDRA HILLS TIGER RESERVE, RAJASTHAN

Ms. Aayushi Jain and Dr. Ajay Vikram Singh Chandela

Abstract

Many researches have been done from time to time at local and global level in the context of climate change and biodiversity loss, many reports have been published. However, we all can feel these changes around us. We see the increasing environmental pollution around us and its impact on the life on land. This crisis has increased further due to changes in land use pattern in the last few years. With time, the area under forest cover and water bodies is decreasing while the area under man-made landscape is increasing. This destruction of natural habitat has led to greater decline in biodiversity. The 2022 global Living Planet Index shows an average 69% decrease in relative abundance of monitored wildlife populations between 1970 and 2018. Therefore, keeping in mind the need to conserve biodiversity, we should pay attention to the conservation of their natural habitats and saving top predators is essential for natural habitat conservation. Top predators, like tigers play an important role in maintaining the harmony of the planet's ecosystems. By preying on herbivores, tigers help to keep the balance between the prey animals and the forest vegetation which they feed upon. From the world's largest mangrove forests in the Sundarbans, to the snowy mountains in Northeast China and Russia, protecting wild tigers and their natural homes provides benefits for thousands of species and millions of people. (Why Tigers, n.d.) So we need to study their natural habitats, issues and solutions. This paper is based on common issues found in reserved forest areas. For example, it has been almost ten years since Mukundara Hills Tiger Reserve was declared a tiger reserve, but even today human settlements are present here. However, during the survey it was revealed that the residents themselves are not safe here. They also want to go out of these difficult situations and live a safe and healthy life. Apart from this, the context of water, food and safe habitat for wildlife has been discussed in this research paper also. Satellite images and field survey have been used for analysis. This forest area was also inhabited by

wild animals earlier and even at present there has been no significant change in this area. Most of the human settlements here are natural. Only a few road routes have been constructed. These can also be replaced by the Delhi-Mumbai Expressway in the future and made wildlife-friendly. Therefore, this area can be made a safe wildlife habitat. Moreover, the connectivity of Mukundra Hills Tiger Reserve with Bhainsroadgarh Wildlife Sanctuary in the south and Ramgarh Vishdhari Tiger Reserve and Ranthambore Tiger Reserve in the north makes it an excellent habitat for wildlife.

Introduction

In the Era of Machines and Development, many efforts are being made for environmental protection by the United Nations at the global level for the conservation of biodiversity. In this series, in the Conference on Sustainable Development held at Rio de Janerio in the year 2012, SDG goals were proposed by the United Nations. The purpose of which was to present goals globally to deal with the environmental, political and economic challenges faced by all countries of the world. In this series, in September 2015, United Nations Summit on Sustainable Development was organized in New York and the General Assembly adopted the 2030 Agenda for Sustainable Development with 17 SDGs. This research paper is based on one of them, on SDG 15: 'Life on land.' This goal includes study of our planet's ecosystem. As we know, without forest, there is no possibility of sustainable life on earth, but for the protection of forests, the presence of wildlife is also essential. Conservation of both forests and wildlife is essential for a balanced and secure life on earth, as stated as "The real wealth of the nation lies in the resources of the earth – soil, water, forests, minerals, and wildlife (Racgel Carson) If seen in the context of Rajasthan, the number of wild animals like bear, panther and tigers is increasing continuously, and for their protection it is necessary to study the available forest areas, which provide suitable living conditions for the wildlife. Moreover, seeking a favourable habitat for the cheetahs brought to the Kuno National Park in Madhya Pradesh, is also a need of the hour. To fulfill this objective, we need a place which has been preserving wildlife even in ancient times and which has not changed much even today, like Mukundra Hills Tiger Reserve. Although there are some challenges in front of Mukundra Hills Tiger Reserve even today, but their solution can be derived. In this research paper, we will discuss about those challenges and their solutions.

Study Region

Study area of this research work is Mukundra Hills Tiger Reserve, which has considerable diversity in topography, climate, vegetation, water resources etc. It is situated in the extension of Hadoti Plateau and Aravalli in the south-eastern Rajasthan, where Chambal, Bamani, Ahu, Kalisindh etc. rivers give life to land, make the forest flourish and create fertile plains.

Mukundra Hills Tiger Reserve (MHTR) was formed in 2013, which includes the area of Mukundra Hills National Park, Dara Sanctuary, Jawahar Sagar Sanctuary and National Chambal Gharial Sanctuary (from Garadia Mahadev to Jawahar Sagar Dam), which constitutes the core area of the Mukundra Hills Tiger Reserve in the Rajasthan. The tiger reserve is spread over an area of 759.99 square kilometers and is located in Ladpura, Sangod, Ramganjmandi tehsil of Kota district, Jhalarapatan tehsil of Jhalawar district, Talera tehsil of Bundi district and Rawatbhata tehsil of Chittorgarh district in Rajasthan. Jawahar Sagar Sanctuary is located between North Latitude 24°56' to 25°7.5' and East Longitude 75°26.50' to 75°41'. It is located 35 kilometers from Rawatbhata and 75 kilometers from Bundi. It is governed by the Government of Rajasthan Notification No. F 3(5) (13) Rev. 18/73 dated October 9, 1975 was declared as a sanctuary. The Mukundra Hills Tiger Reserve is named after the narrow central range with two continuous flat-topped and almost parallel hills, which is part of the Vindhya Range system, which extends from the Chambal River to Kalisindh and is about 80 kilometers in length and is 2 to 5 kilometers in width.

Objectives

(1) To analyze the problems faced in harmonizing the habitats of all living beings on the Earth as SDG 15.

(2) To study Mukundra Hills Tiger Reserve as suitable wildlife habitat for ever increasing tiger population in Rajasthan.

(3) To evaluate significance of Project Tiger in Rajasthan.

Database and Methodology

This research work is based on both primary and secondary data. The suitability of vegetation, water and habitat in the forest area has been studied with the help of satellite images and for its authentication, the area was surveyed. Satellite images of LANDSAT 8 have been used to analyze the forest area and health of vegetation. NDVI is calculated using Raster Calculator tool. In addition to this field survey was

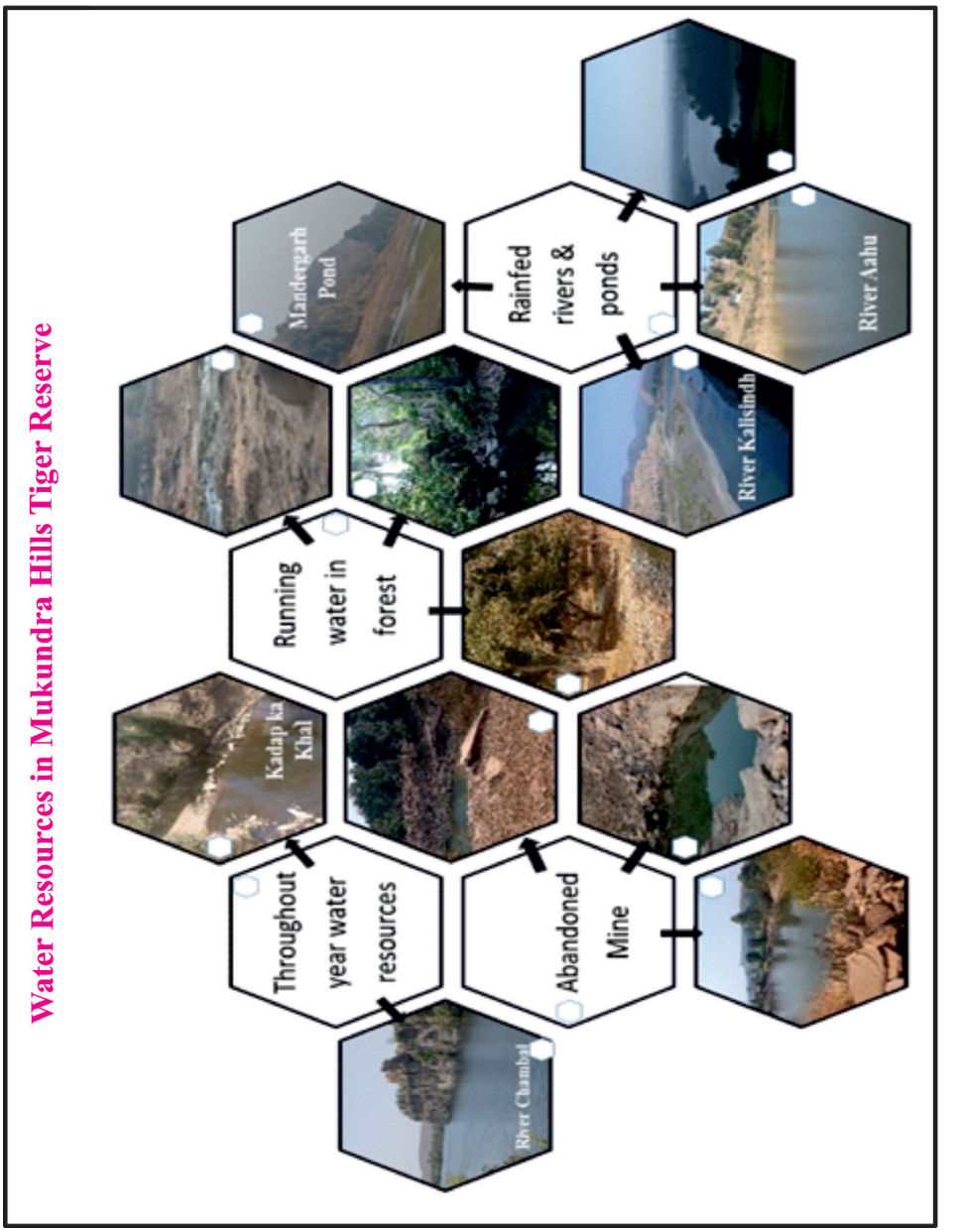

Water Resources in Mukundra Hills Tiger Reserve
Throughout year water resources
Running water in forest
Abandoned Mine
Rainfed rivers & ponds
Kadap ka Khal
Mandergarh Pond
River Chambal
River Kalisindh
River Aahu

Fig. 1

done through schedule to study the human impact and environmental condition of villages located in Mukundra Hills Tiger Reserve. During this survey, information was obtained from the residents about their lifestyle and their dependence on the forest. Apart from this, their impact on the forest was also analyzed. Some research papers and books related to forest management and biodiversity have been studied. Newspapers have been mainly used as secondary data to get information about positive and negative changes happening in Mukundra Hills Tiger Reserve from time to time. Maps were prepared with the help of open-source software. To create maps of the study area, shapefiles taken from forest department portal- 'rajforest' and 'Survey of India' portal were used.

Factors affecting wildlife habitat in Mukundra Hills Tiger Reserve

Water Resources

Mukundra Hills Tiger Reserve is located in the region of Rajasthan with more than 70 cm of rainfall. The only perennial river of Rajasthan, Chambal, and its tributaries, passes through the Mukundra Hills Tiger Reserve. They provide water to the Mukundra Hills Tiger Reserve for most of the year. The topography of Mukundra Hills Tiger Reserve also ensures the availability of water here. The Vindhyan range extends up to the Mukundra Hills Tiger Reserve, locally called Mukundra Hills, from which the rainwater seeps down and accumulates throughout the year in the foothills and lower areas of the valleys. Apart from this, the Forest Department is also conserving more than 100 natural and artificial water bodies in this region. (**Fig.** 1)

Food and Habitat

70 percent area of Mukundra Hills Tiger Reserve is covered with mixed deciduous forest. Dhok (Button), Khair (Black kutch), Churail (Indian elm), Amaltas (Golden shower), Sal, Gurjan, Palash (Bastard), Arjun, Tendu, Ber, Behda (Beleric Myrobalan), Mahua (Buttercup), Khejdi, Babool, Neem, Banyan, Peepal, Khechda, Khakara, Bamboo, Bilvapatra, Amla and many other species of deciduous forests found here. It provides favorable habitat and sufficient food to the wildlife (**Fig.** 2). Thorny autumn forests are found here, whose dry leaves provide food for herbivore animals chinkara, chital, sambar, nilgai, deer, and langurs even in autumn, which provide ample prey base like wolf, jackal, fox, mongoose, wild cat, civet, porcupine, wild boar, panther and tigers. Thus, there is enough food even for carnivorous animals. From the point of view of natural habitat, the total area

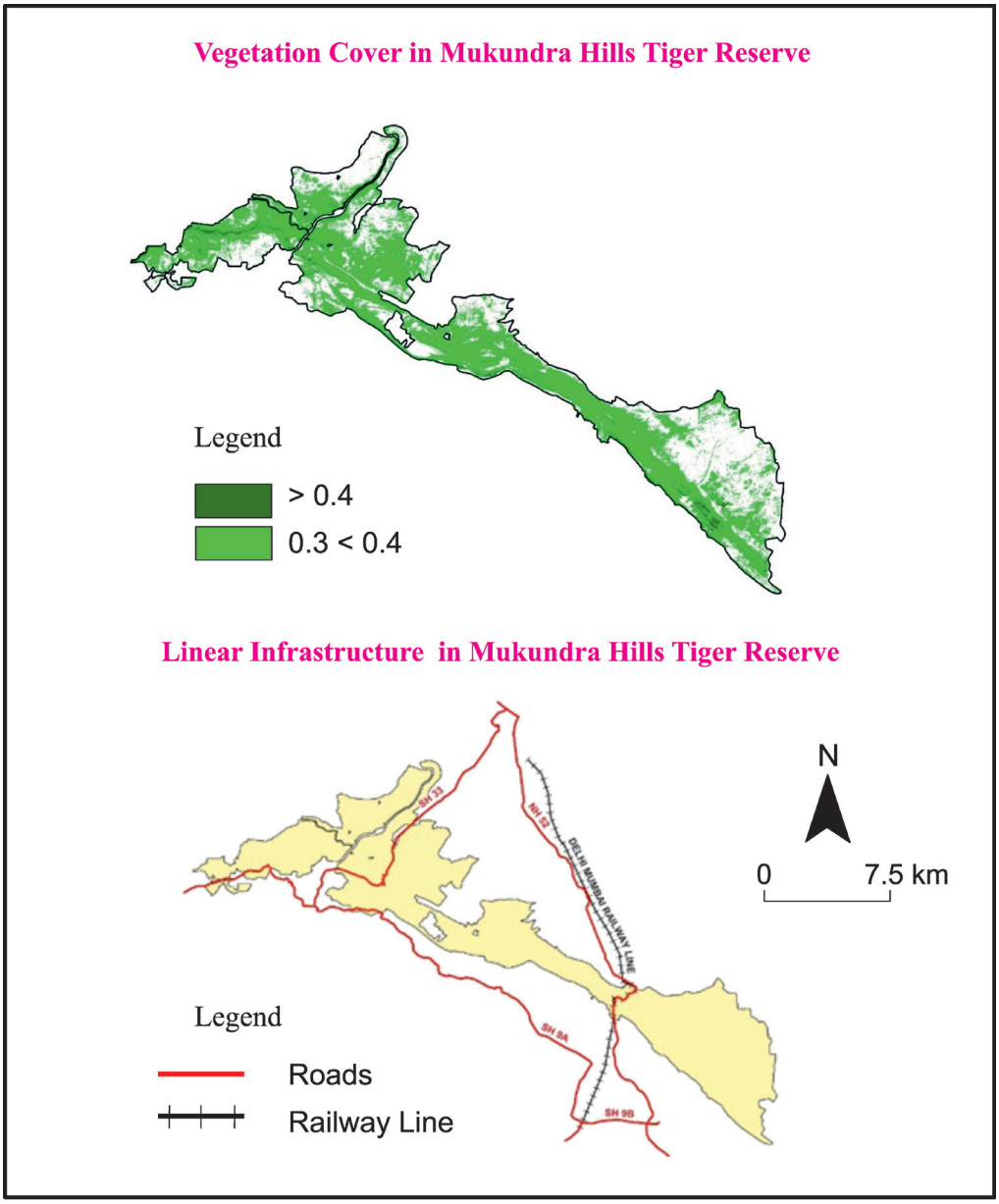

Vegetation Cover in Mukundra Hills Tiger Reserve
Legend
> 0.4
0.3 < 0.4
Linear Infrastructure in Mukundra Hills Tiger Reserve
N
0
7.5 km
DELHI MUMBAI RAILWAY LINE
SH 9A
SH 9B
Legend
Roads
Railway Line

Fig. 2

of Mukundra Hills Tiger Reserve is 759.99 square kilometers, out of which 417.17 square kilometers comes under the core area and the rest under the buffer area. Out of the core area, the area of 82 square kilometers is surrounded by wire fencing. The grassland is well developed within this wire fencing and sufficient prey base is also available in it. Apart from this, one enclosure of one hectare has been made in Selzar area of the tiger reserve and another enclosure of 28 hectares has been made in Sawan Bhado area. (Source: Dainik Bhaskar Newspaper, 05.05.2023) In addition to the above, Mukundra Hills Tiger Reserve has a glorious history as an abode of tigers, but now due to changing land use pattern some disparities have arisen in this area which need to be resolved.

Roads and Railways

National Highway 52 and Delhi-Mumbai railway line pass through Mukundra Hills Tiger Reserve for length of about 50 kilometers. The high speed of vehicles and blind turns of the roads have many times led to the death of wildlife. There are 30 villages located in the core and buffer area of Mukundra Hills Tiger Reserve, in which more than 1500 families reside. Although about 200 families have been relocated from here in the last 8 years, but still the residence and farms of the rest of the families are existing in the forest area. These forest dwellers go to the nearest cities only through the forest area to get the goods they need and for employment. It is dangerous for the life of both humans and wilds (**Fig.** 3).

Project Tiger in Rajasthan

The Tiger Project in Rajasthan started in 1973 when Ranthambore was declared as the first Tiger Reserve of Rajasthan in 1973-1974. In the next phase of the Tiger Project, Sariska was declared a Tiger Reserve in the year 1978-79. But even after three decades of the Tiger Project, there was a continuous decline in the number of tigers in Rajasthan. Tigers vanished from Sariska Tiger Reserve in the year 2005 and only 14 tigers were left in Ranthambore Tiger Reserve. But gradually the conditions started improving; the number of tiger reserves was increased, villages were relocated from Ranthambore and Sariska, mining and deforestation were banned and as a result, gradually the number of tigers started increasing in Rajasthan, which can be understood from the following table: At present, there are about 115 tigers present in Rajasthan. With the formation of Mukundra and Ramgarh Vishdhari Tiger Reserves, a natural wildlife corridor has been created for tigers in the south eastern part of Rajasthan. The number of tigers has grown


Vegetation Cover on Mukundra Hills Tiger Reserve
March 2022
Gagron
December 2022
Human presence in Mukundra Hills Tiger Reserve
Relocated
In processing
Rooppura
Keshavpura
Kothla Ghatti

Fig. 3

substantially in Rajasthan. Due to increasing population of Tigers, the tigers have started migrating to nearby forests of Madhya Pradesh and Rajasthan. This depicts the picture of success of the Tiger Project in Rajasthan.

Conclusions

In conclusion we can say that, Mukundra Hills Tiger Reserve has favourable natural conditions for the habitat of wildlife, but due to anthropogenic activities some anomalous conditions have arisen here. For example, on July 15, 2013, a tiger 'Broken Tail' had come from Ranthambore Tiger Reserve towards the Darrah forest area while roaming. But unfortunately, he was crushed to death by the Rajdhani Express on the Delhi-Mumbai rail route. After this, about 6 years later, in the year 2019, the T-98 tiger, leaving Ranthambhore Tiger Reserve and traveling about 150 kilometers, reached the Darrah region of Mukundra Hills Tiger Reserve via Kalisindh river.

This is the second case of moving from one tiger reserve to another through forest area. Therefore, there is a need to improve following conditions as much as possible and make them wildlife friendly. As (1) The villages should be relocated soon (2) The speed of vehicles should be regulated (3) Grasslands should be developed (4) There is uncertainty of rainfall in Rajasthan. Therefore, to deal with such situations, artificial water points should be developed and water availability should be ensured throughout the year using solar pumps as proposed in Ramgarh Vishdhari Tiger Reserve (5) Security walls should be built around the forest area so that wildlife stays away from rail and road routes and human settlements (6) Tiger reserves of south-eastern Rajasthan should be connected with each other by developing wildlife corridors. Although after the declaration of Mukundra Hills Tiger Reserve as such, many efforts are being made by forest department, and central and state government for the development of Mukundra Hills Tiger Reserve. In view of the protection of wildlife, mining work and deforestation has been banned in this area. Grasslands are being developed so that sufficient food is available for herbivorous animals and sufficient prey base can flourish in the forest. Now if there is any threat to wildlife it is from road and rail routes and human settlements. Forest Department. Apart from this, to ensure wildlife conservation in the area, measures have been taken in the Bharatmala Project, under which Delhi-Mumbai Expressway is being constructed. For wildlife conservation an eight-lane soundproof twin tunnel is being constructed. Along with this, the relocation of six villages settled in core area has also been done. (Shah, 2020)

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IMPACT OF ROADSIDE FRICTION ON ROAD CAPACITY IN ALIGARH CITY, INDIA

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Abstract

Indian cities are notorious for poor road capacity and the slow average mobility. Aligarh city has massive problem of traffic congestion and inadequate transportation infrastructure as the narrow lanes and roads crisscross the city. Absence of the well-designed junctions, footpaths and cycle tracks makes it difficult for pedestrians, cyclists and vehicles to commute safely. Moreover, the lack of traffic management has led to the usual traffic congestion and frequent road accidents. Inadequate parking space causes traffic jams due to road side unauthorized parking. One of the important reasons for this traffic chaos is that the city has one of the fastest growing populations due to the migration of people from rural areas as well as from other parts of the state and country, mainly for education and employment. It is the 77th most populous city in India. Due to Covid -19 lockdown restrictions much of the ridership in Aligarh city was curbed. Still, not much change was being observed in the side friction and traffic congestion. The busy roads of Aligarh city have emerged as the site of parallel economic structure for the migrants, poor and the marginalized section of the city. In this paper we have done a comparative study of two roads of the busy market areas of the Civil Lines zone of Aligarh city during the Lockdown, following all the protocols. The purpose of the study is to analyze the degree of influence the road side friction has upon the road capacity caused by the road side economy. The paper concludes that the side friction has considerable negative impact on the capacity of roads in Aligarh's market areas.

Introduction

Road transportation system has been playing a vital role in the socio-economic development of cities all over the world. Road traffic in India is marred by poor condition and below par performance. The main focus in the studies regarding speed-flow relationship of road traffic is on geometry, street type and urban environment

of roads. Recently many studies have concluded that in the cities of the developing world there are some activities going on or along the roadsides which influence the capacity of the road network which is known as the side friction (R. Amudapuram et.al, 2016). Road capacity is defined as the maximum sustainable flow rate at which vehicles can be expected to traverse a point or uniform section of a lane or roadway during a given time period under the prevailing roadway traffic and control conditions (IRC, 1990). The condition is getting worse in the cities of developing world where the increasing transport demand is causing the deterioration in the road capacity of the arterial and the local roads, and the inefficient performance of the traffic system (Salini.S et. al., 2014). As per the Indian scenario, the presence of the roadside markets and vendors is a common observation in every city. They attract people to stop by, which reduces the effective road width due to the roadside parking of the vehicles and other parking and un-parking maneuver. Due to lack of the meaningful employment for migrants and unskilled and semiskilled individuals, and the unavailability of the specified area for their informal fringe economic activities; vendors, rag pickers, mechanics etc. are also found to work along the roadside. The presence of road side markets, vendors, food stalls and the lack of pedestrian facilities compel people to walk on or along the road which disturbs the traffic flow. In consequence, traffic flow is considerably interrupted. It diminishes the performance of traffic operations and undermines the capacity and the functional integrity of the road. The road side frictions have negative effect on the road capacity as the width of road decreases and it becomes narrow. Side friction leads to decrease in the speed of vehicles, aids in the delays and becomes a cause of accidents. Literature review reveals that very little work has been done in 'Y' category cities in India like Aligarh till date to measure the impact of roadside friction upon the capacity of urban roads. This study intends to measure the influence of roadside frictions on the capacity of road in Aligarh city during the lockdown period in order to establish that even the regulated opening of the city creates unmanageable side friction reducing the capacity of roads below the base value. The study will be a precursor to the road traffic administration of Aligarh Smart city to find out the ways to regulate the unmanageable urbanization and the exponential motorization.

Study Region

Aligarh has been classified as class Y city (HRA, 2015) and one of the National Priority Cities and potential urban growth centers of India (Report of National Commission on Urbanization, GOI, 1988) located outside the National Capital

Region (in 150 km radius). It is the administrative headquarters of Aligarh district, and lies approximately 130 km south east of the capital, New Delhi. Aligarh Muslim University, the world famous seat of learning, is located here. Besides, it is a hub of a large number of small scales household and cottage industries, some of important large-scale food and agro-based industry, and the brass and lock industries. The decadal population growth rate of the city is 30.40 percent for 2001-11(**Table-**1).

Table-1: Geometric Parameters of the Roads under Study

Road Characteristics		Road	
		Marris Road	Dodhpur Road
Geometric condition	Road Types	Single Carriageway 2 Way	Single Carriageway 2 Way
	Carriageway Width	7 m	7.2 m
	Shoulder Width	2.7	1.1
	Road Alignment	Straight	Straight
	Footpath Width intermittent	2.6 m	2.5 m
	Road length	2.57 km	3.08 km
Environmental condition	Weather Condition	Day/Dry	Day/Dry
	Urban/Suburban	Urban	Urban
	Pavement Condition	Paved/Near to Smooth	Paved/Smooth
Traffic control condition	Nearby Major Intersections	Present	Present
	Traffic Signs	Present	Absent
	Pavement Markings	Present	Absent

Source: Based on Survey, 2021

The annual population growth of the city is reported as 3.16, 2.97, 2.89 and 2.81 percent for 4 consecutive years from 2017 to 2020 respectively. The estimated population of Aligarh city is 1,013,089 in 2021(UN- World Population / prospects). The population density of the city has increased from 14,500 persons per square km in 1971 to 24,573 persons per square km in 2011(excluding the University area). 10 percent of the urban population has spread beyond the city limits and in the towns which are also dependent on this city for their major needs.

The city is also having a high rate of motorization. The growth of road length network is not keeping pace with it.

Objectives

(1) To measure the vehicle composition and traffic flow rate of Marris and Dodhpur roads.

(2) To identify the major sources of side friction on these roads and to estimate the magnitude of side friction.

(3) To calculate the actual capacity of both roads.

(4) To estimate reduction in base capacity of both roads due to the side friction.

Database and Methodology

The present study is based on the primary sources of data generated through the comprehensive field survey, traffic counting (TC) survey, side friction (SF) survey, and geometric survey carried out during year 2021 in the month of April. The secondary data is collected from the Census of India (2011). For determining the influence of road side frictions on the capacity of road, two roads of Aligarh city are selected, with roadside friction activities. These are the Marris road and the Dodhpur Road which are undivided two lane two ways (2/2 UD). The survey was conducted for four hours from 8:00 am to 12:00 pm on these two roads. On each road a 50-meter length is specified for the surveys. In this study the evaluation of traffic flow, roadside friction (Pal and Roy, 2016) and capacity (Indonesian Highway Capacity Manual Urban Roads, 1993) is done according to the techniques mentioned in the sources shown in the parentheses. The traffic count survey was done manually by counting the number of each type of vehicle that had passed the fixed spot on the road in both the directions for every 5 minutes under four categories namely, two wheelers, animal drawn vehicles, three wheelers, cars and heavy vehicles. The vehicles in these categories are heterogeneous in nature. Therefore, for finding the total flow each vehicle type is converted into the homogenous category. Flow is calculated by converting the volume of vehicles per 5 minutes into the equivalent PCU (passenger car unit) as per IRC code. The peak hour factor (PHF) is calculated for finding the peak flow of an hour by the formula given by (HCM, 1965) as:

$$PHF = v \frac{60}{av} \Big/ 12xv \frac{5}{av}$$

Average volume during the peak 60 minute period v_av^60 is divided by twelve times to get the average volume during the peak 5 minute's period v_av^5. For the side friction survey a section of 50-meter length on both roads was delineated and width was measured with the help of a measuring tape. On these two sections of the both roads the survey was done to count the number of pedestrian /hour walking, vehicles parked or stopped on their way for a while /hour/width, number of vendors standing/hour/width, number of stray animals moving/hour/width, number of beggars present along the road/hour/width. Pedestrian is considered unit of friction. Impact of side friction included the physical dimension of the side friction as well its position on the carriage way. Area effect of an element of friction is considered as the ratio of projected area of a particular friction to pedestrian and expressed as area ratio (AR). Positional disturbance effect of an element is calculated as the ratio of distance of particular midpoint of strip from edge of carriageway on which friction element is positioned to midpoint of the edge strip named as distance ratio (DR). Weight factor for each element is determined by summing up area ratio and distance ratio. After assigning weight these frequencies are converted into a single unit of roadside friction index (RSVI). To plot the side friction frequency graph all categories of side friction frequencies are summed up and then average frequency per five minutes is calculated for the whole study duration. The geometric survey was done to measure the width of the carriageway, and its edge strips and the middle strip. These capacity parameters have helped in finding the capacity of two roads. Capacity is F calculated as follows.

$$C = C_0 \times FW \times FKS \times FSD \times FSF \times FCS$$

Whereas:

C_0 = Base Capacity

SF = Curb and shoulder adjustment factor

FW = Carriageway width adjustment factor

FSF= Curb and shoulder adjustment factor

FKS = A directional split adjustment factor

FCS = Side friction adjustment factor

FSD = City size adjustment factor

The actual capacity is determined by multiplying the base capacity with all the adjustment factors as mentioned above. The capacity is dependent upon the

geometry of road (the width of road, shoulder width, city size, and median width), side friction activities and the city size. So the values of different adjustment factors have been taken from (Indonesian Highway Capacity Manual Urban Road, 1993). Actual capacity of both roads is estimated by calculating percentage of base capacity reduction.

Results and Discussion

Composition of Vehicles of Roads, (2021)

Traffic Composition is shown in Fig 2 and it is clearly indicated, at Marris Road the vehicle composition is found to be as; two wheelers' 61 percent (bicycle 2.99%, motorcycle and scooter 58.543%), animal drawn vehicle 0.5 percent, car 20 percent, e-rickshaw 15 percent, bus 2 percent and others 2.07 percent. On Marris Road two wheelers and cars have the greatest contribution in traffic flow. However, at Dodhpur it is found that two wheelers constituted 62 percent (bicycle 3.08%, motorcycle and scooters 59.35%), car 14.24 percent, e-rickshaw 18.08 percent and others 5 percent (animal drawn vehicles, truck, van, tractor etc.) of the total traffic. Two wheelers and e rickshaws are the most ubiquitous vehicles here. (Fig 1)

Traffic Flow Analysis

The traffic flow is greater at Marris Road as compared to at Dodhpur road. At Marris Road peak hour volume is 2269.353 pcu/hour observed in between 9.40am-10.40am. Marris road's connectivity with the Center Point, a major marketing area of Aligarh city, Ramghat road and railway junction is the main cause of greater traffic flow. At Dodhpur road peak hour volume is found to be 1803.6 pcu/hour between 9.20 am-10.20 am and it is mainly due to the vendors and regular shops attracting the major share of the traffic flow.

Composition of Road Side Friction

Fig 2 and 3 show, at Marris Road main components of the roadside friction are roadside parking, vendors, food stalls, squatters etc. occupying the footpath and allowing less space for pedestrian's movement resulted into the movement of pedestrians on the road or along the road causing hindrance to the flow. There are three schools located along this road but because of COVID 19 their contribution in hindering the flow is negligible due to the online. In normal time these schools cause considerable road side frictions.

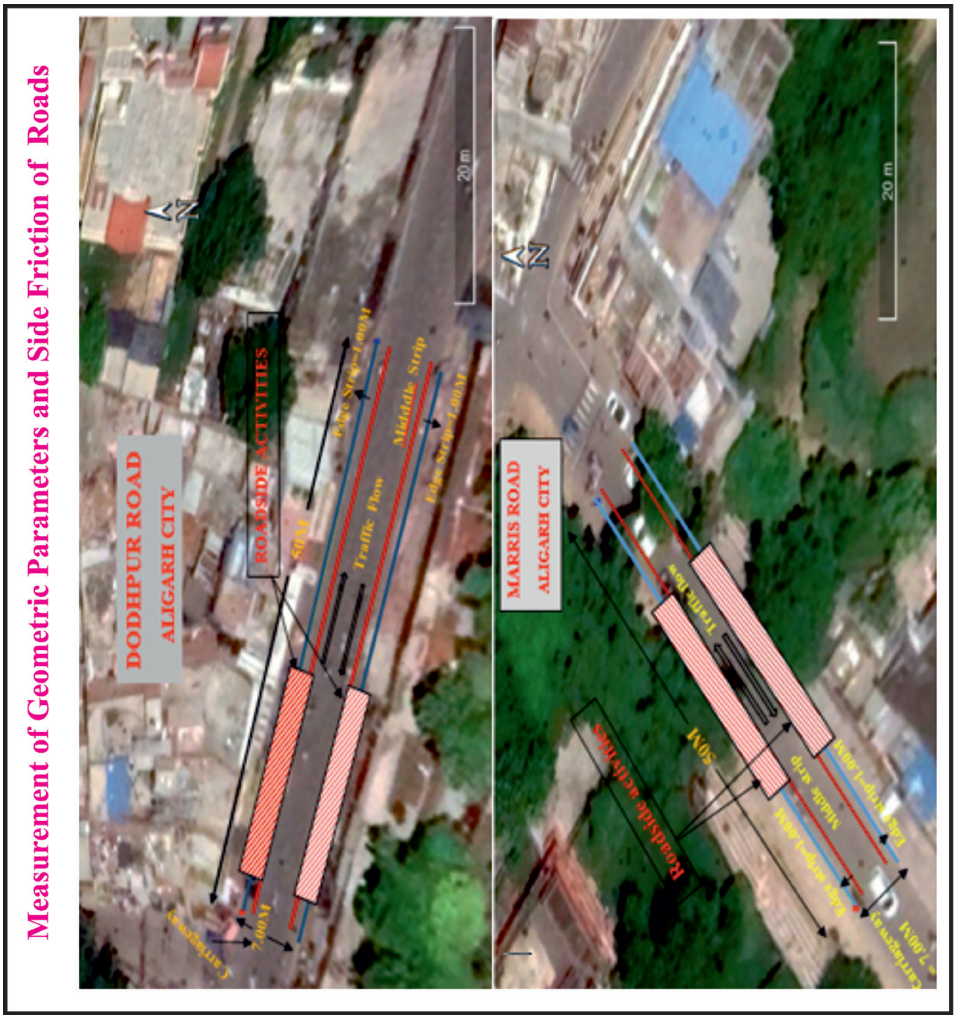

Measurement of Geometric Parameters and Side Friction of Roads
DODHPUR ROAD
ALIGARH CITY
ROADSIDE ACTIVITIES
50M
Traffic Flow
Middle Strip
20 m
N
MARRIS ROAD
ALIGARH CITY
Roadside activities
50M
Traffic Flow
Middle strip
20 m
N

Fig. 1

At Dodhpur road the roadside friction is mainly due to the presence of vendors compelling pedestrian movement along the road. The roadside parking has emerged as the second biggest factor causing the side friction on Dodhpur road as here no official legalized parking space is found. Squatter, begging and dumping also act as other sources of friction for the traffic flow on this road. Due to increasing rate of in migration and lack of suitable employment more people are turning up to the road side informal economy as vendors. Due to absence of the decent public transportation and traffic infrastructure, private ownership of vehicle is increasing but absence of proper parking facilities it is creating more road side frictions. Road side friction is greater at Dodhpur road as compared to at Marris Road. At Dodhpur road the peak hour for the roadside friction is between 9.45 am to 10.45 am. The frequency of roadside friction count is found as 110-116 per hour. Roadside vendors, Restaurants, and Market attracted the flow during this time. At Marris Road the frequency of roadside friction is found to increase and decrease alternately and being maximum between 10.35 am-11.35 am.

The frequency of friction is found to be 80-75 per hour as it is the time when restaurants, shops, banks, offices etc. located here and the vendors attract the flow causing road side parking and pedestrians' movement on the road. It is evident that the overall roadside friction during peak hour is less at Marris Road as compared to Dodhpur road. During the study it was found that the edge of the roads experienced more side friction as compared to the middle part of the road. Therefore, for the better results the sections of both roads under the study were divided into two portions, one meter edge strips on both sides of the carriage way and the remaining 5 meter and 5.2-meter middle strip for Marris and Dodhpur road respectively. **Table-**2, 3 and 4 shows a detailed analysis of the weighted factors assigned to the different types of side friction element found along the edge strips and the middle strips of Marris Road and Dodhpur road. di is distance of ith friction element from carriageway edge, A_i projected area of ith friction element, AR is area ratio, DR is distance ratio and PA is projected area. These calculated values are used to develop the road side friction index (RSFI) (**Fig.** 2 and 3). It is clearly indicated in **Table-**3 that RSFI is greater at Dodhpur road (3937) as compared to that of Marris Road (2564.4). Therefore, we can deduce that the encroachment of road by the road side friction activities is greater at Dodhpur road as compared to that of Marris Road.

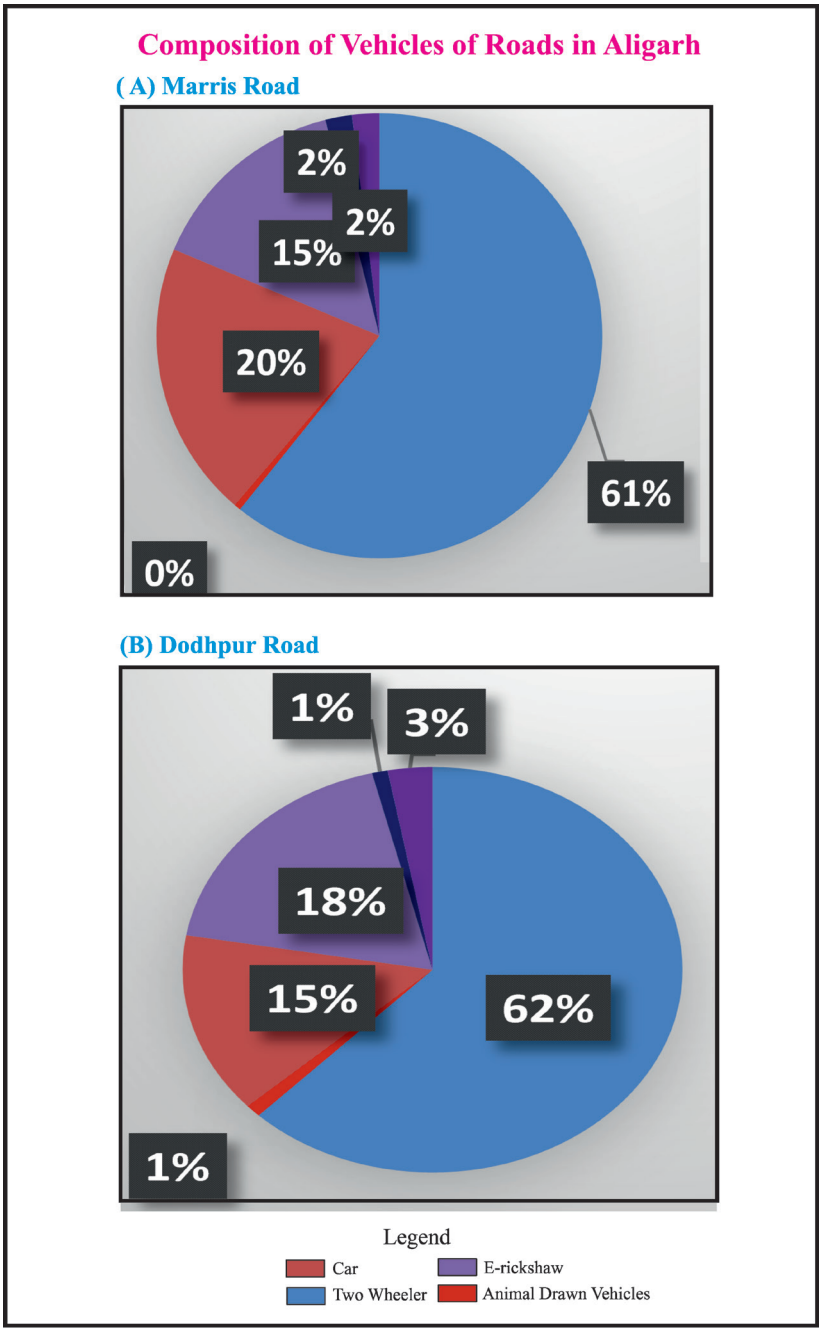

Composition of Vehicles of Roads in Aligarh
(A) Marris Road
2%
2%
15%
20%
61%
0%
(B) Dodhpur Road
1%
3%
18%
15%
62%
1%
Legend
Car
E-rickshaw
Two Wheeler
Animal Drawn Vehicles

Fig. 2

Roadside Friction Index

Table-2: Side Friction on Edge and Middle Strip of Marris and Dodhpur Roads

Friction Element Marris Road	PA (Projected Area)	Edge of Strip 1m			
		Distance of carriage width edge from strip midpoint (m)	AR (area ratio) Ai/Ap	DR (distance ratio) Di/Dp	AR + DR
Pedestrian	0.5	0.5	1	1	2
Roadside Parking	2	0.5	4	1	5
Vendor	1.2	0.5	2.4	1	3
Squatter	2	0.5	4	1	5
-	-	-	-	-	-
Middle strip = 5.00m					
Pedestrian	0.5	3.5	1	7	8
Roadside Parking	2	3.5	4	7	11
Vendor	1.2	3.5	2.4	7	9.4
Squatter	2	3.5	4	7	11
-	-	-	-	-	-
Friction element Dodhpur road					
Pedestrian	0.5	0.5	1	1	2
Roadside Parking	1.8	0.5	3.6	1	4.6
Vendor	1.5	0.5	3	1	4
Dumping	0.5	0.5	1	1	2
Begging	1	0.5	2	1	3
Middle strip = 5.20m					
Pedestrian	0.5	3.6	1	7.2	8.2
Roadside Parking	1.8	3.6	3.6	7.2	10.8
Vendor	1.5	3.6	3	7.2	10.2
Dumping	0.5	3.6	1	7.2	8.2
Begging	1	3.6	2	7.2	9.2

Source: Based on Survey (2021)

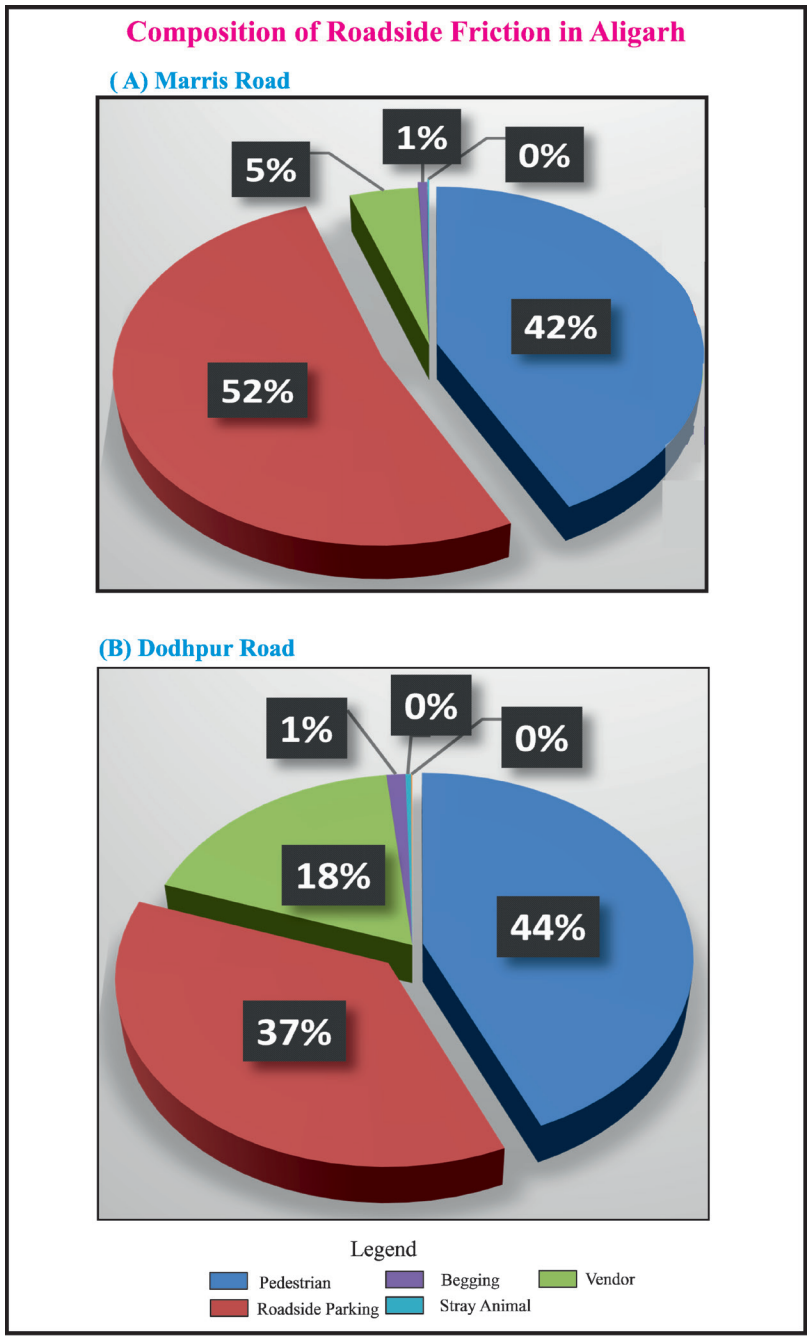

Composition of Roadside Friction in Aligarh
(A) Marris Road
1%
0%
5%
42%
52%
(B) Dodhpur Road
0%
1%
0%
18%
44%
37%
Legend
Pedestrian
Begging
Vendor
Roadside Parking
Stray Animal

Fig. 3

Table-3: Marris Road: Average Number of Friction Element

Time	Average number of Friction Element (Marris road)												Total
	Left edge strip				Middle Strip				Right edge strip				
	PD	RP	V	S	PD	RP	V	S	PD	RP	V	S	
Friction element	360	200	30	2	2	-	2	-	118	84	18		
Weightage factor	2	5	3	5	8	11	9.4	11	2	5	3	5	
RSFI	720	1000	90	10	16	-	18.8	-	236	420	54		2564.8

Source: Based on survey done by the researchers in 2021.

Table-4: Dodhpur Road: Average Number of Friction Element

Time	Average number of Friction Element (Dodhpur road)														Total
	Left edge strip					Middle Strip					Right edge strip				
	PD	RP	V	D	B	PD	RP	V	S	B	PD	RP	V	D	B	
Friction element	220	300	100	2	2	100	-	10	-	-	100	120	70	1	1	
Weightage factor	2	4	4	2	3	8.2	10.2	10.2	8.2	9.2	2	4	4	2	3	
RSFI	440	1200	400	4	6	820	-	102	-	-	200	480	280	2	3	3937

Source: Based on survey done by the researchers, 2021

Capacity Analysis

Adjustment Factors of Parameters of Capacity is given by (IHCM1993) and Actual Calculated capacity of Marris and Dodhpur Road (2021). It is clearly revealed that the actual capacity of Marris Road being 2680.05 pcu/ hour is greater than the actual capacity of Dodhpur road which is 2297.47pcu/hour. The base capacity at Marris Road is decreased from 2900pcu/hour to 2680.05 pcu/ hour and at Dodhpur road from 2900pcu/hour to 2297.24 pcu/hour due to high and very high levels of side friction respectively. **Table-**5 shows the reduction in capacity of both roads due to side friction. This finding is in conformity to other studies conducted in India and Indonesia (Sulistyono et.al. 2018). These studies highlight a reduction of capacity to the extent of 10-60 % due to different elements of side friction (**Table-**5).

Table-5: Capacity Reduction in Study Region

Location	RSFI	Base Capacity	Actual Capacity	% Reduction in Capacity due to side friction	% Reduction in Capacity including side curb
Marris Road	3679.2	2900	2680.05	10.76%	19.63%
Dodhpur Road	4960	2900	2297.47	20.78%	20.78%

Source: Based on Survey, 2021

Conclusion

The study reveals that the private vehicles have greater contribution in traffic flow (80%) on both the roads as compared to the public transport. The activities which cause main roadside friction (94%) at Marris Road is mainly by the roadside parking and the pedestrian movement making. The activities along Dodhpur road are mainly pedestrian movement roadside parking and vendors, comprising overall 99 percent of the total side friction activities. RSFI calculated to show the magnitude of roadside friction is found to be greater at Dodhpur road (4960) as compare to at Marris road (3679.2). The percentage reduction of the base capacity only due to side friction is greater at Dodhpur road as compared to at Marris Road, thus, it concludes that the roadside frictions have a greater impact on the capacity of road. The availability of the legalized parking area on both the roads, specified area for the hawkers and vendors, and footpath for pedestrian movement can drastically reduce the frequency of roadside friction. Installation of the intelligent traffic monitoring system, regulation on loading and unloading of the passengers by e-rickshaws, redesigning and readjustment of roads, construction of a roundabout at Dodhpur intersection are some of the actions which are required to be implemented on the priority basis.

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SPATIO-TEMPORAL DYNAMICS OF FLOOD SEVERITY USING MULTI-TEMPORAL SATELLITE DATA: A CASE STUDY OF KOSI FLOODS

Dr. Supriya and Dr. Shipra Soni

Abstract

Flood is a natural phenomenon and frequent disaster that occurs in the North Bihar Plain and causes damage to life and property almost every year. The main cause of floods in Bihar is usually known by people to be the shifting and slitting of rivers. The continuous silting has made the rivers shallow and losing their depth, so they are unable to face the forceful rain during the monsoons, which in turn results in breaking their banks and spreading water on the plains. Which is further reflected in the distinctive events like river course change and river capture in the flood plains of Bihar. Since floods increase each year, resulting in loss of life, property, and farm output, it is possible to use a generic approach as an estimate of flood damage. To mitigate flooding, spatial analysis is of paramount importance for the timescale and temporal characteristics of flood-affected areas. The Kosi River is one of the highly vulnerable to flood and is known for its frequent flooding, river course changes, and river-capturing events. The Kosi region faced a devastating flood on August 18, 2008, due to a breech at Kusaha village, which caused not even loss of property and lives but the change in the river course itself. Satellite imagining technology emerged as a powerful tool for the analysis of inundation areas and flood severity in the Kosi flood-prone basin during breech and flood. In order to better understand seasonal and yearly variations in the number of floods and to facilitate emergency response, this research provides an algorithm for mapping precipitation and flood inundation. Hence, the present study made an attempt to analyze the changes in rainfall and severity of flood using multi-spectral-temporal satellite data of the Kosi River basin for the 2008 Flood, Pre-flood (2007) and post-flood (2009) situations. The paper aims to describe thresholding and unsupervised classification methods to determine inundated areas, changes in persistent rainfall, and rising Kosi River water levels.

Introduction

Floods are the most widespread natural hazard that account for most damage and loss of life. They also can have serious secondary impacts on the economy and agriculture. Geographers have studied the complexity of such flood hazards for many years and have made significant contribution to their understanding. Flood is defined as any flow that exceeds the bank full capacity of a stream or channel and flows out of the floodplain, greater than bank full discharge. According to the World Meteorological Organization, a flood as a "(1) Rise, usually brief, in the water level in the stream to a peak from which the water recedes at a slower rate. (2) Relatively high flow as measured stage height or discharge. (3) Rising tide" (WMO, 1992). The magnitude of the floods and their probability of occurrence are strongly connected, although these relationships are regionally specific and depend on climatic conditions and characteristics of river catchment. On 18th August 2008, the eastern embankment of Kosi River was breached near Kusaha village, Nepal, about 12 km upstream of the barrage. At the time of breach, the river flow was below average, considering the same time-period in different years. The water inundated the adjoining villages of Kusha and Haripur (Nepal) immediately and reached Bhimnagar, Birpur (India) within a few hours. In Birpur, flood water rose alarmingly to a height of 5–6 ft within a short time after the breach. Subsequently, the flood water spread over a great extent covering Supaul, Saharsa, Madhepura, Araria and Purnea districts, causing severe damage to life and property.

In fact, after the 18th August breach, the Kosi River has altogether taken a new course, that of the 1930s, as reported by residents near Muraliganj. The Kosi River system is a monsoon-fed river system which has a long history of devastating floods in its lower catchment. After the 1954 floods in Nepal and Bihar, the flow of the Kosi River has been regulated by an embankment, constructed in 1963, on both sides of the river. The 2008 flood happened after breach of a levee on 18 August 2008 near Kusaha in Nepal, 12 km upstream on the eastern embankment of the river. The avulsion abandoned the current river course and the water followed an ancient channel midway through the alluvial fan. This led to inundation of a huge area, devastating the lives of millions of people (UNICEF Report 2008). Kosi River is considered as 'Sorrow of Bihar' since a long time due to its recurring and substantial flooding and repeated change in its course over the years. The change of river course has well documented in British rule. The river has changed its course in a westerly direction and it has laterally moved nearly 150 kilometers (Gole and Chitale, 1966; Wells and Dorr, 1987).

The movement of the river has not been gradual but of avulsive nature (sudden change in river course) originating from a nodal point (Wells and Dorr, 1987). The average avulsion frequency has been recorded as 24 years which is among the lowest in the world compared to 1400 years for the Mississippi river (Slingerland and Smith, 2004). Several paleochannels on the satellite image of the Kosi basin testify the migratory behavior of the river (**Fig. 1**). The river is typically braided in nature and has formed a very large alluvial fan due to a large sediment supply from the Himalaya and a generally aggregational regime. Further complications arise due to (a) very high rainfall in the catchment (1200- 2000 mm in most parts; Sinha and Friend, 1994), and (b) high seismicity in the hinterland causing landslides and large sediment production which eventually fill up the basin. The initial flood control schemes were introduced during late 19th century which included construction of marginal embankments, high dam at upstream section, river training in lower reaches and a series of barrages and canals. However, no consensus was reached and no definitive action could be taken until 1953. A very severe flood in 1953–54 and the subsequent social and political pressure led to the first serious attempts towards flood control the Kosi basin and the formulation of the 'Kosi project' in 1954. This project was primarily aimed at flood control and to provide irrigation for increasing agricultural productivity. The project started in 1959 and the river was diverted through the barrage in 1963. The embankments on both sides have been designed to protect nearly three thousand square kilometers of land in north Bihar and Nepal. Although the embankments have checked the lateral movements of the Kosi, the flooding problem continues in the Kosi basin and the objectives predicted in the Kosi project have been only partially met. Several large floods and frequent breaches in the embankments have continued to occur in the region. In addition, several adverse effects of the Kosi project have been noted viz. drainage congestion and water logging rise of river bed level, and reduction in crop productivity due to reduced silt flux on the floodplains (Ghani, 2001). In the view of above mention facts the present paper attempts to analyze the severity of 2008 Kosi flood and the spatio-temporal dynamics of flood severity of Kosi floods with pre (2007) and post (2009) flooding situation using multi temporal satellite data. It also examine the effectiveness of precipitation.

Study Region

The Himalayan terrain, the Kosi river is formed by the confluence of seven smaller streams, viz. Indravati, Sun Kosi, Tama Kosi, Likhu Kosi, Dudh Kosi, Arun Kosi and Tamar Kosi at different places in China, Tibet and Nepal,

before its entry into the Indian state of Bihar In India, the Kosi river merges with the mighty Ganges near Kursela village, Katihar District, Bihar. Kamla, Baghmati (Kareh) and Budhi Gandak are the major tributaries of Kosi in India, besides many minor tributaries like Bhutahi Balan. The mountain-fed Kosi River has a total basin area of nearly 84,739 sq.km of which only 11,842 sq.km lie within Indian Territory and spans a total length of 730 km from its source to the confluence with the Ganga at Baltara. (Gole and Chitale, 1966; Sinha and Friend, 1994). The Tibetan region of the Kosi basin comprises 22% of the total drainage area and is characterized by high elevation and flat plateau on the leeward side of the Himalaya with many glaciers and glacier lakes (Bajracharya et al., 2007). About 40% of the drainage area of the Kosi basin lies in the Nepal Himalaya and is characterized by alpine and mountainous areas.

The alluvial part of the Kosi basin in the Bihar plains in India comprises 38% of the total drainage area and comprises low elevation and flat plains with high population density (**Fig.** 1). The climate of this region is monsoon sub-tropical. The Kosi region or Kosi division is an administrative unit of Bihar comprising three districts i.e. Saharsa, Supaul and Madhepura. The present study is confined to assess the severity of deluge falling under this region. NASA's Shuttle Radar Topography Mission (SRTM) DEM (Digital Elevation Model) data shows that the topography of Kosi region ranges from 30 meters near the confluence in Ganga River to 89 meters near Kosi Barrage at Bihar – Nepal border.

Objectives

(1) To study interpolated precipitation map of three years i.e. 2007, 2008 and 2009 to understand the rainfall pattern of the study area.

(2) To assess side by side comparison of precipitation and flood intensity and to extract numerical values of the extent of flood in all three study years.

Database and Methodology

Climatic Research Unit (CRU) gridded Time Series data is used for preparing precipitation map. Flood inundation layer for each year was generated using ISRO's multi-temporal satellite datasets (2007 to 2009) comprising of either IRS WiFS (188 meters) / IRS P6 AWiFS (56 meters) / Radarsat ScanSAR Wide / Narrow (100 meters & 50 meters) acquired during the flood season of that particular calendar year are used. The Raster data of flood inundation was downloaded using compatible software and with the help of Kosi region vector data study area masked out.

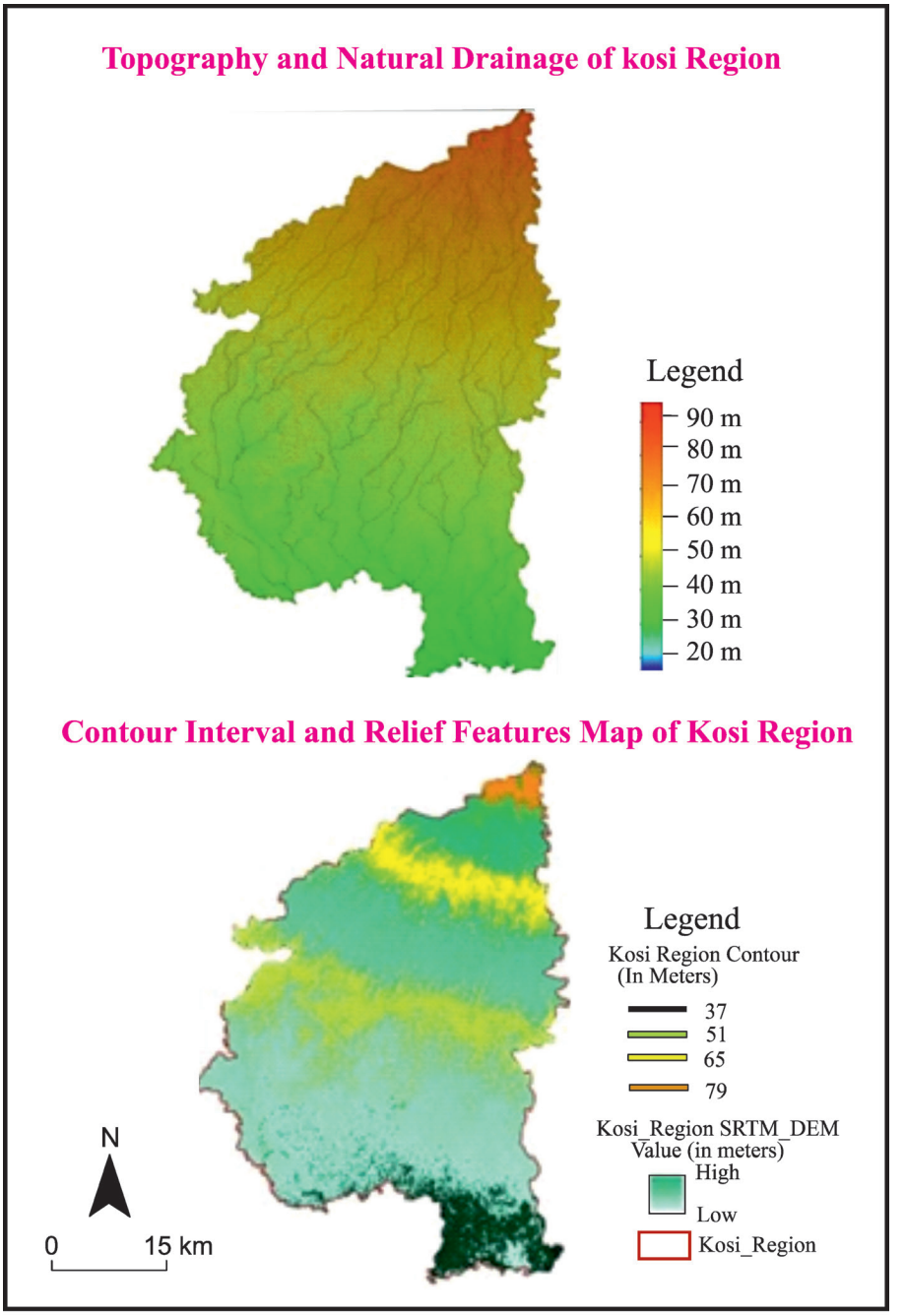

Topography and Natural Drainage of kosi Region
Legend
90 m
80 m
70 m
60 m
50 m
40 m
30 m
20 m
Contour Interval and Relief Features Map of Kosi Region
Legend
Kosi Region Contour
(In Meters)
37
51
65
79
Kosi_Region SRTM_DEM
Value (in meters)
High
Low
Kosi_Region
N
0
15 km

Fig. 1

The flood inundation layer for each year was delineated from satellite data by applying suitable classification technique. The precipitation map was prepared using the interpolation techniques in ArcMAP. Inverse Distance Weighted (IDW) was used to determine the temporal intensity of rainfall in Kosi region. Identification of flood prone area was done using the raster file in Global Mapper by using creating area feature using equal value tool in layer menu. The flood area vector layers were created and then smoothened using smoothing tool. The flood inundated area for each year was calculated and numerical values were noted in sq.km.

Results and Discussion

One of the main purposes of this study was to acquire interpolated precipitation map to understand spatio-temporal pattern of rainfall in Kosi region. The outcome of the rainfall pattern could be well understood (**Fig.** 1, 2 and 3 and **Table-**1, 2, 3 and 4.

Table-1: Changes in Rainfall in Kosi Basin

Rainfall (mm)	2007	2008	2009
Minimum	1220	1238	1114
Maximum	1664	1800	1547

Source: Computed by Authors

Table-2: Changes in Inundated Area of Kosi Region (2007)

Classified Area (2007)	Pixel Count	Area in sq. km	Area in percent
Uninundated area	5833621	5018.37	84.48050341
Inundated area	1071685	921.9	15.51949659
SUM of Area	6905306	5940.27	100

Source: Computed by Authors

Table-3: Changes in Inundated Area of Kosi Region (2008)

Classified Area (2008)	Pixel Count	Area in sq. km	Area in percent
Uninundated area	4868561	4188.17	70.50471
Inundated area	2036745	1752.1	29.49529
SUM of Area	6905306	5940.27	100

Source: Computed by Authors

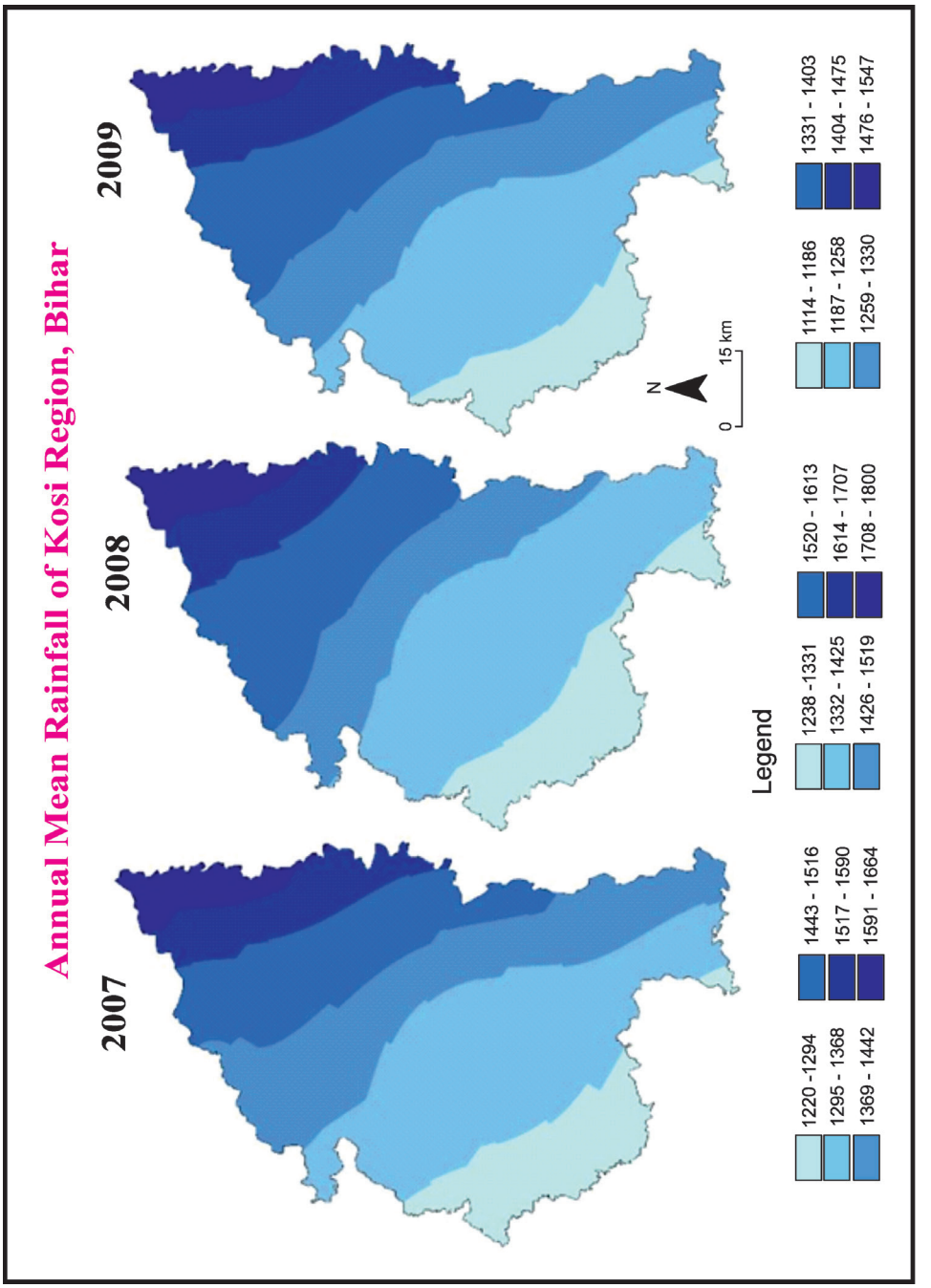

Annual Mean Rainfall of Kosi Region, Bihar
2007
2008
2009
N
0
15 km
Legend
1220 -1294
1295 - 1368
1369 - 1442
1443 - 1516
1517 - 1590
1591 - 1664
1238 -1331
1332 - 1425
1426 - 1519
1520 - 1613
1614 - 1707
1708 - 1800
1114 - 1186
1187 - 1258
1259 - 1330
1331 - 1403
1404 - 1475
1476 - 1547

Fig. 2

Table-4: Changes in Inundated Area of Kosi Region (2009)

Classified Area	Pixel Count	Area in sq. km	Area in percent
Uninundated area	6640423	5712.41	96.16414742
Inundated area	264883	227.86	3.835852579
SUM of Area	6905306	5940.27	100

Source: Computed by Authors

The flood inundation map for all three years was prepared using ISRO's Bhuvan raster data. These raster data contained ISRO's multi satellite sensors ranging from IRS series (WiFS, P6 AWiFS) to microwave satellite data from Radarsat satellites (ScanSAR Wide/ Narrow). The water levels observed at different gauge stations were closely monitored during floods and attempts were made to program the satellite data during peak/near peak positions. The next step was to create flood inundation layer using image processing classification algorithms, water layer was extracted from the satellite data and integrated with the pre-flood river and water bodies layer to derive flood inundation layer. Finally annual flood layer was created. The flood inundation layers generated for different flood waves in a calendar year were integrated to generate the maximum flood inundation extent observed in that year (Fig 1, 2 and 3). The second objective of this paper was to show the flood intensity and extract numerical values to know the extent of flood in study years (2007, 2008 and 2009). This can be analyzed in data obtained through raster data processing obtained from ISRO (**Table-**2, 3 and 4) while the manifestation of deluge could be observed in above processed maps. The processed data of 2007, a year before the famous 2008 flood shows the maximum extent of inundated area of Kosi region was nearly 922 sq kms which was approximately 15.6 percent of the total area under Kosi region. In 2008, the inundated area nearly doubled and in about 1752 sq kms. It accounts around thirty percent of the total Kosi region area. Finally in 2009 which was the post flood year, there was a drastic fall in flood inundation in Kosi region. The flood inundated area reduced to barely 228 sq kms which was less than four percent of total area of the Kosi region. It is also a major fact that 2009 was an El Niño year and it had lesser annual precipitation in comparison of both 2007 and 2008 as well.

Conclusion

In this paper, we have determined the variation of intensity in rainfall with the help of CRU grided time series data, and the spatio-temporal variation is represented

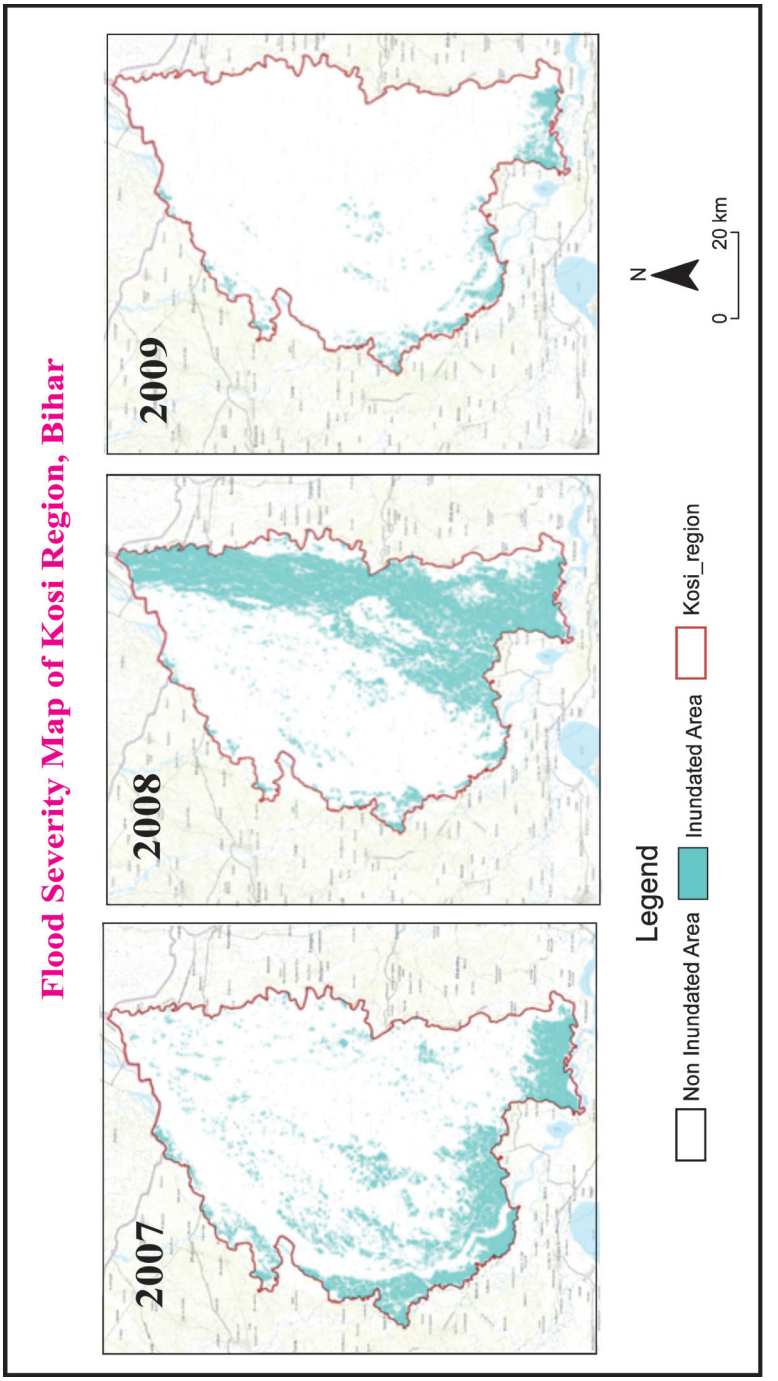

Flood Severity Map of Kosi Region, Bihar
2007
2008
2009
Legend
Non Inundated Area
Inundated Area
Kosi_region
N
0
20 km

Fig. 3

in the rainfall map prepared through ArcMap IDW tools. The result clearly reveals that in 2008, the upper plain of the Kosi River received a higher amount of average mean rainfall (1800mm) than in the post- and pre-flooding years. It was caused by the breach in the upper Kosi basin of Bihar, which helped raise the water level in the entire area and cause flooding. The study also reveals the changes in flood-prone areas with the help of the extraction of flood-inundated areas in Kosi River for the same time period through the analysis of multi-satellite data acquired from different sensors ranging from IRS series (WiFS, P6 AWiFS) to microwave satellite data and Radarsat satellites (Scan SAR Wide/Narrow) data and further converted in pixels to area in Global Mapper by using the Create Area feature. It reveals that approximately 30 percent of the total area was inundated due to floods in 2008; therefore, only 15.52 percent of the area in 2007 and 3.84 percent of the area in 2009 were submerged. It has clearly represented through the flood severity maps that in 2008, the eastward part of the study area was highly inundated, which was changed after 2008 flooding through the westward due to the main channel shifting towards the west and creating a very high flood hazard risk zone. Hence, the combined use of multi-temporal imagery and metrological data analysis achieves the objective of preparing flood severity maps for the study area. The spatio-temporal precipitation data, flood data, and processed maps can be used for the purposes of identification of annual precipitation effectiveness and rainfall pattern in Kosi region threshold area, identification of constantly flooded areas, regulate land use in the inundated areas and spotting safer flood relief shelters. In order to raise awareness among researchers and the scientific community, the possible importance of this research is to include these efforts as part of general flood management measures that do not include structural measures aimed at reducing short-term and longer-term damage. It is also a simple and cost-effective methodology for flood management and mitigation.

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GENDERED PERSPECTIVES OF MIGRATION TO GUJARAT: BEHIND THE NUMBERS

Dr. Harpreet Singh and Ms. Gauri Hanspal

Abstract

Migration is a complex phenomenon with profound implications for individuals and regions. This study explores migration to the state of Gujarat, India, shedding light on the gendered perspectives often overlooked in migration studies. Utilizing data from the Census of India 2011, the research analyzes the volume and patterns of in-migration, emphasizing the role of gender in shaping the demographic landscape of Gujarat. The introduction delineates the significance of migration, differentiating between internal and international migration based on administrative boundaries. It underscores the selectivity inherent in migration processes, driven by diverse factors such as age, marital status, education, gender, socio-economic status, and housing situation. Gujarat's status as a counter-magnet for individuals from economically constrained states is highlighted, with a focus on the megacity of Surat and other districts attracting migrants for varied opportunities. Maharashtra, Uttar Pradesh, and Rajasthan emerge as significant contributors to Gujarat's in-migrant population, playing pivotal roles in shaping migration dynamics. The study aims to uncover the nuanced narrative beneath migration statistics, emphasizing the often-overlooked role of gender. The spatial distribution of male and female in-migrants across different districts of Gujarat further reveals distinct patterns. Key findings highlight a notable gender imbalance in the in-migrant population, with higher female representation, particularly in rural areas. Maharashtra, Uttar Pradesh, and Rajasthan dominate in contributing in-migrants, emphasizing their pivotal roles. The study concludes by emphasizing the importance of considering gender-specific migration dynamics for informed policy interventions that address the diverse needs of both male and female migrants. This research contributes valuable insights for policymakers and scholars seeking a comprehensive understanding of migration dynamics, particularly the gendered perspectives, in the vibrant state of Gujarat.

Introduction

The movement of people within the boundaries of a country, is classified as internal migration whereas the process of movement of people away from national border, is called international migration(Rahul, 2022). The nature of migration process is selective. The selectivity is due to the differences between the individuals aspirations belonging to different groups. The most important differences are related to age, marital status, level of education, gender, socio-economic status, and housing situation. In case of migration selectivity is not only age based but also a gender based specific process(Khan et al., 2016). The role of gender, often relegated to the periphery in migration studies, is a crucial lens through which we can gain a deeper understanding of the social fabric woven by those who choose Gujarat as their destination. Gujarat, a crucible of cultural diversity and economic vibrancy, has become a magnet for individuals seeking opportunities, employment, and a new way of life. It has been reported in many studies that Gujarat is becoming the counter-magnet for the megacity like Mumbai, large number of migrants from the different states, like Rajasthan and Madhya Pradesh, Maharashtra, Chhattisgarh, Uttar Pradesh, Jharkhand, Bihar etc. where economic opportunities are rather limited (Shah and Dhak 2014) are attracted towards Gujarat. Also, the intra-state migration from less to more developed regions increased significantly as a result of increased connectivity and infrastructure within the state (Hirway et al., 2014). According to the census data on migration 2011, nearer to the half of the population of big cities composed of migrants including both the migrants from within the state and outside the state. Surat has the highest percentage of the internal migrants including both migrants from other states and from within the states. Ahmedabad is also one of the important city which attracts migrants. The major migrants sending states are Rajasthan, Uttar Pradesh and Maharashtra. The main reasons of migration that mentioned in the census are work employment and movement due to marriage (Half of the People in Gujarat's Big Cities Are Migrants | Ahmedabad News - Times of India, n.d.). Though there are large number of micro studies focusing on migration in Gujarat but less focus is on the gender-based migration study.

Objectives

The primary objective of this research is to unravel the often-overlooked gendered dimensions within the migration patterns to Gujarat. By delving into the dynamics of population movement, the study aims to shed light on how

gender influences and shapes the intricate narratives of migration. The study also intends to get information about the spatial analysis of migration across different districts in Gujarat.

Study Region

Gujarat is a state in India located on the western coast along the Arabian Sea. Gujarat is surrounded by the Indian states of Rajasthan to the north, Madhya Pradesh to the east, and Maharashtra to the southeast. It also shares international border with Pakistan in the northwest. Gujarat encircles the territory of Daman and Diu along with the Arabian Sea and shares a short portion of its southeast border with the Indian union territory of Dadra and Nagar Haveli. Gujarat has a 992-mile (1,596-kilometer) coastline. Gujarat is the ninth-most populous state, with a population of 60,439,692. The number of males is 31,491,260 and females is 28,948,432 according to the 2011 census data. The population density is 308 persons per square kilometre (800 persons/sq mi), lower than other Indian states. As per the census of 2011, the state has a sex ratio of 918 females for every 1000 males, one of the lowest (ranked 24) among the 29 states in India. In Gujarat, about three-fifths of the population lives in rural areas, however as urban areas have expanded, so the percentage of people living in rural areas has declined. The main concentration of population is in the eastern part of the state, in the plains surrounding the cities of Ahmadabad, Kheda, Vadodara, Surat, and Valsad; the region is both agriculturally productive and highly industrialized. There are also other population centres on the Kathiawar Peninsula, including on the southern shore between Mangrol and Mahuva, in the inland near Rajkot, and along the Gulf of Kachchh near Jamnagar. The population distribution rapidly declines towards the mountainous areas of eastern Gujarat and the northwest Kachchh district. The literacy rate of Gujarat is 79.31%. Gujarati is the official and primary language (Gujarat State Portal | All About Gujarat | Gujarat at a Glance, n.d.).

Database and Methodology

The present study is descriptive in nature. The study is based on the secondary sources of data. The census of India is the major source of information. The analysis of patterns of migration is based on the secondary source of data that is Census of India 2011. The data has been taken from the Migration Table (D series) of the census data and the place of last residence is taken into consideration for migration. Data based on the streams of migration like urban, rural and duration of migration have been carried out. The analysis and graphical representation of data has been done in excel.

Results and Discussions

Gender Disparity in the Volume of In-migrants to Gujarat

According to 2011 census, in total there are about 26.89 million migrants recorded in Gujarat as per their place of the last residence which forms nearly 45 percent of the total population of Gujarat. This all owing to the infrastructural and industrial development in Gujarat. Out of the total enumerated In-migrants i.e., 26,898,286 male in-migrants are 9,994,352 and female in-migrants are 16,903,934 females. In term of percentage males are 37 percent whereas females are 63 percent, suggesting a notable gender imbalance with a higher count of females. The In-migrants coming to rural and urban areas of Gujarat are 49 percent and 51 percent of the total In-migrants. Delving into the urban-rural breakdown, the total In-migrants enumerated in the rural area of Gujarat is 13,098,287, with 3,140,671 males and 9,957,616 females. In rural areas, the gender disparity leans towards females. In term of percentage the females are 76 percent of total migrants coming to rural areas. Conversely, the urban population of 13,799,999 exhibits a different pattern, with 6,853,681 males and 6,946,318 females. This indicates that urban areas attract a higher number of males. Males are dominated in all three basic industries like construction, textile and diamond industry the ratio of female workers is very less in these sectors (Hirway et al., 2014). These observations could be indicative of complex migration patterns, where males may be more inclined to migrate to urban centers for employment or other opportunities, leaving a higher proportion of females in rural settings.

The comprehensive analysis of in-migration patterns to the state of Gujarat delineates intriguing dynamics across various States and Union Territories (States/UTs). At the forefront, Maharashtra emerges as the primary contributor with 24.82% of the total in-migrant reported in the state of Gujarat, a substantial figure amounting to 971,975 individuals. Following closely by the state of Uttar Pradesh which contributes significantly with 23.73% in-migrants. The volume wise number is 929,411. According to a repot whenever a migrant from Uttar Pradesh visited their homes they bring their relative along with them to work in the textile industry the next important industry is diamond industry. Rajasthan, with 19.09%, constitutes another substantial share, which is 747,445 individuals enumerated in Gujarat. Migrants from the tribal areas of Rajasthan like Dungarpur and Banswara migrate to the state of Gujarat for work in constructional sites. Together, these three states form a significant portion, totaling 67.64% of the overall in-migrant population, indicating their pivotal roles as preferred origin place for those seeking

new opportunities, employment, and improved livelihoods. The main industries providing employment to migrants in Gujarat are construction industry, brick kiln industry, diamond cutting and polishing industry, textiles and power looms, and garments, engineering and electrical industries, domestic work, salt pan workers and other informal sectors(42 Lakh Migrants Have Made Gujarat Their Home | Ahmedabad News - Times of India, n.d.). Beyond these leading contributors, Bihar, Madhya Pradesh, Odisha, and West Bengal also play crucial roles in the intricate tapestry of in-migration, contributing to the overall diversity of population movement within the region. The other states are Bihar, Madhya Pradesh and Odisha. The odhiya workers are mainly engaged in the Surat power loom industries (Hirway et al., 2014). The complexity of these migration patterns underscores the interplay of diverse factors such as economic prospects, urbanization trends, and regional developmental disparities (**Fig.** 1 and **Table-**1).

Table-1: Gujarat: Percentage of In-migrants to Gujarat, 2011

State/UT's	Males	Females
Total In-Migrants	55.93	44.07
Maharashtra	46.34	53.66
Uttar Pradesh	64.61	35.39
Rajasthan	48.71	51.29
Bihar	70.28	29.72
Madhya Pradesh	49.37	50.63
Odisha	76.01	23.99
West Bengal	61.07	38.93
Jharkhand	77.33	22.67
Andhra Pradesh	50.91	49.09
Kerala	51.93	48.07
Remaining States/UT's	49.82	50.18

Source: Census of India, 2001

The analsis of in-migration patterns from States and Union Territories (States/UTs) reveals intriguing gender dynamics, showcasing variations in the male-to-female ratio among in-migrants. On an overall scale, in-migrants exhibit a slightly higher representation of males at 55.93%, compared to 44.07% females. Notably, Maharashtra demonstrates a gender distribution leaning toward females,

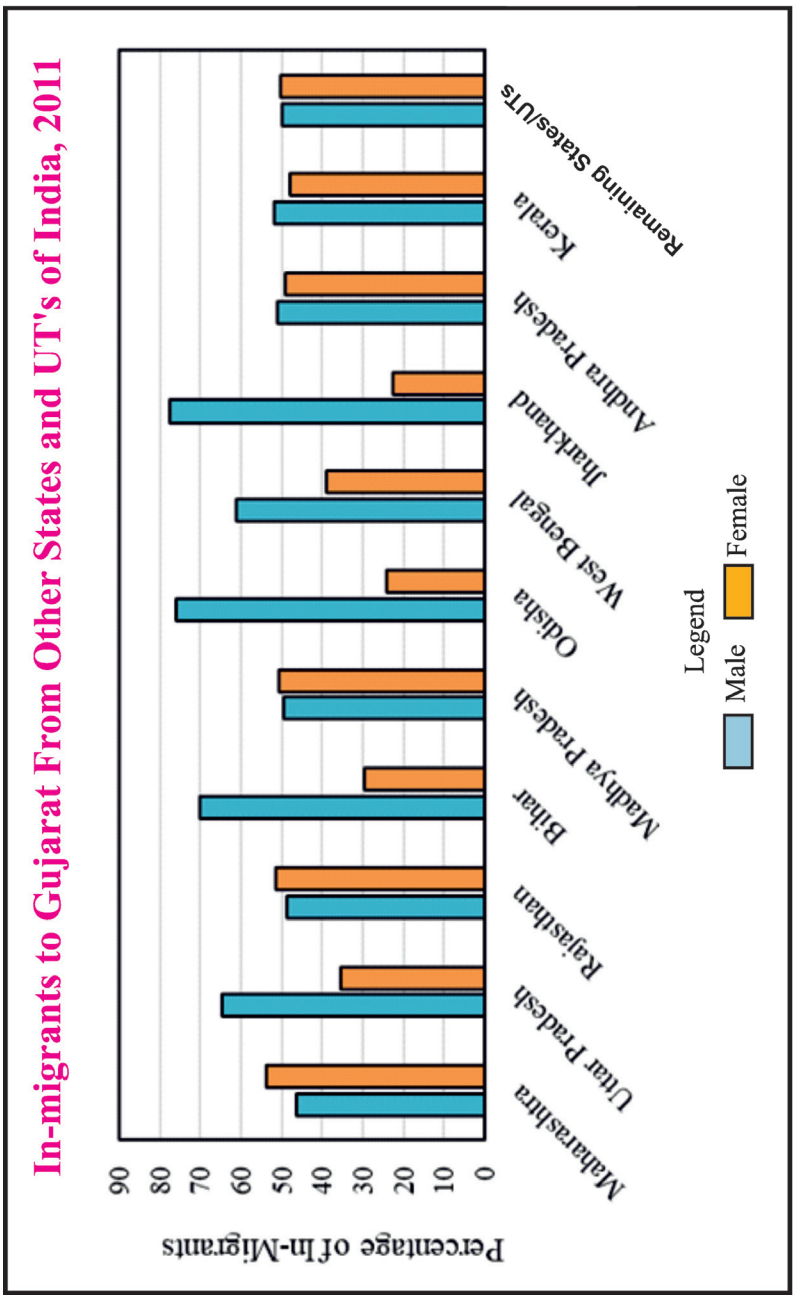

In-migrants to Gujarat From Other States and UT's of India, 2011
Percentage of In-Migrants
0
10
20
30
40
50
60
70
80
90
Maharashtra
Uttar Pradesh
Rajasthan
Bihar
Madhya Pradesh
Odisha
West Bengal
Jharkhand
Andhra Pradesh
Kerala
Remaining States/UTs
Legend
Male
Female

Fig. 1

with 53.66%, while Uttar Pradesh sees a higher male representation at 64.61%. Rajasthan maintains a relatively balanced ratio, with 51.29% females. Bihar presents a significant gender disparity, with 70.28% males dominating the in-migrant population. Madhya Pradesh shows a nearly equal distribution, with 50.63% females. Odisha exhibits a substantial male majority at 76.01%, contrasting sharply with Jharkhand, where females constitute 77.33% of the in-migrants. West Bengal displays a more balanced representation, with 38.93% females. Andhra Pradesh, Kerala, and the remaining States/UTs exhibit fairly equal gender distribution patterns, with minor variations. This nuanced analysis underscores the importance of considering gender-specific patterns in understanding in-migration dynamics, potentially influencing policy considerations related to healthcare, education, and social services catering to the diverse needs of both male and female in-migrants (**Table-**2).

The analysis of In-migration across all the districts of Gujarat provides insights into the gender distribution among in-migrants, revealing distinct patterns in various locales. From the **Table-**2, it is clearly seen that there is dominance of male in-migrants in case of more urbanized districts like Surat, Ahmedabad, and the main reason behind this is the availability of male oriented wok and employment. Surat, with a total of 10,60,934 in-migrants, exhibits a male-dominated influx with 63.99%, whereas females constitute 36.01% of the migrant population. In contrast, Ahmadabad sees a more balanced gender distribution, with 52.38% males and 47.62% females among the total 3,79,097 in-migrants. Vadodara displays a slight female majority at 51.73% among its 1,33,451 in-migrants. Valsad follows a similar trend, with 55.49% males and 44.51% females among its 1,33,422 in-migrants. "Golden Corridor" is the industrialized center of state formed by the districts of Valsad and Vadodara. These are the fastest growing cities in Gujarat, one can see the boom in constructional activities there, lot of construction happening in the real estate & major infrastructure projects are being undertaken by private as well as public sectors, the people migrated here to work in the constructional sites, these districts are also known for their textile and the diamond industry. The women workers didn't get jobs in the large and medium diamond polishing units. They tend to work in the low-profile jobs, in constructional works, cotton fields etc. In the less urbanized area we find the dominance of females the major reason behind this is the marriages (Hirway et al., 2014). Banas Kantha and Sabar Kantha, however, portray significant gender disparities, with a notably higher percentage of females at 76.39% and 75.9%, respectively. The highest gap between male and

Table-2: Gujarat: Spatial Pattern of In-migrants to Gujarat, 2011

Sr. No.	Districts	Total In-Migrants	Males In-Migrants (Percent)	Females In-Migrants (Percent)
1	Surat	10,60,934	63.99	36.01
2	Ahmadabad	3,79,097	52.38	47.62
3	Vadodara	1,33,451	48.27	51.73
4	Valsad	1,33,422	55.49	44.51
5	Kachchh	99,875	61.78	38.22
6	Rajkot	51,812	54.72	45.28
7	Navsari	46,899	53.39	46.61
8	Bharuch	49,637	57.13	42.87
9	Banas Kantha	16,782	23.61	76.39
10	Jamnagar	31,017	54.39	45.61
11	Sabar Kantha	13,696	24.1	75.9
12	Tapi	15,807	31.33	68.67
13	Gandhinagar	24,595	52.39	47.61
14	Bhavnagar	31,014	66.71	33.29
15	Dohad	6,000	15.68	84.32
16	Anand	17,416	48.46	51.54
17	Mahesana	15,237	49.23	50.77
18	Kheda	12,738	45.07	54.93
19	Junagadh	12,489	37.4	62.6
20	Panch Mahals	10,064	33.23	66.77
21	Narmada	5,489	45.92	54.08
22	Surendranagar	6,729	49.3	50.7
23	Amreli	6,595	41.84	58.16
24	Patan	4,258	21.23	78.77
25	The Dangs	1,649	48.61	51.39
26	Porbandar	3,510	41.76	58.24

Source: Census of India,2011

female migrants recorded in the districts of Dohad, Patan and Banas kantha. These all are the bordering districts and share close connection with the bordering states and linked by the social and cultural ties. Bharuch, Jamnagar, and Navsari maintain a more balanced gender distribution, reflecting the diverse patterns in migration. Bhavnagar, on the other hand, stands out with a substantial male majority at 66.71%. Districts like Dohad and Patan exhibit pronounced gender imbalances, with 84.32% and 78.77% females among their respective in-migrant populations.

Conclusion

In conclusion, the study illuminates the intricate dynamics of migration to Gujarat, with a specific focus on gendered perspectives. The state's economic vibrancy and cultural diversity have attracted a significant influx of migrants, both from within and outside its borders. The migration patterns highlight Gujarat as a counter-magnet for individuals from states with limited economic opportunities. Gender disparities in migration are evident, with a higher representation of females in the overall In-migrant population. Urban areas, particularly districts like Surat, witness a male-dominated influx due to the availability of male-oriented employment. Conversely, less urbanized districts, especially those bordering other states, exhibit a notable dominance of females, often driven by marriage-related migration. Maharashtra, Uttar Pradesh, and Rajasthan emerge as primary contributors to Gujarat's In-migrant population, collectively playing a pivotal role in shaping migration dynamics. Further research and targeted studies on gender-specific migration dynamics can provide deeper insights for more refined policy interventions in the future.

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BLOCK LEVEL DISPARITY OF HEALTH CARE FACILITY AND THE PERFORMANCE OF RURAL HEALTH CARE OF NORTH BENGAL, INDIA

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Abstract

Health is one of the determining factors that can expedite the process of social and economic development of the nation. The general health condition of the people of an area is indicative of the quality of the health care facilities available in that area. The present study strives to analyse different dimensions of health care facilities to find out the status of health care system of North Bengal, India and assess the performance of the rural health care units. To do so, Health Care Facility Index (HCFI) has been measured to appraise the overall health care condition of North Bengal. The analysis estimates the efficiency of the healthcare system at block level using data of census 2011, district statistical hand book 2014 and State Bureau of Health Intelligence, Govt. of WB 2016-2017. The English Bazar block of Malda district has shown the height HCFI and Goalpokhar-I of North Dinajpur shows the minimum level of HCFI. There is a substantial difference in performance between these two blocks, resulting from inadequate utilization of available health care resources. The study also identifies complementarities of private health care resources and the role of other factors, such as Health Care Institution Population Ratio (HCIPR), Bed Population Ratio (BPR), Doctor Population Ratio (DPR), Doctor Health Care Institution Ratio (DHCIR) and Bed Health Care Institution Ratio (BHCIR). The results suggest a need for better utilization of budgetary resources to increase health infrastructure and manpower to improve the quality of rural healthcare through training and better management of resources in order to overall performance of the rural healthcare systems in North Bengal.

Introduction

"Health is a condition of complete physical, mental, and social well-being, not only the absence of sickness or disability," (World Health Organization, 1948). This definition explains the significance of health, which is seen as a fundamental human right and a key indication of human growth. In recent years, there has been

renewed emphasis on efficiency in resource utilization in the healthcare sector. A number of studies have focused on the overall performance of the healthcare system and its impact on health outcomes (Murray & Frenk 1999; World Health Organization [WHO] 2000). Some notable studies, for instance, have concentrated on hospitals, nursing homes, Health Maintenance Organizations (HMOs) and district health authorities (Wang, (1999); Sankar & Kathuria 2004). India had made remarkable progress in the field of health. The first important initiative was made in 1943, by Health Survey and Development Committee Report and known as Bhore Committee (KPMG and ASSOCHAM, 2011). It was a detailed plan for healthcare in the country. The initiatives' list included the adoption of a National Health Policy in 1983, the 73rd and 74th Constitutional Amendments devolving power to local institutions in 1992, the National Nutrition Policy in 1993, the National Policy on Indian System of Medicine and Homeopathy and Drug Policy in 2002, introduction of a first health insurance schemes for poor people in 2003 and the inclusion of health in the Common Minimum Program of Government in 2004.

In order to improve the National Health System of India it is therefore necessary to evaluate and assess the health services in terms of quantity, quality, cost and sustainability (Capolongo et al. 2016b, 2015a). Moreover, most important aspects is the adjusting service delivery structures to meet the health needs of the population in terms of quantities and modalities of networked, affordable and sustainable evidence based services (Buffoli et al. 2015) and modernizing outdated structures. Currently India has 0.6 beds every 1,000 inhabitants. This scenario is worsened by the scarcity of architectures for health and support staff that leads to have 50% of beds in the public health sector and 30% in the private one not utilized totally. Nevertheless, the situation has, however, slightly improved by NRHM, founded by 85% the Union and the remaining 15% by the states, which aims to bring its action in rural areas strategic, engaging more than 800,000 workers paid according to the performances Capolongo S, B. M. (2015a). The public health is mainly guaranteed by primary levels, with differences between rural and urban areas; in urban areas there is a double level system: a Basic Health Post for few thousand inhabitants and a Health Centre Urban, or Urban Family Welfare Centre, for 100,000 people attached with a general hospital. Instead, in rural areas there is a triple level system: a Sub-Centre for 5,000 inhabitants manages by two professionals (a man and a woman); a Primary Health Care Centre for 30,000 people with medical and paramedical staffs; a Primary Hospital with 30 beds per 100,000 inhabitants and some basic specializations (WHO, India 2012). The last cases include primary care services, which mean that they are specialized, mainly, in vaccinations,

prevention of malnutrition, pregnancies, postnatal care and treatment of common diseases. The public health infrastructure in West Bengal area is wide covering even in the remotest villages. As HOPE Annual NGO Report reported, there are 9 Medical College Hospitals, 16 District Hospitals, 45 Sub divisional Hospitals, 346 Community Health Centers, 922 Primary Health Centers and 10.356 Sub-Centers across West Bengal (HOPE, 2014). More recent data, by Ministry of Health and Family Welfare, estimate that there is a rise in health Infrastructure: 13,186 Sub-Centers, 2,166 Primary Health Center and 541 Community Health Center. However, the level of welfare seems to be very poor in the entire region (Ministry of Health and Family Welfare, 2015). The healthcare system has a primary healthcare network, a secondary care system comprising district and sub□divisional hospitals and tertiary hospitals providing specialty and super specialty care. Each of the nineteen districts is coordinated by a Chief Medical Officer of Health (CMOH), together with Deputy and Assistant CMOHs, whose responsibility is to manage the primary health care and to ensure the effective implementation of the various medical, health and family welfare programs (Rebecchi, 2018).

The secondary level hospitals are managed by medically trained Superintendents, who directly report to the CMOH, all the useful information and take part into a hospital management committee. In addition, there is the Block Medical Officer, who is responsible for providing services, monitoring and supervising the primary health centres and health program implementation. The third level hospital is referred by two levels before; its specialist care needs to be identified and then patients can be directed to specialized departments. West Bengal Health Service provides the health care professionals for the state wide infrastructure, while Medical Education Service employs teachers at the training institutions (Office of the Registrar General and Census Commissioner, 2011). In general, the community based primary healthcare services have been formulated with the objective of bringing an overall improvement in the urban health scenario in West Bengal; 62 urban local bodies have completed training of honorary health workers. Ministry of Health and Family Welfare of the Government of West Bengal is responsible for healthcare administration in the region. The program budget for two years (2020-2021) was around ₹11,280 crore (US$1.4 billion, Ministry of Health &Family Welfare, West Bengal, 2022). The current study aims to examine the health-care facility system in the North Bengal districts of West Bengal on a block wise to see the disparity among the block in terms of health care facility and their performance.

Objectives

(1) To determine the block wise disparities in health care facilities in all Districts of North Bengal.

(2) To assess the block wise performance of Rural Health Care Facilities of North Bengal.

Study Region

North Bengal is a region located in the northern part of the Indian state of West Bengal. It is renowned for its breath-taking natural beauty, varied flora and wildlife, and extensive cultural history. The region is bounded by the lofty Eastern Himalayas in the north, and it shares its borders with countries like Nepal, Bhutan, and Bangladesh. The study area extends from approximately 24°40'20"N to 27°13'N latitude and 87°45'50"E to 89°53'E longitude. North Bengal consists of eight districts, namely Cooch Behar, Alipurduar, Jalpaiguri, Kalimpong, Darjeeling, Uttar Dinajpur, Dakshin Dinajpur, and Malda. It is characterized by a division into two distinct geographical zones. The northern part is classified as the Sub-Himalayan Zone, while the southern part is composed of sediment and debris brought by rivers descending from the slopes of the Himalayas. Consequently, except for the northern fringe, the entire region consists of plains. Numerous rivers, including the Teesta, Torsha, Jaldhaka, Raidak, Sankosh, Mahananda, Punarbhaba, Atrai, and Kulik, drain the study area. The climate in the study area is characterized by hot, humid conditions and heavy rainfall, although the northern hilly areas experience a cooler climate. The region is also home to diverse species of fauna and flora. This region is characterized by its diverse physical and socio-cultural aspects, displaying notable variations in economic and human development across the districts. It covers an area of 21,855 square kilometres, which accounts for 24.62% of the state's geographical area. According to the 2011 census total population of the region were 17291050, which were 18.83% of the state's total population, with a higher concentration of Scheduled Caste (SC) and Scheduled Tribe (ST) populations, as well as a significant influx of immigrants. The region has a total of 462 healthcare institutions with 13949 beds and 1628 registered doctor's facilities only, which is not sufficient to cater to the present population.

Materials and Methods

The present study is fully based on secondary database, gleaned from District level Census report, 2011, State Bureau of Health Intelligence,

Govt. of WB 2016-2017 and District Statistical Handbooks, 2014 of eight districts i.e., Alipurduar, Cooch Behar, Darjeeling, Jalpaiguri, Kalimpong, Malda, North and South Dinajpur of North Bengal. In order to compute the Health Care Facility Index, block level total population, numbers of health care institutions (both public and private), total number of beds and total number of doctors have been collected for total 69 blocks of North Bengal region. All the Hospitals including Rural Hospitals, Block Primary Health Centres (BPHC), Primary Health Centres (PHC), other clinical Departments of Govt. of West Bengal including State Govt. Undertakings, Local Bodies, and Govt. of India including Central Govt. undertaking, N.G.O. / Private Bodies (Nursing Homes) have been considered as Health Care Institutions (HCI). Total number of beds and total number of Doctors of each C. D. Blocks have been collected from District Statistical Handbooks of Eight Selected District, 2014 (Census, 2011; District Statistical Handbooks, 2014). The Health Care Facility Index (HCFI) is a combination of five selected dimensions. These dimensions have been calculated on the basis of above-mentioned data for each block it includes – Health Care Institution Population Ratio (HCIPR), Bed Population Ratio (BPR), Doctor Population Ratio (DPR), Doctor Health Care Institution Ratio (DHCIR) and Bed Health Care Institution Ratio (BHCIR). The HCIPR dimension/indicator is used to find out the number of health care institutions to serve one lakh population in the region. Bed Population Ratio or BPR is used to measure the number of beds available per 10000 populations in the study area. On the other hand, the Doctor Population Ratio or DPR helps to indicate the number of doctors per one lakh population in the region. The DHCIR dimension/indicator is used to find out the number of doctors per health care institution and the last dimension i.e., Bed Health Care Institution Ratio or BHCIR is used to measure the number of beds per health care institution in the study area. The following formulas have been incorporated to measure the above-mentioned dimensions/indicators for health care facility system-

$$HCIPR = \frac{Health\,Care\,Institution\,(HCI) \times 1,00,000}{Total\,Population} \tag{1}$$

$$BPR = \frac{Number\,of\,\,Beds\,in\,HCI \times 10,000}{Total\,Population} \tag{2}$$

$$DPR = \frac{Number\,of\,\,Doctors\,in\,HCI \times 1,00,000}{Total\,Population} \tag{3}$$

$$DHCIR = \frac{Number\ of\ Doctors\ in\ HCIs}{Number\ of\ HCIs} \quad (4)$$

$$BHCIR = \frac{Number\ of\ Beds\ in\ HCIs}{Number\ of\ HCIs} \quad (5)$$

After calculating the ratio of the five variables the values of each indicator are first normalized to an index value of 0 to 1, using Dimension Index formula. With the actual value for a given block, and the overall maximum and minimum, the dimension (indices) value for each metric is calculated as:

$$HFCI = \frac{A_i - m_i}{M_i - m_i}$$

Where,

d_i = Dimension index of ith dimension,

A_i = Actual Value of ith dimension,

M_i = Maximum value of ith dimension and

m_i = Minimum value of ith dimension.

Now, in order to measure the Health Care Facility Index for each block of North Bengal the composite index has been calculated using the five mentioned indicators. The formula used in the UNDP Goal Post technique uses minimum and maximum values that have been specified. However, in this technique, we have taken into account the observed minimum and maximum values for each dimension. According to Goel and Sharma (2017), the dimension's value (*di*) is between *0* and *1*. The success of the C.D. Blocks/Municipal Corporation is predicted to be higher in the i^{th} dimension by a high dimensional value (*di*). Considering all the five dimensions, i^{th} C. D. Block can be represented by a point (d_1, d_2, d_3) in three-dimensional Cartesian space like $0 \leq d_1, d_2, d_3 \leq 1$. In the three-dimensional Cartesian space, the point '*0*' would indicate the worst condition whereas '*1*' would indicate the ideal or perfect condition. HCFI is measured by the normalized inverse Euclidean distance of the point (d_1, d_2, d_3) from the best or perfect point.

$$HFCI = 1 - \sqrt{\frac{(1-d_1)^2 + (1-d_2)^2 + (1-d_3)^2 \ldots}{5}}$$

The value of HCFI ranges from '*0*' to '*1*'. The value '0' indicates the worst health care facilities system and '*1*' indicates the Perfect health care facilities. On the basis of the HCFI values, the C. D. Blocks of North Bengal region are classified into three categories. The range $0.5<HCFI\leq1$ indicates 'High' or 'Very Good' health care facility system; $0.2<HCFI\leq0.5$ indicates 'Moderate' health care facility system and $0<HCFI\leq0.2$ 'Low' or 'Poor' health quality facility system.

Result and Discussion

Health Care Institution Population Ratio (HCIPR): The population serviced by a single healthcare facility in the research area is determined using this dimension. In this dimension, Matigara C.D. Block of Darjeeling District is in the best position, while Goalpokhar-I of North Dinajpur District is in the worst. Bed Population Ratio (BPR): The bed population ratio is used to calculate how many beds are available for every 10,000 people. In North Bengal region, the greatest BPR is found in the Kurseong block of Darjeeling District, while the lowest BPR is observed in Goalpokhar-I of North Dinajpur District (**Table-**1).

Table-1: Health Care Facility Dimensions of North Bengal

Dimensions	Goalposts of the Dimensions			
	Maximum Value		Minimum Value	
Health Care Institution Population Ratio (HCIPR)	10.17	Matigara	0.61	Goalpokhar I
Bed Population Ratio (BPR)	40.50	Kurseong	1.23	Goalpokhar I
Doctor Population Ratio (DPR)	55.61	English Bazar	0.99	Itahar
Doctor Health Care Institution Ratio (DHCIR)	9.54	English Bazar	0.25	Rangli Rangliot
Bed Health Care Institution Ratio (BHCIR)	78.25	Darjeeling Pulbazar	8.00	Tufanganj II

Sources: (1) District Statistical Handbooks, 2014, Census, 2011;

(2) Computed by the Authors

Doctor Population Ratio: The number of doctors per lakh of people in the study region is indicated by this dimension. According to the Planning Commission of India's 2011 report, the doctor population ratio should be 1 doctor per 1000 people (**Fig.** 1). However, in North Bengal as a whole, none of the blocks can reach this crucial DPR threshold. The lowest DPR is found in Itahar block of

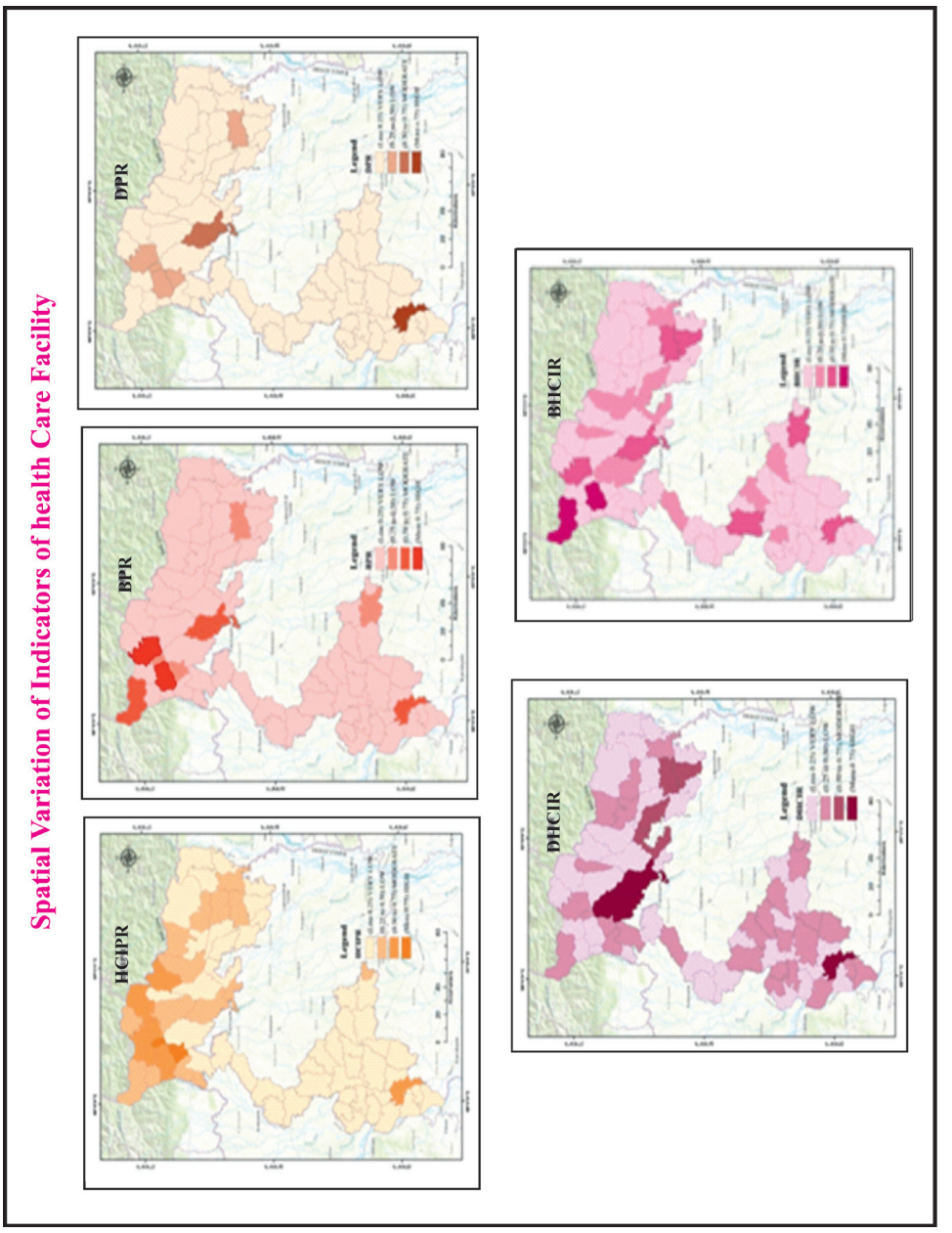

Spatial Variation of Indicators of health Care Facility
DPR
BPR
HGIPR
BHCIR
DHCIR

Fig. 1

North Dinajpur District, while the highest DPR is observed in English Bazar block of Maldah District (**Fig.** 1).

Doctor Health Care Institution Ratio: To determine the number of doctors per healthcare facility in the study area, this dimension is used. After analysing the dataset, it is observed that Rangli Rangliot block of Darjeeling District has the poorest DHICR conditions in the entire North Bengal, whereas English Bazar C.D. block of Maldah District has the maximum number of doctors per institution.

Bed Health Care Institution Ratio: In the study area, this dimension is used to calculate the average number of beds per healthcare facility. The more beds in a hospital means the better for the local people and shows the better healthcare facilities. Tufanganj II in Cooch Behar District has the minimum number of beds per institution whereas Pulbazar in Darjeeling District has the maximum number of beds per institution.

Health Care Institution Population Ratio: This indicates Health Care Institution Population Ratio which is one of the five main indicators of the Health Care Index. Based on the ratio of the HCIPR it is observed that Matigara block of Darjeeling district is in the top with index value 1 and Goalpokhar-I of North Dinajpur district has the lowest index value of 0. Based on the index values all the blocks have been categorized in four parts. Very low having the index value of 0 to 0.25, low 0.25 to 0.50, moderate 0.50 to 0.75 and last one is high more than 0.75 value. The map revels out of the total 68 blocks 46 blocks are comes under very low category which is 67.64 percent of the total block of the entire region all the blocks of Uttar Dinajpur and Dakshin Dinajpur. Low HCIPR has been recorded in 15 blocks out of 69 and it consists of 22.06 percent. Rest 7 blocks has been recorded as moderate HCIPR which comprise 10.29 percent of the total blocks and out of the 7 blocks 5 are from Darjeeling district which shows that Darjeeling district has the good health care institution as per their total population. High HCIPR is recorded in Matigara block which is again in the Darjeeling District. So, the map indicates that with in the north Bengal part out of the 8 district only Darjeeling district has the proper population and health care Institution ration, the main reason behind is that the biggest city of the north Bengal Siliguri. Siliguri has a quit large number of the private health care institution as the population is high of the city and the hinterland of the city also huge. There is few private super-speciality Hospital also functioning.

Bed Population Ratio: The bed population ratio is used to calculate how many beds are available for every 10,000 people. In North Bengal region, the greatest

BPR in the Kurseong Block of Darjeeling District, while the lowest BPR is observed in Goalpokhar-I block of the North Dinajpur District. The BPR ratio has been normalized based on the dimension index prescribed by UN in the HDI index. All the dimension index values of the BPR is categorized in four parts. Very low index value having less than 0.25, low (0.25 to 0.50), Moderate (0.50 to 0.75) and High more than 0.75 index value. The maps revels that out of the 68 blocks of North Bengal 61 come under very low BPR index which comprises 89.70 percent of the total blocks. Rest 10 percent are from the three different categories. Balurghat block of South Dinajpur, Cooch Behar- I block of Cooch Behar District and Matigara block of Darjeeling district shows low BPR index which comprises 4.41 percent of the total number of the blocks. Moderate BPR index has been found English Bazar block of Malda District, Jalpaiguri Sadar of Jalpaiguri District and Pulbazar block of Darjeeling district. All the six blocks are very close to their district town and some blocks surrounded the district town because of that the BPR index is much higher from the other blocks. Kalimpong Block of newly formed Kalimpong district and Kurseong block of Darjeeling district has the highest value in terms of the BPR index and both fall under the high BPR.

Doctor Population Ratio: The number of doctors per lakh of people in the study region is indicated by this dimension. According to the Planning Commission of India's 2011 report, the doctor population ratio should be 1 doctor per 1000 people. However, in North Bengal as a whole, none of the blocks can reach this crucial BPR threshold. The highest DPR in North Dinajpur District is in Itahar block, while the lowest DPR is in English Bazar in Malda District. From the map of DPR it is observed that 62 blocks out of 69 blocks of North Bengal is under very low (<0.25) category which is comprise 91.17 percent of the total blocks. Only four blocks fall under low (0.25-0.50) category. Jalpaiguri Sadar block of Jalpaiguri district comes under moderate DPR and English Bazar block of Malda district has the high DPR in the entire North Bengal which shows the actual condition of the health care facility.

Doctor Health Care Institution Ratio: To determine the number of doctors per healthcare facility in the study area, this dimension is used. After analysing the dataset, we have discovered that Rangli Rangliot in Darjeeling District has the poorest conditions in North Bengal, whereas English Bazar C.D. Block in Maldah District has the maximum number of doctors per institution. DHCIR ratio again used for the dimension reduction and the values of the dimension index has been categorized in four categories similar to the other dimension as very low, low, moderate and high with the same value rage of the index value to compare with the other indicators and

based on the dimension index value the map has 0 been prepared. Bed Health Care Institution Ratio (BHCIR): In the study area, this dimension is used to calculate the average number of beds per healthcare facility. The more beds a hospital has, the better off the local healthcare facilities are. Tufanganj II in Cooch Behar District has the lowest Bed per health care institution while Pulbazar in Darjeeling District has the highest beds per health care institution (**Fig.** 2).

The map revels that 35 blocks out of the 69 blocks of North Bengal have fall under the category of very low index (<0.25) which indicates 51.47 percent. 27 blocks out of the 68 blocks of the North Bengal are comes under the low (0.25-0.50) category as per the dimension index which comprise 39.70 percent and Moderate DHCIR is observed only in four blocks and all the four blocks are from Cooch Behar District. High (>0.75) DHCIR has been observed only in the rest 3 blocks out of the three 2 from Jalpaiguri District and one from Malda District. From the calculated ratio of the bed per health care also go through the process of the dimension reduction using the dimension index to compare with the other dimension of the health care facilities and the dimension index has been categorized in to the four category, very low (<0.25), low (0.25-0.50), moderate (0.5-0.75) and high (>0.75). Best on the dimension index value the map has been prepared. From the map it is observed that very low index has been found among 50 blocks out of the 69 blocks which comprises 73.53 percent of the blocks. Ten blocks out of 68 have fall under low BHCIR index which comprise 14.70 percent of the total blocks. Moderate BHCIR index is observed in the 8 blocks and only Pulbazar block of Darjeeling district has the highest number of beds per health care institution The above map (**Fig.** 2) indicates the healthcare facility of North Bengal. Similar to the other indices health care facility also categorised into four categories based on the index value which various from 0 to 1. Out of 69 blocks 52 blocks have shown the very low health care facility (less than 0.25) which is 75.36 percent of the total blocks of North Bengal. After calculating the district level health care as a whole it shows the worse condition in Malda and Uttar Dinajpur district are really in a very poor condition followed by the Dakshin Dinajpur and Darjeeling district has the better health care facility among the eight districts of North Bengal followed by Jalpaiguri and Cooch Behar. Low health care facility (0.25 to 0.50) has been observed among the 15 blocks out of 69 which comprises 21.73 percent of overall blocks. Out of the 15 blocks 5 blocks from Cooch Behar which is one third of the total, 3 block from Darjeeling, 2 each from Alipurduar and Dakshin Dinajpur. There is not a single block from Malda district in the low health care facility.

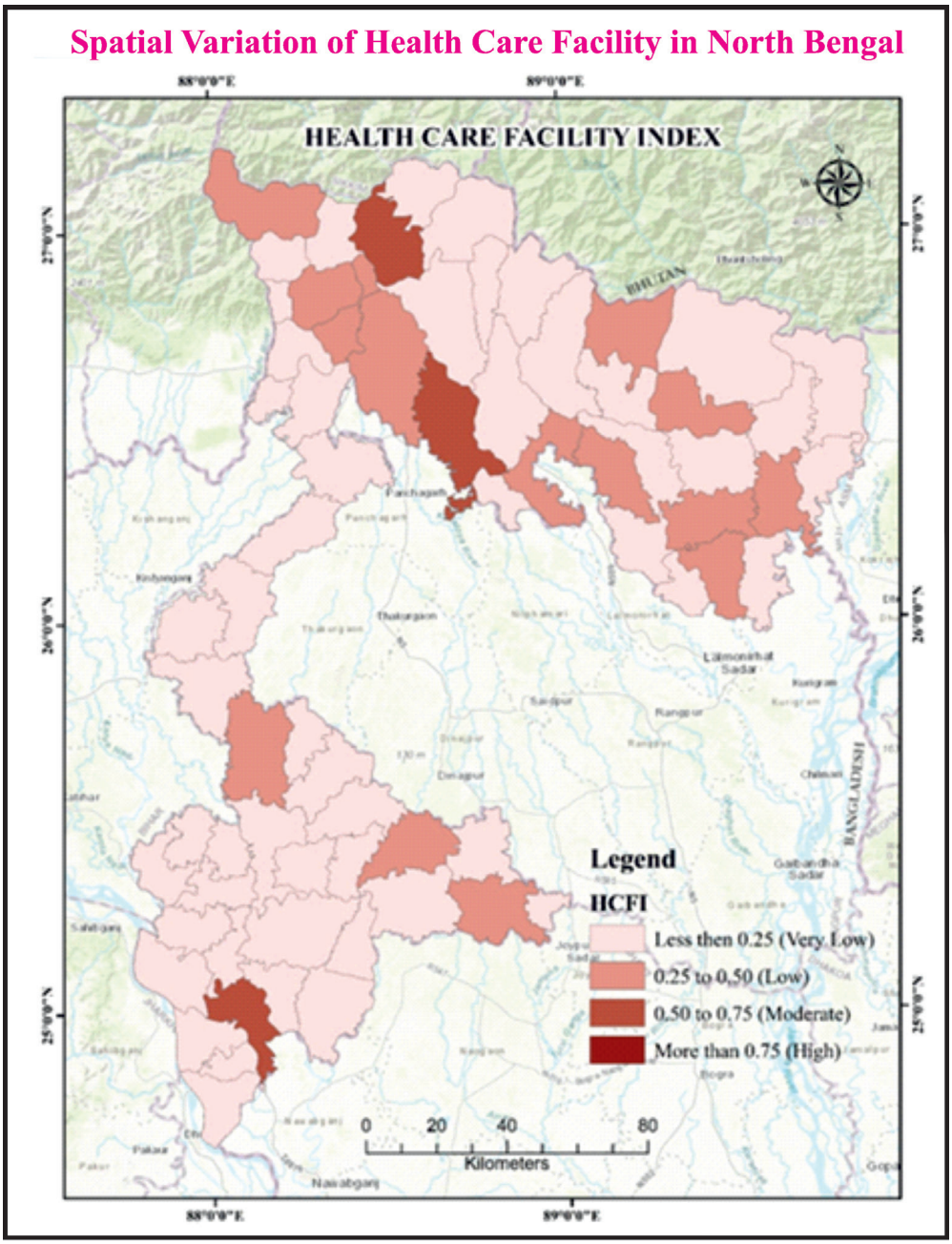

Spatial Variation of Health Care Facility in North Bengal
HEALTH CARE FACILITY INDEX
BHUTAN
BANGLADESH
Legend
HCFI
Less then 0.25 (Very Low)
0.25 to 0.50 (Low)
0.50 to 0.75 (Moderate)
More than 0.75 (High)
0 20 40 80
Kilometers

Fig. 2

Only 3 blocks out of the 69 blocks of North Bengal are fall under the moderate health care facilities (0.50 to 0.75) which comprises 4.34 percent. These three blocks are from three districts, Kalimpong I (0.54) block from Kalimpong district, Jalpaiguri Sadar Block (0.59) of Jalpaiguri district and English Bazar (0.65) of Malda District are under this category. There is no single block has found with high health care facility with more than 0.75 index value which show the real face of the health care facility of the region (**Table-**2).

Table-2: Dimension for the Performance of Rural Health Care Unit in North Bengal.

Dimensions	Goalposts of the Dimensions			
	Maximum Value		Minimum Value	
Bed Turn- Over Rate (BTR)	690.2	Kaliachak-III	13.9	Rangli Rangliot
Bed Occupancy Rate % (BOR)	460.5	Raiganj	6.1	Tapan
Average Length of Stay (ALS)	5.7	Falakata	0.2	Harirampur
% of Deliveries to Admission	47.2	Kaliachack-I	3.7	Alipurduar-II
Emergency Admission Rate %	139.4	Karandighi	0.1	Madarihat
% Of Imaging and Electro Medical Tests Total of IPD & OPD	5.6	Kurseong	0	In most of the block do not have the facility
% Of Laboratory Test to Total IPD & OPD	287	Madarihat	0	In most of the block do not have the facility
% Of Patient Referred Out to Total Discharge Patient	87.1	Falakata	6	Chanchal-II

Source: State Bureau of Health Intelligence, Govt. of WB 2016-2017

Performance of Rural Health Care Units

There are several ways for the assessment of the performance of the health care facilities but in the study simply few parameters have been taken into consideration which is given by the government in their report. For assessing the health care facility here Bed Turn over rate, Bed Occupancy Rate, Average length of stay in hospital, outpatient per day, percentage of deliveries to admission, percentage of emergency admission, percentage of imaging and electro medical test, percentage of laboratory test, and percentage of patient referred to the other hospital these

nine parameters has been taken into consideration. The information related to the performance of rural health care facilities have stated. Bed Turn Over rate (BTR) is maximum in Kaliachak-III (690.2) block of Malda District and Minimum in Rangli Rangliot Block (13.9) in Darjeeling District which indicates the number of patients treated per bed in the specific year (2016-2017) is maximum in Kaliachak-III as compare to the other block of North Bengal. The Bed Turnover Rate is a measure of productivity of Hospital beds. Out of the eight districts of North Bengal, Malda (318.65) is in the 1st rank in BTR followed by Jalpaiguri (168.66) and North Dinajpur (157.42) and lowest BTR is observed by the Kalimpong district (20.63) as Kalimpong is a newly formed district with low population and a smaller number of rural hospital and other health care facilities. Hospital Bed Occupancy Rate means the number of beds occupied for the treatment of the patient divided by the total number of beds over a specific year multiplied by 100. So, in terms of the BOR Rajganj block (460.5) of Jalpaiguri district is in the first rank followed by Nagrakata (445.5) of same district, Kaliachak-III (267.1) and Manikchak (243.1) of Malda district which indicates the patients pressure is very high in these blocks whereas Tapan (6.1), and Banshihari (8.9) block of South Dinajpur show the very low Bed Occupancy Rate as the health care facility is not good of these block so they prefer to go other hospital and the number of bed and hospital in this block also very few in number.

Average length of stay in hospital is another important parameter to assess the performance of health care facility. Average length of stay is mainly depended on the facility and care provided by the health care unit like number of beds, availability of doctors and admission facility and more over to deal with little complicated illness. Average length of stay is maximum in Falakata block (5.7) of Alipurduar district followed by Kalimpong-I and Gorubathan block of Kalimpong district and minimum length of stay in hospital has been observed in Harirampur block (0.2) of South Dinajpur. Percentage of the patient taken admission of delivery is one om the other important parameters of the study. It is observed that Kaliachak-I block of Malda district has the highest percentage of admission related to delivery (47.2%) followed by Chopra (43.9%), Raiganj (41.50%) block of North Dinajpur district (Appendix-3). Although the health care facility of these blocks are not good as these blocks fall under very low health care facility (**Fig.** 2) but due to population pressure the admission percentage is high. On the other hand, Kalimpong-II and Garubathan block has the lowest percentage of admission related to delivery. District wise Malda is in the height rank followed by North Dinajpur main reason behind it

as per the 2011 census birth rate and growth rate of population in high in these two districts of North Bengal. Similarly in terms of the emergency admission in health centre is maximum in these two districts. Karandighi block of North Dinajpur is high in terms of emergency admission in hospital followed by Harischandrapur-I and Raiganj block and minimum percentage of emergency admission has reported in Madarihat block (0.1%) followed by Cooch Behar-I block. Percentage of Imaging and Electro Medical tests are very low in all the blocks of North Bengal, in Alipurduar district only Falakata has reported 0.6% of imaging and eletro medical test and rest other blocks hospital do not have this kind of facilities. Similarly in Cooch Behar, North Dinajpur and South Dinajpur district reported one hospital each with this kind of facility. So the study shows that imaging and electro medical test is not much available in the rural hospital of north Bengal for this service people has to depend on the district of subdivisional hospital. Percentage of Laboratory test also shows the similar type of result but as compare to the imaging and electro medical tests laboratory test is quite higher. Percentage of laboratory test is maximum in Madarihat block of Alipurduar district as Madarihat block hospital is the only hospital in the entire block so the pressure is huge and on the other hand Cooch Behar-II block is nearer to the district hospital so most of the people goes to district hospital than the rural block hospital so it recorded the minimum laboratory test and there are so many blocks shows zero value which mean the imaging and laboratory test facility is not there in those blocks. Percentage of patient refer to the other hospital to discharge patient indicates that height refer percentage is found in Kalimpong district followed by Alipurduar district and lowest refer rate is observed in Malda district. Kalimpong -II and Garubathan has the maximum percentage of refer to the other hospital, the main reason to refer the patient is lack of medical facility in these blocks as per the health care facility map (map3) shows that both the block fall under the very poor category in terms of health care facility.

Conclusion

This paper has attempted to show the health facilities and challenges in North Bengal where the problem of providing effective health care services to the majority of its citizens has become an impossible task. Rural health services which form the backbone of public health system, is lacking in basic infrastructure, staff and essential medicines. The sufficient manpower is an important prerequisite for the efficient functioning of the Rural Health Infrastructure. Health indicators are very poor and the poor face financial ruin if visited by a serious health event. India is committed to the goal ‘health for all’ and in the last four decades, a wide network

of primary health centres and sub-centres has been created. Yet most of the states including West Bengal are far away from this goal. One of the fundamental metrics for assessing a society's well-being is the availability of health care. The health care system in North Bengal has been evaluated in this study by measuring several aspects of healthcare services. Each Block's Health Care Facility Index (HCFI) rating reflects the state of the healthcare facilities there as well as their location within the district. The average HCFI score for North Bengal is 0.19, which suggests that the majority of Districts have modest to subpar health care services. The HCFI of North Bengal, on the other hand, has a standard deviation value of 0.14, indicating that all Districts have moderately good health care services. Among all districts of North Bengal, the mean value is highest in Bed Health Care Institution Ratio, 23.38 whereas Health Care Institution Population Ratio and Doctor Health Care Institution Ratio is lowest like 2.81 and 2.87.

The number of beds in health care institutions per 10000 populations is not better numbered in all districts of North Bengal with 7.32/10000 population. The average Doctor Population Ratio is 8.03 in all Districts per one lakh population is not better in North Bengal. But at present, medical facility offered by Darjeeling is no match for its past glory. Since Darjeeling is the district headquarter Sadar or District Hospital is located here. However, the condition of these 308 bedded hospitals needs much improvement. Now hospital offers quality services to the resident of Darjeeling and their surroundings. As the regional headquarters of the Jalpaiguri district, the city of Jalpaiguri has a prominent position in North Bengal. The nearby population in the region often flocks to the city to get proper health care services. This position is amplified by the systemic industrial development of the district and rapid influx of people who needs proportionate medical care. Healthcare Facilities in Cooch Behar is quite effective with number of hospitals, path-labs, chemist shops and allied medical services. The citizens of the city enjoy well administered and well provided health services. Healthcare facilities in Cooch Behar are at par with other metro cities of West Bengal. But the problem of the health care facility in north Bengal is it mainly concentrated in the district town or particular in the blocks which are nearer to the main tow. The main problem is for the people who stayed in the blocks which is far from the district town so they could not access the medical facility due to their locational disadvantage for that parity should be there to improve the infrastructure for all the block hospital instant of concentrating a particular hospital or health centre. Although the government has taken initiation to improve the rural health care by

National Rural Health Mission which contribute a lot but it is not sufficient. Since the development of a region's health care facilities is intimately related to the wellness of that society, the government may seek for a strategy to raise the standard of those facilities from the ground up. Apart from economic condition, the social hierarchy or the system of social stratification existing in the society of West Bengal is likely to influence the health behaviour of individuals. Social stratification system determines the living conditions, privileges, obligations and cultural traditions surrounding the life of a person which in turn affect his perceptions regarding health, knowledge of health care and accessibility to health resources (SNM Kopparty, 1994). Who is responsible for this dilapidated health structure of North Bengal? This question echoes in the panorama of the broken health structure of the North Bengal.

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CROP REGIONS IN TUNGABHADRA RIVER BASIN IN KURNOOL DISTRICT, ANDHARA PRADESH

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Abstract

The current study focuses on the regionalization of crops in the Tungabhadra River basin of Kurnool District. The basin is characterized by a rural population, and agriculture serves as the primary source of livelihood for the inhabitants due to the lack of an industrial base. Traditional and subsistence agricultural practices have been prevalent in the basin for a long time. The basin consists of 45% block cotton soil and 30% red soil. Primarily farmers are cultivating this area like commercial crops, particularly cotton and groundnut, along with food grains such as bengal gram, red gram, fruits, and vegetables. The choice of crops grown in the basin during an agricultural year is greatly influenced by physiographic, climatic, soil, and socio-economic conditions, as well as the people's are following traditional agricultural practices. As a result, specific crop regions have emerged in the basin. The study also examines the spatial variation at the mandal level in terms of temporal change, using data from two periods: 2009–10 and 2019–20. This paper aims to calculate and delineate crop regions based on a ranking method.

Introduction

The Tungabhadra River basin is located in the western part of the Kurnool district; it is characterized by its unique agricultural landscape. More than 75% of the region comprises Pedi plains, with 45% of the soil being cotton-rich block soils and 35 % of being red soils due to its geological connection to granite and gneisses. The primary mode of agriculture in this region is rain-fed, and agriculture stands as the predominant land use. Over 70% of the population relies on agriculture for their livelihoods. However, the agricultural system here is primarily based on traditional practices and operates at a subsistence level due to the limited availability of irrigation facilities and the prevalence of marginal and small landholdings. A significant portion of the working population is engaged in agricultural labor. In this particular context, the examination of crop regionalization assumes a crucial role in evaluating the arrangement and

distribution of crops across the basin. The concept of crop regionalization holds integral and significant within the realm of agricultural geography. Krishnakumari has expressed the view that the identification and demarcation of crop regions are immensely beneficial in the context of regional agricultural planning, particularly in optimizing crop cultivation. Agricultural regionalization holds a long-standing position in the field of agricultural classification and plays a crucial role in the planning and advancement of agriculture in developing nations. It serves as a tool to group together various agricultural phenomena, both apparent and hidden, across the Earth's surface. This tool allows geographers to partition an area into multiple regions based on the diversity found within the agricultural system. Moreover, it provides valuable insights into the spatial distribution of crops at a regional level (Dayalan, 2018). Therefore, a systematic investigation of agricultural regions based on crop associations is imperative for geographers as an initial step towards comprehensively understanding the Agricultural geography of the region. Ultimately, this aids in the planning and development of crops at a regional level. The objective of the present study is to identify the major crop regions in the Tungabhadra River basin of Kurnool district. The ranking method was employed to delineate the crop regions into primary (first rank), secondary (second rank), and tertiary (third rank) categories. The first three crops, regardless of their percentage of occupation were selected for the purpose of crop regionalization analysis. Given that the basin falls within a semi-arid climatic zone, effective planning is a great significance, and the present study sheds light on this aspect.

Study Region

The study area of the Tungabhadra River basin is in the north-western region of the Kurnool district in the state of Andhra Pradesh, India. It lies between North Latitude 15°15'00" to 16°'00" and East Longitude 77°0'0" to 78°15'00". The area falls within the Survey of India (SOI) Toposheet Nos. 57E/1 to 57E/16 and 57I/1 to 57I/5. The total area of the basin is 6,934 square kilometers. The basin consists of 30 mandals, with 21 mandals fully covered and the remaining 9 mandals partially covered. The basin receives an average annual rainfall of 670 mm and experiences temperatures ranging from 26°C to 46°C in the summer and 12°C to 31°C in the winter. The northwestern portion, which includes Adoni, Peddakadubur, Alur, Aspari, Chippagiri, Halaharvi, Holagunda, Pathikonda, Devanakonda, Krishnagiri, Veldurthy, Kodumur, and Kallur mandals, has a desolate appearance with vegetation mostly limited to small pockets of reserve forests. This portion of the basin covers an area of 41,712 hectares, which accounts for 4.46% of the total geographical area.

The terrain in this region slopes from south to north and is drained by the river Hundri, which joins the river Tungabhadra at Kurnool. The soils in the northwestern parts traversed by the river Hundri are black cotton, while the southeastern parts are predominantly pure red soils. Geologically, the basin is underlain by the crystalline rock of the Peninsular Gneissic Complex (PGC), which includes the granite gneisses and granite in the western and southern parts of the basin.

Objectives

(1) To identify and demarcate the crop regions, such as First, Second, and Third ranking crop regions, of the Tungabhadra River Basin for the years 2009–10 and 2018–19.

(2) To study the changes in crop regions during a 10-year period.

Data and Methodology

The current study has collected secondary data from the Chief Planning Officer (C.P.O.), Handbook of Statistics, Kurnool district, focusing on the general cropping pattern for two specific time periods: 2009–10 and 2019–20. The data has been collected at the 'Mandal' level, ensuring a comprehensive analysis. The data has been analyzed using basic statistical techniques such as percentages and averages. The objective of the study is to investigate the spatial patterns of crops that are ranked from first to third in terms of the percentage of the total cropped area, with a specific focus on First, second, and third crop regions. The first-order crop regions, which are those with the highest ranking, have been identified by considering the crops that contribute the highest percentage to the total cropped area in each of the component area units, regardless of their overall percentage. Similarly, second-order and third-order crop regions have been delineated based on their ranking in terms of percentage. In order to accomplish the objectives of the study, the percentages of different crops cultivated in the basin have been calculated and organized in descending order to define the crop regions.

Results and Discussions

First ranking crop regions or first order crop regions (2009-10)

Out of the 30 mandals, 11 mandals have groundnut as first-order crops, 10 mandals have bengal gram as first-order crop, 5 mandals have cotton as first-order crop, 2 mandals have red gram as first-order crop, 1 mandal has paddy as first-order crop, and one mandal has fruits and vegetables as first-order crops.

Groundnut and Bengal gram Region

Groundnut is the leading crop cultivated in the basin, with its cultivation spread across 11 mandals. The favorable environmental conditions in the basin have proven to be advantageous for the growth of groundnut, particularly on light mixed red and block soils. The distribution of groundnut cultivation is predominantly concentrated in the southern and central regions of the basin. It is the basin's second-largest crop cultivated as the first-ranking crop, next only to groundnut. Within the basin, it holds the top position in 10 mandals, namely Kurnool, Kallur, Orvakal, Kodumur, Gudur, Nanikotukur, Miduthur, Alur, Aspari, and Maddikera. The distribution of these mandals is predominantly concentrated in the northeastern and southwestern parts of the basin.

Cotton, Red gram Region

Cotton is the third most significant first-ranking crop cultivated in 5 mandals, namely Adoni, Kowthalam, Nandavaram, Mantralayam, and Holagunda. These mandals are primarily concentrated in the northwestern region of the basin. Red gram crop farming was limited to only 2 mandals, namely Bethamcherla and J. Bunglow.

Paddy and Fruits and vegetable Region

These are too tiny in their extent, as they comprise of 1 mandal each, i.e., paddy in Pagidayala mandal and fruits and vegetable crops in C. Belagal mandal.

First ranking crop regions or first order crop regions (2019-20)

In the year 2019–20, a total of 5 crops were observed in the primary crop regions, each with varying degrees of prominence. Among these regions, the cotton crop region stood out as the largest primary crop region, with 16 mandals. Followed by the Bengal gram region with 5 mandals, the red gram region with 4 mandals, the maize region with 3 mandals, and finally, the groundnut region with 2 mandals.

Groundnut, Bengal Gram and Cotton Region

As a first-ranking crop region, the groundnut crop is registered in two mandals, respectively, Krishnagiri and Tuggali mandals. Bengal Gram region is the 2nd largest first ranking crop region in Tungabhadra River basin during 2019–20, occupying five mandals located in a few mandals in the north-east and western mandals of the basin. The cotton crop is the dominant primary crop region among all other crops, and it was the first-ranking crop in 16 mandals.

It emerged as the largest crop region in the study area during 2019–20. Their concentration is high in the western, northern, and central mandals of the basin.

Red Gram and Maize Region

4 mandals, namely Dhone, Bethamcherla, Veldurty, and Peapully, are noticed as the first-ranking crop regions, with the red gram crop in the study area. The maize region is a newly formed primary crop region during the period 2019–20, replacing Bengalgram, paddy, and red gram crops. The region has been found in three mandals, such as Nandikotukur, Pagidayala, and J.Bunglow, which are located in the north-eastern part of the basin.

Changes in First Ranking Crop Regions (2009-10 to 2019-20)

Significant changes have occurred in the primary crop regions of the basin over a period of ten years. In the year 2009–10, six primary crop regions were registered, namely groundnut, bengal gram, cotton, red gram, paddy, and fruits and vegetables. Even after ten years, groundnut, Bengal gram, cotton, and red gram remained as primary crop regions. However, the crop regions of paddy and fruits and vegetables disappeared in 2019–20. A new crop region, maize, was recorded during this period. Other changes include an increase in the number of mandals (administrative divisions) in the cotton crop region (+11 mandals) and red gram (+2 mandals). On the other hand, there was a decrease in the number of mandals in the groundnut (-9 mandals), Bengal gram (-5 mandals), paddy (-1 mandal), and fruit and vegetable (-1 mandal) crop regions. Additionally, a new region for maize emerged, consisting of 3 mandals that were previously part of the Bengal gram, paddy, and red gram crop regions. (**Fig.** 1 and **Table-**1).

Second Ranking Crop Regions or Second Order Crop Regions (2009-10)

The second ranking of crops comprises a greater number of crops compared to the first ranking of crops. In the year 2009–10, a total of 10 crops were classified as second-ranking crops. Among these, Castor held the highest position with 8 mandals of the basin. These are located in the north-western and southern parts of the basin. Next in importance among the second ranking of crops is groundnut. It is extended to only 6 mandals, namely Kodumur, C. Belagal,Bethamcherla,Adoni, Aspari, and Maddikera. Bengal gram is the third-important second-ranking crop cultivated in 5 mandals. They are J. Bunglow,Kowthalam, Nanavaram, Holagunda, and Pattikonda. The sunflower crop is the fourth important crop grown in 3 mandals located in the north-central part of the basin. They are in Kallur, Gudur, and Gonegandla.

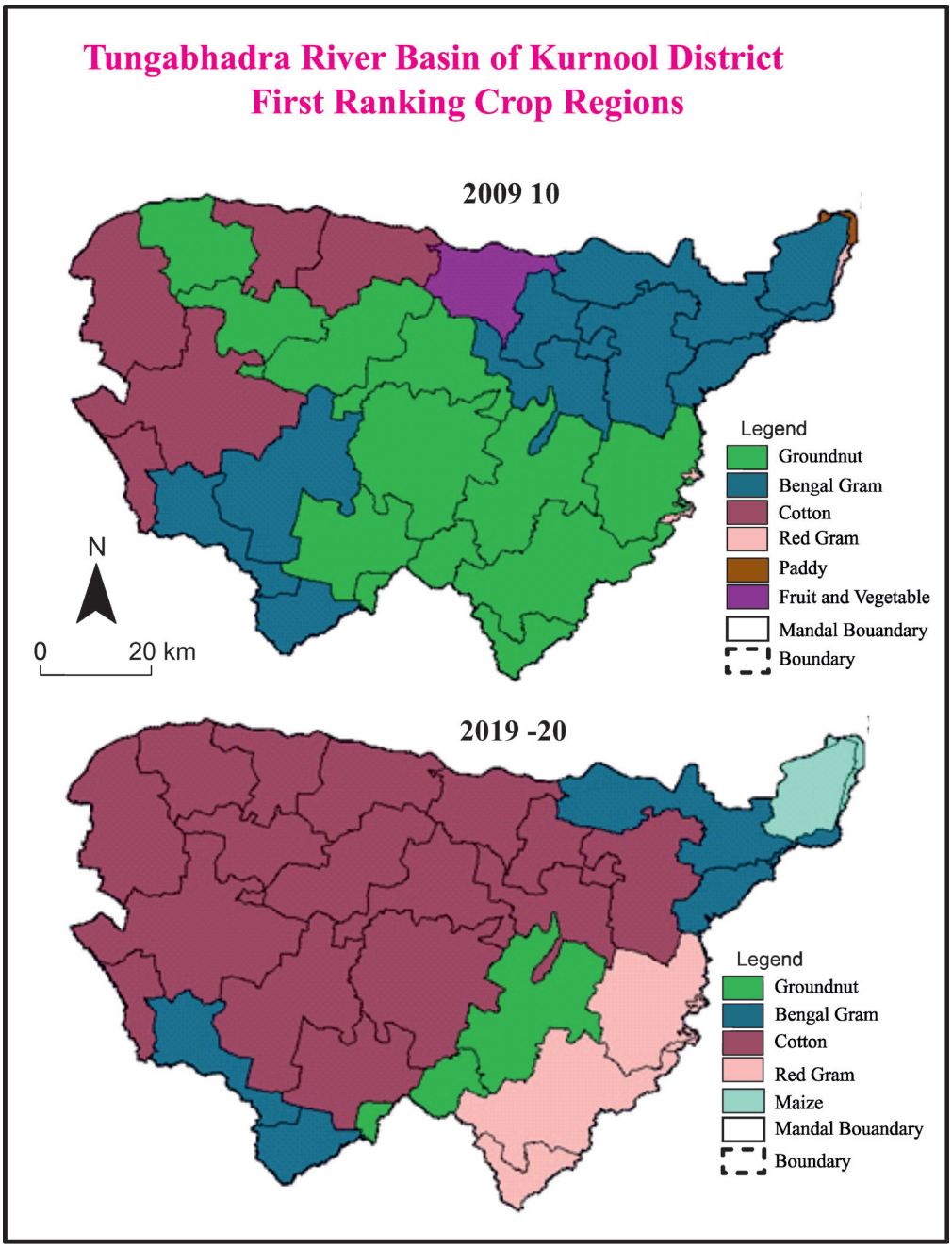

Tungabhadra River Basin of Kurnool District
First Ranking Crop Regions
2009 10
N
0
20 km
Legend
Groundnut
Bengal Gram
Cotton
Red Gram
Paddy
Fruit and Vegetable
Mandal Bouandary
Boundary
2019 -20
Legend
Groundnut
Bengal Gram
Cotton
Red Gram
Maize
Mandal Bouandary
Boundary

Fig. 1

Table-1: First Ranking Crop Regions in Tungabhadra River Basin 2009-10 & 2019-20

S.No	Crops in First ranking crop region	No. of Mandals in each individual crop region		Decrease/Increase in the number of Mandals during 10 Years Period
		2009-10	2019-20	
1	Ground nut	11	2	-9
2	Bengal gram	10	5	-5
3	Cotton	5	16	+11
4	Red gram	2	4	+2
5	Paddy	1	--	-1
6	Fruits &Vegetable	1	--	-1
7	Maize	--	3	+3
	Total Mandal	30	30	

Source: Computed by Authors

Next in importance among the second ranking of crops are maize, fruits, and vegetables. The cultivation of maize is limited to 2 mandals, namely Nandikotukur and Pagidayala mandals. Similarly, the cultivation of fruits and vegetables is restricted to 2 mandals, namely Kurnool and Orvakal. Furthermore, there are several other crops, namely paddy, red gram, cotton, and tobacco, which are classified as the second ranking of crops in individual mandals. For instance, paddy is cultivated in Yemmiganur, red gram in Veldurthy, cotton in Alur, and tobacco in Miduthur mandals. (**Fig.** 2 and **Table-**2).

Second Ranking Crop Regions or Second Order Crop Regions (2019-20)

In the year 2019–20, there are five crops that contribute to the establishment of second-order crop regions. Groundnut, in particular, holds the most prominent position in the formation of these regions. As the second most significant crop, groundnut is cultivated in 9 mandals within the basin, specifically situated in the western and southern areas. Bengal Gram holds a significant position among the secondary category of crops, following closely after the primary ones. Its cultivation spans across 8 mandals. The distribution of Bengal gram is primarily concentrated in the northeastern region, with a few mandals also found in the southwestern part of the basin. The cultivation of cotton is the third most significant crop in terms of ranking, grown in 7 mandals. Additionally, paddy and fruit and vegetable crops are cultivated in 4 and 2 mandals, respectively.

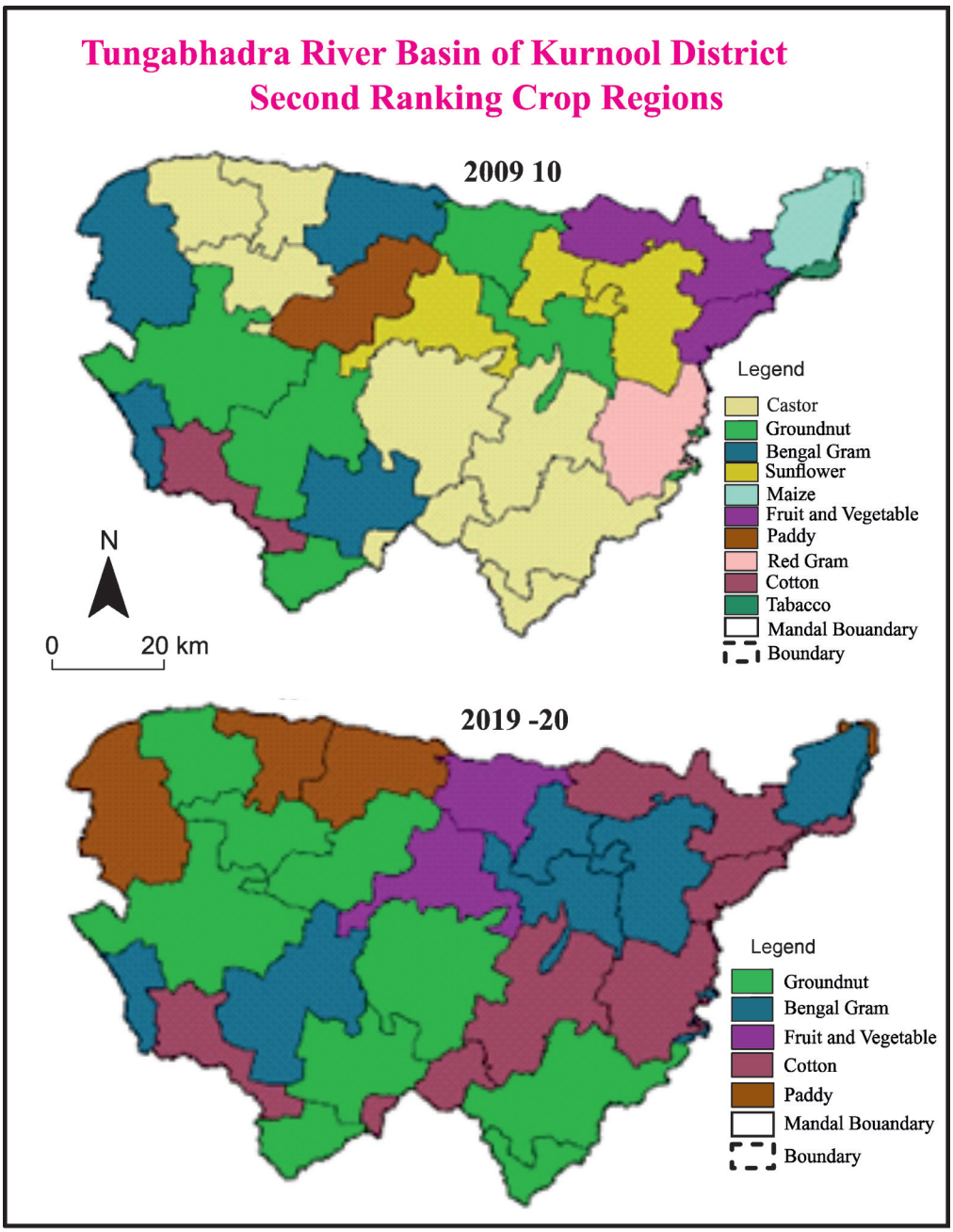

Tungabhadra River Basin of Kurnool District
Second Ranking Crop Regions
2009 10
N
0
20 km
Legend
Castor
Groundnut
Bengal Gram
Sunflower
Maize
Fruit and Vegetable
Paddy
Red Gram
Cotton
Tabacco
Mandal Bouandary
Boundary
2019 -20
Legend
Groundnut
Bengal Gram
Fruit and Vegetable
Cotton
Paddy
Mandal Bouandary
Boundary

Fig. 2

Changes in Second Ranking Crop Regions (2009-10 to 2019-20)

In the years 2009–10, ten crops were reported as secondary crop regions, whereas in 2019–20, approximately five crops constituted secondary crop regions. An increase in the spatial distribution has been observed in cotton (+6 mandals), groundnut (+3 mandals), Bengal gram (+3 mandals), and paddy (+3 mandals). Conversely, a decrease in the number of mandals has been identified in castor (8 mandals), sunflower (3 mandals), maize (2 mandals), red gram (1 mandal), and tobacco (1 mandal). The fruit and vegetable crop region remained unchanged in terms of area, with 2 mandals in both 2009–10 and 2019–20.

Table -2: Second Ranking Crop Regions –Tungabhadra River Basin (2009-10 & 2019-20)

S.No	Crops in First ranking crop region	No. of Mandals in each individual crop region		Decrease/Increase in the number of Mandals during 10 Years Period
		2009-10	2019-20	
1	Castor	8	--	-8
2	Ground nut	6	9	+3
3	Bengal gram	5	8	+3
4	Sunflower	3	--	-3
5	Maize	2	--	-2
6	Fruits & Vegetables	2	2	No change
7	Paddy	1	4	+3
8	Red gram	1	--	-1
9	Cotton	1	7	+6
10	Tobacco	1	--	-1
	Total Mandals	30	30	

Source: Computed by Authors

Third Ranking Crop Regions or Third Order Crop Regions (2009-10)

Among the third-ranking crop regions of 2009–10, about 10 crops have been recorded in the basin (**Fig.** 3). Of these, Castor, Cotton, and Sunflower cultivation occupied first place in forming the largest third-order crop regions, as they comprised 5 mandals each, i.e., Castor in Gudur, Veldurthy, Pattikonda, Maddikera, and Gonegandla; Cotton in C. Belagal, Kosigi, Yemmiganur, Aspari, and Tuggali mandals; and Sunflower in Kurnool, Kodumur, Krishnagiri, Nandavaram,

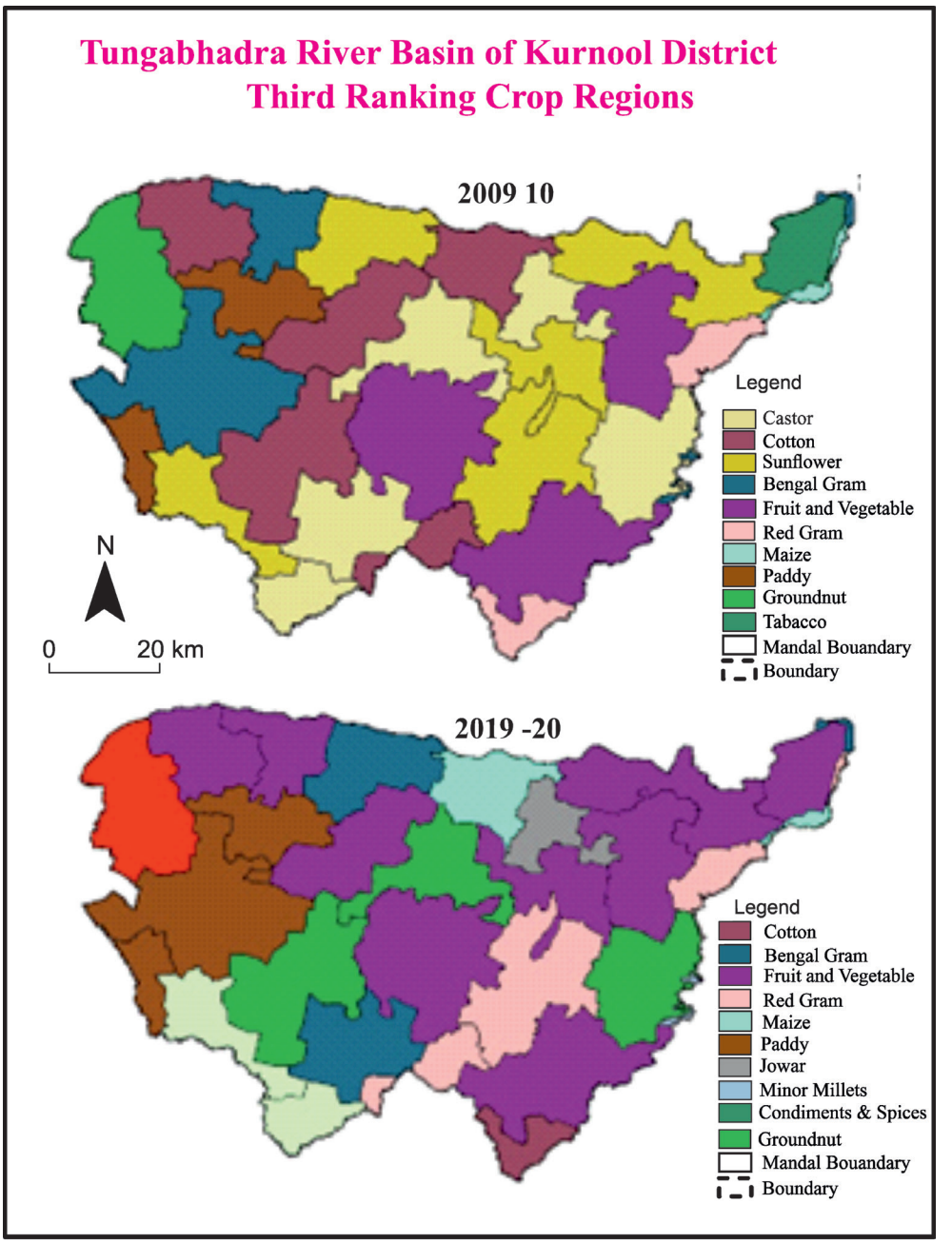

Tungabhadra River Basin of Kurnool District
Third Ranking Crop Regions
2009 10
N
0
20 km
Legend
Castor
Cotton
Sunflower
Bengal Gram
Fruit and Vegetable
Red Gram
Maize
Paddy
Groundnut
Tabacco
Mandal Bouandary
Boundary
2019 -20
Legend
Cotton
Bengal Gram
Fruit and Vegetable
Red Gram
Maize
Paddy
Jowar
Minor Millets
Condiments & Spices
Groundnut
Mandal Bouandary
Boundary

Fig. 3

Table -3: Third Ranking Crop Regions –Tungabhadra River Basin (2009-10 & 2019-20)

S.No	Crops in First ranking crop region	No. of Mandals in each individual crop region		Decrease/Increase in the number of Mandals during 10 Years Period
		2009-10	2019-20	
1	Castor	5	-	-5
2	Cotton	5	1	-4
3	Sunflower	5	-	-5
4	Bengal gram	4	3	-1
5	Fruit s& Vegetables	3	9	+6
6	Red gram	2	4	+2
7	Maize	2	2	No Change
8	Paddy	2	3	+1
9	Jowar	--	1	+1
10	Minor millets	--	1	+1
11	Chilies	--	1	+1
12	Condiments & Spices	--	2	+2
13	Ground nut	1	3	+2
14	Tobacco	1	--	-1
15	Total Mandal	30	30	

Source: Computed by Authors

and Alur mandal, followed by bengal gram (4 mandals); fruits and vegetables (3 mandals); red gram (2 mandals); maize (2 mandals); paddy (2 mandals); ground nut (1 mandal); and tobacco (1 mandal).

Third Ranking Crop Regions or Third Order Crop Regions (2019-20)

During the year 2019–20, eleven crops have been registered under tertiary crop regions with varied intensity. Fruits and Vegetables crop region emerged as the largest third ranking crop region with 9 mandals, followed by red gram (4 mandals), Bengal gram (3 mandals), paddy (3 mandals), groundnut (3 mandals), maize (2 mandals), condiments and Spices (2 mandals), cotton (1 mandal), jowar (1 mandal), minor millets (1 mandal), and chilies (1 mandal).

Changes in the Third Ranking Crop Regions (2009-10 to 2019-20)

Totally, about fourteen crops have been recorded in the study period under third ranking crop regions. They are castor, cotton, sunflower, Bengal gram, fruit and vegetables, red gram, maize, paddy, jowar, minor millets, chilies, condiments and spices, ground nuts, and tobacco. A decrease in the number of mandals under each third ranking region during the 10 years is observed in castor (-5 mandals), Cotton (-4 mandals), sunflower (-5 mandals), Bengal gram (-1 mandal), and Tobacco (-1 mandal). The increase in the number of mandals under each third ranking crop region during the 10 years of the study period is noticed in fruits and vegetables (+6 mandals), red gram, condiments and spices, and ground nuts (each with +2 mandals), paddy, jowar, minor millets, and chilies (+1 mandal). The maize region remained the same with two mandals, both in the 2009–10 and 2019–20 study periods.

Conclusion

During the years 2009–10, only six First Ranking crop regions, namely groundnut, Bengal gram, cotton, red gram, paddy, and fruits and vegetables, were noticed in the basin. Even after ten years, groundnut, Bengal gram, cotton, and red gram remained as First ranking crop regions. However, the crop regions of paddy and fruits and vegetables disappeared in 2019–20. A new crop region, maize, was recorded during this period. With regard to second ranking crop regions, ten crops were registered in 2009–10, and five crop regions, namely castor, sunflower, maize, red gram, and tobacco, disappeared in 2018–19, resulting in Five crop regions were recorded. About ten different third ranking crop regions have been reported in the year 2009–10 in the Tungabhadra River Basin, and eleven different third ranking crop regions have been noticed in the year 2019–20, with jower, minor millets, chilies, condiments and spices, and cotton as additional regions, replacing four crop regions of 2009–10, i.e., castor, Bengal gram, groundnut, and sunflower crop regions.

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ANNUAL WATER BALANCE AND STREAM DISCHARGE MODELLING AT SHIMSHA WATERSHED OF UPPER CAUVERY BASIN, KARNATAKA

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Abstract

The present study mainly focuses on identifying the factors influencing water balance and stream discharge in Shimsha Watershed. The attempt also been made to analyse the water balance and stream discharge using SWAT model in the study area. Along with the use of SWAT model, geographical information system (GIS) is also used to estimate the HRUs, land use / land cover, calibrate and validate model and sensitivity analysis of SWAT model parameters for the Shimsha Watershed. The results show that Overall model performance was found to be agreeable as indicated by close relation between observed and simulated runoff. Model performance has been done using statistical parameter called Coefficient of Determination (R2). The R2 value were found to be 0. 64864 and 0.639706 after the calibration and validation. The model indicated very good agreement between simulated and observed flow. Therefore, it can be concluded that the SWAT model helps as an effective tool for assessment of water functioning at basin scale.

Introduction

Water is one of the most important natural resource. The Earth's water cycle is a dynamic and intricate system that plays a vital role in sustaining life and shaping our environment. Understanding the complex interactions of precipitation, evaporation, infiltration, runoff, and groundwater flow is crucial for effective water resource management, flood forecasting, and environmental protection. Hydrological models are useful tools that have been used in recent years to provide a visual representation of hydrological processes as well as accurate flow simulations, especially when evaluating the effects of land-use change and climate variability on hydrological cycles and water balance components. It encompasses a range of computational techniques that simulate the behaviour of water within a specific geographical area or watershed. By employing mathematical equations and algorithms, these models replicate the hydrological cycle, allowing us to observe and predict the movement

and distribution of water through the landscape. Hydrological models consider a multitude of factors, such as topography, land use, soil properties, vegetation cover, and climatic conditions, to create realistic representations of how water flows through a particular region. Water balance and stream discharge are important components of the hydrological cycle and are crucial for the management of water resources. Hydrological models provide a means to study the complex interactions between various hydrological processes in the Shimsha Watershed. While studying this we can analyse the relation between different parameters and how it is affecting the watershed Shimsha watershed covered with coconut plantation and medium dense urban settlement with using swat model what is the impact how the parameters are behaving within the watershed determined using the swat model. It is also important for the assessing water quality and pollutant transport within the watershed. Understanding the volume of water flowing through the stream helps in assessing pollutant loads and designing appropriate water quality management strategies in Shimsha watershed.

Study Region

The Shimsha River basin is a sub-basin of the Cauvery basin located in Karnataka, India. Geographically, it extends largely over two districts Mandya and Tumkur. The river has a course length of 221 km and has a catchment area of 8469 km^2 before joining the river Cauvery at shimshapura near the border of Chamarajanagara district. Shimsha river is an important tributary joining from left. The extent of area is latitude 13˚44′0″ N to 12˚8′0″N and Longitude 76˚8′0″ E to 77˚28′0″ E During the course of its travel from the origin many sub-tributaries join the Shimsha river such as Veeravaishnavi, Kanihalla, Chikkahole, Hebbahalla, Mullahalla and Kanva. At the mouth of the Shimsha river, a waterfall is situated at shimshapura in Malavalli taluk located 30 kms from Mandya, which was used to generate Hydroelectric power with an installed capacity of 17,200 kw and is considered to be the first ever hydroelectric project in Asia. The power generated during that time was used to light the Kolar gold fields. The Markonahalli dam, a multi-purpose reservoir has been erected across the river after it originates in Tiptur, Tumakuru district. It is reported to have been erected primarily as a flood-prevention measure for communities lying downstream, as well as to safeguard the safety of the nearby revered Yediyur Siddhalingeshwara Temple. Also, a barrage named after former Prime Minister H.D Devegowda has also been encountered during the course of its travel at Channapatna taluk, Ramanagara district – Igloor Dam Devegowda Barrage. The river then continues a southerly route and reaches

the Mandya district. The river travels in a south-eastern direction through Mandya district, with a waterfall at Shimshapura in Malavalli Taluk. Shimsha river is often referred as Madduru hole as the river passes through Maddur town and many villages of Maddur taluk. Shimsha is the principal irrigation supply for thousands of farmers in Nagamangala, Maddur, and Malavalli taluk, as well as hundreds of riparian villages in Tumakuru, Mandya, and Chamarajanagar taluks. The Shimsha Watershed is a geographical area in Karnataka, India, that is drained by the Shimsha River.

Objectives

(1) To analyses the water balance and stream discharge using SWAT model in study area.

(2) To identify the factors influencing water balance and stream discharge in study area.

Database and Methodology

In the present study following datasets were used to analysis the annual water balance and the stream discharge using SWAT model. Topography map was generated from the USGS-ASTER DEM with the spatial resolution of 30m. FAO – Digital soil map at the scale of 1:500000 used to create soil map. Land use and land cover map was derived from the ESRI Sentinel data with 10m spatial resolution. Followed by the rainfall data from IMD for the following years (1999-2022) and runoff (discharge) data from India water resources information system (WRIS) from 2001-2013 was used in this analysis. The following brief methodology was applied to assess the runoff and the water balance. The input data sets were derived from the above said data sources. Topography, soil texture, lulc, slope and rainfall layers were utilized as baseline parameters. From the DEM data watershed delineation and stream networks were generated. Followed by HRU analysis was carried with the support of DEM, Soil texture, lulc and slope along with rainfall in the SWAT model (SWAT RUN). Finally, surface runoff and the annual water balance were estimated for the Shimsha River basin.

Result and Discussion

SWAT Model Setup

The first step in model setup is to use a DEM raster file to delineate the watershed, sub- basins, and reaches. The definition of the watershed

gave a drainage pattern of land surface terrain, including the stream network and river basin outlets. The model used a DEM-based automated technique to delineate watershed. In which the watershed was divided into 7 sub watersheds, after providing a LU/LC map, soil map, and slope variation, they were further subdivided into 29 HRUs by the model (Hydrologic Response Units). HRUs, on the other hand, are combined units made up of homogeneous land-use and soil characteristics. A 10% threshold percentage has been implemented for all land use, soil, and slope classes in order to exclude minor land use, soil, and slope. The HRU report was then generated which included area of watershed (8694.15 km^2), detailed descriptions of the land use, soil, and slope classes in each sub- watershed.

Model Configuration

The SWAT model, is jointly developed by the United States Department of Agriculture – Agricultural Research Services (USDA–ARS), and Agricultural Experiment Station in Temple, Texas (Singh et al. 2013). By (Michael and Jain 2013), the computational components can be placed into eight major divisions namely: hydrology, weather, soil temperature, crop growth, sedimentation, pesticides, nutrients, and agricultural management, and uses physical inputs such as weather variables, topography, soil properties, land-management practices, and vegetation occurring in the catchment. SWAT explicitly models the physical processes related to water flow, sediment transport, crop growth, nutrient cycling etc. The form of water balance equation used to simulate the hydrologic cycle is depicted through equation.

(1) SWt = SWo + [Rday + Qsurf + Ea + Wseep + Qgw]

(2) SWt = Final soil water content in mm H2O,

(3) SWo = Initial soil water content in mm H2O, t time in days,

(4) Rday = Amount of precipitation on day i in mm H2O,

(5) Qsurf = Amount of surface runoff on day i in mm H2O,

(6) Ea = Amount of evapotranspiration on day i in mm H2O,

(7) Wseep = Amount of percolation and bypass exiting the soil profile bottom

(8) Qgw = Amount of return flow on day i in mm H2O

Watershed Delineation

Watershed is a hydrological unit from which runoff resulting from precipitation flows past a single point into a large stream, river, lake or pond. Watershed delineation

plays an important role in watershed management. Watershed delineation was performed in Arc GIS 10.4.1software. Digital Elevation Model (DEM) was use for watershed delineation. As top sheets provide information related to the location, drainage network and contours. Delineation of watershed has done using the dem, flow direction on map, flow accumulation on map, creation of outlet, snap pour point and watershed delineation.

SWAT Model Run

In this SWAT model to assess based on the Hydrological Response Units (HRUs) with the support of DEM (stream networks, watershed delineation, outlets for monitoring and sub basin parameter) and other thematic layers such as Land use land cover, soil, slope through overlay method. Include with this climatic dataset like rainfall and temperature which has been generated from the SWAT weather database (WGEN), followed by run the model to generate the runoff for the required number of years.

Hydrological Response Units (HRUs) Formation

The model simulates variations in evapotranspiration and other hydrological conditions for various land cover / crops and soils by subdividing the river basin into areas of exclusive land use and soil variations. The source of the hydrological modelling in SWAT is the HRU, which is a lumped land area within the sub-basin that is comprised of exclusive land cover, soil and slope. The sub-basin separation into HRUs improves precision and offers a much clearer physical description of the water balance. There are two options in SWAT for HRU allocation: either to assign a single HRU to each sub-basin or to assign multiple HRUs to each sub-basin (Srinivasan et al. 1998). If a single HRU per sub-basins is selected, the prevailing land use class and soil type surrounded by each river basin determines the HRU. If multiple HRUs are selected, the user must give a threshold level to ensure each grouping of land use and soil category within the sub-basin.

Sensitive Parameters

Sensitivity analysis can give a better understanding of the impact of change in an individual input parameter of the model response and can be performed using various methods. The method in the Arc SWAT interface combines the Latin Hypercube (LH) and One-factor-At-a-Time (OAT) sampling. Van Griensven et al. (2006), characterized Global rank 1 as “very important”, rank 2 to 6 as ‘important”,

rank 7 to 19 as "slightly important" and rank 28 as "not important". Sensitivity analysis was performed on 16 different SWAT model parameters for the Shimsha Watershed. Parameters and parameter ranges used in the sensitivity analysis. By using default upper and lower boundary parameter values, the parameters were tested for sensitivity using without observed streamflow data. The most sensitive factor governing the streamflow for the Shimsha Watershed was SCS runoff curve number for moisture condition II (CN2). This indicates that base flow is very significant in the water yield.

The Effective hydraulic conductivity in main channel alluvium (Ch_K2), threshold depth of water in the shallow aquifer required for return flow to occur (Gwqmn), available water capacity (Sol_Awc) and soil evaporation compensation factor (Esco) are also important parameters. Alpha_Bf and Sol_Awc were correlated to base flow and that could be the reason for their higher ranking in the sensitivity analysis. The sensitive parameters for the present study were selected based on the study conducted by Douglas – Mankin et al., (2010) on 64 selected watersheds. SWAT simulates the interaction of processes; many parameters affect more than one process. It's a kind of ripple effect. (For example, CN has direct impact on runoff; however, change in runoff changes other components of hydrology. There is direct impact of runoff change on soil erosion and nutrient transport affecting plant growth and nutrient cycling). So, Santhi et al., (2001) highlight this as the primary reason for manual calibration to start with hydrology balance and surface runoff, then sediment, and finally calibrating nutrients. From the above studies it was concluded to use the sensitive parameters such as CN2, ESCO, ALPHA_BF, SOL_AWC, SURLAG and RECH.DP and their initial and final values have been illustrated. The sensitive parameters are explained are as follows: Before calibration of CN2, ALPHA BF, GWQMN, ESCO, SOL AWC (84, 0.95, 0.8, 0.95, and 0.05) and after calibration of (35, 0.01, 0.05, 0.08, 1) respectively.

CN2

CN2 Initial SCS runoff curve number for moisture condition II. The SCS curve number is a function of the soil's permeability, land use and antecedent soil water conditions. The Soil Conservation Service Curve Number (SCS-CN) method is widely used in conceptual rainfall-runoff models for describing the runoff response with a curve, which is a function of the cumulative storm rainfall and antecedent wetness conditions. To improve the SCS- CN method.

ALPHA BF

ALPHA_BF Base flow alpha factor (1/days). The base flow recession constant, αgw, is a direct index of groundwater flow response to changes in recharge. Values vary from 0.1-0.3 for land with slow response to recharge to 0.9-1.0 for land with a rapid response. Base flow is the portion of streamflow that is delayed subsurface flow and generally maintained by groundwater discharge. Regardless of the specific climatic environment, its main features are tightly related to geological catchment properties. Base flow is the streamflow that constitutes the majority of the streamflow on a day when rain does not occur or has not occurred recently. Understanding the base flow process is important to deal with various water resources issues, such as water resources management strategies, low flow conditions assessment, hydrological modelling calibration, and water quality studies.

GWQMN

"GWQMN" stands for "Groundwater Quick Flow Manning's n" and it is a parameter used to represent the Manning's roughness coefficient for quick flow from the groundwater zone to the stream channel. In the SWAT model, accurate representation of groundwater dynamics and the interaction between groundwater and surface water is essential for realistic hydrological simulations. The GWQMN parameter contributes to this by influencing the rate of quick flow from the groundwater to the stream channel.

ESCO

ESCO stand for Soil evaporation compensation factor. This coefficient has been incorporated to allow the user to modify the depth distribution used to meet the soil evaporative demand to account for the effect of capillary action, crusting and cracks. ESCO must be between 0.01 and 1.0.

SOLAWC

It refers as the Soil Available Water Capacity parameter. This parameter is a key component of the model's representation of soil properties and their influence on water balance and hydrological processes within a watershed. Available Water Capacity (AWC) represents the amount of water that soil can hold and make available to plants for their growth and development. It is a crucial factor in determining how well a soil can retain and supply water to vegetation. The AWC parameter considers the soil's characteristics, such as texture, depth, and organic

matter content that influence its ability to retain water. Different soil types can have varying AWC values, and these values play a significant role in simulating various hydrological processes, including infiltration, runoff, evapotranspiration, and groundwater recharge. In SWAT, soil data are typically divided into different hydrologic response units, and each unit can contain multiple soil types. The "solawc" parameter is assigned to each soil type within an HRU, allowing the model to estimate how water moves through the soil layers, affects plant growth, and contributes to runoff and other hydrological responses.

Observed Discharge Data

The Runoff values for 18 years from 2004-2022 at the T.K Halli was simulated by the SWAT model and the comparison of output values with the observed data have been presented from which it can be seen that for most of the year, SWAT simulation seemed to overestimates the discharge when compared observed values. This is because of uncertainties in input data, model structure and model parameters. The calibration was carried out as a process of adjustment for these uncertainties. Due to continuous changes in the parameters the model simulated runoff and the observed discharge will correlate. The comparison between the observed and simulated discharge shows between 2004 to 2013. The Runoff values for 18 years from 2004-2022 at the T.K Halli was simulated by the SWAT model and the comparison of output values with the observed data have been presented from which it can be seen that for most of the year, SWAT simulation seemed to overestimates the discharge when compared observed values. This is because of uncertainties in input data, model structure and model parameters. The calibration was carried out as a process of adjustment for these uncertainties. Due to continuous changes in the parameters the model simulated runoff and the observed discharge will correlate. The comparison between the observed and simulated discharge shows between 2004 to 2013 (**Fig.** 1).

Surface Run-off Calibration

Most of the model inputs are physically based. The successful application of the model which are depends on how well the model is calibrated. The model will be calibrated using observed runoff data from the entire river basin. The calibration tool in the simulation menu of SWAT allows performing global changes on input parameters that are commonly modified during the calibration process. Calibration was performed manually from 2004 to 2005, and validation was performed from 2012 to 2013 run-off matches fairly well with observed runoff in trend and

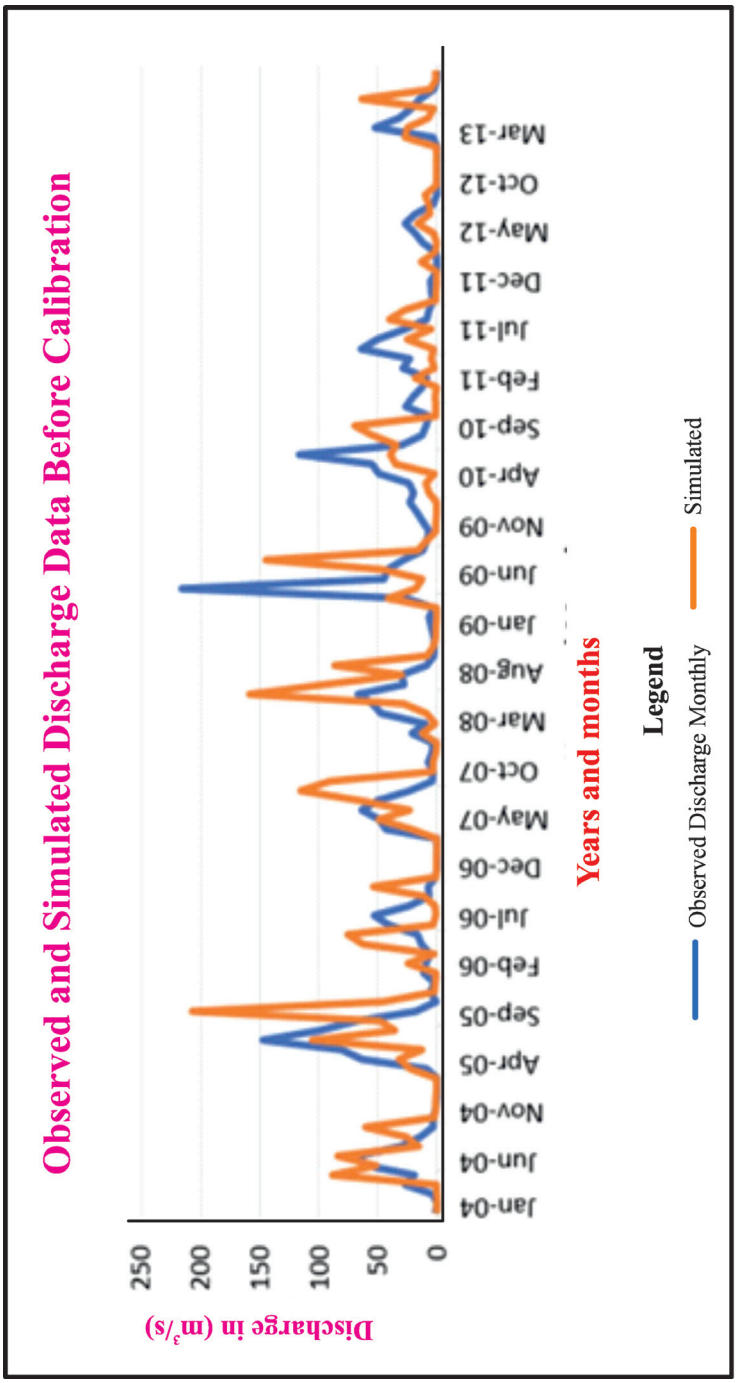

Observed and Simulated Discharge Data Before Calibration
Discharge in (m³/s)
250
200
150
100
50
0
Jan-04
Jun-04
Nov-04
Apr-05
Sep-05
Feb-06
Jul-06
Dec-06
May-07
Oct-07
Mar-08
Aug-08
Jan-09
Jun-09
Nov-09
Apr-10
Sep-10
Feb-11
Jul-11
Dec-11
May-12
Oct-12
Mar-13
Years and months
Legend
Observed Discharge Monthly
Simulated

Fig. 1

magnitude. Overall, model performance was found to be agreeable as indicated by close relation between observed and simulated runoff. Due to changes in the sensitive parameters the model calibration done. The model efficiency checked using coefficient of determination or R square. This is a good method to signify the consistency among observed and good method to signify the consistency among observed and simulated data by following a best fit line. It ranges from zero to 1.0 with higher values indicating less error variance, and values greater than 0.50 are considered acceptable. In the calibration the R square was 0.64864 that's why this model is acceptable (**Fig.** 1).

Model Validation

Proper validation of the calibrated model is essential to understand its performance without any change in the input files except the climatic parameters. The monthly values of the maximum and minimum temperature for the time period for which the model is being validated is set as the input data for the model. The model was validated for similar parameters. Monthly run-off was compared for the river basin, as per the availability of observed data. In validation of the model the R square was 0.639706 which is acceptable. In the calibration and validation, the values of R square are more than 0.5 which is acceptable and is a good sign of model efficiency. So, the model is running properly and due to this model can run the future simulation also but in some points in graph the simulated and the peaks and are not matching is due to the uncertainty in the model's parameters and the input dataset. But the overall model is working properly and efficiently. The discharge is simulated in between 2020 to 2022. Due to the validation and calibration of model is running properly and can be used for future reference. This will help in future simulation as well managing the water movement in the study area will become very efficient. But there is still scope for future use ability of the model (**Fig.** 2).

Water Balance

This is the balance between the inputs and outputs of a drainage basin. Water balance is expressed as:

$$P = Q + E \text{ (+/- change in storage)}$$

Whereas:

P = precipitation Q = run-off

E = evapotranspiration

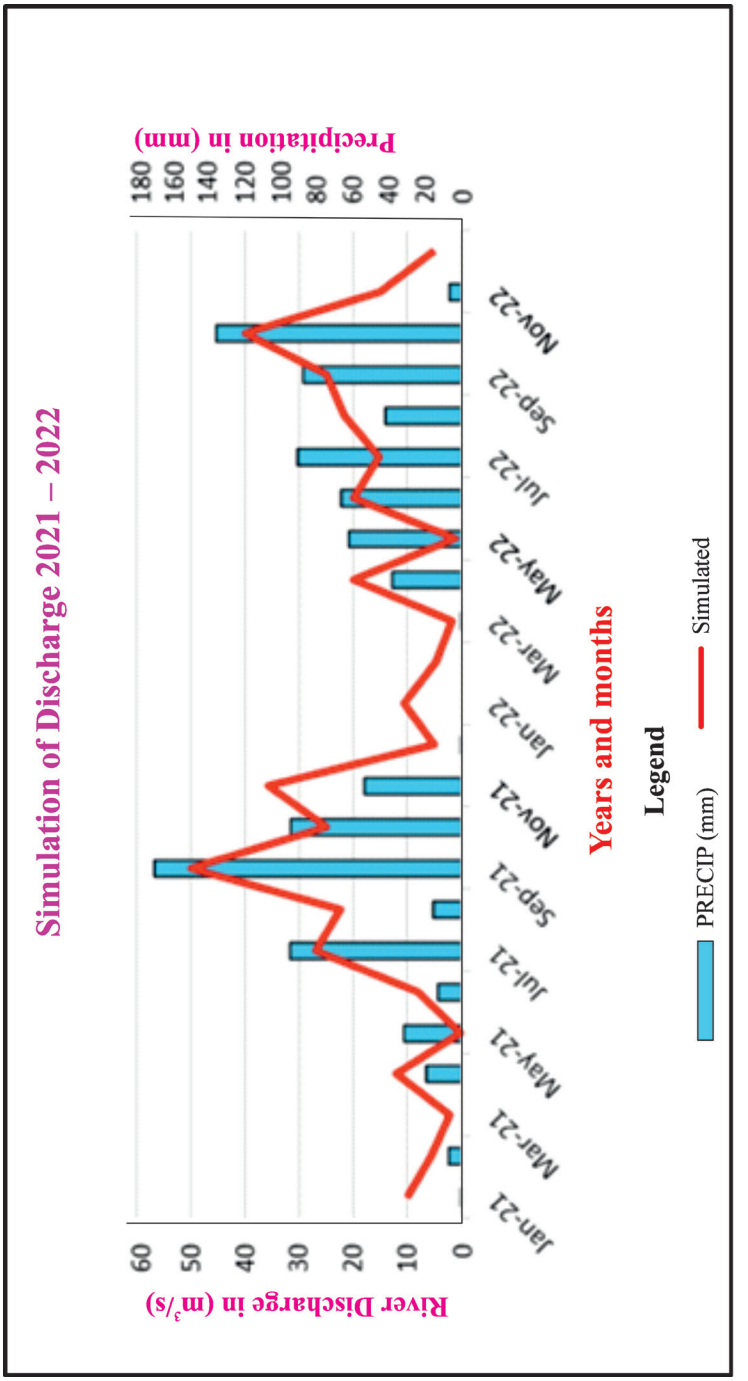

Simulation of Discharge 2021 – 2022
Precipitation in (mm)
180
160
140
120
100
80
60
40
20
0
River Discharge in (m³/s)
60
50
40
30
20
10
0
Jan-21
Mar-21
May-21
Jul-21
Sep-21
Nov-21
Jan-22
Mar-22
May-22
Jul-22
Sep-22
Nov-22
Years and months
Legend
PRECIP (mm)
Simulated

Fig. 2

Rivers will always have a regime which they follow, in that some months the discharge of the river will be higher than others. The water balance looks at how the amount of precipitation compares with the water leaving the system as runoff or as evapotranspiration. This balance will change throughout the year and will be affected by the overall climate of the area near to the river. For example, under 'usual' conditions the precipitation will be matched by run-off and evapotranspiration giving a 'normal' river level. If evapotranspiration becomes greater for a few months in summer while precipitation and run-off remain the same, the river will flow below normal level. Key terms to describe various water balance conditions are, namely, (1) Water Surplus: there is excess water available to the system. This occurs when precipitation exceeds evapotranspiration and the excess is not being used by plants (2) Deficiency: there is a reduction of water available within the system. This occurs when evapotranspiration exceeds precipitation (3) Recharge: after a period of deficiency precipitation will occur and replace the lost water in the soil. This needs to occur before a period of surplus can reoccur (4) Field Capacity: The maximum amount of water that soil can hold before it becomes saturated. A surplus can result in wet soils, high river levels and additional run-off whereas a deficit lead to dry soil, falling river levels and possibly a drier micro climate. The soil water content is around 4%, the surface runoff is 38%, percolation is 26% and the evapotranspiration is 32%.

The percolation of water is less in the Shimsha watershed; this study area is facing problem in the depletion of ground water. The main reason for this area is due to deep bore well digging which cause the problem in the area. It's necessary to understand the relation between the various water balance components. Using swat model, it is easy to understand how water is actually behaving in the study area and how the role of water is changing. In this study results shows that overall, model performance was found to be agreeable as indicated by close relation between observed and simulated runoff. The Calibration and validation were performed manually for the year 2004 to 2005 and 2012 to 2013 respectively on monthly basis. The Model performance has been done using statistical parameter called Coefficient of Determination (R2). Also shows that after calibration and validation R2 value were found to be 0.64864 and 0.639706 respectively. The model indicated very good agreement between simulated and observed flow. Therefore, it can be concluded that the SWAT model helps as an effective tool for assessment of water functioning at basin scale.

Conclusion

As the population growing impulsively, demanding urbanization, the expansion of industries and development in agricultural practices adds up to the increasing demanding for water and it is very much essential to manage the resource wisely. In the present study, to understand the status of water resources as well as hydrological process in the Shimsha river basin, SWAT model was applied. Since the river Shimsha waters vast areas of cultivation land our study at estimating the surface runoff at ungauged stations for effective watershed management practices. Calibration and validation were performed manually for the year 2004 to 2005 and 2012 to 2013 respectively on monthly basis. Model performance has been done using statistical parameter called Coefficient of Determination (R2). After calibration and validation R2 value were found to be 0. 64864 and 0.639706 respectively. The model indicated very good agreement between simulated and observed flow. Therefore, it can be concluded that the SWAT model helps as an effective tool for assessment of water functioning at basin scale. Under practical conditions it may be difficult to install discharge gauges everywhere along the stretch of stream, and may be in the future it is necessary to know the surface runoff at a required stretch where the discharge gauge station facility is not available or gives faulty measurements.

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ETHICAL DIMENSIONS OF PROMOTING GIRL CHILD EDUCATION FOR SOCIAL EMPOWERMENT

Dr. Mohd Akhter Ali and M. Kamrajum

Abstract

This research paper explores the ethical considerations and societal implications of promoting girl child education as a means of social empowerment. It examines the intersecting factors of ethics, education, and society, focusing on the ethical challenges faced in ensuring equal access to education for girls and the transformative potential of education in fostering gender equality and social progress. The paper investigates the ethical dilemmas associated with gender disparities in education, the social barriers impeding girls' education, and the role of society in addressing these challenges. By analysing existing research and case studies, it aims to provide insights into the ethical dimensions of girl child education and its impact on the empowerment of girls and the broader society.

Introduction

Education is a fundamental human right that plays a pivotal role in individual empowerment and societal development. This is particularly true for girls, as girl child education has far-reaching implications for gender equality, poverty alleviation, and overall social progress. According to the United Nations (UN) Sustainable Development Goals (SDGs), ensuring inclusive and quality education for all, including girls, is a critical target to achieve by 2030 (UN, 2015). This brief overview will highlight the significance of girl child education, emphasizing the transformative power it holds for individuals and societies. Individual Empowerment. Access to education equips girls with knowledge, skills, and confidence, enabling them to make informed choices, fulfil their potential, and participate actively in society. Education empowers girls by broadening their horizons, expanding their opportunities, and breaking the cycle of poverty. Studies have shown that educated girls are more likely to marry later, have healthier families, and pursue higher education and career aspirations (UNESCO, 2018). Furthermore,

education empowers girls to exercise their rights, promotes critical thinking, and fosters leadership qualities, enabling them to contribute meaningfully to their communities and advocate for their own rights (Ghosh, 2016).

Societal Development

Investing in girl child education yields significant societal benefits and contributes to broader development goals. Educated girls become agents of change, driving social progress and economic growth. Research indicates that increasing girls' education results in reduced infant and maternal mortality rates, improved child nutrition, and healthier communities (Lloyd, 2016).. Moreover, educated women tend to have fewer children, which positively impacts population growth and allows for greater focus on quality education and healthcare for future generations (World Bank, 2018). Educated girls also have a higher likelihood of participating in decision-making processes, contributing diverse perspectives, and promoting gender equality in all spheres of society (UNESCO, 2020). Girl child education is of paramount importance for both individual empowerment and societal development. It not only empowers girls to break barriers and fulfil their potential but also yields far-reaching benefits for communities and nations as a whole. By investing in girl child education, we foster a more equitable and inclusive society, where girls can thrive and contribute meaningfully to the social, economic, and cultural fabric of their communities (Ali, M., & Kamraju, M. 2022. Gender disparities in education give rise to various ethical concerns that highlight the need for equal opportunities for girls.

These concerns revolve around principles of fairness, social justice, human rights, and the promotion of inclusive societies (UNESCO, 2017). Firstly, gender disparities in education violate the principles of equality and non-discrimination, as equal access to education is a fundamental human right (UNESCO, 2017). Denying girls, the same opportunities for learning and personal development that boys enjoy raises ethical concerns about fairness and equal treatment. Secondly, gender disparities in education perpetuate social injustices by reinforcing and perpetuating gender-based stereotypes and norms (Sen, 1999) . Such disparities limit girls' ability to realize their full potential, pursue their interests, and contribute meaningfully to society. Ensuring equal educational opportunities is a matter of social justice, aiming to rectify historical disadvantages and create a level playing field for girls. Moreover, education is a crucial tool for individual empowerment and agency. It equips individuals, including girls, with knowledge,

skills, and critical thinking abilities necessary for making informed choices and pursuing their aspirations (Nussbaum, 2000). Denying girls access to education denies them the opportunity to develop their potential, exercise their agency, and actively participate in shaping their lives and communities. In addition to ethical concerns related to individual empowerment, gender disparities in education hinder socioeconomic development at individual, community, and national levels. Education is strongly linked to economic growth, poverty reduction, and improved health outcomes (World Bank, 2018). By excluding girls from education, societies miss out on their potential contributions to economic productivity, innovation, and social progress. Addressing these ethical concerns requires concerted efforts from various stakeholders, including governments, policymakers, communities, and families. It involves implementing policies and interventions that promote gender equality, eliminate discriminatory practices, and ensure inclusive and quality education for all (UNESCO, 2017). By providing equal opportunities for girls to access education, societies can uphold ethical principles, promote social justice, and foster inclusive and equitable societies. Promoting girl child education. Promoting girl child education holds significant transformative potential and has far-reaching societal implications. By ensuring equal access to education for girls, societies can experience positive changes across various dimensions. Here is an overview of the societal implications and transformative potential of promoting girl child education:

(1) Gender Equality and Women's Empowerment: Girl child education is a critical step towards achieving gender equality. It enables girls to break free from traditional gender roles, challenge stereotypes, and pursue their aspirations. Educated girls are more likely to participate in decision-making processes, advocate for their rights, and contribute to policy discussions, leading to greater gender equality and women's empowerment within societies.

(2) Economic Development: Education plays a crucial role in driving economic growth and reducing poverty. Promoting girl child education leads to a more skilled and educated female workforce, enhancing productivity and innovation. Educated women can secure better employment opportunities, earn higher incomes, and contribute to the economic development of their families and communities. The World Bank estimates that investing in girls' education can lead to significant economic returns for societies.

(3) Health and Well-being: Educating girls has a positive impact on health outcomes for both individuals and communities. Educated girls are more likely to make informed decisions regarding their health, seek healthcare services, and adopt healthy behaviors. They are also better equipped to address maternal and child health issues, leading to improved healthcare practices and reduced mortality rates. Promoting girl child education contributes to better overall health and well-being outcomes for societies.

(4) Social and Political Participation: Education empowers girls to actively engage in society and participate in social and political processes. Educated girls develop critical thinking skills, become more aware of their rights, and are more likely to challenge social norms and discriminatory practices. Their participation in community development, civic activities, and political decision-making brings diverse perspectives and contributes to more inclusive and representative societies.

(5) Sustainable Development: Promoting girl child education aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 5 (Gender Equality). Education is recognized as a catalyst for achieving multiple development goals. Educated girls become agents of change, promoting sustainable practices, addressing environmental challenges, and contributing to sustainable development in their communities.

By recognizing and investing in the transformative potential of girl child education, societies can break cycles of poverty, discrimination, and inequality. Empowered and educated girls become catalysts for positive change, creating more inclusive, equitable, and sustainable societies for present and future generations.

Ethical Considerations in Girl Child Education

Exploring the ethical dimensions of gender disparities in access to education sheds light on the underlying issues of discrimination, cultural biases, and social norms that hinder girls' educational opportunities. The following points delve into these ethical considerations:

(1) Discrimination: Gender disparities in education are rooted in discriminatory practices that systematically disadvantage girls. Denying girls equal access to education based solely on their gender violates principles of fairness, equality, and human rights. Such discrimination perpetuates social and economic inequalities and denies girls the opportunity to develop their potential.

(2) Cultural Biases: Cultural norms and beliefs can reinforce gender-based stereotypes, limiting girls' educational opportunities. Societies that assign traditional roles to girls often prioritize domestic responsibilities over education. Challenging cultural biases and norms requires careful navigation, considering the need to respect cultural diversity while ensuring equal educational opportunities for girls.

(3) Social Norms: Social norms shape attitudes and expectations surrounding girls' education. These norms can discourage families from investing in their daughters' education, perpetuating the cycle of gender disparities. Addressing the ethical dimensions of social norms entails challenging traditional perceptions of gender roles and promoting a shift towards valuing and prioritizing girls' education.

(4) Intersections of Discrimination: Gender disparities in education intersect with other forms of discrimination, such as those based on socioeconomic status, ethnicity, disability, or geographic location. These intersecting dimensions exacerbate the challenges faced by marginalized girls, compounding the ethical concerns surrounding their access to education. Efforts to address gender disparities in education should consider and address these intersecting forms of discrimination.

(5) Human Rights and Social Justice: Ensuring equal access to education for girls is not only a matter of human rights but also an ethical imperative rooted in principles of social justice. Every child has the right to education, regardless of their gender. Failing to address gender disparities in education perpetuates social inequalities and hinders societies from achieving inclusive and equitable development.

Recognizing and addressing these ethical dimensions requires a multifaceted approach. It involves promoting inclusive policies, challenging discriminatory practices, and fostering societal shifts towards gender equality and girls' empowerment. Ethical considerations in girl child education call for proactive measures to dismantle barriers, challenge biases, and ensure equal educational opportunities for all children, irrespective of their gender. Addressing gender disparities in education and ensuring equal educational opportunities for girls presents several ethical challenges. These challenges arise from complex social, cultural, and economic contexts and require thoughtful consideration and action. The following points discuss the ethical challenges associated with addressing these disparities:

(1) Cultural Sensitivity and Respect: Promoting girls' education while respecting cultural diversity can be a delicate balancing act. It requires acknowledging and appreciating diverse cultural norms and values while challenging discriminatory practices that hinder girls' education (Freeman, 2004) . Ethical challenges arise in navigating cultural sensitivity and ensuring that interventions do not inadvertently undermine cultural identities or perpetuate cultural imperialism.

(2) Overcoming Resistance and Changing Attitudes: Resistance to change and deeply ingrained attitudes and beliefs can pose significant ethical challenges. Challenging deeply rooted gender biases and stereotypes requires engaging with communities and addressing their concerns and misconceptions. Ethical considerations include promoting dialogue, fostering understanding, and building consensus to overcome resistance to girls' education (Sutton, 2011).

(3) Resource Allocation and Prioritization: Ethical dilemmas emerge when limited resources must be allocated among competing priorities. Governments and organizations face challenging decisions in distributing resources to address gender disparities in education. Balancing investments in girls' education with other pressing needs, such as infrastructure development or healthcare, requires ethical considerations in ensuring equitable resource allocation (Zaidi, 2012)..

(4) Sustainable and Context-Specific Interventions: Implementing sustainable interventions that address gender disparities in education necessitates understanding the specific contexts, needs, and aspirations of girls within different communities. Ethical challenges arise in developing interventions that are contextually relevant, sensitive to local dynamics, and responsive to the unique challenges faced by girls in various socio-cultural settings (Moosa, 2020) .

(5) Intersectionality and Inclusivity: Ethical considerations arise from the recognition that gender disparities intersect with other dimensions of identity, such as socioeconomic status, ethnicity, disability, or geographic location. Ensuring inclusivity and addressing the needs of marginalized girls requires an intersectional approach that acknowledges and responds to the unique challenges faced by different groups of girls (Crenshaw, 1989).

Addressing these ethical challenges requires a comprehensive approach that incorporates principles of justice, fairness, and respect for human rights. It involves engaging with communities, fostering dialogue, and tailoring interventions to specific contexts. Furthermore, addressing gender disparities in education should involve collaboration with diverse stakeholders, including governments, communities, civil society organizations, and international bodies, to collectively navigate the ethical challenges and work towards achieving equal educational opportunities for all children. Investing in girl child education carries significant ethical implications and has the potential for positive impacts on society. By understanding and addressing these ethical implications, societies can promote social justice, equality, and sustainable development. The following points examine the ethical implications of investing in girl child education and its potential positive impact on society:

(1) Ethical Imperative of Equal Opportunity: Investing in girl child education aligns with the ethical imperative of providing equal opportunities for all individuals. Education is a basic human right, and denying girls access to education is a violation of their rights to equality and non-discrimination (UNESCO, 2015) . By investing in girls' education, societies uphold principles of fairness, justice, and human rights.

(2) Empowerment and Agency: Education empowers girls, enabling them to exercise their agency, make informed decisions, and participate actively in society. Ethically, investing in girl child education acknowledges and supports the agency and autonomy of girls, enabling them to shape their lives and contribute to the betterment of society (Nussbaum, 2000) . Empowered girls become agents of change, promoting gender equality, social progress, and sustainable development.

(3) Breaking the Cycle of Poverty: Education is a powerful tool for breaking the cycle of intergenerational poverty. Investing in girl child education can lead to improved economic opportunities, higher incomes, and enhanced socioeconomic well-being for girls and their families (World Bank, 2018) . Ethically, by breaking the cycle of poverty, societies reduce inequalities and promote social inclusion.

(4) Health and Well-being: Education is closely linked to improved health outcomes for individuals and communities. Educated girls are more likely to make informed decisions regarding their health, adopt healthier behaviours, and contribute to healthier families and communities (UNESCO, 2017).

Ethically, investing in girl child education contributes to the promotion of health, well-being, and the fulfilment of individuals' right to health.

(5) Sustainable Development: Investing in girl child education is a strategic investment in sustainable development. Educated girls become agents of change, promoting sustainable practices, addressing environmental challenges, and contributing to the achievement of the United Nations Sustainable Development Goals (SDGs) (UNESCO, 2018) . Ethically, investing in girls' education acknowledges the interconnectedness of social, economic, and environmental well-being and the need for a holistic approach to development.

By recognizing the ethical implications and investing in girl child education, societies promote social justice, gender equality, and inclusive development. Empowering girls through education not only benefits individuals but also leads to positive societal transformations, fostering a more equitable, prosperous, and sustainable future.

Societal Barriers and their Ethical Implications

Societal barriers to girl child education pose significant ethical implications as they perpetuate inequality, restrict opportunities, and hinder social progress. These barriers arise from deep-rooted social norms, cultural practices, and systemic issues that must be addressed to ensure ethical and equitable access to education for all children. The following points examine some societal barriers and their ethical implications:

(1) Gender-Based Discrimination: Gender-based discrimination is a pervasive societal barrier that denies girls equal access to education. Discriminatory practices, such as early marriage, gender stereotypes, and biased cultural norms, limit girls' educational opportunities. Ethically, such discrimination violates principles of equality, fairness, and human rights, undermining girls' potential and perpetuating social inequalities.

(2) Child Marriage and Early Pregnancy: Child marriage and early pregnancy are significant barriers to girls' education. These practices not only deny girls the opportunity to complete their education but also expose them to health risks and limit their future prospects. Ethically, addressing child marriage and early pregnancy is crucial for protecting girls' rights, promoting their well-being, and ensuring their equal access to education.

(3) Socioeconomic Constraints: Socioeconomic barriers, including poverty, lack of financial resources, and economic inequalities, hinder girls' access to education. Ethically, it is imperative to address these constraints to ensure equal opportunities for all children, irrespective of their economic background. Tackling socioeconomic disparities requires targeted interventions, resource allocation, and equitable policies that prioritize education as a fundamental right.

(4) Cultural Norms and Stereotypes: Cultural norms and stereotypes often reinforce traditional gender roles and perpetuate biases against girls' education. Ethical considerations arise in challenging these norms while respecting cultural diversity. Balancing cultural sensitivity with the promotion of equal educational opportunities requires engaging with communities, fostering dialogue, and promoting awareness about the importance of girls' education.

(5) Lack of Infrastructure and Resources: Inadequate educational infrastructure, such as schools, classrooms, and sanitation facilities, can disproportionately affect girls' access to education. Limited availability of educational resources, including textbooks, teaching materials, and technology, further exacerbates disparities. Ethically, addressing these barriers requires investment in infrastructure development and resource allocation to ensure inclusive and quality education for all children.

(6) Gender-Based Violence and Safety Concerns: Gender-based violence and safety concerns in and around educational institutions create a hostile environment for girls, deterring them from attending school. Ethical implications arise in ensuring a safe and secure learning environment that protects the rights and well-being of girls. Combating gender-based violence and addressing safety concerns is essential to creating an ethical educational ecosystem (Pranathi, O., & Kamraju, M. 2023) .

Addressing these societal barriers requires collective action, involving governments, civil society organizations, communities, and individuals. Ethical considerations call for transformative measures that challenge discriminatory practices, promote gender equality, and uphold the principles of fairness, justice, and human rights. By removing these barriers, societies can create an inclusive and equitable education system that empowers girls, promotes social progress, and fosters a more just and sustainable future.

Role of Society in Promoting Girl Child Education

(1) Ethical Responsibilities of Stakeholders: Various stakeholders, including governments, policymakers, educational institutions, communities, and families, have ethical responsibilities in promoting girl child education. Governments and policymakers bear the responsibility of enacting and implementing policies that ensure equal access to education for all children, regardless of their gender (UNESCO, 2015) . Educational institutions should create inclusive environments free from discrimination, while communities and families must actively support and encourage girls' education, challenging harmful gender norms and stereotypes.

(2) Importance of Community Involvement: Community involvement plays a crucial role in promoting girl child education. Communities can create a supportive environment by recognizing and valuing the importance of girls' education. Engaging community leaders, parents, and local organizations in dialogue and decision-making processes helps address cultural barriers, dispel myths, and foster acceptance of girls' education (Gupta, 2013) . Ethically, community involvement ensures that interventions are contextually relevant, sustainable, and respectful of local customs.

(3) Awareness Campaigns and Advocacy: Raising awareness about the importance of girl child education is essential for creating a supportive environment. Awareness campaigns and advocacy efforts can challenge societal perceptions, highlight the benefits of educating girls, and mobilize public support (Ghosh, 2019) . Ethically, advocacy campaigns promote social justice and human rights by challenging discriminatory practices and influencing societal attitudes towards girls' education.

(4) Successful Initiatives and Interventions: Numerous successful initiatives and interventions have addressed ethical challenges and promoted girl child education. For example, the Kishoree Kontha program in Bangladesh focuses on empowering adolescent girls through education, life skills training, and community engagement (World Bank, 2020) . The Room to Read organization implements interventions that address cultural and economic barriers, providing girls with access to quality education in various countries (Room to Read, n.d.). These initiatives highlight the importance of context-specific approaches, community involvement, and multi-stakeholder partnerships in promoting girl child education ethically.

Integrating ethical considerations into interventions involves promoting social justice, equity, and human rights. It requires engaging with stakeholders, fostering dialogue, and ensuring the participation of marginalized communities. By recognizing and fulfilling their ethical responsibilities, stakeholders can collectively contribute to creating an enabling environment that supports and promotes girl child education.

Conclusion

In conclusion, the research highlights the ethical dimensions of promoting girl child education and the transformative potential it holds. It emphasizes the ethical responsibilities of various stakeholders, including governments, policymakers, educational institutions, communities, and families, in ensuring equal access to education for girls. The research underscores the importance of addressing societal barriers, such as discrimination, cultural biases, and social norms, which hinder girls' education and perpetuate inequality. Investing in girl child education is not only an ethical imperative but also a pathway to empowering girls and fostering social progress. Education equips girls with knowledge, skills, and agency, enabling them to overcome challenges, make informed decisions, and contribute positively to society. By providing equal educational opportunities, societies can promote social justice, gender equality, and sustainable development. However, there are ethical challenges associated with addressing gender disparities in education. These challenges include cultural sensitivity, overcoming resistance to change, resource allocation, developing context-specific interventions, and addressing intersectionality and inclusivity. Tackling these challenges requires collaborative efforts, dialogue, and transformative measures that uphold principles of fairness, justice, and human rights. Further research is needed to deepen our understanding of the ethical implications of promoting girl child education and to identify effective strategies to overcome barriers. Policy changes should prioritize girls' education, allocate resources equitably, and address systemic issues that perpetuate gender disparities. Collective action involving governments, communities, civil society organizations, and individuals is necessary to ensure equal access to education for all children, irrespective of their gender. In conclusion, promoting girl child education is not just an ethical imperative but also a means to create a more inclusive, equitable, and prosperous society. By recognizing and addressing the ethical challenges, we can unlock the full potential of girls, empower them as agents of change.

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GEOPOLITICAL CONFLICT SITUATION AND PERSPECTIVE- A CASE STUDY OF INDIAN OCEAN

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Abstract

The geopolitics of the Indian Ocean region holds paramount significance in the contemporary global landscape. This paper delves into the multifaceted dimensions of Indian Ocean geopolitics, encompassing historical, economic, environmental, and strategic considerations. Employing a comprehensive methodology that incorporates geopolitical databases, economic and trade statistics, environmental data, and historical archives, the study aims to unravel the intricate interplay of actors, interests, and power dynamics in the region. The Indian Ocean, boasting critical choke points like the Strait of Hormuz and Bab-al-Mandeb, serves as a nexus for international trade and political activities. As the repository of a substantial share of the world's oil, gas, uranium, gold, and diamond reserves, the Indian Ocean region emerges as a focal point for global economic dynamics. Furthermore, it houses vital minerals, amplifying its strategic importance. The region's geopolitical landscape is marked by the presence of diverse littoral states, each with its unique historical trajectory, economic aspirations, and security concerns.

Introduction

Geopolitical analysis often examines the Earth's composition of land and water, a concept with a long history spanning hundreds of years. This perspective considers the interconnectedness of humanity, states, and the environment. The Earth can be categorized into hemispheres based on water and land distribution. The rise of globalization has amplified the importance of the Indian Ocean in economic affairs. In terms of size, the Indian Ocean ranks third globally, holding approximately 20% of the world's water. Analyzing the world map through Mercator's projection provides insight into the geopolitical importance of the Indian Ocean, which extends from 20 degrees E to 120 degrees E longitude. Notably, all nations along the Indian Ocean coastline, excluding Australia and South Africa, fall within the underdeveloped or developing categories. Furthermore, the majority of these nations comprise a significant portion of the Third World, sharing common

characteristics, notably having been part of colonial empires of Western European nations until gaining independence, primarily between the 1940s and 1960s. With limited exceptions, these nations were integral components of the colonial empires of Western European nations for substantial durations throughout the 19th and 20th centuries. They achieved liberation, whether through peaceful methods or other means, from colonial dominion between the 1940s and 1960s.

Study Region

This article is study of Indian Ocean region. The emerging nation-states facing heightened vulnerabilities and instabilities due to their underdeveloped status. Their ambitions and frustrations stem from the allure of development benefits on one hand and the constraints of economic backwardness on the other. These nations collectively grapple with the challenges and disruptions associated with the shift from traditional cultural values to those required by industrial economies in the nuclear age. Access to the ocean can be gained through either two narrow northern "choke-points" – the Suez Canal/Horn of Africa and Singapore/Straits of Malacca – or two southern border "gateways" at the southern extremities of Africa and Australia. The southern Indian Ocean, in reality, provides the most direct route between the Pacific and Atlantic Oceans. Moving beyond the coastal states, the northern landmass is primarily shaped by the influence of the Soviet Union and China, both Communist powers in ideological conflict with the Western world. Specifically, the Soviet Union, as a superpower, has been in a conflict with the United States, the other superpower. Strategically, the Indian Ocean region represents a vulnerable aspect for the Soviet Union, with limitations in reducing its vulnerabilities. Following the British announcement in 1968 regarding their withdrawal from the Indian Ocean Region by 1971, the two superpowers – the United States and the Soviet Union – became deeply involved. The subsequent two decades witnessed an escalation in militarization and superpower rivalry. The economic and political aspects of the Indian Ocean have seen growth alongside the expansion of globalization.

Objectives

(1) The significance of Indian ocean in geopolitics of region

(2) How is Indian Ocean strategically important for India?

(3) Why United States is interested in Indian Ocean region?

(4) Why china wants its domination in Indian Ocean?

Database and methodology

This article used primary and secondary data. Articles, books, newspaper, government documents, reports. Utilize geopolitical databases that compile information on international relations, conflicts, and geopolitical events. Access databases that provide economic and trade statistics for countries in the Indian Ocean region. International organizations like the World Bank and the International Monetary Fund (IMF) offer comprehensive datasets. Explore historical archives and libraries for primary sources that offer insights into historical geopolitical events in the Indian Ocean region. The methodology used in article is qualitative. Analysis of indian ocean rgionis conducted to know its significance. Conduct a thorough literature review to understand existing theories, frameworks, and scholarly work on Indian Ocean geopolitics. Identify gaps or areas for further exploration. Analyze specific case studies within the Indian Ocean region to gain a nuanced understanding of geopolitical dynamics. Focus on historical events, conflicts, or cooperative efforts. Explore different scenarios and potential future developments in the region based on geopolitical, economic, and environmental factors.

Results and Discussion

Initially, the United States demonstrated a lack of interest in filling the gap left by Britain's withdrawal from the Suez Canal. However, developments in the 1970s and 1980s compelled the U.S. to become involved in the Indian Ocean region. The U.S. strategically nurtured relations with China, capitalizing on the rivalry between China and the Soviet Union. Simultaneously, the U.S. refrained from intervening in South East Asia to allow China to reap the benefits. The U.S. directed its efforts toward maintaining influence in South Asia, West Asia, and Southwest Asia for its own strategic advantage. In contrast, the Soviets adopted a policy of supporting anti-imperialist forces and advocating for the independence of nations in former colonies. The shared anti-imperialist sentiment served as a basis for cooperation among states aspiring for socio-economic improvement in partnership with the Soviet Union. The Soviet Union aimed to diminish the influence of the United States in newly independent and developing countries, particularly given the growing collaboration between the U.S. and China. The Indian Ocean holds significance for trade and commerce, serving as a crucial link between the East and West. The political importance of the Indian Ocean has grown due to the ideological conflict between the two superpowers. According to the United States, the Indian Ocean is pivotal to its strategy of fostering positive relations and exerting influence in newly independent states. Conversely, the USSR views the U.S. strategy as a potential

threat to the sovereignty of these newly independent states and a hindrance to its own security. The geostrategic relevance of the Indian Ocean is heightened by its access to sensitive global areas and key choke points, such as the Malacca Strait.

Strategic Significance of Ports

China and India are making substantial investments in the development of seaports in the Indian Ocean, recognizing its strategic significance. India is actively involved in the construction of the Chabahar port in Iran, aiming to secure access to landlocked Central Asian countries. In response, China is building the Gwadar port in Pakistan, directly challenging India's interests. The presence of an anti-Sunni regime in Iran introduces vulnerabilities in the operational efficiency of the Chabahar port, posing challenges to India's maritime interests. In 2008, the Chief of the Indian Navy highlighted the strategic implications of the Gwadar port, emphasizing its potential to empower Pakistan in controlling strategically important energy sea lanes in the Persian Gulf. The growing geopolitical importance and cohesion of the Indian Ocean region are substantiated by at least three factors: the proliferation of regional strategic connections, the Indian Ocean policies pursued by external powers, and the collective indigenous responses to external intervention. The proliferation of regional strategic linkages underscores the increasing interconnectedness of events in the Indian Ocean area.

These events may be linked in two primary ways. Firstly, through a "linkage of instabilities," wherein the instabilities and imbalances in one sub-region not only affect neighboring countries but can also extend into more distant parts of the region, forming a comprehensive "linkage of instabilities" throughout the area. The impact of a situation may vary based on its occurrence, with implications differing for events near and further away. For instance, the Vietnamese invasion of Kampuchea has led to a significant refugee crisis and concerns about a direct security threat in Thailand, while in Indonesia and Australia, it is perceived as an unwelcome and perilous manifestation of regional instability. Similarly, the Soviet invasion of Afghanistan raised fears of a direct Soviet threat to Pakistan and Persian Gulf oilfields, causing apprehension in distant parts of the region about the means and objectives of Soviet policy. Consequently, due to such developments over the past decade, it is now improbable that any event impacting the security of even the smallest state in the Indian Ocean region will be dismissed as inconsequential to the other states in the area. Subsequently, interconnections arise among sub-regions when individual states or groups of states deliberately implement security policies on a scale beyond their immediate sub-regional context.

An example is the collaborative efforts of black states in southern Africa, in conjunction with other African nations, actively working to isolate and apply pressure on white-ruled South Africa. Similarly, there is widespread support from the nations along the Indian Ocean coast for the proposal to designate the area as a zone of peace. Another illustration is Saudi Arabia's policy, which seeks to integrate security postures from the Red Sea area through the Gulf to the extremities of the Indian subcontinent. Presently, the process of linkage seems fragmented, with states in one subregion generally not seeking security alliances with those in another. Security linkages have primarily been extra regional, involving a local state and an external power, such as Australia with the United States, India with the Soviet Union, and Pakistan with China and the United States. Although limited, the success of formal alliances between states of different subregions, as seen in SEATO (South-East Asia Treaty Organization) and CENTO (Central Treaty Organization), suggests the potential for more formal sub-regional coalitions in the future. Additionally, the Gulf Cooperation Council is progressing towards forming a security alliance, as previously mentioned.

The strategies of the two superpowers hold paramount significance. Their immediate concerns in the region have intertwined with the broader dynamics of their global competition, making the Indian Ocean a strategically vital arena for both. In contrast to Japan and Western Europe, which relied on Gulf oil for approximately 90% and 75% of their respective needs during the 1973-1974 embargo, the United States did not have a comparable dependence on Gulf oil. The significant outcome of the embargo wasn't just the impact on Western economies but the intense discord and internal conflicts within the Atlantic alliance. Member states and Japan engaged in fierce competition for privileged access to unembargoed oil and future access to Arab oil. The United States is eager to avoid a prolonged denial of Persian Gulf oil to the West, not only for economic reasons but also to maintain alliance solidarity. Despite the current surplus in global oil supplies and declining prices, Persian Gulf oil, constituting about 55% of the world's proven reserves, will remain strategically crucial for the West until the end of the century. In the past, the United States leaned on local allies to protect its fundamental political, economic, and strategic concerns in the Indian Ocean region. Yet, a shift occurred in the late 1970s, with the U.S. adopting a new strategy for its security interests in the area. This approach actively aimed to enhance access to naval, air, and communications facilities across the region. It involved improving the operational capabilities of the British-owned Diego Garcia, increasing naval deployments in the Indian Ocean,

and establishing the Rapid Deployment Force. These initiatives significantly strengthened the U.S.'s capacity to exert influence in the Indian Ocean, indicating a commitment to a more engaged role in the region. While the focus of these efforts might appear centered on the Persian Gulf, it is crucial not to characterize the policy as exclusively Gulf-centered. Although additional forces and facility improvements suggest a concentrated approach, U.S. military resources are limited and must be allocated based on strategic priorities. The emphasis on the north-west quadrant of the Indian Ocean highlights the importance Washington attributes to its Gulf interests and an overarching concern for the stability of that subregion. However, the U.S. has not neglected its military and political interests in other parts of the region, as evidenced by recent endeavors to strengthen military capabilities in the eastern approaches to the Indian Ocean, including securing landing rights for B-52 bombers in Australia

Non State Actors and their Threat

Non-traditional threats to global security have experienced significant growth, and India is grappling with major challenges such as maritime terrorism, gun-running, drug trafficking, and piracy along its sea borders. Given the crucial shipping lanes traversing the region, India has been underscoring the significance of maritime security in the Persian Gulf and the Gulf of Aden. Various terrorist organizations, including Al Qaeda, utilize maritime routes around India in the Indian Ocean region for narcotics and arms trafficking, financing their operations. Indian intelligence agencies have cautioned the government about potential seaborne attacks by terrorist groups targeting the nation's oil rigs, encompassing production and support platforms along both coasts. Piracy poses a significant threat in various parts of the Indian Ocean, notably the Malacca Straits and the Horn of Africa, necessitating a robust Indian maritime presence. Reflecting this perspective, the Indian maritime doctrine asserts that the arc from the Persian Gulf to the Straits of Malacca is a legitimate area of interest for India in the twenty-first century. The majority of attacks and hijackings on the high seas concentrate in three key areas: the Gulf of Aden and the eastern coast of Somalia, the coast of West Africa (particularly off Nigeria), and the Indonesian archipelago. In the initial quarter of 2008, over half of all attacks occurred in the Gulf of Aden. In 2008, a significant surge in piracy incidents took place, with at least 92 ships attacked in and around the Gulf of Aden, surpassing the number in 2007. An estimated $25 to $30 million was paid in ransom to Somali pirates. Responding to heightened concerns,

particularly after the hijacking of the merchant vessel MT Stolt Valor off the coast of Somalia in September 2008, the Indian government authorized the Indian navy to initiate patrols in the Gulf of Aden and provide escorts to Indian merchant vessels. India holds an economic stake in safeguarding not only Indian-owned but also non-Indian-owned cargo ships in the Gulf of Aden shipping lanes. Approximately 85 percent of India's sea trade on this route is transported by foreign-owned ships, and about one-third of India's entire fleet of 900 cargo ships operating in international waters is vulnerable to risks. The patrolling conducted by the Indian navy aims to secure the nation's sea-borne trade, instill confidence in the maritime community, and serve as a deterrent to pirate activities. While Russia, NATO, and EU forces have initiated patrols in the region, coordination efforts remain disjointed. India argues for the establishment of a peacekeeping force under a unified command to ensure security in pirate-infested regions for international shipping.

In a noteworthy operation—the first of its kind since the 1971 war with Pakistan—India's stealth frigate, INS Tabar, engaged and sank a pirate "mother vessel" in the Gulf of Aden, later revealed to be a Thai trawler. The Indian naval vessel fired in self-defense as the trawler, commanded by pirates who refused to surrender, posed a threat. This incident underscored the Indian navy's capabilities on the high seas, previously demonstrated during tsunami relief operations and the evacuation of Indian nationals in the Lebanon War of July-August 2006. The Indian navy showcased its autonomy and proficiency in serving a collective good: the protection of global maritime trade. India utilized this demonstration to project itself as a nation capable of safeguarding its maritime interests and commercial sea routes in international waters. While this highlighted the Indian navy's prowess on the high seas, questions were raised about its ability to counter terrorism on the home front, especially following a severe assault on Mumbai in November 2008, where terrorists managed to outwit the Indian navy and Coast Guard.

The terrorists successfully infiltrated Mumbai using a trawler, revealing a systemic failure within Indian security agencies. India's Coast Guard is responsible for securing the Exclusive Economic Zone within 200 nautical miles, while the navy oversees the blue water beyond. Despite the clear recognition of the threat of terror attacks from the sea, no measures were taken to reinforce anti-terror defenses. India's extensive coastline, coupled with insufficient policing, facilitates the clandestine landing of arms and explosives at isolated coastal points. This method was exploited in 1993 for the bomb blasts in Mumbai, and it was employed again in the 2008 terrorist attacks. The Indian Naval Chief took

responsibility for the lapse, citing weak infrastructure for patrolling and surveilling coastal areas. Despite actionable intelligence, both the Coast Guard and the navy failed to detect or intercept the Pakistani ship transporting terrorists from an Indus creek near Karachi, Pakistan. The escalating global threats from non-state actors necessitate India's collaboration with other major naval powers, not only to address issues like piracy but also to tackle broader security concerns for maritime commerce. Given the Indian navy's demonstrated effectiveness in providing the government with operational leverage in the Indian Ocean, its role in projecting power and safeguarding national interests is expected to grow. However, a significant challenge to the Indian navy may emerge from the expanding influence of another major Asian power in the Indian Ocean i.e. China.

In 2006, China surpassed Japan as the largest military spender in the Asia-Pacific, now holding the fourth-largest defense expenditure globally. While there is contention over the exact figures, with estimates ranging from China's official claim of $35 billion to the US Defense Intelligence Agency's estimate of $80-115 billion, the clear trend is a significant increase in Chinese military spending, showing a 195 percent rise from 1997 to 2006. The official Chinese figures do not encompass costs for new weapons purchases, research, or other major items for its secretive military. Calls for transparency in China's military intentions and capabilities have arisen globally, from Washington to Tokyo, Brussels, and Canberra. According to the 2006 Defense White Paper, China's navy aims to gradually expand its strategic depth for offshore defensive operations, enhance capabilities in integrated maritime operations, and develop nuclear counter-attacks. The Chinese navy now ranks as the third-largest globally, surpassing the Indian navy both qualitatively and quantitatively.

Historically a coastal force with a continental security outlook, China's economic rise since the 1980s has led to a maritime orientation with intentions to project power into the Indian Ocean. China is investing significantly more in modernizing its armed forces, particularly its navy, than India currently appears willing or able to sustain. China's growing submarine fleet, including sophisticated submarines, ballistic missiles, and GPS-blocking technology, positions it to potentially challenge the United States. There are indications that China plans to build an aircraft carrier by the end of the decade, a departure from its earlier focus on Taiwan. As China's economic and political influence expands, its profile in the Indian Ocean region has grown, with efforts to acquire naval bases along crucial chokepoints for economic and strategic purposes. China's comprehensive development of maritime power reflects

its ambition to dominate the strategic maritime space in the Indian Ocean region. To overcome the geographical distance, China relies on bases in the littoral regions of the Indian Ocean. The "String of Pearls" strategy exemplifies China's increasing naval power and encircling approach, particularly evident in its efforts to dominate the South China Sea and deploy submarines near the Strait of Malacca, a vital entry point to the Indian Ocean. Despite India's geographical advantage, China's expanding naval capabilities pose a strategic challenge for India in the region. China is actively pursuing the development of its maritime economy and aims to establish the world's largest merchant fleet, backed by extensive port and shipbuilding infrastructure. While China-India relations have been steadily improving since the 1990s, there has consistently been an underlying sense of competition. China has effectively cultivated strong ties with Pakistan through its economic and military influence. Although China aspires to dominate the Indian Ocean and achieve naval supremacy, this goal remains a distant prospect.

Indian Response to China in Indian Ocean

Strategic Partnerships: India has fostered strategic partnerships with countries in the Indian Ocean region to counterbalance China's influence. Bilateral and multilateral engagements with nations like the United States, Japan, Australia, and those in Southeast Asia have become more pronounced. Naval Modernization: India has been investing in the modernization of its naval capabilities to enhance maritime security. This includes the development of a robust naval fleet, acquisition of maritime surveillance systems, and the establishment of coastal surveillance networks. Infrastructure Development: India has been working on enhancing its maritime infrastructure, including port facilities, to strengthen its presence in the Indian Ocean. Projects such as the development of the Chabahar Port in Iran aim to provide India with strategic access to Central Asia. Diplomacy and Regional Cooperation: India has engaged in diplomatic efforts and regional cooperation to address common security concerns. Initiatives like the Indian Ocean Naval Symposium (IONS) and the Indian Ocean Rim Association (IORA) have been platforms for dialogue and collaboration. Focus on Maritime Domain Awareness (MDA): India has increased its focus on MDA to monitor and respond to maritime security threats effectively. This involves intelligence-sharing agreements, joint patrolling, and coordinated efforts with partner nations. Anti-Piracy Operations: India has actively participated in anti-piracy operations in the Gulf of Aden. The Indian Navy has deployed warships to ensure safe passage for merchant vessels and counteract piracy in the region. It's important to note that the geopolitical

landscape is dynamic, and developments may have occurred since my last update in January 2022. For the latest and more detailed information, please refer to recent academic publications, official government statements, or reputable news sources.

Conclusion

The Indian Ocean has evolved into a focal point for global economic and political endeavors, attaining strategic significance due to key chokepoints like the Strait of Hormuz and Bab-al-Mandeb. There exists a need for a renewed geopolitical framework for the Indian Ocean region, departing from traditional military-centric perspectives, and challenging the imperialist history of international maritime relations. The notion of 'mastery' or 'conquest' of the oceans must be reevaluated, recognizing the finite capacity of the marine environment and prompting exploration of new perspectives. Establishing a peaceful, socially equitable, gender-sensitive, and environmentally sustainable 'order' for the oceans requires patient negotiations and consensus-building, steering away from exclusively state-led management or region-specific development approaches. The Indian Ocean region and its coastal areas harbor over two-thirds of the world's oil reserves, 35% of global gas reserves, and significant proportions of uranium (60%), gold (40%), and diamond reserves (80%). Moreover, the region's importance is underscored by its mineral wealth, encompassing reserves of beryllium, coal, copper, iron, tin, chromite, manganese phosphate, and lithium. Positioned strategically, the Indian Ocean holds a unique geopolitical status, being the only ocean named after a country.

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STUDY OF LITERACY GAP AMONG GENDER: A BLOCK LEVEL ANALYSIS OF LUCKNOW DISTRICT

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Abstract

Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy is considered an important key to social-economic progress. Literacy & education attainment are important indicators of the development of a society. It helps in eliminating gender disparity at all level. In India the reality of gender inequality is very complex and diversified because it exists in various fields like literacy, health, employment etc. According to the Census of India 2011, the overall literacy rate of India is 74% with male literacy being 82% & female literacy at 65%. A sizeable gender difference of 17% can be observed in the literacy rate. Such disparities between male and female literacy can be seen at both state and national levels. Recent decades manifest growth in literacy but the gap still exists and is predominant in rural areas. Lucknow district also witnesses gender disparity in literacy. The present study is an attempt to evaluate literacy gap among gender & its regional variations in the administrative blocks at the district level. This paper provides an insight into the Spatio-temporal patterns of male-female literacy & its level of disparity. This study is based on secondary sources of data collected from the District Census Handbook. The method adopted in the study to calculate the disparity in literacy is Sopher's Disparity Index (1974). Between the years 2001 and 2011, the study area has seen a fall in the gender gap and an increase in the male-female literacy rate. The gender literacy gap has been bridged largely due to initiatives like Beti Bachao, Beti Padhao, and the National Program of Education for Girls at the Elementary Level (NPGEL). But still, there is a scope for improvement in women's literacy levels for this the research will be useful in suggesting some relevant strategies and policies with implications for reducing gender inequality and promoting the dignified position of women.

Introduction

Literacy is a crucial indicator of the social and economic development of a nation. It plays a significant role in removing inequality along with the development of society and its individuals. It is the fundamental building block for a country's development. Literacy is a highly important tool for people to learn and develop skills that will enable them to understand and have a positive attitude for society. It also helps in analyzing the inequalities and factors responsible for poverty and exploitation in the society. Kofi Annan, Former Secretary General of the United Nations had quoted, "Literacy is a bridge from misery to hope. It is a tool for daily life in modern society. It is a bulwark against poverty and building blocks of development, an essential component to investments in roads, dams, clinics & factories. It is a platform for democratization & a vehicle for promotion of cultural & natural identity. It is the way to human progress & the means through which every man; woman & child can realize his or her full potential". The definition of literacy given by UNESCO (1957), "A person is literate who can with understanding both read and write a short simple statement on his/her everyday life". In simple words according to UNESCO it means "Literacy is the ability to identify, understand, interpret, create, compute & use printed & written material associated with varying contracts". According to Census of India 2011, "Any person (aged 7 & above) is considered a literate, if he or she can read & write in any language with complete understanding". Researchers, Academicians & policy makers have rated literacy as the starting point of development (Pattinson1982, Strect 1984).

Literacy unlocks the door to learning throughout life is essential, is essential to development & health & opens the way for democratic participation & active citizenship (Kofi Annan, Former Secretary General of the United Nations). Literacy influences & determines qualitatively & quantitatively not only human resources but also other demographic attributes like fertility, mortality, and economic participation of women &age of marriage ultimately aiming towards welfare of the society (Sawant & Lewis, 2004). Literacy is both the cause & result of development (Mohapatra,1993). Literacy is tool to empower women in the wider struggle against inequality & injustice in society (Patel & Dighe,1997). Higher levels of literacy are a good predictor of both a growing economy and a high standard of living. According to the Census of India 2011, the overall literacy rate of India is 74% with male literacy being 82% & female literacy at 65%. Uttar Pradesh recorded as a whole 77.3% of males & 57.2% of female literates. Lucknow district as a whole accounted for 82.6% of male & 71.5% of female literates respectively. At the national, state,

district, and block levels, disparities between males and girls in literacy can be observed. Recent decades have witnessed growth in literacy rate but the disparity in literacy still exists and can be predominantly seen in rural areas of the country. This is generally because the rural areas are dominated by agricultural activities while the urban regions are driven by the tertiary sector. Thus, a difference in economy, infrastructural facilities, accessibility, the standard of living, and women status can be observed. Differences in literacy are important for a variety of reasons. Due to the underutilization of potential human capital, a biased allocation of educational resources implies significant costs for social welfare. Some important factors like-poverty, early marriage, dowry, preference for boy's education, lower enrollment, etc are responsible for creating such disparities in literacy. Grover R.P., & Bhardwaj, R., (2002) have rightly pointed out that administrators & planners must pay greater attention in bridging the gap between literacy of males & females. As literacy is related to both social needs and economic development, there is a need to implement integrated literacy programs for rural development, with a particular focus on skill development and income generation programmes. A woman holds a pivot position & plays multiple roles in the development of modern society. It is widely argued, "When you educate a man, you educate a person; but when you educate a woman, you educate a generation." The Sustainable Development Goal (SDG) 4 also talks about ensuring inclusive & equitable quality education & promote lifelong learning opportunities for all. It will confront a holistic approach to educating people & boosting literacy levels to meet sustainable development goals that have yet to be made by 2030.

Study Region

Lucknow is the capital city of Uttar Pradesh which is located on the banks of river Gomti dividing the whole city diagonally into cis-gomti & trans-gomti regions . The total area of the district is 2528sq km. It exists between 26°30' to 27°10' North latitude and 80°34' to 81°12' East longitude. The district is surrounded in the northern side by district Sitapur, on the southern side by district Raebareli, on the eastern side by Barabanki district, on the south-western side by Unnao district & on the north-western side by Hardoi. The administrative setup of the district is divided into 4 tahsils & 8 development blocks namely Mal, Malihabad, Bakshi Ka Talab, Chinhat, Kakori, Sarojaninagar, Gosainganj & Mohanlalganj. There are total of 12 towns (10 statutory towns & 2 census towns. The adjoining districts are dependent on Lucknow district & mostly the Lucknow city for better education & health facilities & various job opportunities.

Objectives

(1) To find out the gender disparity in literacy rate.

(2) To suggest suitable measures for reducing disparities in literacy rate.

Database and Methodology

The present study is based on secondary data & sources obtained mainly from the Census of India, relevant issues, 2001 & 2011 & District Census Handbook of Lucknow-2001 & 2011. The block-wise data of the literate population & literacy rate for the 2001 and 2011 censuses are available. The tabulation and graphical representation of the data are done and represented through maps. The methodology adopted to measure gender disparity is Sopher's Disparity (1972). It is calculated using the following expression:

$$DI = \text{Log } X2/X1 + \text{Log } 100\text{-}X1/100\text{-}X2$$

Whereas: $X2 \geq X1$

DI- Disparity Index

X2- Percentage of Male Literates

X1- Percentage of Female Literates

Q- 100

To measure gender disparity in literacy, male literacy is taken as X2 & female literacy as X1, Where X2 is generally more than that X1. The Log value is taken to reduce the leveling-off effect (Sopher 1972). The value should range between +1 & -1. In the case of perfect equality, no disparity exists between the two variables. If the value is greater, it represents high disparity and if the value turns out to be lesser it shows low disparity. It is generally used in measuring the relative disparity. The study of the disparity index of literacy is grouped into 3 categories, namely, Low Disparity, Medium Disparity and High Disparity.

Results and Discussion

Being a universal phenomenon, the disparity in male-female literacy varies from region to region. The study area is also not free from this disparity. According to Census 2001, the total literacy rate of Lucknow district was 68.25% with male & female literacy rates being 75.98% & 60.47% respectively. With the passage of time, the study area witnessed a significant jump in total literacy by 77.3% with 82.6% as male literates & 71.5% as female literates in the 2011 Census (**Fig.** 1.)

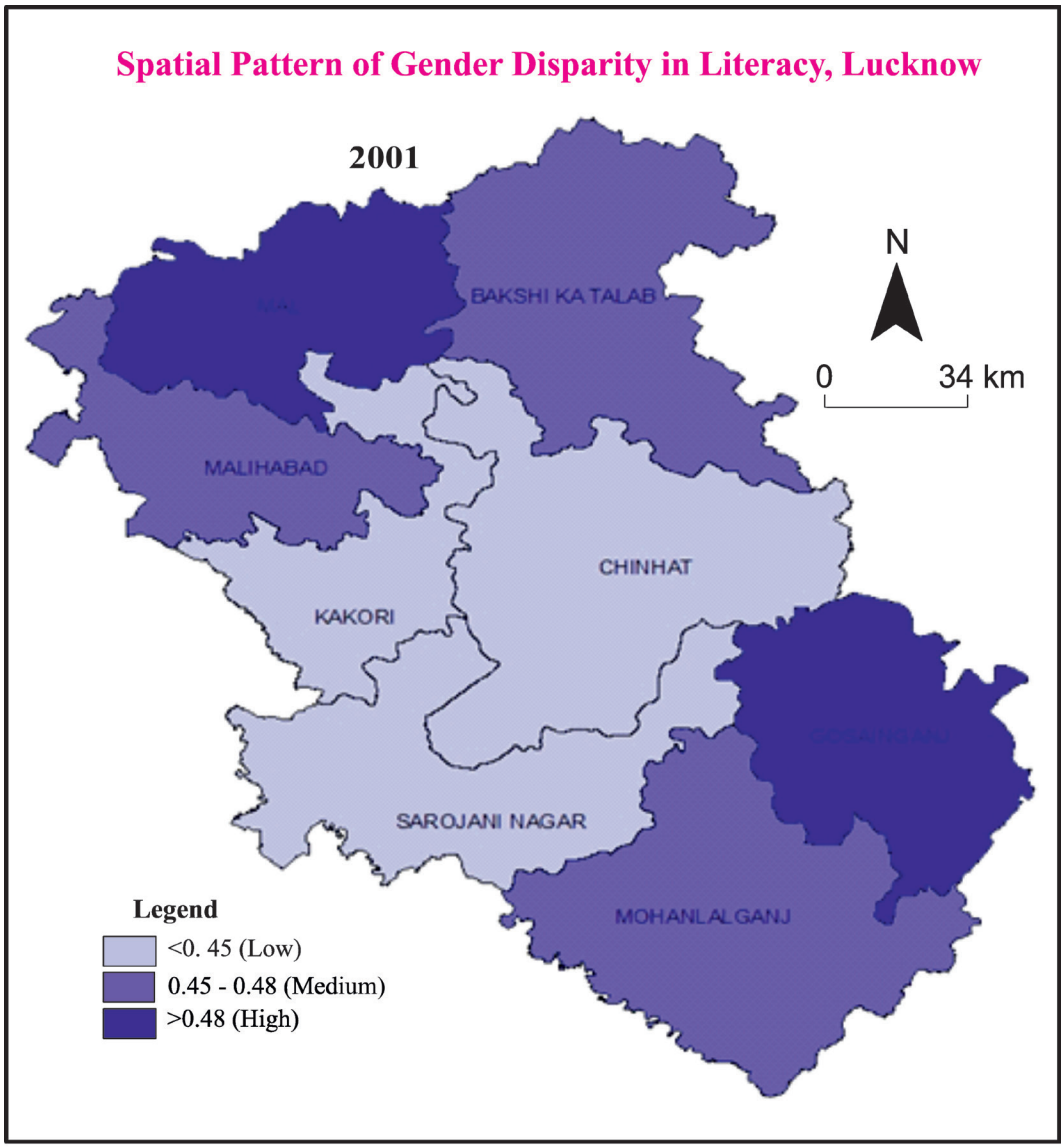

Spatial Pattern of Gender Disparity in Literacy, Lucknow
2001
N
0
34 km
BAKSHI KA TALAB
MALIHABAD
CHINHAT
KAKORI
SAROJANI NAGAR
MOHANLALGANJ
Legend
<0. 45 (Low)
0.45 - 0.48 (Medium)
>0.48 (High)

Fig. 1

Though, the disparity got narrowed down from the 2001 to 2011 census but, still, a large number of people are illiterates existing in the study region & acting as a major obstacle in the socio-economic development of the area. The present paper is an attempt to study regional variation of gender disparity in literacy in the study area by using Sopher's Disparity Index. This disparity is calculated for all the administrative blocks for the censuses 2001 & 2011. On the basis of values of literacy, the disparity index is calculated & by applying the standard deviation technique the study area is divided into low, medium & high disparity regions. The disparity was 0.45 in 2001 which came down to 0.36 in 2011 (**Table-**1 & **Table-**2 and Fig 2).

Table-1: Gender Disparity Index (GDI) in Literacy Rate, 2001

Blocks	% of literacy to the total population in Lucknow 2011				
	Total Literacy	Male Literacy Rate	Female Literacy Rate	Gap in Male-Female Literacy Rate (%)	Gender Disparity Index (GDI)
Mal	47.1	60.2	32.4	27.8	0.49
Malihabad	51.3	63.7	37.0	26.7	0.47
Bakshi Ka Talab	55.5	67.7	41.3	26.4	0.47
Chinhat	55.8	67.1	42.8	24.3	0.43
Kakori	50.4	61.2	37.9	23.3	0.41
Sarojaninagar	58.4	69.5	45.5	24	0.43
Gosainganj	53.7	66.7	39.0	27.7	0.49
Mohanlalganj	55.6	67.7	42.1	25.6	0.45
District (Rural)	53.9	65.9	40.1	25.8	0.45

Source: District Census Handbook of Lucknow, 2001

Areas of Low Disparity

In 2001, low disparity range (Below 0.45) was observed in 3 blocks namely Chinhat (0.43), Kakori (0.41) & Sarojaninagar (0.43). The highest rural literacy of 58.4% with 69.5% of male literacy & 45.5% of female literacy was recorded in Sarojaninagar block. In 2011 the same blocks except Sarojaninagar (0.38) i.e. Chinhat (0.33) & Kakori (0.32) were in the low disparity range (Below 0.36). This low disparity in these blocks can be attributed to good socio-economic development, high literacy, better opportunities for women, suitable environment etc.

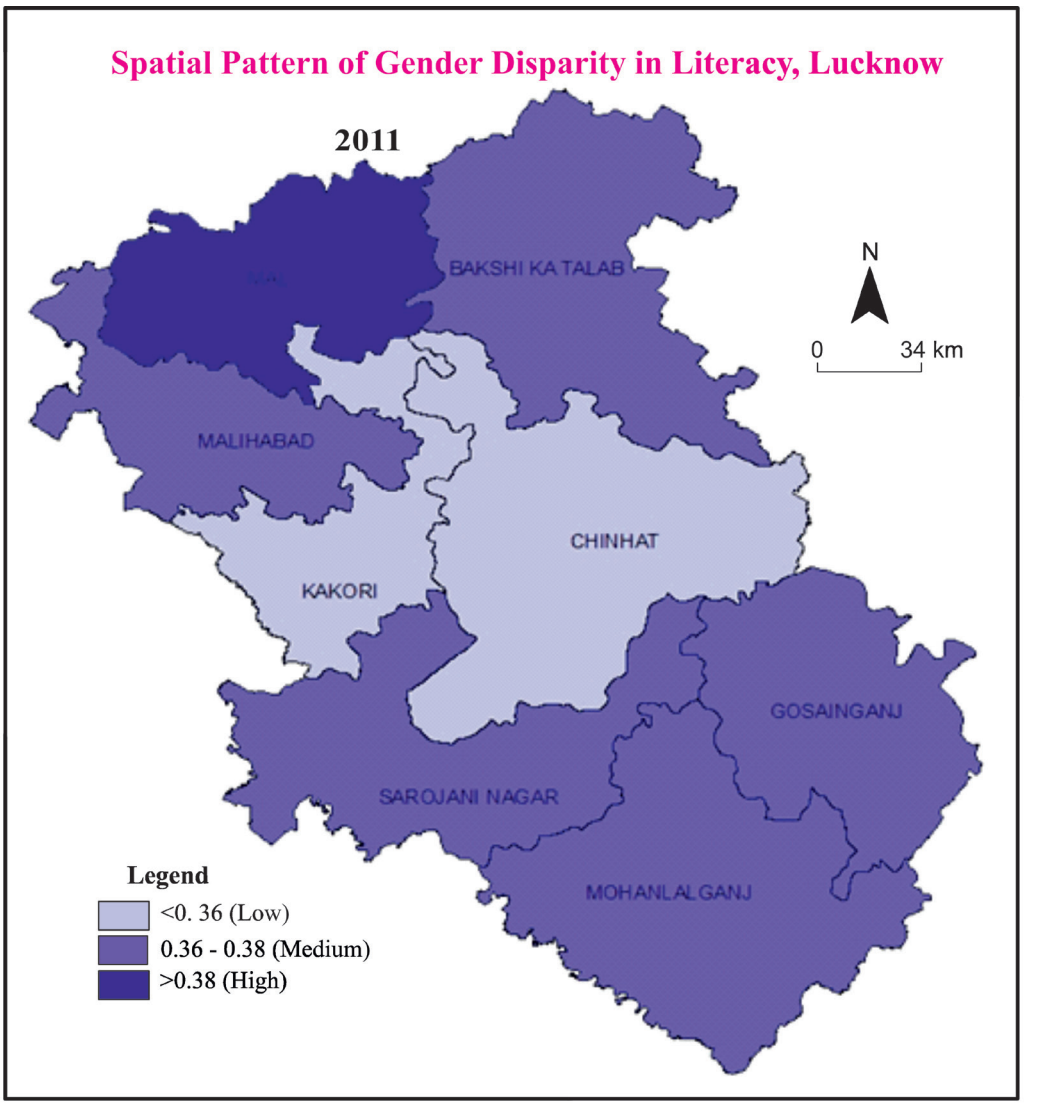

Spatial Pattern of Gender Disparity in Literacy, Lucknow
2011
BAKSHI KA TALAB
MALIHABAD
CHINHAT
KAKORI
GOSAINGANJ
SAROJANI NAGAR
MOHANLALGANJ
N
0
34 km
Legend
<0. 36 (Low)
0.36 - 0.38 (Medium)
>0.38 (High)

Fig. 2

Table-2: Gender Disparity Index (GDI) in Literacy Rate, 2011

Blocks	% of literacy to the total population in Lucknow 2011				
	Total Literacy	Male Literacy Rate	Female Literacy Rate	Gap in Male-Female Literacy Rate (%)	Gender Disparity Index (GDI)
Mal	64.3	74.3	53.3	21.0	0.40
Malihabad	65.7	74.7	55.6	19.1	0.37
Bakshi Ka Talab	67.1	76.0	57.2	18.8	0.37
Chinhat	73.5	80.5	65.8	14.7	0.33
Kakori	66.8	74.4	58.2	16.2	0.32
Sarojaninagar	73.0	81.1	64.1	16.9	0.38
Gosainganj	64.3	73.3	54.6	18.7	0.36
Mohanlalganj	68.1	76.7	58.3	18.4	0.37
District(Rural)	67.8	76.4	58.3	18.1	0.36

Source: District Census Handbook of Lucknow, 2011

Areas of Medium Disparity

In 2001, the medium disparity was between (0.45-0.48) range. Under this range, there were 3 blocks namely Malihabad (0.49), Bakshi Ka Talab (0.47) & Mohanlalganj (0.45). In 2011, medium disparity range (0.36-0.38), 2 more blocks were added in the range, now there were 5 blocks in total namely, Malihabad (0.37), Bakshi Ka Talab(0.37), Sarojaninagar (0.38), Gosainganj (0.36) & Mohanlalganj (0.37) (Fig 2 and **Table**-3 and 4).

Table-3: Gender Literacy Rate in Census, 2001

Low Disparity Region (< 0.45)	Medium Disparity Region (0.45-0.48)	High Disparity Region (>0.48)
Chinhat, Kakori, Sarojaninagar	Malihabad, Bakshi Ka Talab, Mohanlalganj	Mal, Gosainganj

Source: Calculated by Authors

Areas of High Disparity

In 2001, high disparity range (Above 0.48) was observed in 2 blocks namely Mal (0.49) & Gosainganj (0.49). The lowest literacy rate is witnessed in Mal block

with total literacy being 47.1%, the male & female literates being 60.2% & 32.4% respectively. In 2011, there was only 1 block i.e. Mal (0.40) which showed high disparity range (Above 0.38). Though, the overall iteracy was improved in the block with 64.3% with 74.3% & 53.3% as male and female literates but, the gender gap was widest with 21%.

Table-4: Gender Literacy Rate in Census, 2011

Low Disparity Region (<0.36)	Medium Disparity Region (0.36-0.38)	High Disparity Region (>0.38)
Chinhat, Kakori	Malihabad, Bakshi Ka Talab, Sarojaninagar, Gosaingan, Mohanlalganj	Mal

Source: Calculated by Authors

Policy Measures

Being the largest populous state, Uttar Pradesh requires more efficient & inclusive policies to attain high literacy levels. The government needs to address the urgent needs in the education sector. To achieve socio-economic development following measures should be initiated: Education being a state subject, it is the responsibility of each state government to ensure the proper infrastructure of schools in rural areas, increase the number of teachers, incentives like textbooks, scholarships & free uniforms. The accessibility of educational facilities should be penetrated more in rural areas. All the administrative machinery at different levels should ensure proper functioning. Committees should be formed to ensure the proper utilization of funds allotted for improving literacy levels with a dedicated monitoring mechanism. (1) Social awareness campaigns should be launched to fight against the social evils existing in society like dowry the system, preference for a male child, child marriage, female infanticide, etc. The issues with education and literacy should be addressed by society as a whole. NGOs & civil society organizations play a vital role in enhancing awareness in society & educating individuals about the consequences of illiteracy (2) Due to various socio-economic constraints, the problem of early dropouts in rural areas can be observed. The National scheme Beti Bachao, Beti Padhao (BBBP) shows great success in encouraging the education of the girl child. Schemes like- UP Free Education Scheme, Kanya Sumangala Yojana (KSY), Bhagya Laxmi yojana, and Abhyudaya yojana, are important initiatives launched by the government to improve gender inequality.

'Mid-Day Meal' scheme is a scheme launched by the central government, under which mid-day meals are provided free of cost to the students of primary & junior primary schools. This programme has been a big success, but it should also focus on providing village children with sufficient nutrition & nourishment in addition to enrolling them in school. Recently, the Tamil Nadu government has supplemented midday meals in government schools with a breakfast scheme which is changing the dynamics of primary education & gross enrollment & active participation of the children in schools. (4) Job-oriented skill training, workshops, etc at secondary & higher secondary levels for girl children should be conducted to minimize gender discrimination. Vocational courses for- farming, dairy farming, handloom & textiles, poultry farming etc should be provided to the women of rural areas.

Conclusion

The paper is an attempt to evaluate the existing patterns of literacy rate & the level of the male-female disparity in literacy in the Lucknow district. The study area witnesses an increase in literacy rate from 53.9% in 2001 to 67.8% in 2011. However, a wide gap between male & female literacy can be observed. Though great numbers of female literacy can be seen from 40.1% in 2001 to 58.3% in 2011 in the study area, female literacy still lags behind male literacy. The female literacy rate of 58.3% is lower than the literacy rate of the male 76.4% population in 2011. The lowest literacy in 2001 was recorded in Mal & Kakori block with 47.1% & 50.4% respectively & in 2011, Mal & Gosainganj block recorded the lowest literacy with 64.3%. In 2001, the largest gap in gender literacy was seen in Mal & Gosainganj block with almost the same numbers of 27.8% & 27.7% while in 2011, the maximum gender disparity in literacy was seen in the Mal block with 21%. Chinhat block recorded a higher proportion of literacy rate in the urban area. Thus, it can be concluded that there exists an inverse relation between literacy & gender disparity. The literacy gap between men and women has narrowed through time, and this pattern should be continued in the future years.

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CHALLENGES FACED BY WOMEN STREET VENDORS OF VARANASI CITY

Nitish Kumar Bhardwaj and Vishal Vikram Singh

Abstract

With the increasing rate of unemployment street vending has become a source of livelihood for a larger section of population. Uttar Pradesh records highest number of vendors followed by Madhya Pradesh. Vending is a source of livelihood with low capital and a temporary structure, which fulfills the goods and services need of the public. They mostly Belongs to the lower section of the society, and don't have the opportunity, education or skill to work in formal sector. So, they operating in the informal economy with no job security and uncertainty. The aim of this paper is to study the challenges faced by women street vendors in Varanasi city. For this purpose100 women street vendors were selected through simple random sampling method. The respondents were interviewed accordingly in order to access the information. Through the survey it was found that most of the female street vendors are between age group of 30-55 years. They are mostly married and sell fruits, flowers, vegetables, food items, clothes and other groceries. These women street vendors face many problems at their home and workplace. Lack of proper sanitation, unhygienic environment, unavailability of toilets are prominent issues as well as misbehaving of police personnel and local authorities at the workplace are common. The respondents told that working late night is also not safe. As a result of the efforts made by various NGOs and organizations for years, the Government of India has focused on the plight of street vendors and has created some policy and schemes for their progress like Street Vendor Act 2014, PM SVANidhi Scheme 2020. Nevertheless, most of the street vendors are deprived of these schemes due to ignorance and accessibility.

Introduction

Despite the existence of various constitutional and legal provisions safeguarding women's employment a large number of women workers, particularly in the unorganized sector suffer from various disadvantages relating to their

working lives as well as home. In 2005 the Confederation of Indian Industries (CII) commissioned a study titled 'Understanding the Levels of Women's Empowerment in the Work Place' revealed that women constitute only 6% of total workforce in corporate houses. The percentage of women in leading managerial positions is abysmally low. Only 7% labour force is in the organized sector and 93% work in unorganized or informal sector. Most of them are in street vending and others are engaged in household activities. The reason for the employment of women in such large numbers in the informal sector is women's weaker bargaining power, low skilled labour, generally lower wages than men and lack of unionization. Street vendors are those one who buy the goods at whole sale and sell it at retail price in the streets, road side, at bus stand or at other places of decent crowd for their daily livelihood. NASVI has defined street vendors as "a person who offers goods or services for sale to the public without having a permanently build structure but with a temporary static structure or mobile stall". Street Vending is one of the most visible aspects of the informal sector and practiced globally.

The major characteristics of street vending are low level of income, ease of entry, self-employed and it involves large number of people. About 80% of the population is engaged in the street vending. It does not only provide self-employment but also a means to provide affordable and convenient service (Jaishankar and Sujata, 2016). Street vending serves as important income generating activity which gives employment to sufficient number of poor women living in urban peripheral areas or slums. Street vendors sell their goods mostly on pavement and streets. However, street vending can be considered as an integral part of rural and urban economy characteristized with specific insecurities and challenges. The contribution of street vendors in generating a considerable amount of money in to the informal sector is often a crucial factor in driving the economy. Street vendors fulfill the requirements of the society and cater to the need of a sufficient number of customers especially from middle- and lower-income class. Women can be seen doing street vending along the pavements and streets. Mostly women enter in the street vending due their poor economic conditions. Their motive is to maintain their financial condition so as to fulfill their daily needs of the family. Apart from the problem of earning money for survival, women street vendors face several issues of uncertain and insecure working conditions at the workplace. Some major issues and problems faced by street vendors are lack of support, regular threat of eviction, and harassment by local officials and authorities. According to the report of ILO, 85 % of the street vendors face several health hazards.

It includes disease like increased depression, acidity, high blood pressure and increased blood sugar and others health complications. Except this, women face problem, related to sanitation, economic pressure, social cultural challenges, adverse political conditions and operational challenges (Tambunam. 2009). During COVID- 19 period Most of the women street vendors lost the means to work and livelihood which witnessed a significant fall in their income and earnings. With the loss in employment opportunities during COVID period, many of the women street vendors were not able to shift to alternative employment opportunities and were forced to continue with the same street-vending activity.

Study Region

Varanasi lying between 82°56' E to 83°03' E and 25°14'N. (also known as kashi or Banaras) is one of the oldest living cities in the world dating back 3000 to 5000 years. Being located on the crescent shaped bank of the Ganga River it is considered as cultural and spiritual capital of India. Due to high population growth and rapid development of the city during the decades of 1991 and 2000 it became a million city. Rapid urbanization has led to many urban problems such as pollution, living space, sanitation and unemployment. The increasing population and faulty government policies has forced a large segment of people towards the informal sector. In this Street vending has become a major source of livelihood for the people living in peripheral urban spaces. These people face several issues and challenges at their workplace. The present study is an attempt to highlight those issues and provide a better understanding of the factors operating therein.

Objectives

(1) The present study seeks to provide a better understanding of the demographic characteristics of women street vendors in the study area.

(2) To know the socio-economic and political constraints of women street vendors in Varanasi city.

(3) To evaluate the relevant issues and challenges faced by women street vendors at their Workplace and to provide insights of policy implications and remedial measures to deal with the issues and challenges faced by women street vendors.

Database and Methodology

The study is entirely based on primary data which have been collected through personal level survey in the study area. A structured interview schedule

containing pertinent questions related to the issues and problems faced by women street vendors in the Varanasi city was used in order to access the required data. Some open-ended questions were also incorporated in order to know the views and opinions of the women street vendors towards government policies, officials and local authorities. For the purpose of study, the samples have been choosen from five administrative zones of the Varanasi city namely, Varuna par, Kotwali, Bhelupur, Aadampur and Dashaswamedh. On the basis of simple random sampling method 20 sample have been taken from each zone and interviewed accordingly. Total 100 respondents have been interviewed and data have been analysed in order to draw conclusions. Data have been analysed and interpreted with the help of different tools like MS Excel 2012 and SPSS-22 version. Maps, charts and diagrams are incorporated wherever necessary. Maps have been prepared with the help of ARC GIS 10.3 software.

Results and Discussion

Results have been derived from the responses collected through the interview schedule which contained questions related to the respondent's demographic characteristics and the challenges being faced by them at their work place. An attempt has been also made to suggest the remedial measures and expected solutions.

Age; During the survey it was found that majority of the women street vendors were above 41-60 age-group. In most of the cases she herself was the head of the house and therefore they had taken the responsibility of earning the bread for themselves and their families. They also take care of other amenities in the house. It was also observed that 22 percent of women street vendors were between age group of 51-60. The younger age groups witnessed comparatively low proportion of women street vendors. Feeling unsafe is major factor behind such low proportion of women street vendors in the younger age groups. Being asked, the vendors told that their husband either do farming in the village or earn in the outer region through daily wages or help them in vending along road side, streets and pavements.

Marital Status: Marital status is another significant demographic characteristic which was considered during the survey. The data recorded reveales different nuptial categories of women street vendors in the Varanasi city. The highest percentage (78 percent) of women street vendors are married followed by 8 percent of unmarried women. This is because of the fact that married women street vendors of higher age groups feel more confident regarding feeling safe at the workplace in comparison to married and und unmarried women of the younger age groups.

Another significant demographic feature of the table is the proportion of widowed women street vendors in the city. It was recorded that 13 percent of women street vendors were widowed. This is the bitter fact of the Indian society that whenever a woman is widowed, she becomes economically vulnerable which forces her to do vending and other low level economic activities to run the livelihood of her family. Type of Street Vending: The responses during the survey portraits the proportions of women street vendors engaged in different stuffs in different zones of Varanasi city. It was observed that highest percentage (37 percent) of women street vendors were engaged in selling vegetables and fruits along the pavements and streets followed by 25 percent in tea and food stuffs while 25 percent of them were engaged in selling flowers and garlands. The highest proportion of women street vendors in selling vegetables and fruits along with other food items is due to easily availability of these items in the market. Another significant factors behind this may be the good returns and affordability of these items.

Access to Workplace Amenities

During the field survey the data was also collected regarding access to work place amenities like toilet facilities, availability of fresh drinking water, storage and alike in order to measure hygiene and sanitation at work place. The results found are quite disgusting that above 90 percent of women street vendors don't have facility of toilets, safe drinking water, storage and other amenities. Due to working in such a unhygienic environment the women street vendors are prone to several diseases like stress, hypertension and acidity (**Fig.** 1).

Awareness about Right and Interests: Responses were also recorded regarding the awareness of women street vendors towards their rights and interests. The data reveals that Majority of the respondents (88 per cent) disagree that the government protects the rights and interests of women street vendors. Another significant factor behind such situation is the ignorance and high level illiteracy among the women street vendors. Due to this most of the women street vendors are unaware of their rights and are often harassed by government officials and local authorities. Because they are illiterate or less educated and have no information about the government's plans and policies made for street vendors; local police exploit them at the workplace. These factors play crucial role behind the vulnerable conditions of women street vendors in Varanasi city. Proper measures and steps should be taken in order to safeguard the rights and interests of women street vendors in the study area. Harassed and Abused by the Authorities: In order to analyses the factors behind the vulnerable condition of women street vendors in Varanasi city

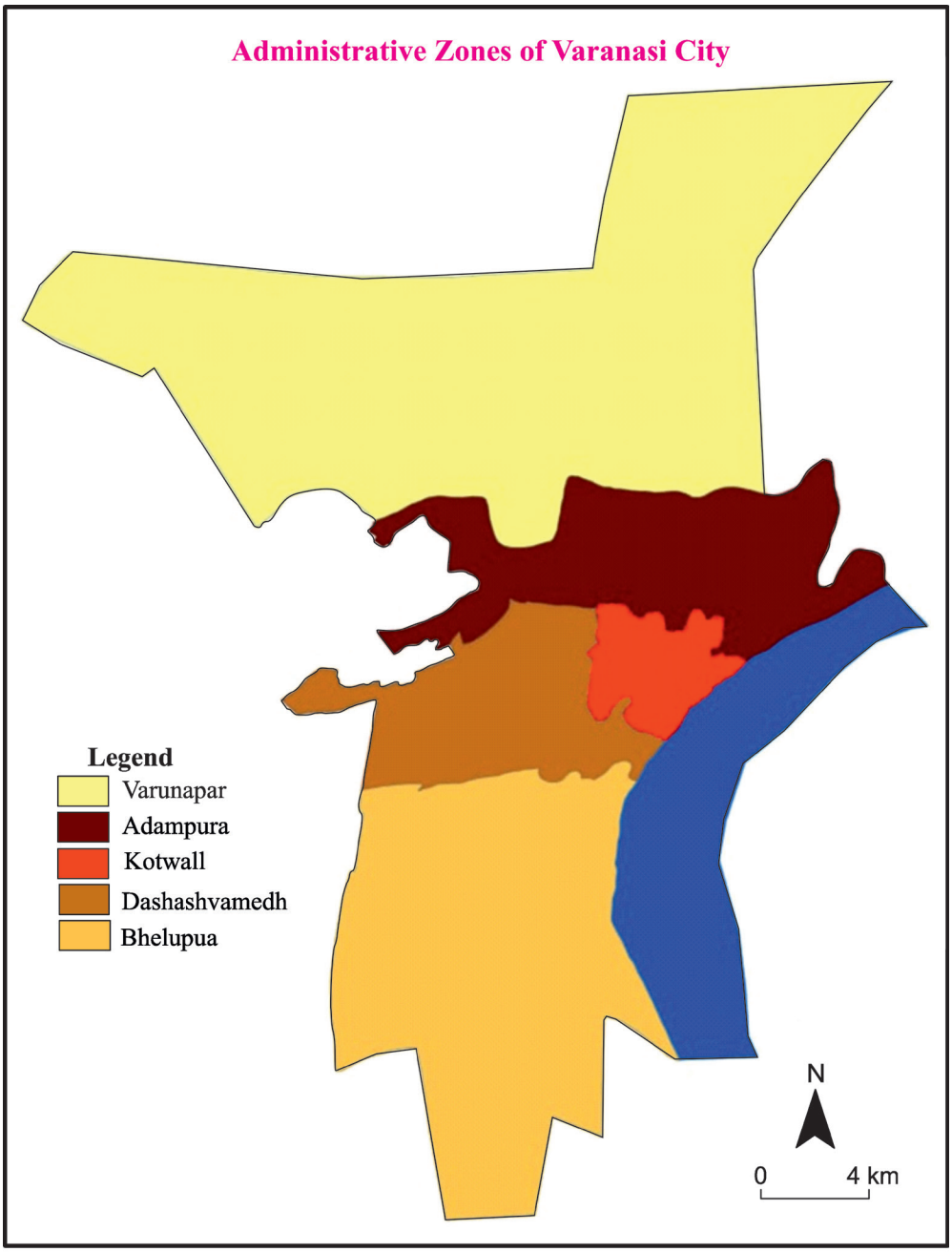

Administrative Zones of Varanasi City
Legend
Varunapar
Adampura
Kotwall
Dashashvamedh
Bhelupua
N
0
4 km

Fig. 1

the responses were also recorded know the status of being harassed, teased or abused by concerned government officials and local authorities. The study reveals that 70 per cent of the women street vendors in the city reported that they are being harassed and abused by the concerned city authorities or police at the workplace while 30 per cent of the respondents said that they are not being harassed by the city authorities or police. Being ignorant of their rights and safeguards provided by government policies these women street vendors are prone to exploitation through several means by police and local authorities. (**Fig.** 1)

Security at Work Place: Among the several significant constraints of women street vendors the prominent one is security at the workplace. There are sufficient number of studies which advocates for the safety of women street vendors while working late hours in the night. Due to several efforts government has drafted policies to safeguard the interests and rights of the women street vendors. In spite of this insecurity is the major issue for the women street vendors while working late hours in the Varanasi city. On the basis of responses recorded during the survey it was observed that 92 per cent of the women street vendors in the Varanasi city do not feel safe and secure while working late hours in the night. While only 8 per cent said that they feel secure even while working late hours in the market. As mentioned above security is the key issue among the several socio-economic barriers being faced by women street vendors in the Varanasi city.

Health Issues

Many studies reveal that street vendors work in severe unhygienic environment because of this they are prone to several diseases. In the Varanasi city an effort was made to record the responses of the women street vendors in order to know the status of hygiene and health issues. However the study conducted reveals that 41per cent of the women street vendors stated that they have health related disorders like blood pressure, Sugar, deafness, low vision while 59 per cent of the respondents said that they don't have any kind of health issues. As the study found that women street vendors don't have proper sanitation measures like toilets, fresh drinking water and air they are prone to several diseases.

Remedies

Some responses were also recorded in order to know the status of remedial measures. The data reveals quite disgusting factor that the women street vendors in Varanasi city don't believe that their status can be improved through policies and safeguards provided by government or some NGO organization. Most of the

women street vendors are of the view that their status can be improved only by themselves. According to the responses recorded 12 percent of the women street vendors said that their condition can be improved with the help of government initiatives, 15 percent said, it can be improved with the help of NGOs & their association and lastly, 73 percent said that it can be improved only through him/her self. The recorded responses show that there are many drawbacks and Loopholes which need to be taken care of while drafting and implementing the policies for women street vendors. It is also a bitter fact that association and NGO organization are not working well.

Conclusion

As mentioned, total 100 women street vendors were interviewed and their responses were recorded. 1. One significant demographic feature is that majority of women street vendors are between age group of 41-60. It may be because of the fact that women in comparatively older age groups feel more confident and safer at the workplace than those who are unmarried or in younger age groups. 2. Because of easy availability of in the local market majority of the women street vendors in Varanasi City were engaged in selling vegetables and fruits. Very few Of them are engaged in other economic activities. 3. Major socio-economic and administrative constraints being faced by the women street vendors are those of their basic necessities and amenities at the workplace like lack of hygienic space, toilets, feeling unsafe at the workplace during late hours and continuous harassment by local authorities, government officials and police. 4. The responses recorded during the survey reveals the fact that the policies and safeguards provided by government have some loopholes and drawbacks due to this most of the women street vendors are unaware of these policies. Other factors behind this may be the ignorance and illiteracy among the women street vendors or lame efforts of government officials in implementation and execution of these policies. However, it has been also reported that few of the women street vendors are receiving some kind of benefits from the government and they are keenly looking forward for their support and guidance. 5. There is a urgent need to take care of the issues and challenges being faced by the women street vendors in Varanasi city. The policies and safeguards should be implemented in a very effective manner so that it can cover most of the women street vendors. Other remedial measure which is to be taken is the proper education of the women street vendors so that it can enable them towards their rights and interests. Other amenities which are necessary at the workplace should also be taken care of like permanent place for vending, proper sanitation and hygiene etc.

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BALANCING AGRICULTURAL DEMAND AND WATER RESOURCES: A STUDY OF IRRIGATION INTENSITY TRENDS IN MANDYA DISTRICT, KARNATAKA

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Abstract

Irrigation intensity in agricultural regions is influenced by various factors, including water source, quantity and quality, and channel network density. This study explores irrigation intensity variations in Mandya District, Karnataka, over the period 1991-2017, considering factors like cropping patterns, land-use efficiency, and adoption of cultivation methods. Mandya District, located in South India, is dissected into seven taluks. The study examines changes in irrigation intensity across these taluks, highlighting the district's geographical and agricultural diversity. The primary objective is to assess irrigation intensity changes in Mandya District from 1991 to 2017. Using historical documents and government reports, the study traces the evolution of water management in Mandya. Statistical analyses of net irrigated areas for 1991, 2001, and 2017 reveal shifts in irrigation methods. The intensity of irrigation is calculated using the ratio of net irrigated area to net sown area. Taluk-wise analyses and categorizations are conducted to understand spatial patterns. The findings indicate a significant increase in irrigation intensity from 41.4% in 1991 to 75.7% in 2017. Taluk-wise analyses reveal dynamic changes, with Mandya taluk consistently showing high intensity. Positive changes are attributed to canal construction, increased cultivable areas, well irrigation, and advancements in agriculture. Despite advancements, certain areas in Mandya remain rainfall-dependent, impacting crop productivity and income inequality. The study suggests utilizing rainwater through farm ponds and watershed structures. Emphasizing efficient canal water usage, including lining distributaries and field channels, is recommended. The district irrigation plan aims to mitigate drought, expand irrigated areas, and optimize water usage through innovative cropping patterns. This research provides valuable insights into the evolving landscape of irrigation intensity in Mandya District, offering a foundation for sustainable water resource management strategies.

Introduction

The term "irrigation intensity" usually refers to the amount of water used to irrigate a specific area of land. It measures how effectively water is used during the irrigation process. Irrigation intensity is commonly expressed in millimeters or inches and is calculated by dividing the total volume of water applied by the irrigated area. Irrigation intensity varies across agricultural regions due to a variety of factors such as irrigation source, water supply quantity and quality, and water channel network density. Cropping seasons, crop types, and other factors all have an impact on it. Cropping patterns, land-use efficiency, area yield efficiency, and the adoption of improved cultivation methods all benefit from increased irrigation intensity. The intensity of irrigation has a significant impact on agricultural productivity, water conservation, and environmental sustainability. Water stress and reduced crop yields can result if the amount of water applied is insufficient for the needs of the crops. Inadequate irrigation can also cause soil degradation and harm the agricultural ecosystem's overall health. Excessive irrigation, on the other hand, can result in waterlogging, soil salinity, and water resource waste. High irrigation intensity can also contribute to environmental issues like runoff, fertilizer and pesticide leaching, and negative impacts on local water bodies. Irrigation intensity is typically low in areas with limited infrastructure for expanding irrigation or where irrigation is used as a precautionary measure to address moisture scarcity in areas prone to heavy rainfall. All else being equal, irrigation intensity increases with decreasing rainfall and decreases with increasing rainfall in agricultural contexts. Irrigation intensity is typically low and negligible in rain-fed areas with constrained surface water, saline subsoil, and hilly or undulating topography. Typically, irrigation intensity is expressed in two ways, namely, the ratio of gross irrigated land to net irrigated land. The proportion of net irrigated land to net sown land.

Study Region

Mandya District is located in the South Indian Peninsula on the Mysore plateau, between 76° 19' and 77° 20' East Longitude and 12° 13' and 13° 04' North Latitude. It is bounded to the north by Hassan and Tumkur districts, to the east by Tumkur and Bangalore districts, to the south by Mysore district, and to the west by Hassan and Mysore districts. Mandya is the 19th largest district in Karnataka, covering a total area of 191,976 square kilometres (**Table-**1). Nagamangala, K.R. Pet, Mandya, Malavalli, Maddur, Pandavapura, and Srirangapatanna are the district's seven taluks. Notably, Nagamangala has the largest geographical area at 1,044.7 square kilometres, accounting for approximately 21% of Mandya's total area.

Table-1: Talukwise Irrigation Intensity in Mandya District 1991-2017

Sl No	Taluk	1991			2001			2017			Irrigation intensity change in 1991-2017
		Net Irrigated area	Net Sown area	Intensity of Irrigation in %	Net Irrigated area	Net Sown area	Intensity of Irrigation in %	Net Irrigated area	Net Sown area	Intensity of Irrigation in %	
1	K.R. Pet	16865	38890	43.4	20263	48646	41.6	25016	40407	61.9	+ 18.5
2	Maddur	20827	41161	50.6	22586	39794	56.7	20919	30202	69.3	+ 18.7
3	Malavall	15832	36254	43.7	17931	42245	42.4	22190	31568	70.3	+ 26.6
4	Mandya	25127	44966	55.9	19588	28560	68.6	28148	33268	84.6	+ 28.7
5	Nagamangala	2845	38772	7.3	4307	42234	10.2	6329	29691	21.3	+ 14
6	Pandavapura	6654	22862	29.1	10131	25598	39.6	14834	22185	66.7	+ 37.6
7	Srirangapattana	11413	17874	63.8	12146	20311	59.8	9752	14057	69.4	+ 5.6
	Total	99563	240779	41.4	106952	247388	43.2	127188	168110	75.7	+ 34.3

Source: Data compiled from Directorate of Economics and Statistics, Government of Karnataka, Bangalore.

Despite having a higher population density, Mandya taluk ranks fourth in terms of area, covering 699.06 square kilometres. Srirangapatna, on the other hand, has the smallest area, accounting for only 6.9% of the district's total area.

Objective

The present paper attempted to study the irritation intensity in Mandya district, Karnataka.

Methodology

In order to conduct a thorough investigation, I reviewed a large body of existing literature on water resource utilization, irrigation methods, and disparities within comparable geographic regions. My focus was on the Mandya District in South India, a region chosen for its importance in terms of water resource imbalances and diverse irrigation practices. I traced the evolution of water management in Mandya District using historical documents, research papers, and governmental reports. Supplementary data was obtained from the Government of Karnataka's Directorate of Economics and Statistics, which provided critical historical records of irrigation sources and trends. I assessed changes in net irrigated area using statistical analyses for the years 1991, 2001, and 2017, using percentages to identify shifts in the dominance of specific irrigation methods. I investigated specific instances of water resource utilisation within Mandya District using a case study approach, delving into local contexts, socioeconomic factors, and infrastructure development nuances. The findings were systematically compared to historical data, revealing insights into changes in irrigation methods, areas covered, and the overall landscape of water resource utilisation in the Mandya District. In the present study researcher has used the second method to express the intensity of irrigation in the region. Here the intensity has been calculated with the help of following formula.

$$\text{Intensity of irrigation} = \frac{\text{Net irrigated area}}{\text{Net sown area}} \times 100$$

Result and Discussion

The present study reveals that the variation in the intensity of irrigation. **Table-**1 and 2 explain that the Mandya district has about 41.4% of irrigation intensity in the year 1991 and it has been increased to 43.2% in the year 2001, further it has increased to 75.7% in 2017 (**Fig.** 1 and **Table-**2). The analyzing of spatial pattern of intensity of irrigation in Mandya district shown in **Table-**2 there is a significant change has been observed in the intensity of irrigation in the region from 1991-2017,

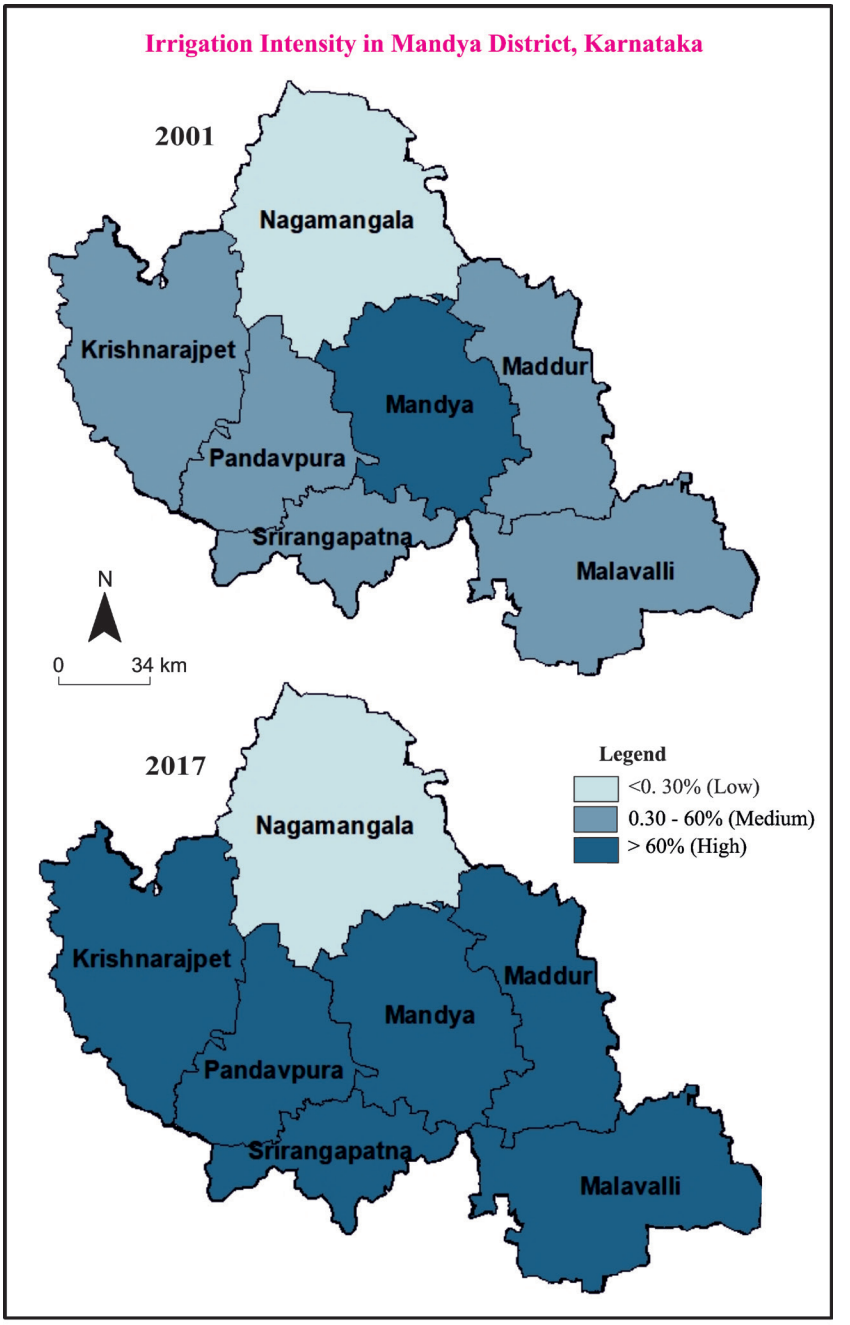

Irrigation Intensity in Mandya District, Karnataka
2001
Nagamangala
Krishnarajpet
Maddur
Mandya
Pandavpura
Srirangapatna
Malavalli
N
0
34 km
2017
Nagamangala
Krishnarajpet
Maddur
Mandya
Pandavpura
Srirangapatna
Malavalli
Legend
<0. 30% (Low)
0.30 - 60% (Medium)
> 60% (High)

Fig. 1

Table-2: Irrigation Intensity in Mandya District, 1991.

Sl. No.	Irrigation intensity Range	No. of Taluks	Name of the Taluks
1.	< 30% Low	02	Pandavapura, Nagamangala
2.	30-60% Medium	04	Mandya, Maddur, Malavalli, K.R. Pet
3.	> 60% High	01	Srirangapattana
Categories of Irrigation Intensity in Mandya district 2001.			
1.	< 30% Low	02	Pandavapura, Nagamanagala
2.	30-60% Medium	04	Srirangapattana, Maddur, Malavalli, K.R. Pet
3.	> 60% High	01	Mandya
Categories of Irrigation Intensity in Mandya district 2017.			
1.	< 30% Low	01	Nagamangala
2.	30-60% Medium	00	
3.	> 60% High	06	Mandya, Malavalli, Srirangapattana, Maddur, Pandavapura, K.R. Pet

Source: Computed by Authors

the taluk wise analysis reveals that in 1991 Srirangapattana (63.8%) taluk have recorded high (More than 60%) intensity of irrigation. The medium irrigation intensity (30%-60%) is noticed Mandya (55.9%), Maddur (50.6%), Malavalli (43.7%), K.R. Pet (43.3%) taluks of the region. The taluks like Nagamangala (7.3%) and Pandavapura (29.1%) fall in low intensity of irrigation (less than 30%). The taluk wise analysis reveals that in 2001 Mandya (68.6%) taluk have recorded high (More than 60%) intensity of irrigation. The medium irrigation intensity (30%-60%) is noticed Srirangapattana (59.8%), Maddur (56.7%), Malavalli (42.4%), K.R. Pet (41.6%) and Pandavapura (39.6%) taluks of the region. The Nagamangala taluk (10.2%) fall in low intensity of irrigation (less than 30%) (**Fig.** 1). The taluk wise analysis reveals that in 2017 Mandya (84.6%), Malavalli (70.3%), Srirangapattana (69.4%), Maddur (69.3%), Pandavapura (66.7%), K.R. Pet (61.9%) taluks have recorded high (More than 60%) intensity of irrigation and Nagamangala taluk (21.3%) fall in low intensity of irrigation (less than 30%). In the study period there is positive change in irrigation intensity. It is because of the progress in the construction of new canals to provide water for tank irrigation and every year more and more cultivable areas are brought under cultivation and also increased number of well irrigation and advanced agriculture due to development

of transportation facility. During the study period (1991-2017) the district as whole has shown a significant change in the intensity of irrigation. These taluks have shown a positive change in the intensity of irrigation. It is clear that during the year 1991 the irrigation intensity was about 41.4% and it increased to 75.7% in 2017. The net increase in the volume of intensity of irrigation was about 34.3%. The taluk wise changes in the intensity of irrigation during the study period depicts that only Pandavapura taluk have shown high percentage of change i.e., 37.6%, Srirangapattana taluk have shown less change in intensity of irrigation i.e., 5.6%.

Taluka wise Analysis

The intensity of irrigation in Mandya district increased from 41.4% in 1991 to 43.2% in 2001 and further to 75.7% in 2017. The spatial pattern analysis indicates a significant change in irrigation intensity from 1991 to 2017. In 1991, Srirangapattana taluk had the highest intensity of irrigation (63.8%), classified as high. Mandya, Maddur, Malavalli, and K.R. Pet taluks had medium intensity (30%-60%). Nagamangala and Pandavapura taluks had low intensity (less than 30%). In 2001, Mandya taluk now has the highest intensity (68.6%). Srirangapattana, Maddur, Malavalli, K.R. Pet, and Pandavapura taluks had medium intensity. Nagamangala taluk remained in low intensity. In 2017, Mandya, Malavalli, Srirangapattana, Maddur, Pandavapura, and K.R. Pet taluks recorded high intensity. Nagamangala taluk remained in low intensity. Positive changes in irrigation intensity are attributed to the construction of new canals, increased cultivable areas, well irrigation, and advanced agriculture facilitated by improved transportation. (**Fig.** 1) The overall district experienced a significant increase in irrigation intensity from 41.4% to 75.7% during 1991-2017, representing a net increase of 34.3%. Pandavapura taluk showed the highest percentage change (37.6%). Srirangapattana taluk showed the least change in irrigation intensity (5.6%).

Conclusion

Despite being irrigated by two commands, Mandya district has 1.46 lakh ha fully dependent on rainfall. The crop productivity in such areas is limited to dry crops like ragi, horsegram, avare, maize, groundnut etc. Irrigated area predominantly grows paddy and sugarcane. Irrigated farmers invariably record higher incomes, while farmers from dry areas continue to reel under poverty. The inequality of growth rate in income of these two distinctly different areas has not been able to be neutralised by any other sources of irrigation, including well irrigation. Mandya district has only 5000 ha under bore well irrigation, while open wells irrigate around 6800 ha.

However, there is excellent scope to harvest rain water in smaller structures like farm ponds, check dams, nala bunds and other water shed structures in un-irrigated areas. The present district irrigation plan focuses on use of rain water more efficiently by various water shed structures for protective irrigation as a measure of drought mitigation. Further, nearly 630 tanks are available in Mandya district. They have created irrigation potentiality of around 16000 ha. But, there is need to utilise this tank irrigated area, by effective measures like tank desilting, renovation or filling tanks with canal/ lift irrigation schemes. There is general lacuna in utilizing the canal water, in terms of efficiency. Most distributaries/ field channels unlined and there is vast scope to improve the irrigation efficiency by proper lining to these structures, and attending to other canal maintenance works timely. This way, the created potential can be utilized fully. All these aspects are considered, while Mandya district Irrigation Plan is developed- with the ultimate objective of utilizing the created potential with expansion, wherever possible irrigated area and drought mitigation in non- command areas. A new cropping pattern involving regulated sugarcane cultivation and reducing other water intensive crops can save large quantity of water and this can ensure water availability to tail end areas.

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WORKFORCE ASSESSMENT OF PRINCIPAL EMPLOYEES AND AGRICULTURAL WORKERS IN KANNAUJ DISTRICT, UTTAR PRADESH

Kalpana Devi and Dr. Shashi Bala Singh

Abstract

The research focuses on assessing the workforce dynamics within Kannauj district for the year 2021-22, emphasizing the distribution and prevalence of principal employees and agricultural workers across its development blocks. The study examines the proportions of principal employees in comparison to the total population in various blocks. Umaruda and Gugarapur exhibit notably high percentages, signifying substantial principal employment, followed by Talgram with a significant figure. Haseran and Jalalabad portray a slightly lower ratio, while Kannauj, Saurikh, and Chhibramau demonstrate relatively comparable patterns. These percentages elucidate the distribution and concentration of principal employees, showcasing varying proportional representations among the development blocks. Moreover, the study investigates the proportions of agricultural workers within the total principal employee workforce across the district. Areas like Saurikh, Haseran, and Chhibramau showcase high percentages of agricultural workers among the principal employees, indicating significant agricultural employment. Umaruda and Kannauj also demonstrate substantial agricultural labour presence, while Gugarapur shows a slightly lower ratio. Talgram and Jalalabad exhibit relatively fewer agricultural workers compared to the total principal employees in those specific blocks. These percentages offer insights into the distribution and concentration of agricultural workers concerning the total principal workforce across different development blocks in the Kannauj district, reflecting distinct levels of agricultural employment across these regions during the specified period. The study utilized data sourced from official government records, statistical reports, and surveys conducted by relevant authorities, encompassing population figures, principal employee counts, and specific employment statistics for agricultural workers. The research aims to depict variations in employment patterns and workforce concentrations, focusing on the proportional representations of principal employees and agricultural workers across the district's diverse blocks during the specified period.

Introduction

Kannauj district in the year 2021-22 witnessed varied proportions of principal employees and agricultural workers dispersed across its distinctive development blocks, portraying notable employment diversities. This study scrutinizes the intricate dynamics of workforce distribution within the district, focusing on the prevalence of principal employees and agricultural workers across different regions. The analysis reveals significant disparities in the proportion of principal employees concerning the entire population across various development blocks. Umaruda emerges as a frontrunner, boasting the highest percentage of principal employees at 27.44%, closely shadowed by Gugarapur at 27.07% and Talgram at 26.59%. Contrastingly, Haseran, Jalalabad, Kannauj, Saurikh, and Chhibramau exhibit relatively lower percentages, portraying a discernibly varied distribution of principal workers within these areas. Moreover, the study unveils an intriguing variation in the proportion of agricultural workers relative to the total principal employee workforce across the district's development blocks. Saurikh, Haseran, and Chhibramau stand out with notably high percentages of agricultural workers among the principal employees, ranging from 84.74% to 84.13%. Umaruda and Kannauj display substantial agricultural labour presence, whereas Gugarapur, Talgram, and Jalalabad depict relatively lower ratios of agricultural workers compared to the total principal employees in their respective blocks. This research draws upon comprehensive data sourced from official government records, statistical reports, and surveys conducted by relevant authorities. Employing a meticulous methodology involving precise demographic data collection, and cross-referencing of population figures with employment records identified principal employees across development blocks. Additionally, statistical calculations discerned the distribution and concentration of agricultural labour within the principal employee workforce across diverse areas within the Kannauj district.

Objectives

(1) The primary objective is to analyze the distribution of principal employees across different development blocks within Kannauj district during 2021-22.

(2) To examine the variation in the proportion of agricultural workers relative to the total principal workforce across different development blocks.

Database and Methodology

The data used for analyzing the distribution of principal employees and agricultural workers in the Kannauj district for the year 2021-22 was sourced from

official government records, statistical reports, and surveys conducted by relevant authorities. This data includes information on the total population figures, the count of principal employees in various development blocks, and the corresponding employment statistics specific to agricultural workers. The methodology involved collecting accurate demographic data from the census and employment records for the Kannauj district. The total population figures were cross- referenced with employment records to identify principal employees in different development blocks. The percentage of principal employees relative to the entire population was calculated for each block to ascertain their proportional representation. Analyze agricultural employment, the total count of agricultural workers within the principal employee category was identified based on official records. The percentage of agricultural workers concerning the total principal employees in each development block was computed to discern the distribution and concentration of agricultural labor across various areas within the district. This analysis involved statistical calculations, ratios, and percentage computations to understand the representation of principal employees and agricultural workers concerning the total population and the total principal employee workforce, respectively. The study aimed to depict variations in employment patterns and workforce concentration across the diverse development blocks within the Kannauj district for the specified period.

Results and Discussions

Principal Employees

In the Kannauj district for the year 2021-22, the percentage of total principal employees about the entire population varies across its development blocks. Among these blocks, Umaruda stands out with the highest percentage, comprising 27.44% of principal employees. Compared to the overall populace. Gugarapur closely follows with 27.07%, demonstrating a significant presence of principal workers within its boundaries (**Table-**1 and **Fig. 1**). Talgram maintains a substantial figure at 26.59%, indicating a considerable proportion of principal employees relative to the population. As we move further, Haseran and Jalalabad exhibit 24.5% and 24.32% percentages, signifying a noticeable but slightly lower ratio of principal workers compared to the total population. The district's administrative centre, Kannauj, registers a percentage of 23.87%, suggesting a slightly lower presence of principal employees concerning the overall populace (**Fig. 1** and 2). Overall, these percentages delineate the distribution and concentration of principal workers across the development blocks within the Kannauj district, portraying variations in their proportional representation concerning the total population for the specified period.

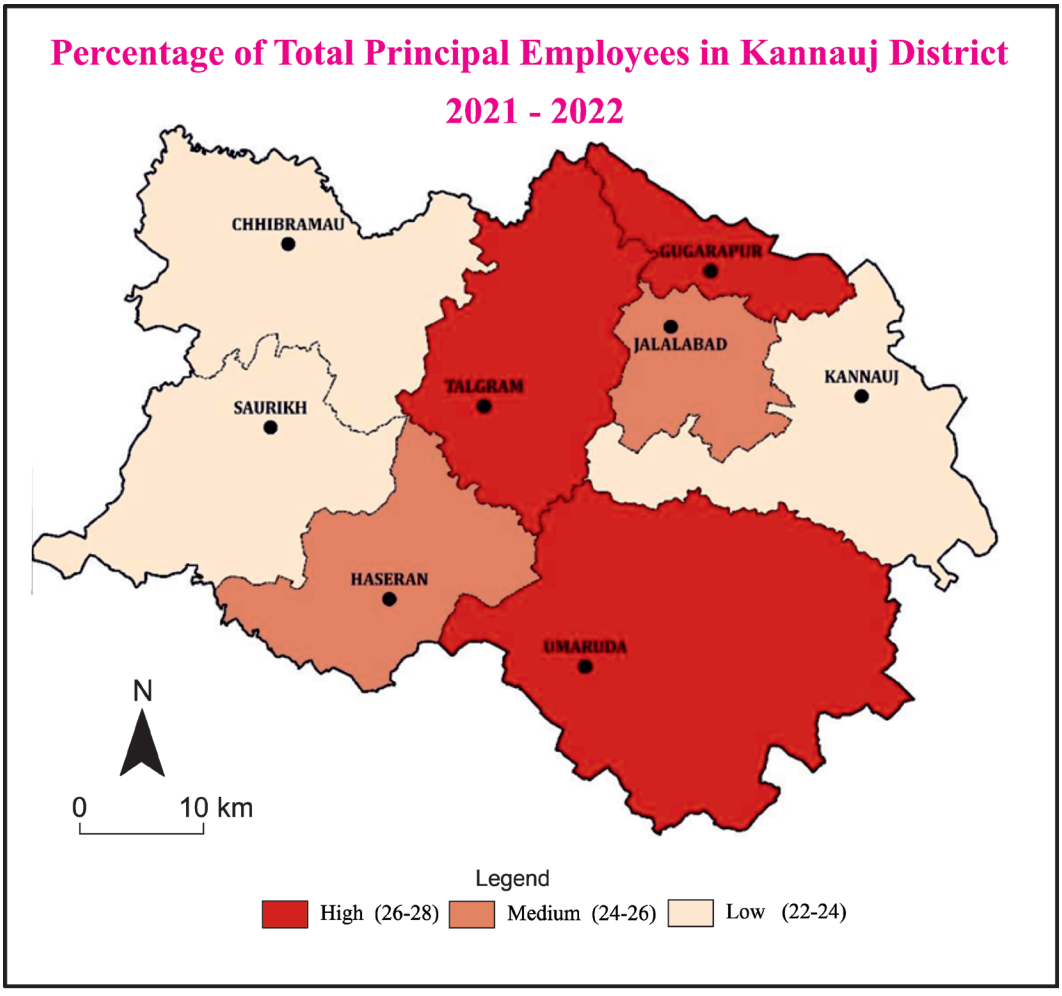

Percentage of Total Principal Employees in Kannauj District
2021 - 2022
CHHIBRAMAU
GUGARAPUR
JALALABAD
KANNAUJ
TALGRAM
SAURIKH
HASERAN
UMARUDA
N
0
10 km
Legend
High (26-28)
Medium (24-26)
Low (22-24)

Fig. 1

Table-1: Percentage of Total Principal Employees and Population in Kannauj District, 2021-22

Development Blocks	Percent	Development Blocks	Percent
Umaruda	27.44	Jalalabad	24.32
Gugarapur	27.07	Kannauj	23.87
Talgram	26.59	Saurikh	23.67
Haseran	24.5	Chhibramau	23.62

Source- https://updes.up.nic.in

Agricultural Workers

In the Kannauj district for the year 2021-22, the percentage of total agricultural workers in comparison to the total principal employees varies across its development blocks. The blocks of Saurikh, Haseran, and Chhibramau exhibit the highest percentages, with 84.74%, 84.55%, and 84.13% respectively. This indicates a significant portion of agricultural workers about the total principal workforce within these areas. Umaruda and Kannauj showcase percentages of 83.71% and 83.69% respectively, signifying a substantial presence of agricultural workers among the principal employees within these blocks. Gugarapur, with a percentage of 79.96%, with the highest percentage of principal employees at 27.44%, indicating a significant presence of this workforce category in comparison to the total population. Gugarapur and Talgram followed closely, showcasing noteworthy figures of 27.07% and 26.59% respectively, underlining substantial concentrations of principal employees in these regions. Haseran, Jalalabad, Kannauj, Saurikh, and Chhibramau exhibited percentages ranging from 23.62% to 24.5%, depicting a lower but noticeable representation of principal employees relative to the overall populace. The findings demonstrate varying degrees of proportional representation of principal workers across the development blocks, signifying localized employment patterns within the district. Saurikh, Haseran, and Chhibramau emerged as areas with the highest percentages of agricultural workers among the total principal employees, ranging from 84.13% to 84.74%. This signifies a predominant agricultural workforce in these regions. Umaruda and Kannauj exhibited substantial proportions of agricultural workers at 83.71% and 83.69% respectively indicating a significant presence of agricultural labour within the principal employee category. Gugarapur displayed a considerable but slightly lower ratio of agricultural workers at 79.96% compared to the total principal employees,

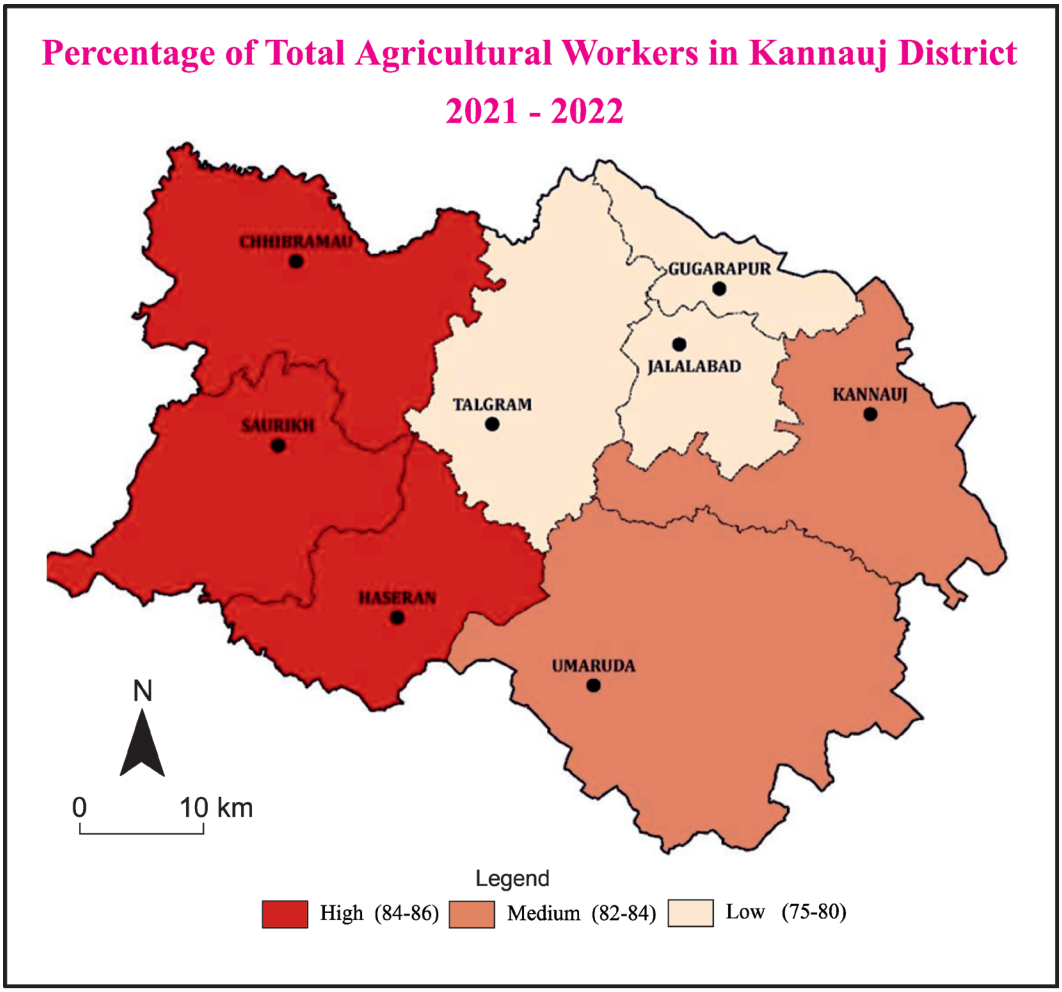

Percentage of Total Agricultural Workers in Kannauj District
2021 - 2022
CHHIBRAMAU
GUGARAPUR
JALALABAD
TALGRAM
KANNAUJ
SAURIKH
HASERAN
UMARUDA
N
0
10 km
Legend
High (84-86)
Medium (82-84)
Low (75-80)

Fig. 2

Table-2: Percentage of Agricultural Workers to Principal Employees in Kannauj District in 2021-22

Development Blocks	Percent	Development Blocks	Percent
Saurikh	84.74	Kannauj	83.69
Haseran	84.55	Gugarapur	79.96
Chhibramau	84.13	Talgram	77.62
Umaruda	83.71	Jalalabad	75.86

Source- https://updes.up.nic.in

showcasing a moderate agricultural employment level. Talgram and Jalalabad depicted relatively lower proportions of agricultural workers at 77.62% and 75.86%. Overall, these findings provide valuable insights into the employment patterns and the prominence of principal employees and agricultural workers across diverse development blocks within the Kannauj district, shedding light on the multifaceted nature of employment dynamics within the region.

Conclusion

In conclusion, the analysis of principal employees and agricultural workers across the development blocks within the Kannauj district for the year 2021-22 offers valuable insights into the employment landscape of the region. The findings highlight distinctive patterns in the distribution and concentration of principal employees and agricultural workers, underscoring the variations in their proportional representation concerning the total population and the total principal employee workforce. The examination of principal employees revealed significant disparities across development blocks, with Umaruda, Gugarapur, and Talgram recording notably higher percentages compared to other areas. These figures depict areas with substantial employment in non-agricultural sectors, suggesting a potentially diverse employment landscape with varying opportunities in industries beyond agriculture. Understanding the dynamics of principal employees and agricultural workers across different blocks is crucial for informed policy formulation and resource allocation, aiming to address regional disparities, promote inclusive growth, and enhance overall socio-economic development within the Kannauj district. Further research and ongoing monitoring of employment patterns will be vital to track changes, identify emerging trends, and implement strategies that foster balanced and inclusive development across the region's diverse socio- economic landscape.

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DYNAMICS OF ELECTORAL BEHAVIOR OF PANCHAYAT ELECTION IN NADIA DISTRICT, WEST BENGAL

Dr. Nizamuddian Khan, Dr. Firoj Biswas and Dr. Mostafijur Rahaman

Abstract

The present study investigates the events and circumstances that shape the voter's decisions and their involvement in the electoral process. It also aims to analyze factors that have affected electoral politics and voting behavior in the Nadia District Panchayat election. India's geo-political, socio-economic, cultural, and religious conditions played an important role in the formation, identity, and growth of the political parties in West Bengal. The present study deals with the comparative analysis of the major political organizations and their role in future political developments in the province. This research article also provides a deep political insight into the nature and quality invested in the leadership of the West Bengal political parties. The paper analyzes the analytical overview of Nadia's electoral politics from the 2008 to 2018 Panchayat elections. The study examines the causes of the Trinamool Congress's landslide victory in the Nadia district elections and why residents overwhelmingly voted for the Maa Mati Manus model of development promised by the party in the state's Panchayat election. The present study is based on both Primary and secondary data sources and adapted the qualitative and quantitative methods. The fundamental approaches include participatory research methods, narratives, discourses, and grounded theory. The data has been analyzed and interpreted with the help of various statistical methods like Factor Analysis, Correlation, and cartographic techniques for analyzing data like percentages, choropleth, line Graphs, and Arc GIS 10.2. It is being observed that political party-based association, local groupings, language, class, factors of caste, social welfare policy, ideology, and religious identities are the main contributing factors in defining the trend of voting behavior in Nadia District, West Bengal.

Introduction

Democracy embodies public participation and people empowerment necessary to address the power inequities in social, economic, and political spheres

(Bandyopadhyay, 2012). It affects real change in society. Democratic participation of the grassroots in policy formulation and execution is necessary to bridge the gap between the people and the policy-makers at the highest levels (Dasgupta 2020). The decentralization of state power is essential to ensure developing societies' democratization (Biswas & Mondal 2019). Therefore, the Panchayat election is an integral part of the decentralization and democratization process in the rural areas of India. The village Panchayat existed even before independence, but they were unofficial, informal bodies without significant power. After independence, reference to the village Panchayat in the Directive Principles of State Policy of the Indian Constitution did not give much leeway to Panchayat formation in the country. "The states shall take steps to create village Panchayat and invest them with such rights and authority as necessary to allow them to function as self-government units," the Indian Constitution's Article 40 declared. Long after the adoption of the Indian Constitution, the Panchayats were recognized as an important political tool for involving the vast majority of the rural population in public policy-making at the grassroots level. The idea of the Panchayati Raj system has been prescribed in the preamble of our constitution, which speaks about the right of liberty of thought, expression, belief, faith and worship, equality of status and opportunity, fraternity, as well as to participate in all types of functions and to have faith in any religion (Banerjee, 2012).

Local government strengthens the foundation of democracy. It links people at the grass-root level and the central or state level. The basic idea behind the formation of Local Government is people's participation in their day-to-day developmental activities. But elections are examined from various angles, including political, social, cultural, and geographic ones. A politically organized community's socio-cultural aspiration is reflected in its elections. Caste and religion are the main variables affecting voters' political participation and casting their ballots. Caste issues, however, have largely taken control of political participation in Indian states after the Mandal Commission Report's 1991 recommendations (Jeffrey & Young, 2012), most notably in northern states. Though linked with the electoral politics in the West Bengal political space, it can be claimed that as a social space, Bengal has a very different political and cultural ethos rooted in the identity of place. From the very perspective of humanistic geography through phenomenological inquiries, the place and lived experiences of "beings" largely control the "subjectivity" of electoral responses. Bengal can be adjusted to this theoretical frame of place connections because of its specific genre. However, political movements like the Renaissance,

social reform, and the communist-peasant movement further enhanced the state's political value on the phenomenological–existential ground—the persistence of social movements caused normative standardization and politicized this particular place (Biswas et al 2018). The Left Front government has fostered an environment where caste and religious politics are no longer valid, in line with the Marxist theoretical framework that only applies to superstructure (Bandyopadhyay, 2012). When the Left Front lost its majority in the Panchayat election for the first time since 1975, West Bengal politics underwent a significant upheaval. The primary supporters of the left, such as landless and marginal landowners, Scheduled Castes (SC), and Scheduled Tribes, are becoming more anti-incumbent due to increased accountability constraints brought on by changes in voter characteristics and more substantial governance failures. New youthful voters, aggressive anti-incumbency, and the Nandigram and Singur issue significantly altered West Bengal's political scene (Chatterjee, 2018), and the Nadia district was no exception. Hence, the long-term regime of the left front subsided the caste issue in electoral politics in Bengal. However, "class" was a key component of social stratification during the communist regime. Class constitutes the central focal theme in political discourse. The concept of "class" offers a contemporary foundation for political parties founded on Marxism.

However, it is believed that the left's demise has allowed identity politics; significantly, caste and religious identities are centrally involved in post-communist West Bengal electoral politics. Combined efforts of Abdur Razzak Mollah, a former member of the Communist Party of India (Marxist) CPI (M) and current minister of the AITMC and Matua Mahasangha helped Mamata Banerjee win the 2013 and 2018 Panchayat elections (Biswas et al 2022). In 2018, the Bhartiya Janata Party (BJP) structured planned electoral mobilization techniques to mobilize the Hindu voters in West Bengal (Palshikar, 2015). Additionally, the BJP, led by Narendra Modi, made a conscious effort to intermix pan-national identity, nationalism, and economic developmental issues (Shastri, 2019). He nurtured the idea that nationalism is correlated to Hindutva's national frame. Developmental issues were a fundamental drive within the electoral principles. The BJP's success in the 2018 Panchayat elections is notable for the geographic scope of its triumph, the increase in vote share, its capacity to convert votes into seats, and the broad socio-economic coalition that made this victory possible. However, recent observations of the Nadia district's political culture have revealed several traits. The communal versus non-communal fault line is one of the most important political fault lines in West Bengal.

The "communal" viewpoint frequently asserts that India's nationhood is founded on the Hindu community's cultural, religious, and ethical practices. The non-communal perspective, in contrast, holds that India's nationalism is not based on any particular community or culture. The socio-cultural existence of India is increasingly complicated and pluralistic as a result. The dominance of regional parties and the continued rise of national parties are reflected in how Nadia politics have changed over the past ten years. However, in recent years, caste and religious affiliation have been important factors in the Nadia election. Power-driven identity politics damage the ideal of democracy and draw attention away from other socio-economic problems, including unemployment, poverty, crime, corruption, the safety of women, and farmer suffering. Caste, class, and community divisions sometimes result in political violence, conflict, and tensions.

Objective

The main objective is to examine the factors that influence the voting behavior of the people in the Nadia District of West Bengal.

Database and Methodology

The present study based on both the arm of research primary and secondary source of data. The primary data constituted the significant input for the study. Primary data was collected from voters through a field survey. For that, a total of 500 voters have been selected from twenty Panchayat segments of Nadia district. In addition, direct field observations and a focus group discussion (FGD) have also been carried out to supplement the survey data. Qualitative methods and approaches are this research work's dominating tools and techniques. Participatory research methods, narratives, discourses, and grounded theory are the fundamental approaches for this study. It analyses the grounded theory of cultural space and place's identity influencing electoral behavior and its variations across the state. The study is also based on historical and analytical methods. The historical method helps understand the past experiences of electoral behavior of certain issues and challenges pertaining to voting behavior and party performances in Nadia District, West Bengal. This study is based upon secondary data sources collected from the Election Commission of India, New Delhi. The data has been analyzed and interpreted with the help of various statistical and cartographic tools and techniques like percentage. The Newspaper report, election documents, and manifesto are the archival sources consulted to explain political parties' role in the electoral campaigns and mobilization.

Results and Discussions

Electoral Politics in West Bengal with Special Reference to Nadia District

As a social space, Nadia District has produced a distinct political culture since the historical memoir. The meaning of place intrinsically nurtured its cultural evolution. Monarchical and feudal regimes have significantly influenced the political history of Nadia District in addition to democratic civic administration (Sinharay, 2012). However, the extreme political socialization of the residents of Nadia District, who predominantly reside in rural areas, largely governs the district's electoral dynamics. The people are controlled by the levels of social stratification based on caste and class identities. People will not be free but respond as members of a particular social group (McMillan 2012). Political parties use voters' cognitive frames for their electoral mobilization in this social context. However, the recent elections in West Bengal, where populist inclinations attempted to supplant the pre-existing political environment, were influenced by general influences of "waive elections" and their characteristics. Media, propaganda, and other outside entities work to instill their justification in voters' minds as "bio colonization" tools. A few political parties are trying to erode caste distinctions and make them more fluid to influence voters more broadly. Political parties make an effort to participate in accommodation politics.

They form alliances and use their identities to mobilize voters and win elections (Nath & Ray, 2022). However, religion has become a significant factor in controlling voters' imaginations and voting behavior in Bengal. Religion is one of the most important factors that can quickly mobilize a wider range of demographic compositions (Hasan 2010). Religion and caste are important tools to mobilize voters and win elections in the Nadia District. This particular emotion develops the environment of "self and other selves," "binary structuralism," and "bipolar religious order of society." Social feelings and already-existing social order serve as a ready-made canvas for political parties' electoral campaigns (Jungherr 2016). The Nadia District elections served as an important case study for empirical research on the effects of various socio-economic instruments on electoral politics. In this context, it is viable to feature these elements and their consistent impact on elections. Therefore, this study investigates the role of caste, class, religion, historical memories, iconization, and populism in the Panchayat election of the Nadia district. The political culture of the Nadia district is significantly different from that of the rest of the state. Caste and religion were declared invalid by the left-front government. Marxists are the proper form of social organization since it

offers a current framework for categorizing, organizing, and mobilizing individuals (Chakrabarty 2017). In the decline of the left as a significant force in the district, caste played an important role. In the politics of postcolonial West Bengal, no doubt left culture has produced the sense of ideological essence of electoral politics. However, caste-based identity politics has transformed the values of left politics in the state. It is a fact that caste played a significant role in Nadia district's Panchayat elections. The Matua Mahasangha's growing affiliation and support with BJP, a mainstream political party. Abdur Razzak Mollah's recent efforts to forge a united political front of Dalits and Muslims (Sinharay 2019). Although most of the left-front leadership in Bengal comes from the upper castes, the communists have always enjoyed unwavering support from the Dalits. The Dalits have never felt the need for their independent political platform. The left front's apparent awareness of his demise creates a favorable environment for identity politics. In such circumstances, West Bengal will unquestionably see a rise in identity-based political mobilization. The past election witnessed a bipolar contest between the CPIM and the AITMC.

However, the last two elections have seen the emergence of the BJP as a significant political force in Nadia district politics. The BJP performed very well in the 2013 and 2018 Panchayat elections. The inherent values of imagined identities nurtured the cognitive environment of individual voters. However, identity associations on the emotional line are short-lived and challenged by the existential reality and rooted intentionality of "self" performing in individuals as electorates (Bondi 2004, Fukuyama 2018). Caste, community, clan, and kinship are the identities drastically involved in elections for large-scale political mobilization. These variants undermine the ideal democratic spirit and divert focus from other "realistic" socio-economic issues like poverty, unemployment, crime, corruption, women's security, and farmer unhappiness. The politics of daily life geography raises political questions as emerging disparities based on caste, class, and community. It may occasionally lead to hate, conflict, and even violence. Instead, regionalism and the multi-party system have created a new political environment where voter expectations are evaluated following variances in voter consciousness and information flows (Biswas, 2022). The decline of Congress and CPIM created an atmosphere for the Bhartiya Janata Party (BJP) in the Nadia district of Bengal politics.

Electoral Trends and Performance of Political Parties in Nadia District Panchayat Election from (2008- 2018)

Our study deals with the spatial and temporal variations of electoral behavior in the three Panchayat elections in the political space of Nadia district, West Bengal.

It covers the elections of 2008, 2013, and 2018. The primary focus of the study is to identify, describe, and analyze the participation patterns and associated parameters with the help of electoral data, maps, and empirical observations. The electoral seat of a political party in the legislature reflects its relative strength and determines which party will form the government. The percentage of seats won and overall seats contested is used to measure a political party's level of success. In comparison to other political parties, Trinamool Congress had the highest success rate in the Panchayat election of 2018, with a score of 67.7 percent. It shows that, under Mamata Banerjee's leadership, Trinamool Congress enhances its electoral value by capturing voters' imaginations at a larger scale, covering a larger segment of social groups. In the 2008 Panchayet election, the Communist Party of India (CPIM) was the leading political party, winning more than 30% of the vote. However, in the 2013 panchayet election, its performance slipped. From the 2008 Panchayat elections to the 2018 Panchayat elections, the Indian National Congress's performance has declined on trends. Voter behavior in the Nadia District observed a paradigm shift from 2008 to the 2018 Panchayat elections. **Table-**1 displays the performances of political parties based on the percentage of seats and votes they got in the 2008, 2013, and 2018 Panchayat elections (**Table-**1).

Table-1: Patterns of Party Performances

Political Party	Patterns of Party Performances					
	2008		2013		2018	
	No of Seats	% of Votes	No of Seats	% of Votes	No of Seats	% of Votes
CPIM	891	28.22	547	22.16	340	16.2
AITMC	809	30.22	1384	39.3	1595	44.79
INC	650	14.3	515	13.12	379	3.61
BJP	205	7.14	385	13.14	759	26.7
CPI	20	3.6	10	1.6	4	0.5
AIFB	37	4.12	27	3.12	15	1.1
SUCI	26	4.7	20	1.8	11	0.8
CPIML	5	1.8	5	0.8	0	0.4
RSP	5	1.2	5	0.5	0	0.3
IND	43	4.7	72	4.46	106	5.6
Total	2691	100	2970	100	3209	100

Source: Based on Statistical Report in West Bengal Panchayat Elections from 2008 to 2018. West Bengal State Election Commission, Kolkata

Table-1 shows the TMC won 809 out of 2691 seats in the 2008 Panchayat election, with a vote percentage of 30.22. It gained 1384 seats out of 2970 in the 2013 election. It shows the increasing tendencies as 1595 seats were positively secured out of 3209 in the 2018 election. It achieved a vote percentage of 44.79 in this election. Compared with the 2013 Panchayat election, AITMC's party performances have improved regarding seats and vote share from 2008 to 2018. With this outcome, Trinamool Congress and Left political organizations dominated most of the political spaces in the Nadia district up to the 2013 Panchayat election. With the widespread criticism of the Leftist government, particularly in light of the Nandigram and Singur crises, the Trinamool Congress established itself in the Nadia district. Later, state politics viewed Mamata Banerjee as an influential leader in the state. In the struggle of Mamata Banerjee against the left, she proved herself to be the true alternative to the opposing voice. She was the only opposition leader who relentlessly opposed the left, which yielded her electoral benefit. Muslims constitute about 23 percent of the votes. Their votes are decisive, constituting 30 percent of the seats in the Nadia district. Trinamool Congress Government gives a monthly stipend of 2500 imams and muezzins. It distributed bicycles to girl students enrolled in madrassas. Provided scholarships for minority students.

Trinamool Congress offered reservations to Muslim OBC and declared Urdu the second language in the Muslim-populated district. Trinamool Congress intact Muslim voters due to the factors mentioned above that gave Trinamool Congress massive electoral victory in the Panchayat elections. The numerous welfare policies initiated by Mamata Banerjee, like the Rupashree Scheme, Kanyashree Scheme, Sabuj Sathi Scheme, Khadya Sathi Scheme, Swasthya Sathi, Imam Bhata, Pandit Bhata, etc., are the most popular schemes that influenced the voters and culminated in the resulting outcome of 2008, 2013 and 2018 Panchayat elections. **Table-**1 shows the 2008 Panchayat election; BJP won 205 out of 2691 seats with a vote percentage of 7.14. It got 385 out of 2970 seats, with a vote percentage of 13.14 percent in the 2013 election, and 759 out of 3209 seats in the 2018 election, with a vote percentage 26.7. In the 2008 Panchayat elections, the Bhartiya Janata Party did not have a significant impact. However, in 2008, left-wing organizations had more influence over a wider range of voters. The Trinamool Congress and the Left Front even balanced the 2013 Panchayat elections. It implies that the Bhartiya Janata Party's arrival strongly impacted the Panchayat elections in the Nadia district in 2013 and 2018. It means that the iconized political spaces have transformed with Narendra Modi's ascent to the position of a national populist leader. In these Panchayat elections, there were considerable differences between the seat and vote shares.

Compared to the 2013 Panchayat election in West Bengal's Nadia district, the BJP's party performance in the 2018 Panchayat election improved in terms of vote and seat share. The charismatic leadership of Narendra Modi, given his Gujarati roots belt, was largely nurtured through dedicated work as a skillful state leader. Hindu voters were not only institutionalized in saffron ideology and remained electorally loyal to Modi but also became the torchbearers of his novel brand of right-wing Hindutva politics. Saffron color comprises three political components: charismatic leadership, the strength of electoral rhetoric, and a vision of transformational governance. This pattern of party performances demonstrates the Trinamool Congress and BJP's intense electoral competition. The BJP has slightly benefited from capturing seats in the Blocks with more Hindu voters. This electoral situation highlights that CPIM, formerly the dominant force in state politics, has a lower voting percentage and likely switched to BJP. In recent elections, votes may have shifted more due to historical conflicts between BJP and AITMC officials and volunteers. The claim is that CPIM has weakened its ideological grip, and its traditional supporters have switched to another political party. The most likely explanation for this phenomenon falls into two categories. First, the CPIM voters have been split into two groups, and they now want the BJP to spread a negative message about the Mamata-led AITMC. Iconized politics, sentiment-based mobilization, and populist politics are other strong factors for the BJP.

The welfare policies that Modi has introduced include Jan Dhan Yojana, one of the largest financial schemes in the world, which opens bank accounts for 30 crore unbanked households, and Kisan Yojana, a direct income support program for the farming community. Awas Yojana, which offered to house 1.5 crore low-income people; Pradhan Mantri Ujjwala Yojana, which installed smoke-free kitchens in 70 million homes; and Swachh Bharat Abhiyan (Clean Bharat), which provided toilets to nearly ten crore people, were other significant programs (Heath & Tillin 2018). Gujarati Model and Narendra Modi's charismatic leadership is important in mobilizing ground-level leaders and voters. Hindu voters stayed electorally loyal to Modi, institutionalized the saffron ideology, and took up the mantle of his innovative form of right-wing Hindutva politics (Dasgupta 2020). The BJP criticized the Trinamool Congress for allegedly favoring Muslims. 'Nation First, national security, zero-tolerance approach to terrorism, the welfare of soldiers, battling infiltration, implementing the Citizenship (Amendment) Bill, combating left-wing extremism, Ram Mandir, Jammu & Kashmir - Article 370' were some of the key themes of Modi's populist campaign. **Table-**1 shows that in the Panchayat

elections of 2008, CPIM won 891 out of 2691 seats, with a vote percentage of 28.22; in the elections of 2013, it got 547 out of 2970, with a vote percentage of 22.16; and in the election of 2018, it occupied the 340 out of 3209 seats having vote percentage of 16.2. Compared to the 2008 Panchayat election in Nadia district, there is a declining pattern of party performance for CPIM in the 2013 and 2018 Panchayat elections regarding vote share and seat share. The CPI(M) cultivates a powerful organization with a broad network to keep a firm hold on the cadres and voters. As a result, Chief Minister Buddhadeb Bhattacharya created the new slogan, "Agriculture is our base, industry our future" (Jaffrelot & Verniers 2020). After acquiring agricultural plots from small farmers and landowners, he zipped across the state, setting the cornerstones for new townships, food parks, industrial units, shopping malls, and catering training facilities. The Left Front Government in West Bengal had created a positive and healthy environment in the industrial sector. The electoral success of the Left Front cannot be explained by economic parameters alone. The fact that the CPIM is a disciplined political party should be kept in mind in understanding the dynamics of power relations in West Bengal. Party discipline facilitates a strong link between the party leadership and the cadres.

This enables the leadership to translate effective organizational goals into grassroots action. The active involvement of the party cadres in the people's everyday life gives the CPIM strategic advantages in election campaigns. In the urban areas, the party maintains mass contact through the local committees and 'Mahila Samiti (Ghosh 2022). The Panchayati Raj revolutionized rural Bengal's economy and created a significant market for industrial goods during the Left regime in the state. The favorable industrial environment strengthened the Left Front Government. It triumphed in the 2008 Panchayat elections. Rising voter unhappiness with local incumbents on corruption, health, education provision, and other local public goods like roads and irrigation are examples of Left Front governance failures. Other programs include private benefit schemes like the Mahatma Gandhi program for drinking water, ration cards, bank loans, agricultural micro kits, old-age pensions, and the Indira Awas Yojana. Failures of state-wide programs, such as the stagnation of employment in rural areas, the inability to contain inflation, and issues with the Left Front's land acquisition practices close to Singur and Nandigram, might be attributed to non-local leaders. All of these problems, taken together, impacted the performance of the left front in the 2013 and 2018 Panchayat elections (Nath & Ray, 2022). The absence of left political force in the state and among the rural masses projects the historical visualization of its emergence in 1977.

Left Front government emerged, riding the wave of anti-Congress mass resentment. In the initial years, it undertook some popular measures like distributing vested lands among the landless, registering the names of the sharecroppers under Operation Barga, and reviving the Panchayati Raj institutions. At the same time, these democratic reforms helped consolidate the new communist party in the rural areas. However, undemocratic measures were followed later to eliminate opposition forces from the countryside. CPIM Neglected the voice of opposition to devalue and suppress the inherent identity forces that led to the decay of left rule even in the rural areas of West Bengal. In this regard, the Left Front rule that systematically and meticulously tried to direct consolidation as a dominating single party, even at the expense of all opposition parties, even junior partners, particularly in rural Bengal, has become irrelevant in electoral mobilization. **Table-**1 shows that in the 2008 Panchayat election, INC won 650 out. During the 2013 elections, INC won 515 out of 2970 seats with a vote percentage of 13.12; in the 2018 election, it won 379 out of 3209 seats with a vote percentage of 3.61. Comparing the 2008 Panchayat election in the Nadia district to the 2018 Panchayat election, there is a declining pattern of INC party performance regarding vote share and seat share. As a result, the INC party's performance has suffered as voters from the upper caste, Dalits, and Muslims have stopped supporting it. The majority of those who vote for Congress are from socially and economically disadvantaged groups. However, AITMC, which speaks directly to these communities, poses a real threat to Congress in the race for their votes.

The identity of the Dalit was historically less politicized. CPIM and Congress both had mileage in the reserved category voting performance, according to behaviors drawn from past electoral behavior of electorates in the Nadia district of West Bengal. It is because voting behavior's class-based orientation overshadowed caste-based mobilization or politics of identities. However, the recent Panchayat elections in 2018 showed the emergence of caste-based identity politics, as the BJP chose a Dalit as its state president. The Nadia district has been using the state president's identity. However, the deterioration of left politics in the state and rural West Bengal also destroyed the ideological essence of West Bengal politics. The ways of electoral mobilization consequently transformed into a pragmatic turn. The issues of labor and class identity-based mobilization are deformed into religion, caste, and identity politics. The features of national identity and issues and national tendencies overshadowed the regional identity of place and local social questions. The instrumental agencies like media and populism drastically shaped the authentic

political voices of rural society. The politics in West Bengal observed a drastic change and transformation from the Left-based political constructs to the emergence of Trinamool as a powerful political voice in the state. The changing demography and political situations are the vital cause of this transformation. Rising population growth, demographic fragmentation, middle-class dissatisfaction, and social and economic detachment are the general factors in the change of political regime.

Caste and Voting

The caste system largely affects the electoral campaign in rural areas, where caste and Baradari (Kinship) loyalty is seen as one of the most decisive factors determining the voting behavior of the villagers (Bandyopadhyay, 2012). In the Nadia district, individuals simultaneously hold multiple ethnic identities of language, religion, politicized umbrella caste categories (such as Upper Castes, Backward Castes, and Scheduled Castes), and highly localized sub-caste/kinship groups biradari or jati. Ethnicity matters in voting behavior and depends on the differences in the economic well-being of ethnic groups in a system (**Table-**2). When some ethnic groups are wealthy and others are poor, the silence of ethnicity in politics should increase. BJP's propaganda invites all majority community members to look at themselves as Hindu first and members of some caste groups second because of the socio-economic differentiation in the society. In a caste group, the richer people were more pro-BJP; they tended to be because of caste and class (mainly because of the party's reservations vis-à-vis caste-based quotas). It is still valid, but some changes have occurred in the context of post-1991 liberalization. Respondents believe Trinamool Congress got full majority support from the minority community (**Table-**2).

Table-2: Caste and Voting Preference of Respondents

Category	Voting Preference of the Political Party (%)			
	AITMC	BJP	Left	Others
General	35	40	20	5
OBC	40	35	18	7
SC	35	45	15	5
ST	30	50	15	5
Minority	82	3	10	5

Source: Field Survey, 2020-21

Factors Influencing Voting Behavior

A number of factors influence an individual's voting behavior. It is mainly determined by race, religion, caste, community, region, language, charismatic leadership, ideology, local issues, political wave, etc. Thus, an attempt has been made to determine the sources of voting behavior (**Table-**3).

Table-3: Distribution of Respondents According to Factors Influencing Voting Behaviour

Factors affecting Voting Behaviour	Number of Respondents	Percentage
The ideology of the Party	100	12.7
Programmes and Policies of the Party	160	15.88
Personality of the Candidate	140	7.94
Religious Consciousness	400	22.22
Caste Consciousness	250	17.46
Local issues of Electricity, Road, and Water	140	15.87
Any Other	10	7.93
Total	1200	100

Source: Field Survey, 2020-21

The reason is that Muslims see the BJP as a party threatening their interests. BJP has successfully increased its popularity among SC/ST community voters with the help of pro-poor policies like the Ujjala Yojana, Pradhan Mantri Awas Yojana, Swatch Bharat Mission free toilet, Free Ration, and CAA/NRC Issues. **Table-**3 displays that the majority of respondents, i.e., 22.22%, gave importance to 'religious consciousnesses in deciding on whom to vote for in the election, while 17.46% of respondents emphasized caste consciousness and 19.20% of respondents emphasized 'local issues of electricity, road, and water of electricity. Other factors viz., 'programs and policies of the party,' 'ideology of the party had received preference of the electorates at the rate of 12.70%. It shows that religion and caste is the most important factor in voting behavior in Nadia district voters. The candidate's personality has minimal influence on the voting decisions of the region's people. Apart from these factors, priority has also been given to other factors like political parties' leadership and their representative's work or performance while voting. Therefore, it is essential to study the voters' preferences regarding political parties' leadership and their representative's work. Considering that the respondents' questions were asked, their opinions are classified below.

Conclusion

Trinamool Congress is becoming increasingly popular in Nadia district, West Bengal. BJP's political performance is a little better where the proportions of Hindu and Matua populations are high. It is a party with a strong ideological foundation that may appeal to the masses of one particular religion. On the other hand, the mutual political rivalries between CPIM and Trinamool congress voters also caused the massive success of the BJP in the Nadia district. The traditional vote banks of CPIM have also transformed their vote and support in favor of the BJP to degrade Trinamool, which has covered the voting scale in the political space of West Bengal. The leadership's quality is still a factor for the Muslim electorate. In regions where Muslims predominate, all major political parties often choose a Muslim as their candidate. They support those parties that promise them more security, respect, and identity. It provides them structurally a wide range of protection. CPIM and AITMC use Muslims as an electoral support base in their respective era of influence. Strategically, both parties succeeded in creating fear and threat of the BJP and rising communalization in the state. Although caste, class, and religion are significant factors in elections and maintaining strong control over people's perceptions. It functioned by identities in general and caste politics in particular. In the Nadia District, these imagined identity variables are particularly crucial and visible in electoral behavior and mobilization in the rural Nadia district. The CPIM has sustained its pro-poor policies for a longer duration. Its policies always benefited the scheduled castes, the Scheduled tribes, and the Muslims in Nadia district, West Bengal. It provided CPIM the power hold for the long term. So, the result revealed that the Trinamool Congress has the more prominent mass acceptance in the Nadia district Panchayat elections. Consequently, an electoral pattern indicates the ideological shifting in order from Left to Centre and now emerging trends of right in the Nadia district.

The politics in West Bengal observed a drastic change and transformation from the Left-based political constructs to the emergence of Trinamool as a significant political voice in the state. The changing demography and political situations are the vital cause of this transformation. Rising population growth, demographic fragmentation, middle-class dissatisfaction, social and economic detachment are the general factors in the political regime change. The emergence of the new middle class in the West Bengal demographic scene caused the degradation of voting influences of left parties. Remarkably, the left's support base was diminished with a long-time sustained problem, including a lack of industry, job opportunities,

and declining health and educational systems in the state. Overall, the civic memories and rise of Mamta Banerjee at a populist scale further challenged the CPIM space among the common masses. The left found the issue of land acquisition in Singur and Nandigram too expensive. In the Nadia district of West Bengal, Most SCs and STs voted for the left until it benefitted their caste interests. The left's policies, such as Land Reform and Panchayati Raj, offered the lower castes a sense of social advancement. It gave them political power at the local level and protected them from the powerful upper-caste landowner class. As a result, the left continued to get support up to the 2008 Panchayat elections. Even after the thirty years of rule by the left parties, the caste and religious consciousness was inherently located among the mindset of electorates. The religious sentiment of social groups was not changed into class consciousness. Economic diversification was not achieved, and the left regime did not address unemployment issues. The socio-economic backwardness of religious minorities projected the inter-ethnic, inter-community gap that leads to the degeneration of left politics. It seemed that the populist movement of TMC and the political iconization of Mamata Banerjee provided a sense of hope among the long-term subjugated social groups. Therefore, it benefitted the TMC in electoral victory.

The numerous welfare policies initiated by Modi, often based on earlier Congress planning, including Jan Dhan Yojana, one of the biggest financial schemes in the world, opening bank accounts for 30 crore uncovered households, and Kisan Yojana, a direct income support scheme for the farming community. Other mega programs were Awas Yojana, which provided housing to 1.5 crore poor people; Pradhan Mantri Ujjwala Yojana, which created smoke-free kitchens for 70 crore families; Swachh Bharat Abhiyan (Clean Bharat) and provided toilets to around ten crore people. The BJP criticized the Trinamool Congress for allegedly favoring Muslims. 'Nation First, national security, zero-tolerance approach to terrorism, the welfare of soldiers, battling infiltration, implementing the Citizenship (Amendment) Bill, combating left-wing extremism, Ram Mandir, Jammu & Kashmir - Article 370' were some of the key themes of Modi's populist campaign. Communalism plays a determining role in the electoral politics in Nadia district, West Bengal. Political parties and politicians use the communal division in population as the primary card during elections. As a result, the voters of the Nadia district very often vote based on religious considerations and local problems and issues.

However, the trend is changing slowly yet gradually. The sign of such consciousness is reflected in the voters' opinion regarding the most crucial issue

in the 2018 Panchayat election. However, there are visible signs that Bengal electorates are maturing, and the election is becoming more competitive. Nadia district is also no exception to that. Maybe in the coming days, communalism in politics may not remain a solid card to win regional elections. It is changing the course of electoral politics in the Nadia district. An electoral pattern indicates the ideological shift from Left to Centre and now emerging right-wing trends in the Nadia district electoral politics.

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ASSESSMENT OF RURAL TOURISM DEVELOPMENT IN KALIMPONG DISTRICT, WEST BENGAL, INDIA

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Abstract

Rural Tourism is understanding and going through the rural lifestyle, nature-based activities, natural products or it could be a modified form of ecotourism. In India it is growing in a vast scale. This paper aims to provide a holistic view of rural tourism sites and the success factors for the development of rural tourism in Kalimpong district, West Bengal. Based on an empirical study with the help of secondary data sources and observation of field study. A qualitative method is used to review the current scenario of the rural tourism sites in Kalimpong District. A SWOT analysis method is also used to identify success factors working behind developed rural tourism in the study area. The study highlights, Kalimpong district as a popular rural tourism destination and recognized the strength, weaknesses, opportunities, and threats of rural tourism in the study area.

Introduction

To enhance and sustain the quality of rural life, tourism is one of the essential sector and act as contributor. Rural tourism (RT), not a new concept for World (Gao & Wu, 2017; Roslina, Dupre & Wang, 2021) but this trend has emerged from last ten years in India. Rural tourism evolved in mid 70s in developed countries (Lane, 1994; Verma and Jain, 2018; Duha, 2021), its interest raised among people in the second half of the 20th century and became a useful tool for the development of rural areas (Duha, 2021). Indeed, globalization and urbanization have had a significant impact on the international, national, and regional tourism industries, leading to increased priority and profitability in many cases (Lane, 1994; Duha, 2021). This combines rural amenities and activities to offer visitors an authentic and enriching experience in rural areas (Fleischer and Tchetchik, 2005; Gartner, 2005). According to the United Nations of World Tourism Organization (2017), this form of tourism focuses on providing tourists with a deeper connection to the countryside (remote or rural areas), local culture, and traditional ways of life and characterize on the basis of population density and settlement size,

land use and economy, and traditional social structure (Lane, 1994). This provides tourist relax from their busy schedule with pollution-free environment, fresh air, open-wide space, connecting with nature, and going back to their roots i.e. far away from the city (Irshad, 2010;). It has many subsets like agri-tourism, cultural tourism, homestay tourism, eco-tourism, etc. (Irshad, 2010; Fleischer and Tchetchik, 2005; Ashtani, 2005). According to the Ministry of Tourism of India (2022), rural tourism is working as an integrated model, because it took account of various resources like cultural, Social, economic, and environmental aspects and the role of the stakeholders (Cawley & Gillmar, 2007). Indian government had indeed been promoting rural tourism as a means of sustainable development in rural areas so that people can become self-reliant or Atma-Nirbhar. It is an effective tool to eradicate poverty, increase the quality of life of local people, development of remote areas (Roberts & Mitchell, 1998). In today's world homestay business is a perfect option for rural tourism and indeed a component of the broader tourism and hospitality industry, and it shares some key characteristics with other service-based businesses within this sector. Rural homestay is an important part; because without staying with local people, tourists cannot participate actively in rural activities. Facilities like accommodation, food, beverages, Products, and infrastructures are taken into consideration to develop rural tourism. Rural tourism gives new rise in generating employment and income, entrepreneurship, and empowering local people and women (Das, 2021). It is also preventing the out-migration of youth from rural areas. Rural tourism not only gives work opportunities but also promotes the environmental, economic, and socio-cultural sustainability of rural areas.

Study Region

Kalimpong district was selected for this research work, as its 21st district of West Bengal in 2017 carved out from the Darjeeling district. The district extents from 26°51'N and 27°12'N latitude and 88°28'E and 88°53' E longitude. The district has consisted of three community development blocks and shares boundary with Sikkim, and Bhutan. It is famous for Orchids and known as the "Land of Orchids". Kalimpong has hilly areas, natural beauty, picturesque villages, river valleys, culture, heritage, etc. It is observed in (**Table-**1) that this district comes under rural areas, bounded by forests, and diversities of flora and fauna. The main source of economy and livelihood is agriculture. There are many variations in agriculture. Cash crops (Ginger, Large Cardamom), Plantation crops (Tea, Medical plants, Cinchona, Pineapples), Horticulture (Orange), floriculture, and Orchid culture are also the attractions of this region.

Kalimpong is recognized as a natural greenhouse region (Sharma & Mandal, 2020), traditionally different from other districts of West Bengal and inhabited by ethnic groups (**Table-**1).

Table- 1: General Information on Kalimpong District to Develop Rural Tourism.

Attributes	C. D Blocks of Kalimpong District		
	Kalimpong I	Kalimpong II	Gorubathan
Total Population	74746	60663	66830
Area (Sq.km)	360.40	241.26	442.72
Density (Sq.km)	210	280	140
Number of households	15358	13172	12662
Rural Areas	Mostly rural areas except one census town Kalimpong	Consist only rural areas	Consist only rural areas
Forest area	Forest area is 52% of the total district		
Bio-diversity	This region comes under eastern Himalayas. It is rich with different types of flora and fauna i.e. Mammals - 90species, Orchids - 300 species Birds- 550 species.		
Economy	Mainly depend on agriculture. About 80% people of this district associated with farming for their livelihood.		
Agricultural Landuse under Cultivate (Percentage)	37.19	34.5	44.17
Variation of Agriculture	Subsistence farming, Cash crop raising, Plantation farming, Horticulture, Floriculture, Orchid culture, Sericulture		
Accommodation for tourist	Homestays		
Tradition	Society is traditional because of inhabited by ethnic people like Gorkha, Lepcha, Bhutia, Etc. Religions are Buddhist, Hindu, Christian, Islam		
Small scale industries	Handicrafts, Agro-based products, Homestay		

Source: District census handbook of Darjeeling (2011)

It is one of the most popular tourist destinations among other destinations of West Bengal, but comparatively is a latecomer on the tourist map. It is attractive for its landscapes, pleasant weather, and richness of biodiversity, ethnic culture, historical heritage, handicrafts, and panoramic view of Mount Kanchenjunga. In current times, tourists prefer niche types of tourism, in which locations are off-beat destinations, rather than known tourist places. This year, eight villages from Kalimpong district have been nominated for the annual "Best Tourism Villages" by UNWTO.

Objectives

The major objective of the present study is to review the current scenario of rural tourism sites and to identify key to success factors of rural tourism in Kalimpong district.

Database and Methodology

For the study, both primary and secondary data have been used. Primary data was gathered from personal observations and interactions with local people and homestay owners and online with local. Secondary data have been collected from relevant documents of published research papers, reports, and books. This dataset include- District census handbook of Darjeeling (2011), Kalimpong the Nest of smile (2018), Kalimpong Calling (2019), document on Homestays of Kalimpong (2022), and Homestays of Kalimpong (2023) published by District Magistrate of Kalimpong, West Bengal Homestay Tourism Policy (2022) published by Government of West Bengal, District survey report of Kalimpong (2022) etc. Reports and books are published by the district administration of Kalimpong. Schemes and policies-related documents published by West Bengal Government in 2022. All these are used to meet the objectives of the study. Based on the primary and secondary data, a SWOT (Strength, weakness, opportunities and threat) analysis has been done to identify key success factors for rural tourism development in the study area. SWOT analysis is a Conceptual Framework (**Fig. 1**) for identifying and analyzing an organization's strengths, weaknesses, opportunities and threats. Strength characterizes business as competitive advantage over others; Weakness characterize business as disadvantage relative to its competitors; Opportunities elements in the external environment that allows it to formulate & implement growth strategies; Threats elements in the external environment that can endanger the business and its ability to operate. The primary goal of SWOT analysis is to increase awareness of the factors that go into making a business decision or establishing a business strategy.

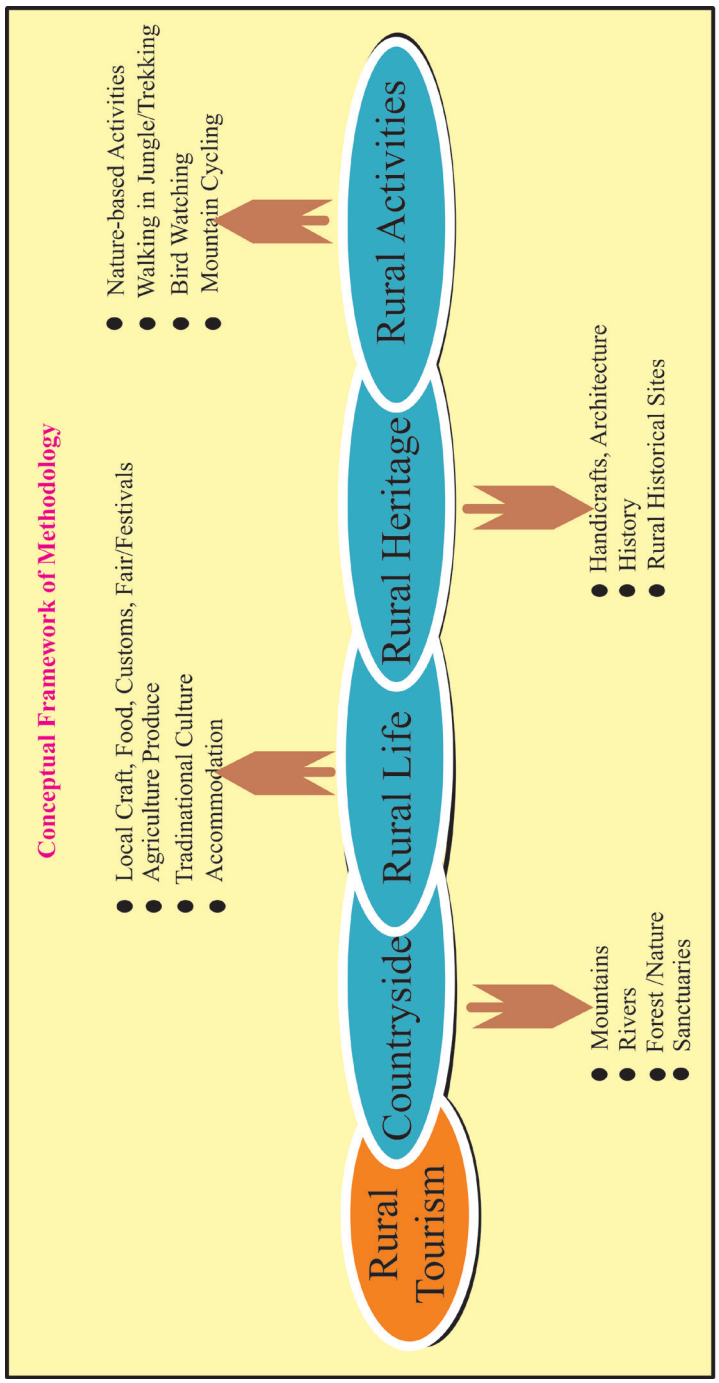

Conceptual Framework of Methodology
Rural Tourism
Countryside
Rural Life
Rural Heritage
Rural Activities
Mountains
Rivers
Forest /Nature
Sanctuaries
Local Craft, Food, Customs, Fair/Festivals
Agriculture Produce
Tradinational Culture
Accommodation
Handicrafts, Architecture
History
Rural Historical Sites
Nature-based Activities
Walking in Jungle/Trekking
Bird Watching
Mountain Cycling

Fig. 1

Result and Discussion

The current scenario of rural tourism sites in Kalimpong District

Kalimpong District is a hill station covered with reserve forests, river valleys, and foothills of the Himalayan region. Its elevation varies from 131 meters to 3163 meters (**Fig.** 2). Out of the total population in Kalimpong, 9.1% of people live in urban areas, while 90.9% of people live in rural areas (Census, 2011). People in rural areas are connected with agriculture with vast area of floriculture and agrarian resources and a few tea gardens along the southern Tarai and Dooars region of Gorubathan block (Podder, 2020). Most of the villages of three blocks of Kalimpong district are inhabited by ethnic people like Tamag and Lepcha. Based on natural and human resources, rural tourism has been growing in different villages of Kalimpong District since 2011-2012 (Sharma & Chettri, 2023, Das, 2021). Mostly tourism sites have been developing in remote villages within the forest and hilly tracts in the Kalimpong region (Das, 2021). Every three blocks of Kalimpong have rural tourism sites, from them some are very popular destinations and others are little known.

Kalimpong-II has the greatest number of rural tourism destinations because it comes under the old silk route circuit, which is connected to Sikkim. Homestays are one of the key factors to develop rural tourism in this area, which varies from 1015 meters to 3163 meters. In Kalimpong I and Gorubathan block, rural tourism sites have been developed at middle altitudes (1015 meters to 2024 meters) and nearby roads and rivers. Kalimpong I mostly come under urban areas. So, here new rural tourism sites are now developing like Chuikhim, and Nimbong. Gorubathan block comes under in Dooars region and due to accessibility hotels are grown up, that's the reason homestays are not more developed here. These rural tourism sites are also known as eco-tourism villages. These are Ramdhura, Sillary Gaon, Ecche Gaon, Rikisum, Loly gaon, Chuikhim, Kagey, Jhandi etc. These villages are picturesque, lush green trees, traditional homes, hills side cultivation, home of Orchids and different flowers, cinchona plantation, tea gardens, and majestic views of Kanchenjunga and hospitality of local people.

Strength

In the study area, under strength mainly 5 factors identified based on literature review and observations, which the potential resources are playing important role in the success of rural tourism (**Fig.** 2 and 3).

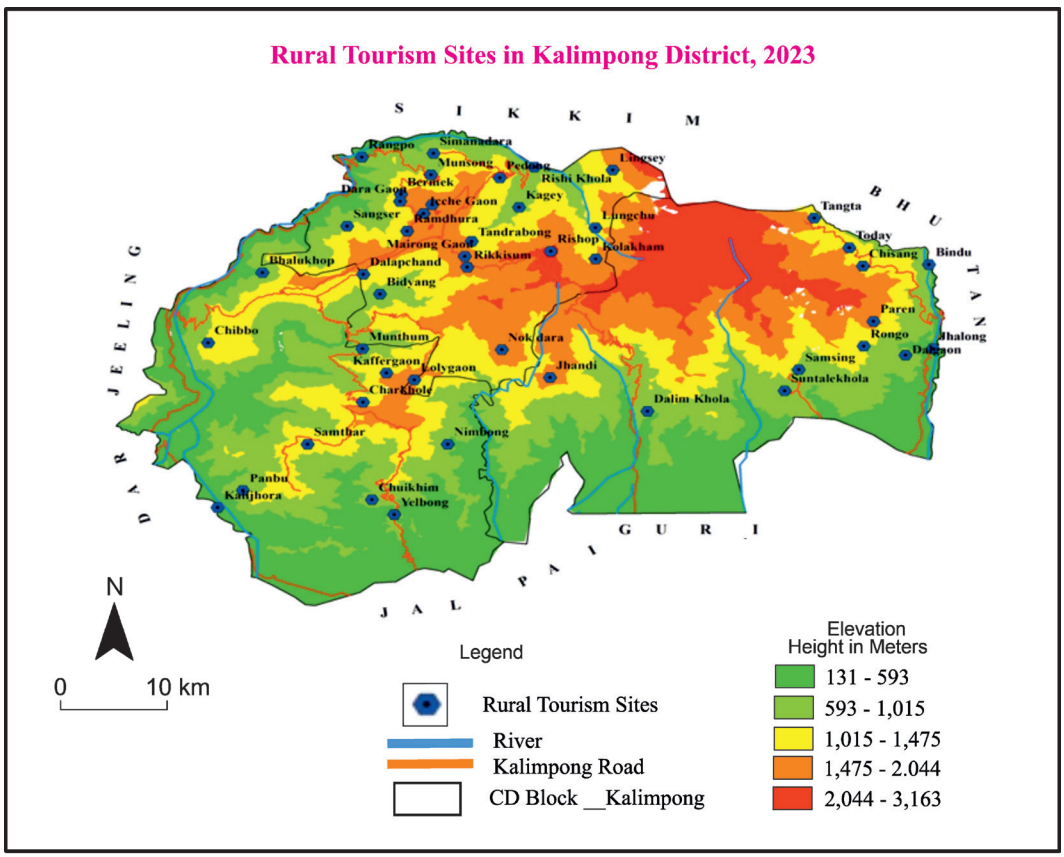

Rural Tourism Sites in Kalimpong District, 2023
S I K K I M
D A R J E E L I N G
J A L P A I G U R I
B H U T A N
Rangpo
Simanadara
Munsong
Pedong
Rishi Khola
Lingsey
Dara Gaon
Berenick
Kyche Gaon
Kagey
Sangser
Ramdhura
Tandrabong
Rishop
Lungchu
Kolakham
Tangta
Today
Chisang
Bindu
Mairong Gaon
Rikkisum
Bhalukhop
Dalapchand
Bidyang
Chibbo
Munthum
Nok dara
Paren
Rongo
Jhalong
Kaffergaon
Lolygaon
Jhandi
Samsing
Suntalekhola
Charkhole
Dalim Khola
Samthar
Nimbong
Panbu
Kanjhora
Chuikhim
Yelbong
N
0
10 km
Legend
Rural Tourism Sites
River
Kalimpong Road
CD Block __Kalimpong
Elevation
Height in Meters
131 - 593
593 - 1,015
1,015 - 1,475
1,475 - 2.044
2,044 - 3,163

Fig. 2

The factors are identified by using SWOT (Strength, Weakness, Opportunities, and Threats) analysis. Strength and Weakness are considered as internal factors i.e. activities involved in these factors are controllable and can be changed like location, team, intellectual properties etc. And on the other hand, Opportunities and Threat are external factors i.e. activities involved in these factors cannot be changed as under opportunities advantage can be taken but under threat only precautionary measures are taken. Ex. competitors, prices and customers (**Fig.** 3).

Historical

Natural: Natural resources are the Potential component to the development of rural tourism in the Kalimpong District (**Table-**3). The unique mountainous topography, river valleys, mesmerizing weather, majestic view of Mount Kanchenjunga, Night view of various cities from the hill region, diversities of flora and fauna, picturesquare villages and lush green trees and forest of pine and Oak, tea garden attracts a huge number of domestic and foreign tourist (Das, 2021: Bhutia, 2014: Khan and Mitra, 2017: Bhattacharya et. al, 2014). These are the key reasons for the successful development of rural tourism in Kalimpong district, Darjeeling Himalayan region.

Cultural

In rural tourism, tourist gains experiences from the local art, culture, and lifestyle of local people (Bhutia, 2014). Kalimpong is a full variation of traditional art, culture, communities, and religions. Because of the trade route to Tibet, this is earlier known as the old silk route passed through Kalimpong. In this region, various types of tribal people inhabited like the Rai, Damis, Limbus, Gurungs, Bhutia, Sanki, Sherpa, Khas, Yolmo, Magar, Newars, Tamangs, Bhujel, Kami, Lepcha, etc. The Lepchas are the original indigenous tribes in the study area. Each of these people is very unique in their culture, religion, and heritage. Most people practice Hinduism, followed by Buddhism, Christianity, and Islam. Their main languages are Nepali, Hindi, Bengali, and English. Here, Hinduism is pre-dominated, but Buddhist and Christian culture is also an attraction of this region. There are so many popular monasteries, temples, and churches (tab no. 3) in the three blocks of Kalimpong District. Kalimpong is also known for its traditional handicrafts, wood carvings, embroidered items, bags & purses with tapestry work, copperware, and Tibetan jewellry. Cuisine: In Kalimpong district, another attraction is delightful ethnic cuisine like Momo, Gundruk, Ko Jhol, Thukpa, Kinema KO Jhol, Sel Roti, Aalu Dum, and Ningroo with Churpi (One Kind of Cheese), Shya Phaley, etc.

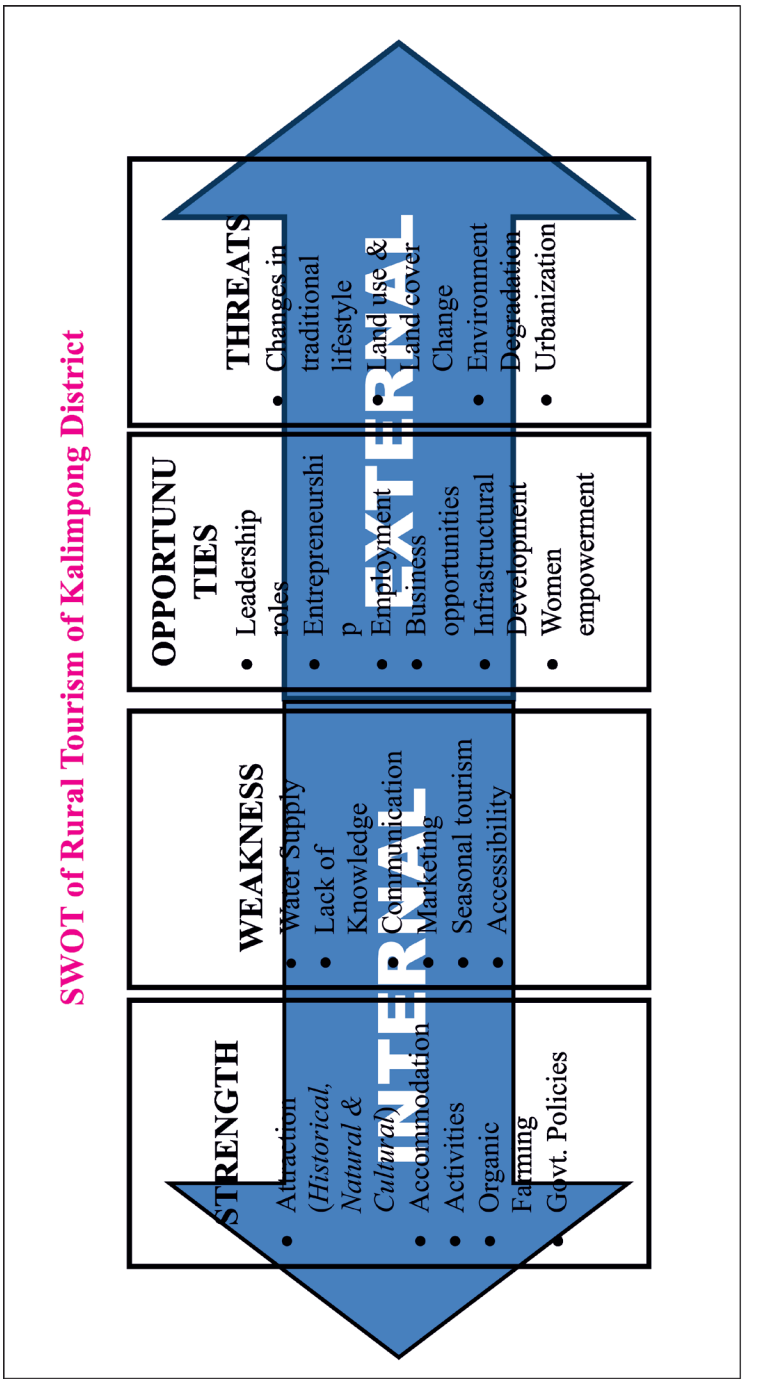

SWOT of Rural Tourism of Kalimpong District
STRENGTH
Attraction (*Historical, Natural & Cultural*)
Accommodation
Activities
Organic Farming
Govt. Policies
WEAKNESS
Water Supply
Lack of Knowledge
Communication
Marketing
Seasonal tourism
Accessibility
OPPORTUNITIES
Leadership roles
Entrepreneurship
Employment
Business opportunities
Infrastructural Development
Women empowerment
THREATS
Changes in traditional lifestyle
Land use & Land cover Change
Environment Degradation
Urbanization
INTERNAL
EXTERNAL

Fig. 3

This region is also renowned for cheese, noodles, and lollipops. Organic Vegetables and homely food of local people are preferred by tourists. It changes the taste buds of tourists and attracts tourists to rural tourism. Fair and Festivals: The people have come from different ethnic groups. There are so many fairs and festivals celebrated with great joy like Christmas, Diwali, Dusshera, and Losar. A large fair is held at Beni (the Confluence point of river Teesta and Rungeet) on the 14th of January every year. They are celebrated their fair and festivals with traditional dance and music like ghatu dance, dhan, damphu, Kaura, Maruni etc.

Historical

Kalimpong has its unique history. Firstly, Kalimpong was ruled by Sikkim still 1706 when Bhutan invaded Sikkim (Podder, 2020). Then it was acquired by the British and established colonial rule. Kalimpong is connected with Tibet, Nepal, and Bhutan by trading and sharing the national and international border. That's the reason many ethnic cultures mixed over. Donzong kingdom of Sikkim and British ruled over Kalimpong. They left their culture, Architecture (tab. no. 3) and artifacts like Tibetan style, Scottish, Roman, etc. In 1947 Kalimpong become a part of West Bengal (**Table-**2).

Table-2: Attractions of Three C.D. Blocks in Kalimpong District.

Attractions	Name of the C.D. Block		
	Kalimpong I	Kalimpong II	Gorubathan
Natural	7th Mile viewpoint, Panbu Dara viewpoint, Deolo viewpoint, Deolo Park, Pine view Nursery, Teesta River Valley, Relli river Valley, Coronation Bridge, Patima Devi Tagore House etc.	Ramtey viewpoint, Jalsa viewpoint, Ramdhura viewpoint, Tiffin Dara viewpoint, Lava viewpoint, Munsong Teesta viewpoint, Sillary Gaon viewpoint, Rishop view point, Tiffin Dara view point. Cinchona Plantation, Neora valley National Park, Dhoksing Waterfall, Changey waterfall. Etc.	Organic Tea Garden, Suntaley viewpoint, Gumba Dara viewpoint, Triveni viewpoint, Dalgaon viewpoint, Bindu viewpoint, Jhandi Dara view point, Bindu barrage, Gorubathan Tar, Bhutan Tendu Valley etc.

Contd...

Religious	Zang Dhok Patri Phodang Monestry, St. Teresa's Church, Dharmodaya Bihar, Macfarlane Church, Gaden Tharpa choling Monestry, Mangal Dham, Kali Mandir, Tongsa Gumba etc.	Gumba Dara Monastery, Kagyu Thekchen Ling Monastery.	Chyakung Dara
Historical	Morgan House, Nature Interpretation center ecological Museum, Dr. Graham's home, Lepcha Museum etc.	Jalsa Bunglow	Damsang Fort

Source: Kalimpong Calling (2019), District Magistrate office

Accommodation

In Kalimpong region, tourism developed in the remote areas, which have natural landscapes, and pollution-free, fresh air. Rural tourism has been implemented in the various villages from three community block of Kalimpong district. The Sites are known as the off-beat destination of rural tourism for their crowded and hassle-free environment from urban areas. Rural Homestays are playing a vital role in rural tourism (Ministry of Tourism, 2023). Here, Homestays are the main accommodation and one of the attractions for tourists in rural tourism in this area. Homestay is an affordable alternative accommodation for tourists (Sharma & Chettri, 2023; Kumaran et. al, 2019). Where tourists are staying with local families, thus enabling them to gain knowledge and experience the culture, cuisine, and lifestyle of local people (Ministry of Tourism, 2023). Also, tourists are welcomed and can experience the traditional hospitality of the host family and the local community. It gives a unique and gracious feel to the tourist. In Kalimpong District, Homestays are a growing phenomenon in rural tourism in the study area (Das, 2021). In 2022,

there were 402 registered homestays in the three blocks of Kalimpong district. Now, it has increased to 1009 in 2023. It has increased significantly around 60% within one year. Mostly Homestays are concentrated in the Kalimpong II block (73%), followed by Kalimpong I block (20%) and Gorubathan block (7%). Kalimpong-II block is highest in the growth of Homestays than the other two blocks (**Fig.** 4). Because of some factors are working in this area like high altitude, conducive climate, large forest area, organic farming and silk route region, etc.

Activities

Kalimpong District has mostly hilly areas except for the South-eastern part of Gorubathan block. The people are associated with agriculture and the nature of this region. They are transforming their traditional agriculture, and nature-based knowledge into tourism activities. These activities are trekking, hiking, camping, river rafting, walk-in Jungle, identifying the plants and organic farming and harvesting, local festivals, nature photography, Mount biking and cycling, and bird watching. The Neora Valley National Park and forest are known as the "Paradise of Birds" in Kalimpong block II. The villagers in a group or individual are working as a guide. These activities keep engaging tourists with the local people.

Organic Farming

Kalimpong district has potential in organic farming and agro-horticulture for its temperate climate. According to Census (2011), more than 80% of people in Kalimpong depend on farming to manage their livelihood. The district is producing paddy, maize, millets, pulses, oilseed, and potatoes in small amounts, and medicinal plant varieties with the help of organic cultivation (Bhattacharya et. al, 2014). But it is widely known as one of the leading producers of large amounts of cardamom, flowers, and various cash crops like ginger, betel-nut, oranges, organic tea, Dalle Khursani (small chilies), and Mulberry Seri-culture (Chakraborty, 2023; Ram and Maji, 2018). The tribal people of Kalimpong like Lepcha, Bhutia, Rai, etc have utilize their family members as agriculture labour and using local resources, through traditional knowledge and methods for organic farming (Patel and Lepcha, 2023). These methods are more environments friendly (Biswas et. al., 2011). Over time period organic farming has been growing interest among tourists. It's become an opportunity for villagers and a success factor of rural tourism. Various villagers (rural tourism sites) of Kalimpong district, offers tourist to stay in farm-stay and homestay to gain knowledge of organic farming and the livelihood of local people.

Government Policies

Government policies are an important factor to develop rural regions through rural tourism. The entire stakeholders, who are related to tourism activities is bounded by local government and state government regulates. The government of West Bengal has taken many initiatives to growth of rural tourism through creating alternative income generate, employment, business opportunities, and community development. Rural homestay is an integral part of rural tourism. To promote homestay and increase local entrepreneurship, the state government gives the incentives of 1.5 lac rupees to each eligible homestay owner to achieve and maintain basic standards of homestay. Also gives subsidies on electricity and homestay businesses. No commercial taxes are levied on homestay owners, who have not more than 6 rooms (**Fig. 4**).

Homestay owners can register their homestay in the District Magistrate office and taken benefits from homestay tourism policy 2022. According to the Department of Tourism (West Bengal), tourism policy (2019) and recognition of tourism service provider policy (2021) promoted guidelines and different criteria to grant loans to tour operators, travel agents, and tourist transport operators. The policies are mainly focused on standards of infrastructure, and quality service through appropriate standardization certification and regulation. It's categorized homestay into two categories i.e. silver and gold, which are based on availability of facilities and infrastructure in homestays. The Department of Tourism associated with the Department of Agriculture of West Bengal encourages indigenous communities to adopt organic farming. Tourists can learn the practices of organic farming procedures from homestay owners and enjoy rural nature.

Opportunities

Rural tourism is focused on rural areas for sustainable rural development (Das, 2021). It has brought many opportunities in rural areas like employment, business, entrepreneurship, women empowerment, and infrastructural development (Wilson et. al, 2014). It also helps to boost self-confidence, leadership role, and various skills in local people.

Employment

In this region, rural tourism has been giving work opportunities to the local people (Bhutia, 2014). Their main economy is depending on Agriculture (Census, 2011). After agriculture, tourism is another main economic source for local people.

Rural tourism is creating an alternative income and employment opportunity for young and old people as well as women in this area. In this region, most of the people are directly and indirectly connected with the tourism industry. At present, the district has many registered and un-register homestays. The total number of registered homestays is 1009. Officially, this 1009 household is working under rural tourism. In rural homestays, women are the main worker, and other family members are also involved in the work. Most of the rural tourism destinations are not accessible by public transport, only private cars as an option. A large portion of local people associated with transportation business. From 2022 to 2023, 60% of Homestays have increased. So, it is also increased employment opportunities. In the study area, floriculture is one of the important components of the development of tourism and employment opportunities for local people (Sharma & Mondal, 2020).

Business Opportunities

Tourism gives new business opportunities in any region. In Kalimpong district, rural tourism boosts the local economy and much more in the peak season of tourism during Mid- February to June and October to Mid-December. People engaged in different types of works, because of the diversification of nature. The people are working as tour guides, car drivers, homestay owners, and cooks, and helping hand in the homestay, entrepreneurs, and handicraft makers. Some people are working as restaurant workers, sellers of local food vendors, etc (Bhutia, 2014; Das, 2021). It can be observed that employment and business opportunities have been increased in the study area.

Entrepreneurship

In rural tourism, rural homestay is an integral part. It is playing a vital role in the development of rural tourism in Kalimpong district. According to Association for Conservation & Tourism (NGO) (2023), North Bengal has a total of 3000 homestays. Kalimpong District has a one-third portion of it. It is observed, that from 2022 to 2023, entrepreneurship has increased. Male entrepreneurship increased by 44.59% and female 15.55%.

Leadership Roles

Local leadership is a success factor in rural tourism development (Wilson, 2005). Leadership should be strong, committed, and effective in destinations across all levels like governments, business persons, and communities so that these

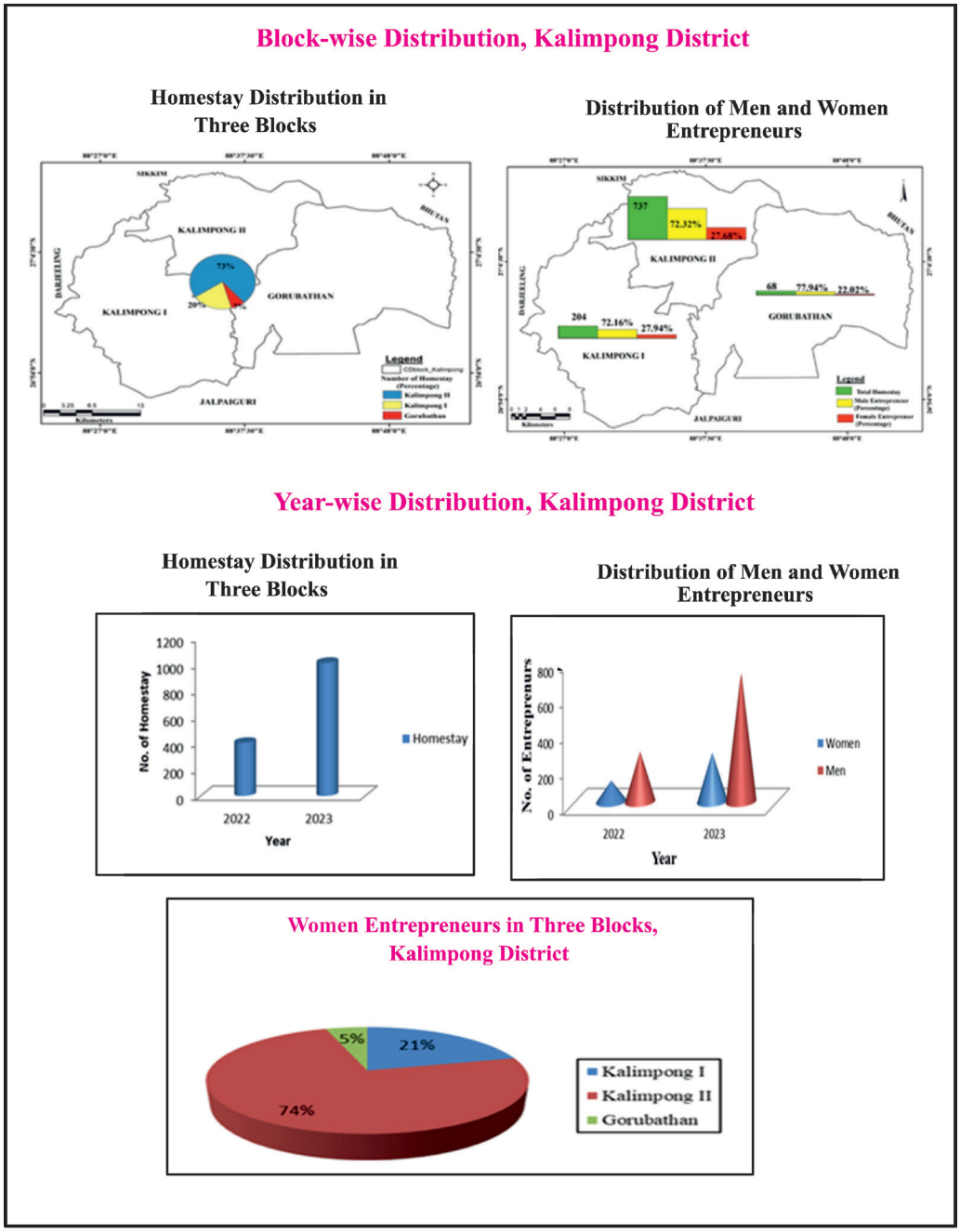

Block-wise Distribution, Kalimpong District
Homestay Distribution in Three Blocks
Distribution of Men and Women Entrepreneurs
SIKKIM
BHUTAN
KALIMPONG II
KALIMPONG I
GORUBATHAN
JALPAIGURI
DARJEELING
Legend
737
72.32%
27.68%
68
77.94%
22.02%
204
72.16%
27.94%
Year-wise Distribution, Kalimpong District
Homestay Distribution in Three Blocks
No. of Homestay
Year
2022
2023
Homestay
Distribution of Men and Women Entrepreneurs
No. of Entreprenurs
Women
Men
Women Entrepreneurs in Three Blocks, Kalimpong District
21%
5%
74%
Kalimpong I
Kalimpong II
Gorubathan

Fig. 4

stakeholders play a proactive role in rural tourism (Dwyer and Edwards, 2010). Destination leadership must include long-term strategic planning, that helps the destination to achieve its potential development (Haven-tang & Jones, 2012, Pp-30). Leadership encourages innovative development of the rural destination, which is creating more sustainable rural tourism with its society, economy, and environment (Mitchell and Hall, 2005; Haven-tang & Jones, 2012). In Kalimpong, rural tourism allows for increasing leadership quality for local people. It also gives support to get social, cultural, and environmental benefits to local businesses. Homestay owners, tourist guides, and small businesses like vendors, food sellers, and those connected with the rural tourism industry in Kalimpong, are gaining self-confidence, and economic independence. West Bengal Government and Various organizations are helping them through skill training to shape their life and build leadership qualities.

Infrastructure Development

Rural tourism gives a new shape of rural areas. Central Government and State Government are trying to rejuvenate the rural areas through better roads, communication, sanitation, electricity, and drinking water. Drinking water has supplying through 'Har Ghar Jol' project. National Highway 717A is under construction, which connects Kalimpong to Sikkim. It helps rural areas of Kalimpong to join the national highway grid.

Weakness

There is no doubt Kalimpong is a famous tourist destination and has potential to develop niche types of tourism. For some factors, it is lag behind in other parts of India. Kalimpong is connected mainly by roads to other districts and states. Most of the beautiful rural tourism destination is located in inaccessible areas. Village roads are in bad conditions like Ramdhura to Icche gaon, Algarah to Rishop, Lave to Kolakham, Simanadara, and a majority of Lingsey, Lingsekha, Kagey, and Gitdabling gram panchayat has no accessible road by Jeep in Kalimpong II block, Chuikhim, Yelbong part of Kalimpong I block and some parts of Gorubathan block, etc. Most of the destinations are accessible by Jeep. Its price is too high and tourists can't afford sometimes. Infrastructure is also not good enough like some destinations have no geyser option in homestay. There are some issues in water supply and communication. Mobile Network is not getting everywhere. For drinking water and domestic work, they are dependent on local Jhoras, Neora sources, Dhaula and Relli rivers, water reservoir. One of the biggest problems is that these tourist destinations are not suitable for all weather. Here tourism is a seasonal cycle i.e. Mid-February

to June and October to Mid-December. Kalimpong comes under seismic zone IV and landslip frequently occurs during monsoon season. Marketing strategies are not well maintained. There is also no option for online booking and online payment and have not any specific web portal. It cannot be reached by others states of India. Most tourists come from various districts of West Bengal, the neighboring state of Bihar Jharkhand, etc, and Bangladesh. Tourists are getting information about destinations from social media like Facebook, YouTube blogs, and family and friend circles. Hosts (local people) and guests (tourists) do have not much knowledge about rural tourism. Local people do have not proper training and skills, knowledge of rules and guidelines, and proper management of rural tourism.

Threats

Kalimpong district has a small area. Due to the improvement in tourism and floriculture, Kalimpong has witnessed urbanization (Subba, 2020). Growth of urbanization, there is a raising problem of traffic congestion. The reasons of traffic congestion are massive congestion of tourists, carrying capacity of roads and numbers of vehicles. It happened due to the pressure of the huge number of tourists at seasonal times in Kalimpong. It is noticed that the unplanned growth of homestays and tourist spots is increasing without proper planning and management. It has an impact on land cover and changing land use pattern of Kalimpong. Due to overcrowding by tourists, places are facing environmental problems like noise pollution, solid waste management, water crisis, etc. Tourists are coming from urban areas and stay with local people. It gives negative impacts on rural youth and changes their traditional lifestyle.

Conclusion

Rural tourism is a new phenomenon in Kalimpong. It reshapes rural areas and enhances the quality of life of local people as well. Kalimpong has many strengths of rural tourism. This gives many opportunities to local people i.e. employment, various business opportunities and economic independence. Here, women are actively participating in rural tourism through homestay. This leads them towards empowerment. With the help of these strengths and opportunities, weaknesses and threats should be overcome. It should be the collective effort of Government, local people as well tourists help to develop sustainable rural tourism. Local people and tourists must be aware of the rural tourism concept and its consequences. So that, through rural tourism creates a positive impact on socio, economic and environmental upliftment of the local communities in Kalimpong.

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Analysis of Rainfall Characteristics and Ground Water Recharge in Hundri River Basin of Kurnool District, Andhra Pradesh

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Abstract

The aim of the study is to examine the Rainfall characteristics, rainfall recharge, and water balance of the Hundri River basin. The basin is situated in a semi-arid climate with low precipitation and high evaporation rates. The primary geological formations in the basin are Granite and Gneisses, which constitute a hard rock terrain with varying degrees of permeability contingent on fracturing and weathering. Over a span of 30 years, monthly precipitation data from 19 stations have been collected, converted, and tabulated to derive seasonal and annual rainfall figures. The mean annual rainfall is distributed as follows: winter (5 mm), summer (68 mm), South-west monsoon (414 mm), North-east monsoon (130 mm), and annual (617 mm). The analysis of seasonal rainfall reveals that the basin experiences the highest precipitation during the south-west monsoon season. The total surface water resources available in the basin are estimated to be 2,189,116,000 m^3. Groundwater recharge through rainfall was estimated using eight different empirical equations proposed by Radhakrishna, U. S. Geological Survey method, Chaturvedi, U.P. Irrigation Research Institute, Bhattacharjee, Amritsar Formula, Kumar and Seethapathi, and Krishna Rao formula. The recharge percentages calculated using these empirical equations were found to be 10, 15, 20, 29, 18, 20, 14, and 8, respectively. The mean annual recharge for the basin is calculated to be 103 mm. Furthermore, the total groundwater resources are estimated to be 365,444,000 m^3, which accounts for approximately 17% of the annual rainfall.

***Key words*:** Mean rainfall, Rainfall variability, Rainfall ratio, Rainfall recharge, Water balance

Rainfall is a critical ecological parameter that has significant impacts on the ecosphere, ecological community, and economic development of any region. In India, a country with a strong agricultural sector, rainfall plays a pivotal role in shaping various aspects of agriculture, including land cover patterns, intensity of land use, farming operations, farming systems, and farm productivity levels [1]. The agricultural sector, which includes horticulture, animal husbandry, dairy, and fisheries, heavily relies on the monsoon rains, which are essential for crop growth and production. However, the distribution of rainfall across the country is irregular and unequal, leading to dry spells during the rainy season, resulting in crop failures and low yields in some areas.

Understanding the rainfall patterns, including total rainfall, daily, monthly, seasonal, and annual distribution, is vital for effective crop and water management planning. It helps in designing irrigation, drainage, erosion control, and flood control structures. Furthermore, the analysis of monthly, seasonal, and annual rainfall patterns is essential for ensuring a continuous water supply for domestic and industrial uses [2]. Therefore, it is crucial to monitor and analyze rainfall patterns to ensure sustainable agricultural practices and water management in India. Policy decisions regarding cropping patterns, sowing dates, and the provision of drinking water in both urban and rural areas are facilitated through the examination of rainfall data [3]. Furthermore, such analyses contribute to the comprehension of micro-level rainfall variability, which is of utmost importance for the planning of agriculture, land, and water resource development [4]. The evaluation of surface and subsurface water resources plays a crucial role in addressing future hydro-meteorological disasters and guaranteeing sufficient water availability for agricultural, irrigation, industrial, and domestic purposes. A normal distribution of rainfall is indispensable for the maintenance of favourable vegetation cover, the promotion of ecosystem health, the facilitation of groundwater recharge, and the assurance of robust crop production and food security.

The analysis of rainfall and studies on groundwater recharge are of utmost importance in comprehending the hydrological dynamics of the Hundri River basin, particularly within a semi-arid climate characterized by restricted water resources [5]. Through an examination of historical rainfall patterns spanning a duration of 30 years, and the subsequent classification of these patterns into distinct seasons, researchers can acquire invaluable insights into the temporal dispersion of precipitation. This enables them to identify the prevailing monsoon season (South-west monsoon) as well as the comparatively drier periods (winter and summer). Such information holds significant significance for the effective management of water resources, the formulation of agricultural

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plans, and the mitigation of potential water scarcity concerns within the region.

The assessment of the overall water balance of a basin is a crucial aspect of groundwater recharge estimation through rainfall. To accurately calculate recharge percentages, researchers utilize various empirical equations proposed by experts, which consider geological characteristics, soil type, and vegetation cover. This analysis aids in determining the replenishment rate of groundwater aquifers, which are vital for sustaining domestic water supply, supporting agricultural activities, and preserving the ecological balance of the region.

MATERIALS AND METHODS

Study area

The Hundri River, a tributary of the Tungabhadra River, originates in the fields of Maddikera in Maddikera Mandal (Fig 1). It receives a stream from Erramalas at Laddagiri in Kodumur Mandal and eventually joins the Tungabhadra River at Kurnool town. The river covers parts of 13 Survey of India Topsheets on a scale of 1:50,000. It drains a significant portion of the Maddikera, Pattikonda, Deverakonda, Gonegandla, Kodumur, and Kallur Mandals. The river falls within the survey of India (SOI) top sheet numbers 57E/6 to 57E/16 and 57I/1 to 57I/3. The river basin is in the southwestern part of the Kurnool district, lying between Northern latitude 140 35' 35" N-160 09' 36" N and longitude 750 58' 42" E to 780 56' 06" E. It covers an area of 3548 square kilometers and spreads across parts of 20 mandals, encompassing 205 revenue villages.

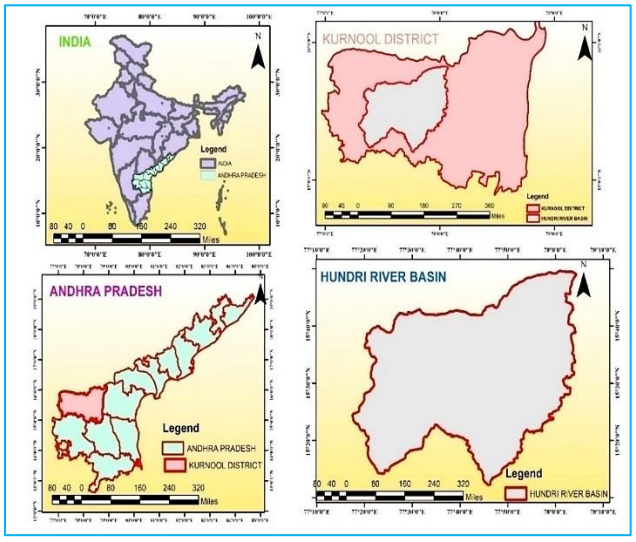


Fig 1 Location map of the study area

The investigation of the surface water resources within the Hundri River basin was conducted through an examination of the precipitation data obtained from 19 rain gauge stations. The monthly precipitation data spanning a duration of 30 years was procured from the Chief Planning Office of Kurnool district for these stations. To assess the precipitation data in terms of seasonal and annual patterns, the statistical methodologies outlined by Bhargava (1977) were employed. The average monthly precipitation, variability in precipitation, and precipitation ratio for each of the 19 stations were computed and organized in tabular form.

1). Mean rainfall = $\frac{\sum X}{N}$, Where X= variates and N = No. of. Varieties

2). Rainfall Variability = $\frac{SD}{AM} \times 100$, Where S.D =Standard deviation, AM =Arithmetic mean

3). Rain fall Ratio = $\frac{P_x P_n}{P_m} \times 100$,Where P_X = Maximum rainfall, P_N =Minimum rainfall

P_M and P_M =Average rainfall

In order to estimate groundwater recharge, a range of empirical methods proposed by Radhakrishna *et al*. [6], the U. S. Geological Survey method (1962), Chaturvedhi (1936), the Amritsar formula (1973), the U.P. Irrigation Research Institute Formula (1954), Krishna Rao (1970), Bhattacharjee (1954), and Kumar and Seethapathi (2002) were employed. The groundwater recharge was determined using each of these methods. Through the implementation of this comprehensive study, valuable insights into the surface water resources and groundwater recharge within the Handri River basin were acquired. These findings will contribute to enhanced water resource management, planning, and decision-making, thereby facilitating the sustainable utilization of water in the region.

Estimation of ground water recharge by using empirical formulas

4) Radhakrishna *et al*. (1974): 10% of the Annual Rainfall

5). U.S. Geological Survey method (1962): 15 % of the annual Rainfall

6). Chaturvedi formula (1936): R_g= 2(P-15) ^0.4

Where Rg is net Recharge and P is annual rainfall, both are measured in Inches

7). Amritsar Formula (1973): Rg= 2.5(P-16) ^0.5

Where R_g is net Recharge and P is annual rainfall, both are measured in Inches

8). U.P.I.R.I. Formula (1954): R_g= 1.35(P-14) ^0.5

Where R_g is net Recharge and P is annual rainfall, both are measured in Inches

9). Bhattacharjee Formula (1954): Rg =3.47(P-38) ^0.4

Where Rg is net Recharge and P is annual rainfall, both are measured in cm

10). Kumar and Seethapathi Formula (2002): Rg =0.63(P-15.28) ^0.76

Where R_g is net Recharge and P is annual rainfall, both are measured in inches

11). Krishna Rao Formula (1970): Rr = K (P-X)

Where R_r and P are measured in mm.

R_r =0.20(P-400) Where annual rainfall between 400- 600 mm

R_r =0.25(P-400) Where annual rainfall between 600- 1000 mm

R_r =0.35(P-600) Where annual rainfall greater than 2000 mm

RESULTS AND DISCUSSION

Seasonal analysis of rainfall of the handri river basin

Winter season

During the winter season, which comprises the months of January and February, the mean rainfall in the study area varies from a minimum of 3 mm at the Krishnagiri station to a maximum of 10 mm at the Asparistation (Table 1). The average rainfall for the entire basin is recorded as 5 mm (Table 1) indicating dry and arid conditions during this period. The Rainfall Variability analysis reveals fluctuations ranging from 155% at the Gudur station to 297% at the Kallur station with an average variability of 220 %. It suggesting significant Fluctuations in the amount of rainfall received during this period. Furthermore, the Rainfall Ratio, a measure of rainfall distribution, shows diverse patterns across the study area. It ranges from 521% at the Gudur station to 1561% at the Yemmiganur station, with average of rainfall ratio of 943%, it signifying substantial variations relative to the mean rainfall, which can have implications for water availability and agricultural planning [7-9].

Summer season

The summer season consists of March, April, and May Months. The values range from a minimum of 60 mm (Tuggali) to a maximum of 76 mm (Pattikonda) (Table 2). The overall average mean rainfall for all stations is approximately 68.5 mm (Table 2). which can be considered a relatively dry period Rainfall variability is a measure of how much the actual rainfall deviates from the mean rainfall. Higher variability indicates more significant fluctuations in rainfall amounts. The values range from a minimum of 47% (Alur) to a maximum of 87% (Bethamcherla). The overall average rainfall variability for all station is around 65.2%, indicating fluctuations in the amount of rainfall received this period. The Rainfall Ratio values ranges from minimum of 184% (Alur) to a maximum of 387% (Bethamcherla). The overall average rainfall ratio for all stations is approximately 264% reflecting considerable variations relative to the mean, which can have implications for water availability and agriculture [10-11].

Table 1 Mean rainfall, rainfall variability and rain fall ratio of the Handri River basin (Winter season)

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	5	223	1094
Alur	5	260	1390
Aspari	10	185	733
Bethamcherla	4	252	1086
Devanakonda	5	211	856
Dhone	3	197	771
Gonegandla	6	178	703
Gudur	5	155	521
Kallur	4	297	1542
Kodumur	6	230	933
Krishnagiri	3	196	815
Kurnool	5	178	718
Maddikera	6	190	700
Orvakal	5	275	1394
Pattikonda	4	220	916
Peapully	6	209	647
Tuggali	4	199	611
Veldurthi	3	232	931
Yemmiganur	6	294	1561

Table 2 Mean rainfall, rainfall variability and rain fall ratio of the Handri River

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	71	59	270
Alur	74	47	184
Aspari	65	53	211
Bethamcherla	67	87	387
Devanakonda	61	65	310
Dhone	67	71	311
Gonegandla	75	66	261
Gudur	68	66	283
Kallur	72	78	254
Kodumur	70	63	242
Krishnagiri	68	84	285
Kurnool	72	65	246
Maddikera	65	51	195
Orvakal	67	74	301
Pattikonda	76	61	251
Peapully	68	58	205
Tuggali	60	54	243
Veldurthi	67	77	316
Yemmiganur	69	62	252

South west monsoon

During the South West Monsoon season, which includes the months of June, July, August, and September, the mean rainfall in the basin varies between 318 mm at Maddikera station and 496 mm at Kurnool station (Table 3). The normal rainfall for the basin during this period is 414 mm (Table 3), Indicating the wettest season in the basin. The rainfall variability ranges from a minimum of 26% in Adoni to a maximum of 50% in Dhone station, with an average variability of 40% for the basin, indicating relatively stable and predictable rainfall patterns during this season. The rainfall ratio, of the basin varies from 110% at Adoni station to 257% at Dhone station, with an average rainfall ratio of 179% for the basin, indicating a relatively balanced distribution of rainfall compared to the mean, which can be favourable for agricultural activates [12].

Table 3 Mean rainfall, rainfall variability and rain fall ratio of the Hadri River basin (South west monsoon)

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	460	26	110
Alur	385	38	150
Aspari	388	35	136
Bethamcherla	411	45	202
Devanakonda	400	43	180
Dhone	405	50	257
Gonegandla	412	38	171
Gudur	469	39	195
Kallur	433	43	211
Kodumur	417	43	177
Krishnagiri	358	36	151
Kurnool	496	37	202
Maddikera	318	39	174
Orvakal	476	39	187
Pattikonda	400	43	173
Peapully	424	38	157
Tuggali	387	43	184
Veldurthi	392	35	162
Yemmiganur	439	45	228

Table 4 Mean rainfall, rainfall variability and rain fall ratio of the Handri River basin (North east monsoon)

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	131	79	401
Alur	142	76	350
Aspari	122	66	220
Bethamcherla	151	58	240
Devanakonda	120	69	244
Dhone	121	67	245
Gonegandla	133	80	410
Gudur	130	76	291
Kallur	126	79	268
Kodumur	113	69	295
Krishnagiri	124	69	284
Kurnool	129	76	261
Maddikera	127	56	249
Orvakal	134	70	270
Pattikonda	135	68	255
Peapully	143	56	216
Tuggali	118	62	231
Veldurthi	129	63	208
Yemmiganur	138	89	397

North east monsoon

During the North East Monsoon season, which covers the months of October, November, and December, the mean rainfall in the basin varies from a minimum of 113 mm at Kodumur station to a maximum of 151 mm at Bethamcherla (Table 4). The average rainfall for the entire basin during this period is 130 mm (Table 4), Making it moderately wet season. Rainfall Variability across the study area shows diversity, ranging from a minimum of 56% at Peapully station to a maximum of 89% at Yemmiganur station, with an average variability of 70%, suggesting fluctuations in rainfall amount during this period. The rainfall ratio in the basin has a wide range, with a minimum of 208% at Veldurthi station to a maximum of 410% at Gonegandla station. The normal rainfall ratio is recorded as 281%, Indicating significant variations relative to the mean, which may impact water resources and local ecosystem.

The basin experiences diverse rainfall patterns across the four seasons, with varying mean rainfall, rainfall variability, and rainfall ratio. Understanding these seasonal characteristics is crucial for water resource management, agricultural planning, and climate adaptation strategies in the region [13-15].

Annual rainfall

The annual rainfall in the basin shows significant variation, ranging from a minimum of 515 mm at Maddikera station to a maximum of 702 mm at Kurnool station (Table 5). The average annual rainfall for the entire basin is calculated to be 702 mm. Regarding rainfall variability, it varies across the stations, with Adoni station experiencing the lowest variability at 25%, and Dhone station witnessing the highest variability at 39%. On average, the rainfall variability for the basin is around 33 %. The rainfall ratio also displays diversity, ranging from 103% at Krishnagiri station to 186% at Yemmiganur station. The normal rainfall ratio is recorded as 140% [16].

Table 5 Mean rainfall, rainfall variability and rain fall ratio of the Handri River basin (Annual)

Station	Mean rainfall in mm	Rainfall variability in %	Rainfall ratio in %
Adoni	665	25	117
Alur	606	34	150
Aspari	585	29	112
Bethamcherla	632	38	172
Devanakonda	586	36	156
Dhone	597	39	178
Gonegandla	627	31	128
Gudur	673	30	125
Kallur	635	38	175
Kodumur	605	32	128
Krishnagiri	552	28	103
Kurnool	702	31	148
Maddikera	515	32	108
Orvakal	683	33	146
Pattikonda	615	35	115
Peapully	641	32	132
Tuggali	569	38	155
Veldurthi	590	29	118
Yemmiganur	652	37	186

The basin experiences varying amounts of annual rainfall, with some stations receiving higher rainfall (e.g., Kurnool) and others have relatively lower rainfall (e.g., Maddikera). The variability in rainfall amounts differs across the basin, with some stations showing more stable patterns (e.g., Adoni), while others exhibit higher fluctuations (e.g., Dhone). The Rainfall Ratio provides insight into how the mean rainfall relates to the rainfall variability at each station, indicating variations in the basin's overall rainfall patterns.

The Total Surface Water resources the Handri River basin: Total Geographical area of the basin × Mean annual rain fall 3548 Km^2 × 617 mm = 218, 911, 6000 m^3.

Ground water recharge

Radha Krishna method (1974)

The Radhakrishna approach (1974) proposes that the basin's aquifer recharge is equivalent to 10% of the total annual precipitation. The recharge rates fluctuate, with the lowest value being 51 mm at Maddikera station and the highest being 70 mm at Kurnool station (Table 6). The mean yearly groundwater recharge for the entire basin is estimated to be 62 mm.

U.S. Geological method (1962)

According to this According to the methodology proposed by the U.S. Geological Survey in 1962, the groundwater replenishment in the studied area, basin, or watershed corresponds to 15% of the total annual precipitation. According to this method, the recharge figures vary, with a minimum of 77 mm observed at Maddikera and a maximum of 105 mm recorded at Kurnool station (Table 6). On average, the annual replenishment of groundwater for the entire study area is assessed to be 93 mm.

Chaturvedi formula (1936)

Chaturvedi's formula (1936) derives the groundwater replenishment using the expression Rg = 2(P-15) ^0.4, with Rg and P expressed in inches. According to this method, the recharge amounts fluctuate, ranging from a minimum of 99 mm at Maddikera to a maximum of 140 mm in Kurnool District (Table 6). The average yearly recharge for the basin is determined to be 123 mm, constituting 20% of the overall annual precipitation.

Amritsar formula (1973)

Amritsar's method (1936) proposes the calculation of groundwater recharge using the formula Rg = 2.5(P-16) ^0.5, with Rg and P measured in inches. According to this approach, the recharge values exhibit variability, ranging from a minimum of 131 mm at Maddikera to a maximum of 217 mm in Kurnool District (Table 6). On average, the basin experiences an annual recharge of 182 mm, which constitutes 29% of the total annual rainfall.

U.P.I.R.I. formula (1954)

U.P.I.R.I has developed a method for estimating groundwater recharge using the formula Rg = 1.35(P-14) ^0.5, where Rg and P are measured in inches. According to this approach, the recharge values exhibit variation, ranging from a minimum of 86 mm at Maddikera to a maximum of 127 mm in Kurnool District (Table 6). On average, the basin experiences an annual recharge of 110 mm, which corresponds to 18% of the total annual rainfall.

Bhattacharjee formula (1954)

Bhattacharjee's approach has derived a means to estimate groundwater replenishment utilizing the equation Rg = 3.47(P-38) ^0.4, where Rg and P are expressed in centimeters. According to this method, the recharge quantities exhibit variability, spanning from a minimum of 98 mm at Maddikera to a maximum of 139 mm in Kurnool District (Table 6). The mean yearly recharge for the basin is determined to be 123 mm, corresponding to 20% of the entire annual precipitation.

Kumar and Seethapathi (2002)

Kumar and Seethapathi have formulated a method to calculate groundwater recharge using the equation Rg = 0.63(P-15.28) ^0.76, where Rg and P are measured in inches. According to this approach, the recharge values show variation, ranging from a minimum of 54 mm at Maddikera to a maximum of 108 mm in Kurnool District (Table 6). On average, the basin experiences an annual recharge of 123 mm, which constitutes 20% of the total annual rainfall.

Krishna Rao formula (1970)

In1970, Krishna Rao introduced an empirical relationship for approximating ground water replenishment, given by Rr = K(P-X), where Rr and P are measured in millimeters. According to Krishna Rao method.

For Regions with annual rainfall ranging from 400 to 600 mm, the recharge can be approximated using Rr =0.20(P-400)

For Regions with annual rainfall ranging from 400 to 600 mm, the recharge can be approximated using Rr =0.25(P-400)

For Regions with annual rainfall Exceeding 2000 mm, the recharge can be approximated using from 400 to 600 mm, Rr =0.35(P-600)

Based on this approach, the recharge values range from a minimum of 23 mm at Maddikera station to a maximum of 75 mm at Kurnool station (Table 6). On average, the basin experiences an annual recharge of 51 mm, which represents 8 % of the total annual rainfall.

Table 6 Average annual recharge of the Handri River basin

Mandal	Rainfall (mm)	Radhakrishna method (mm)	U.S. Geological method (mm)	Chaturvedi's formula (1936) (mm)	Amritsar's formula (1973) (mm)	U.P.I.R.I. formula (1954) (mm)	Bhattacharjee formula (1954) (mm)	Kumar and Seethapathi formula (2002) (mm)	Radha Krishna method (1970) (mm)	Recharge (mm)	Recharge (%)
Adoni	665	60.55	99.82	133.52	202.80	119.77	132.60	98.45	66.37	114.98	17.28
Alur	606	60.56	90.85	121.48	177.84	107.58	120.70	81.85	51.41	101.53	16.76
Aspari	585	58.45	87.68	116.79	168.16	102.95	116.05	75.74	36.91	95.34	16.31
Bethamcherla	632	63.19	94.79	126.98	189.21	113.10	126.13	89.26	57.98	107.58	17.02
Devanakonda	586	58.61	87.92	117.15	168.91	103.30	116.41	76.21	37.23	95.72	16.33
Dhone	597	59.67	89.50	119.53	173.81	105.64	118.76	79.28	39.34	98.19	16.46
Gonegandla	627	62.69	94.04	125.97	187.11	112.07	125.13	87.87	56.73	106.45	16.98
Gudur	673	67.32	100.98	134.95	205.79	121.25	134.02	100.52	68.29	116.64	17.33
Kallur	635	63.47	95.20	127.54	190.36	113.66	126.68	90.02	58.67	108.20	17.05
Kodumur	605	60.47	90.70	121.28	177.42	107.38	120.49	81.57	51.17	101.31	16.75
Krishnagiri	552	55.19	82.78	108.89	151.95	95.31	108.24	65.96	30.37	87.34	15.83
Kurnool	702	70.18	105.27	140.10	216.55	126.60	139.11	108.10	75.45	122.67	17.48
Maddikera	515	51.49	77.24	98.79	131.27	85.89	98.26	54.32	22.99	77.53	15.06
Orvakal	683	68.30	102.45	136.75	209.55	123.11	135.80	103.15	70.75	118.73	17.38
Pattikonda	615	61.54	92.31	123.56	182.14	109.66	122.75	84.62	53.84	103.80	16.87
Peapully	641	64.09	96.13	128.78	192.93	114.92	127.91	91.74	60.22	109.59	17.10
Tuggali	569	56.93	85.39	113.20	160.79	99.45	112.50	71.22	33.85	91.67	16.10
Veldurthi	590	59.04	88.57	118.13	170.92	104.26	117.37	77.46	38.09	96.73	16.38
Yemmiganur	652	65.18	97.77	130.91	197.37	117.09	130.02	94.73	62.94	112.00	17.18

The average annual recharge of the basin has been calculated by taking the average of eight different methods, resulting in a range of values from 78 mm to 123 mm. The overall average recharge for the entire basin is 103 mm. This average recharge accounts for 17% of the annual rainfall in the region. The recharge values vary across different stations in the basin. Maddikera and Krishnagiri stations have the lowest recharge values, being less than 90 mm. Apari, Devanakonda, Dhone, Tuggali, and Veldurthi stations experience recharge between 90 mm and 100 mm. On the other hand, Adoni, Alur, Bethamcherla, Orvakal, Pattikonda, Peapully, and Yemmiganur stations have the highest recharge values exceeding 100 mm.The total Ground water Potential of the basin is worked out by ground water recharge method.

Total water resources recharge to ground water = Geographical area of the basin × Average annual recharge
3548 Km^2 × 103 mm = 365,444,000 m^3

The total Ground water resources accounts to 16.7% of the total surface water resources.

Water balance of the Handri River basin

1). The total surface water resources = Geographical area of the basin × Average annual rain fall 3548 Km^2 × 617 m = 2189116000 m^3.

2). Total water resources Recharge to Ground water=Geographical area of the Basin × Average AnnualRecharge 3548 Km^2 × 103 m =365444000 m^3. (16.7%)

3). Total Water resources stored in Reservoirs, Ponds, lakes etc = 2189711600 m^3 (10%).

4). Total water resources lost in the form of run-off = 437823200 m^3. (20 %)

5). Water lost in the form of Evaporation and Evapotranspiration 2189116000 – 1022178800 = 1166937200 (53.3%)

From the above analysis it is found that out of 218911600 m^3 of water available 10% is stored in the ponds and tanks and reservoirs if the basin, 16.7% recharge to ground water, 20 %is lost in the form of run-off and 53.3% is lost in the form of evaporation and evapo-transpiration. The surface water loss in the form of run-off could be saved and stored efficiently by constructing check dams and percolation ponds in the basin [17-18].

CONCLUSION

In summary, the research reveals distinct seasonal rainfall patterns with significant fluctuations in the study area. Winter and summer experience dry conditions, impacting water resources and agriculture. The South West Monsoon brings the

wettest period with stable rainfall patterns, while the North East Monsoon is moderately wet with variable rainfall. The annual rainfall shows notable variation, affecting water availability and agricultural planning. The study analyzed multiple methods to estimate groundwater recharge, showing diverse values across different stations. The overall average annual recharge for the basin was 103 mm, accounting for 17% of the total annual rainfall. Understanding these variations is essential for effective water resource management and sustainable agricultural planning.

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The Indian Journal of Spatial Science is a publication of the 'Indian Society of Spatial Scientists". The aim of the 'Indian Society of Spatial Scientists' (ISSS) is to make 'Research in Spatial Science' of global standard with worldwide reference. It is concerned with all fields of Geography, Geology, Geoinformatics, Social Science and other Spatial Sciences as well. Basically, it is intended for the publication of research by the young scholars of Geography and allied disciplines all over the world. Currently, it is a Quarterly Journal published as Spring Issue (on the eve of Vernal Equinox: March 21), Summer Issue (on the eve of Summer Solstice: June 21), Autumn Issue (on the eve of Autumnal or Fall Equinox: September 23), and Winter Issue (on the eve of Winter Solstice: December 21).

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Finally, a blanket 'thank you' for all the contributors who chose our journal based on its quality and urge them to keep contributing and spread the news among institutions, researchers, professors and fellow colleagues. I do convey my heartiest congratulations to our Hon'ble Peer Reviewers, Copy Editors, Composer and the Website Manager for their sincerest efforts without which this issue could not be published on time.

I do hope this endeavor by the Indian Society of Spatial Scientists will continue to keep its tradition, style and objectives.

This particular issue is a tribute to our Late President, Prof. Avijit Gupta. An obituary has been added to make our readers, members and others informed about his contribution in the field of fluvial geomorphology, geomorphology of humid tropics, environmental management, and application of remote sensing in the study of geomorphology and environmental management.

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Groundwater Quality Assessment using Water Quality Index (WQI) in Tungabhadra River Basin of Kurnool District, Andhra Pradesh, India

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Abstract

Water is precious in the areas like drought-prone due to inadequate rainfall and surface water. The available drinking water sources are prone to pollution and contamination and content of high percentage of fluoride etc. In a region like Rayalaseema of Andhra Pradesh, which is prone to drought and identified as one of the country's driest regions. In these circumstances, potable water is essential to assess the water quality for Drinking. Groundwater is the rural population's main drinking source in the proposed study area. Therefore assessment of water quality is essential and has far the most important. The present paper is intended to assess the water quality in the Tungabhadra River Basin of Kurnool district to determine the suitability of available Groundwater for drinking purposes. In this connection, the water quality index(WQI) has been applied to determine the different physico-chemical parameters of the Groundwater at various locations in both pre and post-monsoon seasons for 2021. The distribution of water quality parameters across the basin is evaluated by the IDW interpolation method in GIS. The water quality index was calculated from the observed parameters indicating both pre-monsoon (79.68) and post-monsoon (86.82) seasons as poor water quality.

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Introduction

Water safety and security is an emerging issue worldwide which has compound effects on various sectors of the economy. The basin area lies in the semiarid region of Rayalaseema region. The basin faced a severe crisis in managing water resources to meet all requirements, viz., drinking, households use, irrigation and industrial development. In general, surface water is scant in the semiarid regions owing to the inconsistency of monsoon rainfall and high rate of evaporation. Hence, people in such areas must depend more on groundwater resources for life support. The Tungabhadra and its tributary Hundri in Kurnool district are the major sources for increasing groundwater potential. Groundwater makes up most of the drinking water source of the basin area.

Over the years, groundwater has been contaminated, and the quality of the basin area has deteriorated. A common source of contamination of groundwater in the basin area is open defecation, inadequate sanitation facilities, especially in rural areas. Discharge of untreated sewage (Reddy, 2014, Prabavathi, 2015), municipal sewage, chemicals and waste materials (Rajeswari, 2009), construction material and cement manufacturing activities (Tharani, 2021), runoff and seepage of residues of chemical fertilizers and pesticides (Rayudu, 2020) industrial effluents and various malpractices related to waste disposals. The contamination of groundwater can have adverse effects on human health. There is a prime necessity to control water contamination and deterioration substances in the ecology and ecosystem of the Tungabhadra river basin.

Water quality Assessment is an important measure to the health of a basin to make necessary management and decision to control current and future pollution of receiving water bodies. Water quality is inherently linked with public health, food security, livelihoods and preservation of ecosystem and ecology, and socioeconomic growth of our societies (UNESCO, 2015). It is very much needed for policymakers, administrators, and water

quality management; if the quality has deteriorated, remedial measures are to restore it. To assess water quality, the values obtained were compared with standards prescribed by the Bureau of Indian standards (BIS) and the Indian council for medical research (ICMR).

The water quality index (WQI) Is a mathematical instrument which provides a single number that expresses overall quality at certain locations and times based on several water quality parameters (Hulye (2009), Pathak et al., 2015). Therefore, the study's objective was to calculate the water quality index of the Thungabhadra river basin to assess its suitability for Drinking. A similar type of study has been done in India by Chatterjee et al. (2007), Miraj et al. (2017), Jagadeeswari (2012), and Das Guptha (2001).

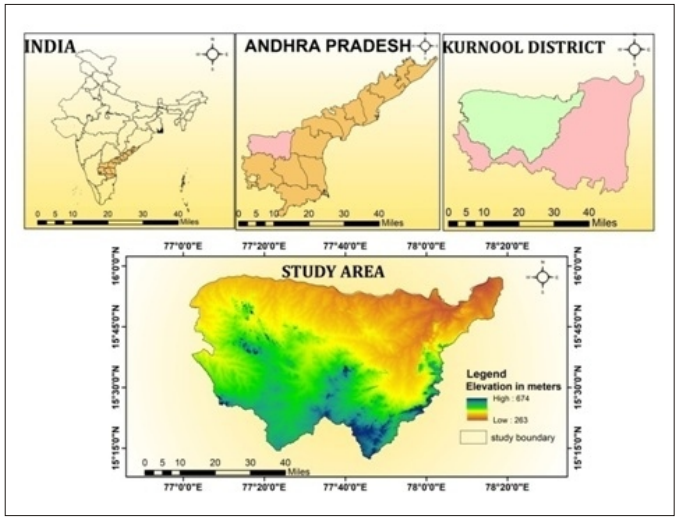


Fig.1: Location Map of the Study Area

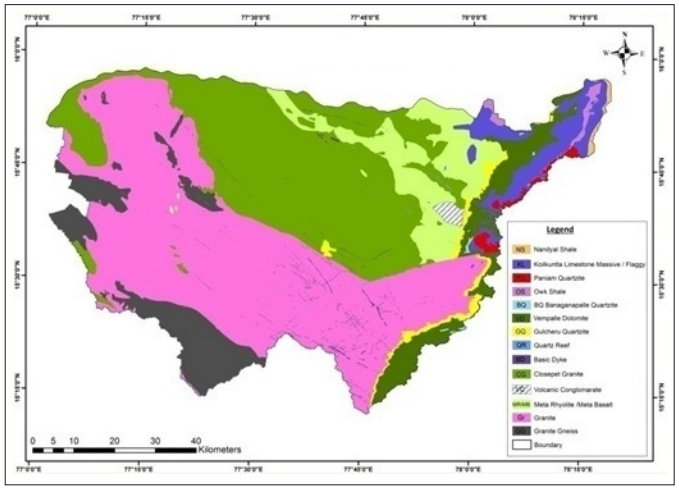


Fig.2: Geological Map of the Study Area

The Study Area

The study area of the Tungabhadra River basin is situated in the northwestern part of the Kurnool district in the state of Andhra Pradesh (India) and occupies an area of 6,993.95 sq. km. It is the southwestern district of Andhra Pradesh, and is one of the country's frequently drought-affected districts, Mainly in the western part of the district, with an average annual rainfall of about 670 mm. The main occupation and source of livelihood for this basin is agriculture. More than 70 % of the people in the basin are engaged in farming. It is predominantly an area of rain-fed agriculture. The climate of Kurnool is tropical, with temperatures ranging from 26^0 c to 46^0 c in the summer and 12^0 c to 31^0 c in the winter. Due to continuous drought, Agriculture is not the main source of income for the last decade. It lies Between North Latitude 15^0 15'00" to 16^0 0'00" and East longitude 77^0 0'00" to 78^0 15'00". It is falling in the survey of India (SOI) Toposheet No 57E/ 1 to 57E/16 and 57I/1 to 57 I/5. Geologically the basin is underlined by the crystalline rock of the peninsular gneissic complex(PGC), comprising the granitic gneisses, and granites in the west and southern part of the basin. The K-rich granite (equivalent to close pet granite) of the lower Proterozoic age, distributed in the northern part of the basin. Conglomerates, quartzite, shale, limestone, and dolomite were found as small patches in the northeastern part of the basin. The basic dykes and quartz veins are noticed in the west and southern part of the basin.

Objectives of the Study

1) To evaluate the groundwater quality in the Tungabadra river basin for drinking purposes by using the water quality index.
2) To explore physico-chemical parameters of groundwater at different locations in the study area.

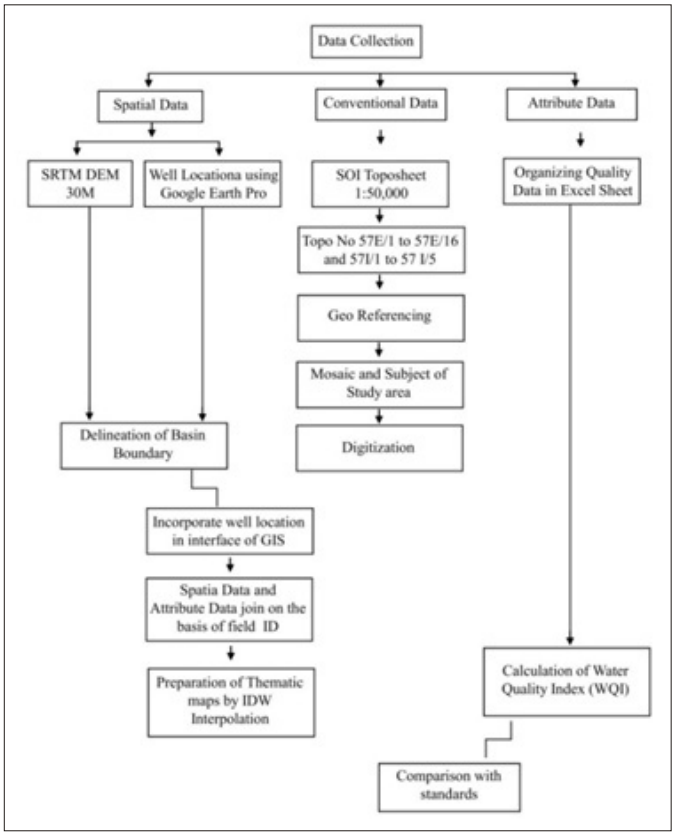


Fig.3: Methodology adopted in the present study

Methodology

The Methodology adopted for the current study is shown in Fig 2. To delineate Basin Boundary, we have used SRTM DEM 30 M Resolution, downloaded from https://earthexplorer.usgs.gov/ and Survey of India (SOI) Topographic maps of 1972 with No 57E/ 1 to 57E/16 and 57I/1 to 57I/5on the Scale 1:50000 were collected from https://www.surveyofindia.gov.in/. Downloaded SRTM DEM data were processed by using the Hydrology tool, and

topographical maps were rectified/referenced and mosaic with the help of Arc GIS 10.3 Software and the extracted basin assigning Universal Transverse Mercator (UTM), world Geodetic system (WGS from 1984) and 44 N zone projection system. The well locations at which quality data are collected from the District Water board are from Google Earth Pro. The well locations in terms of Latitudes and longitudes are written down in a notepad and then converted to a point shape file in GIS Interface. Attribute data corresponding to water quality parameters for the pre-monsoon and post-monsoon of 2021 is properly organized and organized in an Excel sheet. Spatial and attribute data are joined together based on field I.D. using the join and relate tool in Arc GIS. The Water Quality index for the current study is based on eight parameters. The calculation of the WQI was done using the Weighted Arithmetic water quality index, originally proposed by Horton (1965) and Developed by Brown et al. (1972). The first step in the calculation is to rate the quality of each parameter. Let q_n be the quality rating of each parameter where n is the no. of each parameter. It is given by Eq.1

$$q_n = 100 (V_n - V_o) / (S_n - V_o) \ldots\ldots\ldots (1)$$

Where
Q_n =Quality rating for the nth water quality parameter, V_n= Estimated value of the n^{th} parameter at the given sampling station, V_o= Ideal value of n^{th} parameter in pure water, S_n = Standard permissible weight of the nth parameter.

Computation of Quality Rating for pH

For pH, the ideal value is 7.0 (for natural water), and the permissible value is 8.5

Therefore, the quality rating for pH is calculated with the help of the following equation:

$$q_n = 100 (V_{pH} - 7.0) / (8.5 - 7.0) \ldots\ldots (2)$$

Where, V_{pH} = observed value of pH

Each parameter is given a unit weight for water quality index calculation by the Bureau of Indian Standards (BIS) And the Indian Council for Medical Research (ICMR). The standard permissible values according to IS 10500 and unit weights for each parameter are given in table 1.

Computation of Unit Weight

Unit weight has been calculated by a value inversely proportional to the recommended standard values Sn of the corresponding parameters.

$$W_n = k/S_n \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where, Wn = Unit weight of the nth parameter, Sn = Standard value of the nth parameter, K = Constant for proportionality

The overall quality index (WQI) has been calculated by linearly aggregating the quality rating with the unit weight.

$$WQI = \sum Wn*q_n / \sum Wn \ldots\ldots\ldots\ldots (4)$$

Where, WQI = water quality index, W_n = unit weight of the n^{th} parameters q_n =quality rating of the n^{th} parameter.

Results and Discussion

To assess the water quality for drinking purposes, concentration of physico-chemical parameters presents 62 samples have been analyzed for pre and post-monsoon seasons in 2021. The seasonal analysis helps to assess the changes in the concentration of minerals during dry and wet periods due to the fluctuations in the groundwater table, amount of runoff water, duration of contact period with rock strata of the aquifer etc.

Table-3 and Table-4 provide all information about the physico-chemical parameters of the samples. Table-5 shows the descriptive statistics (maximum, minimum, and average) of the physic-chemical parameters of the groundwater samples.

The distribution of water quality parameters across the basin has been mapped by the IDW interpolation for each parameter class. Fig.3 and 4 show the spatial pattern of pH, TDS, SO_4^{2-}, No_3^-, Cl^- ,Ca^{2+},Mg^{2+} and TH in the pre-monsoon period and Fig.5 and 6 show the spatial pattern of pH, TDS, So_4^{2-}, No_3^-, Cl^-, Ca^{2+}, Mg^{2+} and TH in the post- monsoon season.

a. pH

pH is one of the significant parameters of water and decides the Acidic and basic form of water. According to BIS and ICMR, the pH of Good Quality of Water ranges from 6.5-8.5. In the pre-monsoon season, the pH of the study area groundwater sample ranges from 7.1(min) to 8.5 (max) with a mean value of 7.9, and in the post-monsoon, the importance of p^H varies from 7.2 (min) to 8.5(max) with a mean value of 8 respectively. The pH variation shown in Fig. 3-A and 5-A depicts that all the groundwater samples in the pre and post-monsoon seasons were within the permissible limits.

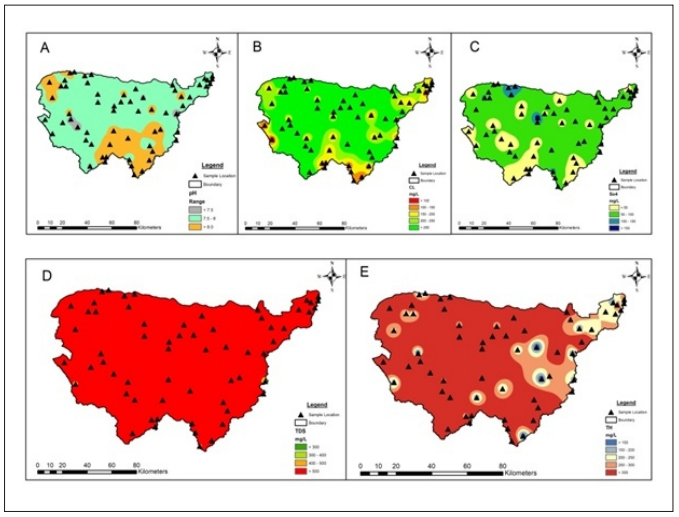


Fig.4: The spatial distribution of pH, Cl^-, So_4^{2-}TDS, and T.H. during the pre-monsoon period

b. Total Dissolved Solids(TDS)

The total dissolved solids in the basin vary from 291.84 mg/l to a maximum of 3962 mg/l with a mean value of 1246.11. The post-monsoon season TDS value ranges from 231.04mg/l to 6304 mg/l with a mean value of 1338.62 mg/l (Table - 5).out of 62 samples, 8 per cent of samples in premonsoon season and in post-monsoon season, 13 per cent of samples were found to have TDS values below the acceptable limits (Fig. 3-D, and Fig. 5-D). In contrast, the rest of the samples had higher values of TDS.

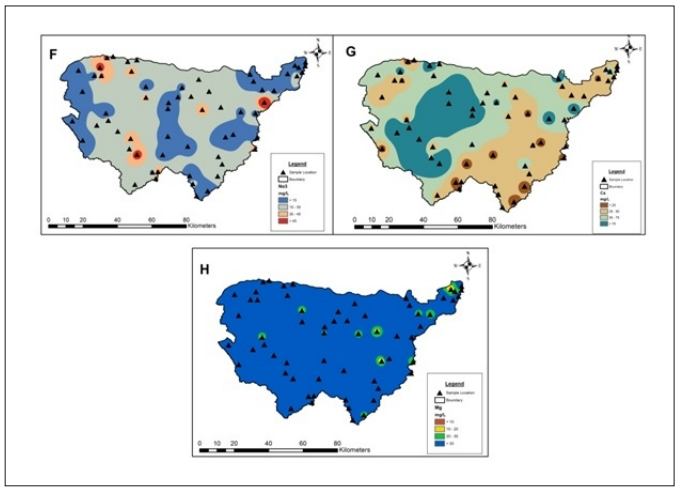


Fig.5: The spatial distribution of No_3^-, Ca^{2+}, and Mg^{2+} during the pre-monsoon period

c. Sulphates

The sulphate distribution in groundwater samples of the basin ranged from 4 to 199 mg/l. The mean value of 65 mg/l indicates that most of the wells in the study area are within the acceptable limit (Table - 5). Percentage-wise, 95 % of the sample in the pre-monsoon season had So_4^{2-} within the acceptable limits (Fig 3-C). In the post-monsoon season, So_4^{2-} ranged from 10 to 210 mg/l with a mean value of 103 mg/l (Table 5). From Fig (5-C) can be said that 72% of the area has sulphate content within the permissible limits.

d. Nitrates

In this present study area, No_3^- ranged from 1 to 83 mg/l, for which the mean value of 19 mg/l during the pre-monsoon season and in post-monsoon season No_3^- varied from 1.5 to 87.3 mg/l with the mean value of 31.16 mg/l respectively(Table-5). The spatial distribution maps(Fig. 4-F and Fig. 6-F) show that 90% of samples in pre-monsoon season and 85 % in post-monsoon season No_3^- were within the acceptable limits per BIS Standards.

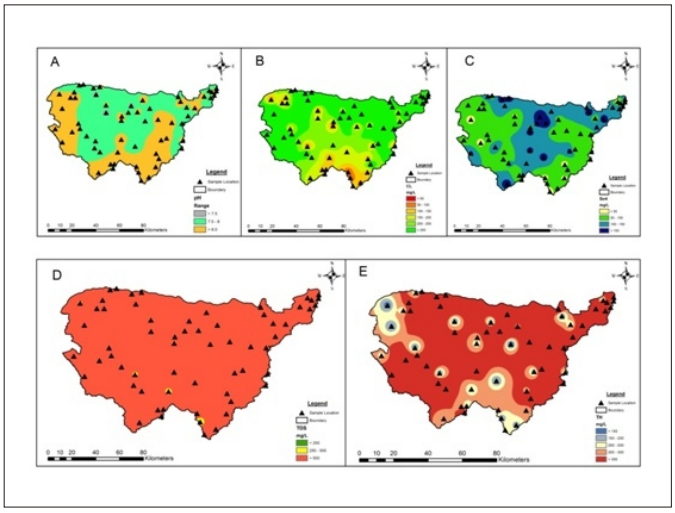


Fig.6:The spatial distribution of pH, Cl^-, So_4^{2-}TDS, and T.H. during the post-monsoon period

e. Chlorides

The chloride in the groundwater samples in the basin varies from 54 to 850 mg/l during the premonsoon season, with a mean value of 273 mg/l (Table-5). Fig 3-B shows that 56% of the area chloride concentration samples were within the permissible limits. For the post-monsoon season, Cl^- concentration ranged from 40 to 930 mg/l, with the mean value at 275 mg/l (Table-5). Fig 5-B shows that 66% of the area has chloride concentration within the permissible limits.

f. Calcium

In the current study area, the Concentration of Ca^{2+} in groundwater samples varied from 8 to 248 mg/l with a mean value of 56 mg/l, whereas, in the post-monsoon Concentration of Ca^{2+} groundwater samples, it ranged from 16 mg/l to 192 mg/l with a mean value of 57 mg/l respectively (Table-5). Figures 4-G & 6-G show that 77 % of groundwater samples in pre-monsoon season and 75 % of post-monsoon samples have Ca^{2+} content within permissible limits per the BIS and ICMR standards.

g. Magnesium

Mg^{2+} Concentration ranged between a minimum of 5 mg/l to a maximum of 97 mg/l during the pre-monsoon period resulting in a mean value of 51 mg/l (Table 5). From Fig 4-H, 21 % of the groundwater samples were found within the permissible limits in pre-monsoon. The remaining samples (79%) have more concentration than the allowable limits. For the post- Monsoon period, Mg^{2+} Concentration varies from 10 to 146 mg/l with a mean value of 50 mg/l. Fig 6-H represents that 37 % of the groundwater samples were within permissible limits. At the same time, the rest of the samples had higher values than BIS standards.

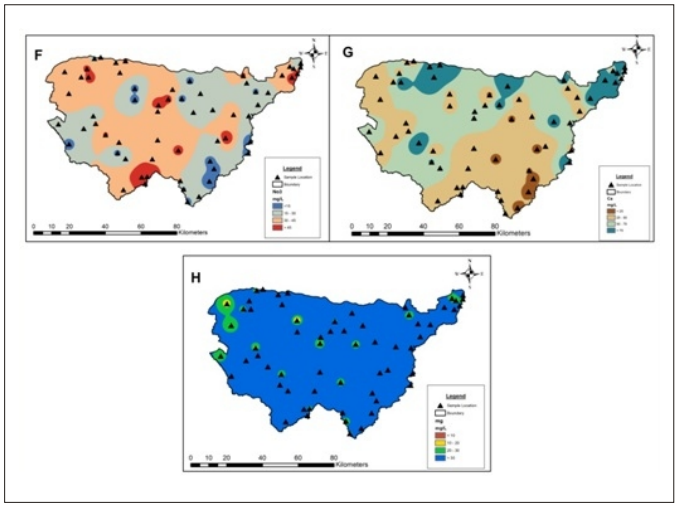


Fig.7: The spatial distribution of No_3^-, Ca^{2+}, and Mg^{2+} during the post-monsoon period

h. Total Hardness(TH)

As per the BIS and ICMR standards, acceptable limits of T.H. in natural water are usually less than 300 mg/l, while water with more than 300 mg/l is unsuitable for Drinking. In premonsoon, the Total Hardness of the Groundwater sample in this basin ranged from 82 mg/l to 978 mg/l with a mean value of 348 mg/l and in post-monsoon season, T.H. varied from 102 mg/l to 899 mg/l with a mean value of 350 mg /l respectively (Table -5). Fig 3-E represents 51 % of samples in the premonsoon season, and Fig 5-E represents 54 % of groundwater samples in the post-monsoon season within the permissible limits.

Water Quality Index

A Water quality index (WQI) summarises a large amount of data into simple terms (excellent, good, poor, very poor, unfit for drinking, irrigation etc.) For reporting to policymakers, administrators, and users consistently. The groundwater quality of the present study area, the Tungabhadra River basin of Kurnool district, Andhra Pradesh, is calculated using different physico chemical parameters such as pH, total dissolved solids, sulphates, nitrate, chlorides, calcium, magnesium and total hardness. The data collected regarding physico-chemical parameters is during pre-monsoon and post-monsoons of 2021.

The physico-chemical properties of groundwater of the Tungabhadra River Basin have been computed for pre-monsoon, and post-monsoon period (Table - 6 and Table - 7). It is followed by the computation of the water quality index (WQI), as follows:

$$WQI = \sum w_n * q_n / \sum w_n$$
$$= 86.82$$

Pre and post-monsoon water quality index values are compared with Chatterjee and Raziuddin, 2002 (Table - 2). we conclude that the water of the Tungabhadra river basin is of very poor quality for drinking purposes and must therefore be treated before use to avoid water-related diseases.

Conclusion

The results obtained from Physico chemical parameters were analyzed to calculate the water quality index during the pre and post-monsoon period (2021). The water quality index values of the Tungabadra river basin can be concluded that water is not fit for drinking purposes. Therefore, an urgent effort should be taken to monitor. Indigenous technologies should be adopted to make them suitable for drinking after treatment (filtration, disinfection etc.) by using remote sensing and GIS technologies to identify and mapping of potential groundwater zones and construction of rainwater harvesting structures such as percolation tanks, recharge pits etc. for suitability of quality of Groundwater.

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Table – 1: Drinking Water Standards and Unit Weights

Sl. No	Parameters	Standards	Recommended Agency	Unit Weight
1	pH	6.5 - 8.5	ICMR/ BIS	0.2190
2	TDS	500 in mg/L	ICMR/ BIS	0.0037
3	Sulphate	150 in mg/L	ICMR/ BIS	0.0124
4	Nitrate	45 in mg/L	ICMR/ BIS	0.0413
5	Chloride	250 in mg/L	ICMR	0.0074
6	Calcium	75 in mg/L	ICMR/ BIS	0.0250
7	Magnesium	30 in mg/L	ICMR/ BIS	0.0620
8	Total Hardness	300 in mg/L	ICMR/ BIS	0.0062

Table – 2: Water Quality Index Standards (after Chatterjee and Raziuddin, 2002)

Sl. No	Parameters
0 - 25	Excellent
26 - 50	Good
51 - 75	Poor
76 - 100	Very poor
>100	Unsuitable for Dirking

Table - 3: Results of Laboratory Investigation (all values except pH and EC are in mg/L)
Pre - Monsoon (2021)

S.No	Mandal	Village	Latitude	Longitude	pH	TDS	SO_4^{2-}	No_3^-	Cl^-	Ca^{2+}	Mg^{2+}	TH
1	Adoni	Peddaharivanam	15.620712	77.090981	7.9	598.4	29	3	90	48	44	301
2	Adoni	Baichigerri	15.623373	77.278075	7.1	2451.2	59	21	540	200	52	714
3	Adoni	Kallubavi	15.604135	77.264472	7.5	2809.6	68	23	623	120	96	695
4	Adoni	Virupapuramu	15.567078	77.328135	7.2	2752	38	19	564	184	75	769
5	Adoni	Adoni	15.631882	77.275883	8.3	742.4	17	1	100	8	15	82
6	Aspari	Aspari	15.475671	77.388425	8	549.7	52	18	361	72	39	340
7	Aspari	Haligera	15.529282	77.3956	8	618.24	31	43	100	24	53	278
8	Bethamcherlla	Cement nagar	15.502514	78.206479	7.9	291.84	76	1	90	40	19	178
9	Bethamcherlla	Bethamcherlla	15.457589	78.151844	7.8	1235.2	63	39	390	16	57	275
10	C.Bellagal	Polakal	15.837671	77.75093	7.5	1510.4	11	20	400	48	62	375
11	C.Bellagal	Kothakota	15.288435	77.767297	8.3	1696	87	13	390	48	34	260
12	Devanakonda	Eduladevarabanda	15.344261	77.812426	8.1	736	30	1	140	56	92	519
13	Dhone	Dhone	15.396043	77.873241	8.4	1907.2	30	23	480	24	82	397
14	Dhone	Kothaburuju	15.324588	77.690832	7.9	615.04	120	9	110	32	58	319
15	Dhone	Malkapuram	15.40214	77.866862	7.7	1228.8	44	18	450	72	74	485
16	Dhone	Kothacheruvu	15.392616	77.862485	8.1	542.72	5	18	100	16	87	398
17	Gonegandla	B.Agraharamu	15.704912	77.595085	7.9	596.48	98	2	130	80	24	299
18	Gonegandla	Gonegandla	15.716249	77.593462	7.8	998.4	199	9	350	120	49	502
19	Gonegandla	H.Kairavada	15.711762	77.632499	7.4	1824	22	13	540	72	53	398
20	Guduru	Guduru	15.77486	77.804787	7.4	2892.8	82	18	520	40	97	499
21	Holagunda	Yellarthi	15.478299	77.124786	7.8	424.32		48	5	60	16	34	180
22	J.Banglow	Pothalapadu	15.867418	78.388355	7.9	869.12		176	1	200	32	44	261
23	Kalluru	Chinnatekuru	15.668367	77.97101	7.8	1256.32		33	13	420	104	51	470
24	Kodumuru	Kodumuru	15.686007	77.770956	8.2	482.56		51	27	100	16	15	102
25	Kodumuru	Pulakurthy	15.748453	77.710971	7.5	2118.4		48	32	580	80	58	439

26	kosigi	Vandagallu	15.857754	77.206024	8.1	442.24	120	6	70	32	34	220
27	kosigi	kosigi	15.856266	77.243149	7.9	1168	64	59	330	104	87	618
28	kosigi	Satanuru	15.857069	77.242216	7.8	2752	74	49	780	16	39	200
29	Kowthalamu	Erigeri	15.774899	77.143827	8.1	718.72	98	2	200	24	44	241
30	Krishnagiri	Lakkasagaramu	15.488707	77.693695	8.3	1273.6	106	12	360	16	39	200
31	Kurnool	Panchalingala	15.864032	78.019876	7.8	1189.76	77	13	380	104	34	400
32	Kurnool	Gargeyapuram	15.779621	78.144329	7.7	750.08	96	10	160	40	24	199
33	Kurnool	Kurnool	15.828126	78.037279	7.8	903.68	77	9.5	210	32	44	261
34	Maddikera	Maddikera	15.938688	77.427974	7.4	1212.8	39	24	380	48	78	441
35	Mantralayamu	Malapalli	15.938688	77.427974	7.7	1117.44	136	21	300	64	92	539
36	Mantralayamu	Suguru	15.940625	77.424316	7.4	3962	112	39	136	48	51	330
37	Mantralayamu	Thungabadra	14.991309	76.888626	7.8	721.92	49	7	130	24	34	200
38	Mantralayamu	Chetnihalli	15.935758	77.418762	8.1	1937.92	157	23	850	120	83	642
39	Nandavaram	Mugathi	15.800127	77.474499	7.8	552.32	11	3	160	72	15	242
40	Nandikotkur	Nandikotkur	15.855593	78.264589	7.9	3917	65	33	54	42	32	237
41	Nandikotkur	Alluru	15.86651	78.2151	7.7	1026.56	74	9	280	16	49	242
42	Nandikotkur	Buujinivemula	15.899278	78.272531	7.9	542.08	4	36	170	40	5	121
43	Nandikotkur	Madigatla	15.900147	78.273167	8	787.84	16	3	270	104	24	359
44	Orvakallu	Nannuru	15.718402	78.093717	7.7	1484.8	61	83	270	104	68	540
45	Pagidiyala	Pagidiyala	15.93548	78.340129	7.6	521.6	103	9	120	32	53	298
46	Pagidiyala	Eastpratakota	15.917306	78.36423	7.8	619.52	50	7	130	16	19	118
47	Pathikonda	Devanbanda	15.446352	77.428601	7.8	1625.6	61	61	440	192	71	772
48	Pathikonda	Pandikona	15.444923	77.562548	8.2	688	42	5.5	130	8	34	160
49	Peapully	Kalichetla	15.261195	77.697813	8.1	669.44	75	17	150	24	82	397
50	Peapully	Racherrla	15.230753	77.740059	8.2	613.12	30	9	90	16	19	118
51	Peapully	Yegnaramapuramu	15.23076	77.739871	8.1	467.2	101	5	110	32	73	380
52	Thugalli	Pendekal	15.86728	77.26925	8.3	758.4	10	9	140	8	58	259
53	Thugalli	Pagidirayi	15.275885	77.590597	8.4	782.72	44	32	110	16	78	361
54	Thugalli	Thugalli	15.31422	77.544029	8.2	635.52	29	51	140	32	82	417
55	Veldurthhy	Veldurthhy	15.550873	77.931028	8	1062.4	90	3	250	16	55	266
56	Yemmiganuru	Gudikallu	15.743274	77.475216	7.5	1843.2	25	36	610	248	87	978
57	kosigi	Halvi	15.884432	77.122629	8.1	738.56	20	2	150	56	73	440
58	Mantralayamu	Narayanapuram	15.950965	77.271869	8.5	1218	96	52	300	8	44	201
59	Kodumuru	Kodumuru	15.686007	77.770956	7.6	3795	39	42	240	46	22	206
60	Veldurthy	Cherukulapadu	15.537138	77.891032	8.5	711.04	85	4	120	24	10	101
61	Kurnool	Sudireddipalli	15.7838	78.082665	8.4	780.8	95	6	150	24	24	159
62	Orvakallu	Orvakallu	15.684056	78.177819	7.1	1521	52	12	242	51	39	158

Table – 4: Results of Laboratory Investigation (all values except pH and EC are in mg/L)
Post-Monsoon (2021)

Mandal	Village	Latitude	Longitude	pH	T D S	SO_4^{2-}	No_3^-	Cl^-	Ca^{2+}	Mg^{2+}	TH
Adoni	Peddaharivanam	15.620712	77.090981	8.2	5452.8	97	25.5	310	64	19	238
Adoni	Baichigerri	15.623373	77.278075	8	1491.2	65	31	240	40	49	302
Adoni	Kallubavi	15.604135	77.264472	8.1	2886.4	17	19.7	850	40	97	499
Adoni	Virupapuramu	15.567078	77.328135	7.9	6304	156	47.4	230	155	90	758
Adoni	Adoni	15.631882	77.275883	8	807.68	53	23.2	110	24	15	122
Aspari	Aspari	15.475671	77.388425	7.4	1312	47	8.49	330	80	49	402
Aspari	Haligera	15.529282	77.3956	7.9	231.04	67	39	50	24	19	138
Bethamcherlla	Cement nagar	15.502514	78.206479	8.1	591.36	74	1.5	80	40	29	219
Bethamcherlla	Bethamcherlla	15.457589	78.151844	7.4	1574.4	82	10	370	140	68	630
C.Bellagal	Polakal	15.837671	77.75093	8.1	2822.4	151	11	760	176	87	798
C.Bellagal	Kothakota	15.288435	77.767297	7.3	666.24	196	44	130	16	24	139
Devanakonda	Eduladevarabanda	15.344261	77.812426	8.1	1051.52	167	31.1	240	40	73	400
Dhone	Dhone	15.396043	77.873241	8.4	1676.8	115	10.6	350	16	107	480
Dhone	Kothaburuju	15.324588	77.690832	8.5	569.6	34	31.3	40	48	39	280
Dhone	Malkapuram	15.40214	77.866862	8.1	648.32	14	9.6	90	24	53	278
Dhone	Kothacheruvu	15.392616	77.862485	8.1	668.8	36	3.75	120	16	53	258
Gonegandla	B.Agraharamu	15.704912	77.595085	8	423.68	193	27.7	40	56	15	202
Gonegandla	Gonegandla	15.716249	77.593462	8.3	678.4	79	67.1	160	56	29	259
Gonegandla	H.Kairavada	15.711762	77.632499	7.5	1817.6	167	52	500	48	92	499
Guduru	Guduru	15.77486	77.804787	8	2636.8	80	14.6	600	24	53	278
Holagunda	Yellarthi	15.478299	77.124786	8.5	1201.28	158	9.3	340	40	73	400
J.Banglow	Pothalapadu	15.867418	78.388355	8.2	769.92	199	86	240	40	34	240

Kalluru	Chinnatekuru	15.668367	77.97101	8.3	1964.8	63	42	570	96	121	738
Kodumuru	Kodumuru	15.686007	77.770956	8.2	1187.84	51	27.3	190	48	82	457
Kodumuru	Pulakurthy	15.748453	77.710971	8.2	2585.6	206	6.56	640	96	146	841
kosigi	Vandagallu	15.857754	77.206024	8	543.36	38	29	70	40	24	199
kosigi	kosigi	15.856266	77.243149	8	648.32	84	49.1	100	40	53	318
kosigi	Satanuru	15.857069	77.242216	8.2	3206.4	102	57.7	210	120	42	473
Kowthalamu	Erigeri	15.774899	77.143827	8.3	2604.8	26	39	850	24	19	138
Krishnagiri	Lakkasagaramu	15.488707	77.693695	7.8	1054.72	182	51.5	150	16	24	139
Kurnool	Panchalingala	15.864032	78.019876	7.6	1817.6	138	48.8	450	96	44	421
Kurnool	Gargeyapuram	15.779621	78.144329	8.2	1760	188	22.9	420	104	63	519
Kurnool	Kurnool	15.828126	78.037279	8.3	1251.2	190	19.9	250	24	19	138
Maddikera	Maddikera	15.938688	77.427974	8.5	643.2	190	34.6	190	40	39	260
Mantralayamu	Malapalli	15.938688	77.427974	8.2	1843.2	183	46.2	450	120	97	699
Mantralayamu	Suguru	15.940625	77.424316	7.2	3001.6	119	34.4	930	192	102	900
Mantralayamu	Thungabadra	14.991309	76.888626	7.4	1262.08	56	42	290	32	63	339
Mantralayamu	Chetnihalli	15.935758	77.418762	7.9	2291.2	210	43.3	560	80	102	620
Nandavaram	Mugathi	15.800127	77.474499	8.1	439.04	37	10	70	40	10	141
Nandikotkur	Nandikotkur	15.855593	78.264589	7.6	1251.84	126	53	340	96	63	499
Nandikotkur	Alluru	15.86651	78.2151	8.1	1278.08	148	42.7	270	96	44	421
Nandikotkur	Buujinivemula	15.899278	78.272531	7.7	804.48	10	29.6	180	32	24	179
Nandikotkur	Madigatla	15.900147	78.273167	8.4	1229.44	19	26.5	400	184	15	522
Orvakallu	Nannuru	15.718402	78.093717	7.4	597.12	153	23.5	190	32	53	298
Pagidiyala	Pagidiyala	15.93548	78.340129	7.5	727.04	168	12.9	260	104	58	499
Pagidiyala	Eastpratakota	15.917306	78.36423	8.1	735.36	138	13.5	160	40	15	162
Pathikonda	Devanbanda	15.446352	77.428601	8	557.44	109	23.1	230	56	63	399
Pathikonda	Pandikona	15.444923	77.562548	8	381.44	123	43.5	90	24	34	200
Peapully	Kalichetla	15.261195	77.697813	8	340.48	53	13	50	24	24	159
Peapully	Racherrla	15.230753	77.740059	8	570.88	87	22	90	16	34	180
Peapully	Yegnaramapuramu	15.23076	77.739871	8.3	829.44	22	11.4	110	40	29	219
Thugalli	Pendekal	15.86728	77.26925	8.2	1078.4	34	66	140	48	44	301
Thugalli	Pagidirayi	15.275885	77.590597	8	517.12	150	87.3	90	32	24	179
Thugalli	Thugalli	15.31422	77.544029	7.9	825.6	64	44.2	150	40	63	359
Veldurthhy	Veldurthhy	15.550873	77.931028	8	1536	53	72.1	460	24	112	521
Yemmiganuru	Gudikallu	15.743274	77.475216	7.2	718.08	59	7.7	170	40	49	302
kosigi	Halvi	15.884432	77.122629	8	441.6	88	34	80	24	15	122
Mantralayamu	Narayanapuram	15.950965	77.271869	8	845.44	147	23	220	48	19	198
Kodumuru	Kodumuru	15.686007	77.770956	7.5	482.56	51	27.3	100	16	15	102
Veldurthy	Cherukulapadu	15.537138	77.891032	8.4	458.88	175	20.7	100	16	29	159
Kurnool	Sudireddipalli	15.7838	78.082665	8	679.04	51	11.2	190	32	29	199
Orvakallu	Orvakallu	15.684056	78.177819	7.5	1721.6	70	15.6	390	64	44	341

Table -5: Descriptive Statistics of Physico-chemical Parameters of Ground Water
(Pre - and Post - Monsoon Seasons, 2021)

Sl. No.	Parameter	Pre - Monsoon			Post - Monsoon			BIS and ICMR Limits	Samples Exceeding BIS and ICMR	
		Min	Max	AVG	MIin	Max	AVG		Pre Monsoon	Post Monsoon
1	pH	7.1	8.5	7.9	7.2	8.5	8	6.5-8.5	____	____
2	T D S	291.8	3962	1246.11	231.04	6304	1338.62	500	57	54
3	SO_4^{2-}	4	199	65	10	210	103	150	3	18
4	No_3^-	1	83	19	1.5	87.3	31.16	45	6	10
5	Cl^-	54	850	273	40	930	275	250	26	24
6	Ca^{2+}	8	248	56	16	192	57	75	12	16
7	Mg^{2+}	5	97	51	10	146	50	30	48	39
8	TH	82	978	348	102	899.75	350	300	31	31

Table – 6: Computation of Water Quality Index Calculation for Pre-Monsoon Season, 2021

Parameter	Average of the Observed Parameter	Unit Weight (W)	Quality Rating (q)	W*q
PH	7.88	0.2190	59.00	12.92
TDS	1246.11	0.0037	249.22	0.92
SO4	64.52	0.0124	43.01	0.53
NO3	19.26	0.0413	42.80	1.77
CL	273.23	0.0074	109.29	0.81
CA	55.92	0.0250	74.56	1.86
MG	51.02	0.0620	170.05	10.54
TH	347.68	0.0062	115.89	0.72
		Total = 0.3770		Total = 30.08
WQI = 30.08 / 0.3770 = 79.78				

Table – 7: Computation of Water Quality Index Calculation for Post-Monsoon Season, 2021

Parameter	Average of the Observed Parameter	Unit Weight (W)	Quality Rating (q)	W*q
PH	7.97	0.2190	64.84	14.20
TDS	1338.62	0.0037	267.72	0.99
SO4	103.35	0.0124	68.9	0.85
NO3	31.16	0.0413	69.24	2.86
CL	274.68	0.0074	109.87	0.81
CA	57.15	0.0250	76.19	1.90
MG	52.26	0.0620	167.53	10.39
TH	350	0.0062	116.56	0.72
		Total = 0.3770		Total = 32.73
WQI = 32.73/ 0.3770 = 86.82				



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Articles in Journals:

[3] Sarkar, A (2011): Urbanization and City Size Distribution of West Bengal, India 1901 2001, *Journal of Regional Science*, Kolkata, 43 (1), pp9 -16.
[4] Patel, P. P and Sarkar, A (2010): Terrain Characterization using SRTM Data, *Journal of the Indian Society of Remote Sensing* 38 (1), March 2010, pp11- 24.

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Land use and Land cover analysis of Tungabhadra River Basin, Kurnool District of Andhra Pradesh using remote sensing and GIS

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Abstract

The present study aims to determine the land use/land cover features of the Tungabhadra River basin of Kurnool District, Andhra Pradesh, for 2023 using remote sensing and GIS Technologies. The study used the Survey of India topographic maps 57E/1 to 57E/16 and 57I/1 to 57I/5 and the remote sensing data of LISS III, 2023 processing in Arc GIS 10.3 and ERDAS software. Understanding existing land use and land cover in a region is crucial for maximizing land efficiency. It allows informed decision-making in urban planning, agriculture, conservation, and resource management. Accurate knowledge empowers stakeholders to optimize land utilization for sustainable development. The analysis reveals that the study area contains components such as Agricultural land, Built-up areas, Forests, Wasteland, Water bodies, and Transportation. Most of the study area is occupied by agricultural land 77.03%, followed by Wastelands 10.68%, Forest land 4.58%, Water bodies 3.90%, Built-up land 3.53%, and Transportation 0.28%.

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Introduction

Land is one of nature's most valuable gifts, and humans perform different activities on it. Sustainable utilization of available land resources determines a region's socio-economic and cultural progress. Land cover refers to the surface cover on the ground, which includes weather, vegetation, urban infrastructure, water rocks, bare soil, or other elements used for identifying, delineating, and mapping purposes. Land use refers to man's activities and the various uses that are carried out on land. Land use involves the manipulation of land's biophysical attributes and the intended purpose for its use.

Understanding the current land use and cover is crucial due to significant environmental challenges such as habitat loss, biodiversity decline, and climate change. The rapid changes caused by urbanization, agriculture, and deforestation put ecosystems and natural resources at risk. Analyzing land use patterns helps inform sustainable development strategies, conservation efforts, and policy interventions to secure a more resilient future. The scope of this analysis ranges from local to global scales, and it involves monitoring changes, assessing impacts, and identifying vulnerable areas. Doing so makes it possible to implement targeted interventions for sustainable land management and adaptation to environmental change. Integrating remote sensing, GIS, and modelling enhances spatial analysis and decision-making. The current land use and land cover significantly shape global environmental, social, and economic outcomes. Managing these dynamics preserves biodiversity, ensures food security, and mitigates climate change impacts. Sustainable strategies promote resilience and adaptability, fostering equitable access to resources, enhancing community well-being, and safeguarding ecosystem health benefits for current and future generations.

Accurate land use information is crucial for properly planning, managing, and monitoring natural resources (Vishwanath, 2014). Effective land use and cover information is crucial for implementing management strategies to meet the rising demands of the growing population for basic human needs and welfare.

(Nagaraju et al. 2016, Veeraswamy, 2019). Land cover mapping is being undertaken at various scales, from local to national to global. Using panchromatic, medium-scale aerial photographs to map land use has been widely accepted since the 1940s. Recently, small-scale aerial and satellite images have been employed for land use and land cover mapping. Land use and land cover are crucial factors in various fields such as hydrogeology and mining, urban planning, agriculture, hydrology, and soil. Accurate land cover identification is critical for various purposes, including global monitoring studies, resource management, and planning activities. It serves as a foundation for change detection and thematic mapping. Land use describes how land apparel is used (for agriculture, residence, or industry). Land use applications require initial mapping and ongoing monitoring to ensure current information on the quantity and type of land use and to detect any changes in land use over time (Haque & Basak, 2017).

Chatterjee (1941) emphasized the importance of studying India's different types of land use cover. He noted that this intricate pattern requires geographical investigation of the physical environment. To this end, he conducted a land use land cover survey in Howrah district and 24 Parganas of West Bengal (Chatterjee 1945, 1952). The study revealed that the district had poor drainage conditions despite having large rivers. It also discussed the impact of soil and climate on land utilization, population pressure on land, trade and transport, nature of land utilization, and agricultural implements. Mukherjee (1967) observed the changing land use pattern in Howrah district and suggested planning strategies for agricultural land use. Roy (1972) emphasized the relationship between land use and agricultural characteristics of the Damodar-Saraswati Doab area. Chatterjee and Jana (1975) studied the pattern of land utilization around Tarakeswar town of Hooghly district.

Singh RB and Dilip Kumar (2012) used remote sensing and GIS to map land use and cover and integrate land management in the Middle Ganga plain. They recommended alternative land use systems and the integration of livestock enterprises with the agricultural system for effective land resource management. In 2014, Sreenivasulu conducted a study using IRS LISS III data to map the land use and land cover of Rajampeta in the Kadapa district. The study revealed a worrying trend of rapid decrease in water bodies and marshy areas and a significant change in land use from agricultural to residential. Additionally, water bodies were converted into marshy terrain and marshy areas into either residential or agricultural land. These findings indicate substantial urbanization and alteration of natural landscapes in the region. In 2017, Gopenaik investigated the land utilization patterns in and around the Dosalavanka watershed in the Chittoor District. Similarly, in 2021, Vinodh Kumar conducted a study on land use and land cover analysis in the Uddanam area of Srikakulam District. Their study revealed that agricultural land occupation was predominant, while uncultivated land was occupied somewhat.

Land use and land cover mapping can be done using satellite sensing data to create a reliable database that includes information on Kharif, Rabi, and Zaid crops, greening of wastelands, surface water bodies, forest vegetation, and other high temporal land-use practices. The National Remote Sensing Agency developed the land use and land cover data in 1989, and it has been updated using visual interpretation techniques recommended by NRSA in 2019.

e and Land cover, Remote sensing, GIS, Tungabhadra River Basin

The Study Area

The study area of the Tungabhadra River basin is in the north-western region of the Kurnool district in Andhra Pradesh, India. It lies between North Latitude 15^0 15'00" to 16^0 0'00" and East Longitude 77^0 0'0" to 78^0 15'00". The area falls within the Survey of India (SOI) Toposheet Nos. 57E/1 to 57E/16 and 57I/1 to 57I/5. The total area of the basin is 6,934 square kilometers. The basin consists of 30 mandals, with 21 mandals fully covered and the remaining nine mandals partially covered. The Tungabhadra River basin receives an average annual rainfall of 670 mm and experiences temperatures ranging from 12°C to 31°C in the winter. Moreover, summer temperatures range from 26°C to 46°C. Agriculture is the primary occupation and main source of livelihood for the people residing in the Tungabhadra River basin. Over 70% of the basin's population is involved in farming. Rainfed agriculture is the most practiced type of farming in the region. The "fallow-chickpea" cropping system is the preferred method for farming by most farm households.

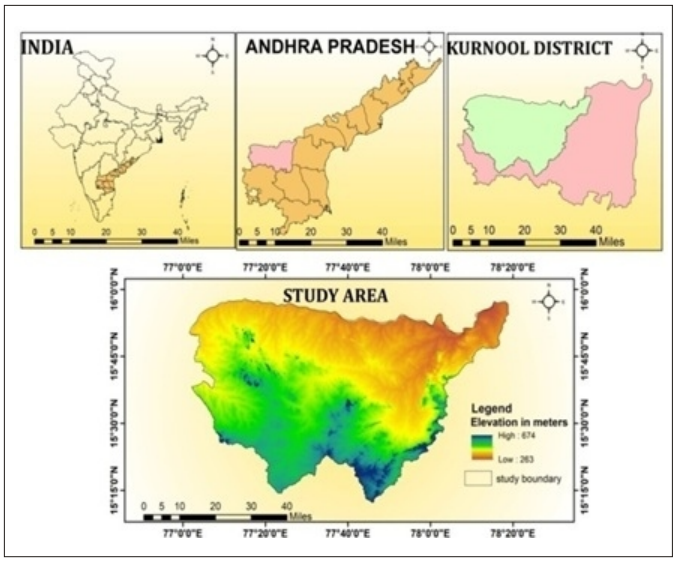


Fig.1 Location map of the Tungabhadra River basin

Objective

This study aims to conduct a comprehensive land use and land cover (LULC) analysis of the Tungabhadra River Basin in Kurnool District, Andhra Pradesh, utilizing remote sensing and Geographic Information System (GIS) techniques.

Database and Methodology

In the present study, we have mainly used two types of data. These are Topographic maps and Remote sensing data. Satellite imagery from the IRS P6 LISS III at a 23m resolution was used to classify land use and cover in 2023. The topographic map 57E/1 TO 57 E/16 and 57I/1 TO 57I/5(1:50,000 scale) is obtained from the survey of India, Hyderabad, surveyed and prepared in 1976; it is converted to digital mode using scanning. The topographic map is georeferenced with longitude and latitudes using the ArcGIS 10.3 software and spatial analyst tools to demarcate the drainage basin. The classification scheme used was developed by the National Remote Sensing Agency (NRSA) in 1995. Visual interpretation techniques were employed to classify features on the satellite images, using a key that helps distinguish features based on patterns, tonal variation, associations, and texture. These data sets

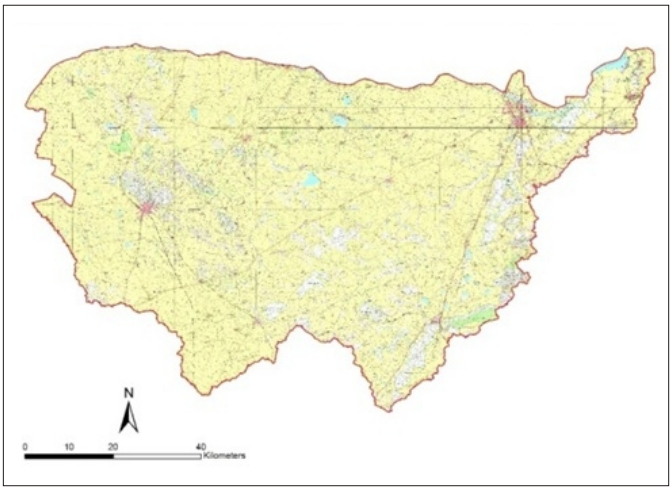


Fig:2: Topographical Map of the Tungabhadra River Basin in Kurnool District

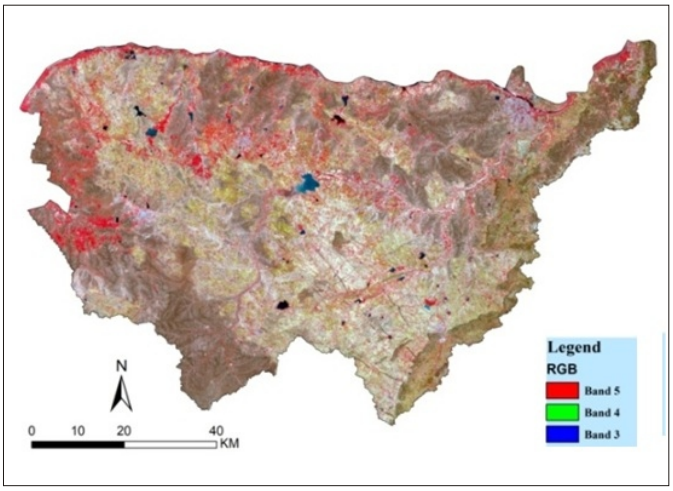


Fig:3: False Colour Composite Map of the Tungabhadra River Basin in Kurnool District

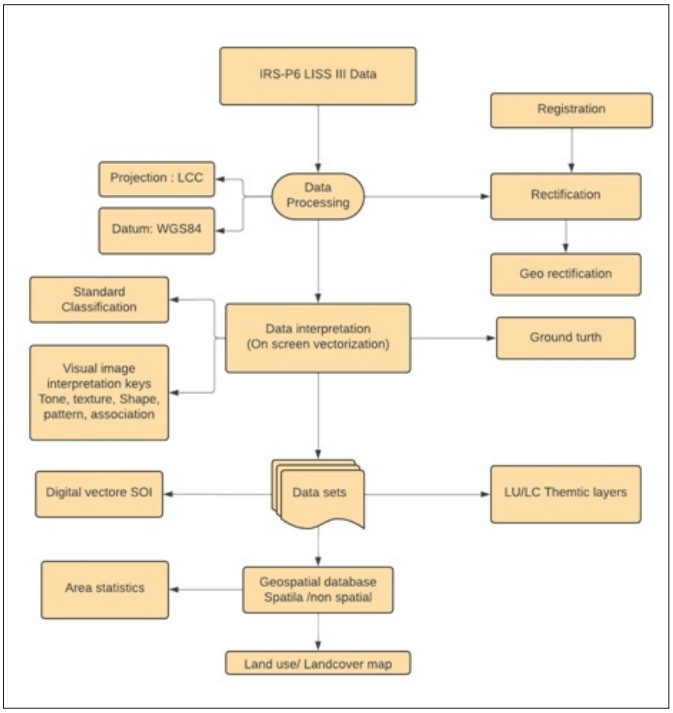


Fig.4. Flowchart of Methodology for LU/LC Map

were imported into ERDAS Imagine, a satellite image processing software, and a false color composite (FCC) was generated. The image interpreter toolbox's layer stack selection produced FCCs for the study area. Georeferencing, subset, mosaic, and projection were performed using ERDAS Imagine 9.0 and ARC GIS 10.3.

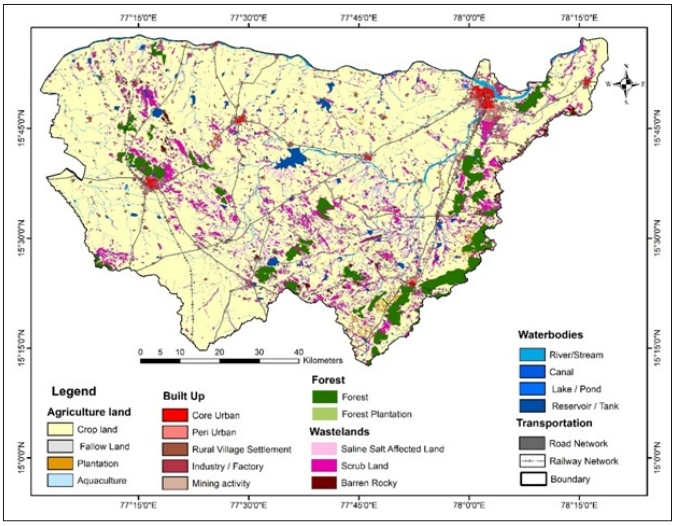


Fig.5: Landuse and Land Cover Map of the Tungabhadra River Basin in Kurnool District

Results and Discussion

Agricultural land

The land use category primarily produces food, Fiber, and other commercial and horticultural crops. It includes land under crops, namely cropland, fallow land, agricultural Plantation, and aquaculture. The agricultural category is the primary category, covering 5341.04 sq. Km (77.03%) during 2022-23.Table.1 & Fig.5

Crop Land: Croplands are typically categorized into Kharif, Rabi, and Zaid crops. Kharif crops, sown during the monsoon season, rely on irrigation rainfall, including paddy, Jowar, maize, chilies, cotton, and others. Rabi crops, planted between October and December, thrive in areas with assured irrigation or residual soil moisture, such as Bengal gram. Zaid crops, cultivated in summer months, primarily in irrigated regions, encompass crops like melons and cucumbers. This classification facilitates understanding seasonal agricultural practices and water management needs in diverse regions, with the total cropland area in the basin is 5279.93 sq. Km (76.15%) during 2022-23. This categorization helps understand the seasonal agricultural practices and water management requirements across different regions.

Fallow Land: Fallow land refers to agricultural areas deliberately left uncultivated for one or more seasons, allowing the soil to recuperate for up to five years. This practice aids in preserving soil fertility and productivity by preventing degradation, erosion, and nutrient depletion. Incorporating fallow periods into crop rotation systems supports sustainable farming, reduces reliance on chemical inputs for weed and pest management, and restores natural balance. With a total area of 13.94 sq. km, representing 0.20% of the land, fallowing plays a crucial role in maintaining soil health and ensuring long-term agricultural sustainability.

Agriculture Plantation: Agricultural plantations encompass

areas dedicated to cultivating tree crops, employing specialized agricultural management techniques. These regions also encompass land use systems integrating the intentional cultivation of herbs, shrubs, and vegetable crops alongside conventional crops, often under irrigated conditions, motivated by ecological and economic considerations. The distinguishing characteristics of these areas include their separability from cropland, which is particularly evident during the rabi/zaid season. Empirical findings for 2022-23 reveal that 43.19 sq. km (0.62%) of land was devoted to plantation crops during this period.

Aquaculture: Aquaculture ponds are areas where fish and shrimp are bred and reared commercially. They are usually located along the coast or in lakes, rivers, and estuaries. This category is mainly found along the coast and occupies an area of 3.98 sq. km (0.06%).

Built-Up Area

These are the areas where people live, work, and communicate with each other. They include buildings, transportation systems, utilities such as water and electricity, and agricultural and industrial areas. These areas are core urban, peri-urban, rural, industrial, and mining/quarry. They cover 244.69 square kilometers, approximately 3.53% of the region's total geographical area. Rural areas account for 1.92% of the total area, more than half of the developed land. Table.1 & Fig.5.

Core Urban Area: Structures, highways, and artificial surfaces cover most of the terrain, encompassing nearly the entire land surface. The built-up-compact class is assigned when the urban structures and transport network (i.e., impermeable surfaces) occupy more than 35% of the surface area. This category occupies 38.10 sq. km (0.55%) and is in urban areas.

Peri-urban Area: Most of the land is covered by buildings, roads, and artificial surfaces, with vegetated areas and bare soil occupying significant but discontinuous surfaces. Between 20 and 40 % of the total surface should be impermeable. This category delineates scattered blocks of residential flats, hamlets, and small villages. It contributes an area of 37.44 sq. km (0.54%).

Rural Village Settlements: Rural settlements have relatively less human habitation than urban settlements, where most people farm. These settlements are categorized as built-up (rural) areas and are associated with non-commercial and allied classes. The rural area accounts for approximately 133.25 square kilometers, representing 1.92% of the total area.

Industrial Area: This class includes non-linear impervious surfaces related to trade, manufacturing, distribution, and commerce. These areas are characterized by human activity in manufacturing and supporting establishments for maintenance. Industrial areas occupy 13.39 square kilometers (0.19% of the total) and are typically found in and around towns.

Mining activity: Mining areas refer to the regions utilized for surface operations to extract valuable ores from the ground. These activities leave a noticeable impact on the landscape, with massive pit mines covering vast areas. The current mining operations are primarily large-scale surface operations that aim to remove economically significant ores. The total area contributed by the active mining operations is 22.51 sq. km, which accounts for only 0.32% of the total area.

Forests

A forest is defined as an area with a tree canopy cover of over 30% and a size greater than 0.5 hectares, characterized by trees reaching at least 5 meters in height. It serves as a vital source of timber and wood products and offers opportunities for outdoor recreation. Forests are pivotal in shaping environmental aspects such as air and water quality, wildlife habitat, climate, and other factors.Currently, the forest cover occupies about 317.63 square kilometers, which is approximately 4.58% of the total land area. Table -1 & Fig.5

Forest Plantation: These are the areas where tree species of forestry importance are grown and managed, especially in notified forest areas. Most of these areas are found in uplands and coastal regions within the notified areas. Many can be identified based on their sharp boundaries. The total area covered by forest plantations is 5.41 sq. km, only 0.08% of the total area.

Wastelands

Wasteland is a term that describes degraded land that can be restored to a vegetative state with reasonable effort but is currently underutilized. This type of land can deteriorate due to a lack of appropriate water and soil management or natural causes. Wastelands can also result from inherent or imposed disabilities, such as location, environment, soil chemical and physical properties, or financial or management constraints. Currently, the total area under this category is 735.59 sq. km, approximately 10.68% of the total land area. Table -1 & Fig.5

Salt-affected Land: These lands have excessive salts (soluble salts, exchangeable saline, or both). If canal irrigation water is not managed correctly, it can lead to salinization. This phenomenon occurs when the groundwater level increases, causing salts to accumulate within the root zone in arid, semi-arid, and sub-humid (dry) environments. Salinization can also occur in coastal regions due to seawater ingress or the utilization of groundwater with high salt content. These lands can also become saline if soils have developed on salt-containing parent materials or have saline groundwater. Coastal saline soils may or may not be inundated by seawater. These lands account for only 120.96 sq. km (1.74%) of the total area.

Scrubland : The scrub is typically found in the elevated regions of hillsides, which are usually surrounded by agricultural lands. These areas have shallow and skeletal soils, which can be chemically degraded. Scrubs dominate the landscapes due to the extreme slopes, severe erosion, and excessive aridity. The scrub can be found in a contiguous or dispersed pattern in small to large areas. The dense scrub is mainly found on hills, while the open scrub is found in foothills surrounded by agricultural lands, which occupy an area of 565.56 sq. km, which accounts for 8.16% of the total land area.

Barren Rocky/Stony Waste: It is mainly found in hilly areas with slopes, rocky outcrops, and stony fragments. The total area under this category is 49.07 sq. Km (only 0.71% of the total area.

Water Bodies

This category includes visible surface water, ponds, lakes, tanks, reservoirs, or flowing water bodies such as streams, rivers, and canals. Depending on the water depth, these areas appear blue to dark blue or cyan on satellite images. The water body category covers approximately 270 square kilometers and represents 3.90% of the basin. Table -1 & Fig.5

Rivers/Streams (Perennial): Rivers and streams are natural water pathways flowing across land, either continuously or intermittently, toward seas, lakes, or other water bodies. They play pivotal roles in the hydrological cycle, shaping landscapes and ecosystems and sustaining biodiversity. Additionally, they facilitate transportation and influence regional climates, marking their significance across ecological, geographical, and geological domains. Rivers and streams represent dynamic forces of nature, carving out valleys, nourishing fertile plains, and providing habitats for diverse aquatic and terrestrial life forms. It contributes an area of 138.12 sq. Km(2.0%).

Canals/Drains: Canals and drains are artificial waterways used for irrigation, navigation, or drainage of excess water from agricultural lands. They are primarily found in coastal plains, covering an area of 21.84 sq km (0.31%).

Tanks/Ponds : Tanks and ponds serve as crucial reservoirs, storing water for irrigation year-round, especially in areas lacking natural water sources like rivers. They enable efficient water management, aiding farmers in optimizing irrigation schedules and minimizing wastage. These reservoirs supplement irrigation supplies during droughts, helping sustain crop growth and mitigate losses. Additionally, they support aquaculture, bolstering food security and rural economies. Overall, creating tanks and ponds significantly enhances agricultural productivity and resilience. This category occupies 5.24 sq. km (0.08%) of the land, highlighting its importance in land use classification and resource management.

Reservoirs/Tanks: Reservoirs, formed by damming rivers, serve diverse purposes like hydropower generation, irrigation, and flood control, while tanks, smaller bodies of water, are mainly for localized irrigation in croplands. Reservoirs are large-scale and cater to multiple needs, whereas tanks, typically found in lowland areas, serve specific irrigation requirements. Both are crucial for managing water resources, sustaining agriculture, and mitigating flood risks across various landscapes. This category occupies an area of 104.79sq. Km (1.50%).

Transportation

The transportation infrastructure in the region is intricately linked with a comprehensive system of roads and railways, facilitating the smooth and effective transportation of goods and individuals. The road network includes significant highways and arterial routes, complemented by an extensive railway system that connects essential destinations. This robust transportation grid is crucial in supporting economic activities, improving accessibility, and fostering regional development. Moreover, continuous efforts to modernize and expand these networks aim to strengthen connectivity and mobility across the region further. This category occupies an area of 19.65sq. Km (0.28%). Table -1 & Fig.5

Conclusion

The Tungabhadra River Basin has diverse land use categories, such as agricultural land, built-up areas, forests, wastelands, water bodies, and transportation infrastructure. The region's agricultural land is essential for food production and economic sustainability, and we need to focus on enhancing agricultural productivity through modern techniques and sustainable practices while preserving fallow lands and promoting aquaculture for diversified income streams. Built-up areas signify urban, peri-urban, rural, industrial, and mining zones, highlighting the region's economic and social development. We need to continue investing in infrastructure, urban planning, and industrial growth, but we should also balance it with environmental conservation and sustainable resource management.

Forests are a significant portion of the Tungabhadra River Basin and are crucial for biodiversity conservation, climate regulation, and recreational activities. We must invest in conservation efforts, afforestation initiatives, and sustainable forest management practices to maintain ecological balance and support ecosystem services. Wastelands present opportunities for restoration and rehabilitation to reclaim degraded lands for productive use. Targeted interventions focusing on soil and water conservation, afforestation, and land reclamation can revitalize these areas and enhance their contribution to sustainable development. Water bodies like rivers, streams, ponds, tanks, and reservoirs are vital for irrigation, aquaculture, and water supply. Conserving and managing water resources involves ensuring sustainability, improving quality, and mitigating human activities and climate change impacts. Transportation infrastructure is pivotal in facilitating connectivity, trade, and economic growth. We must invest in modernizing and expanding transportation networks to enhance accessibility, efficiency, and mobility while minimizing environmental impacts.The findings presented in this report can be used as a foundation for informed decision-making, sustainable land management, and resource planning initiatives to foster environmental conservation and socio-economic development within the Tungabhadra River Basin.

Acknowledgment

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Table 1: Landuse/ Land Cover in Tungabhadra River Basin in 2023

S.No	Landuse /Land Cover Categories	Area (sq. km)	%
1	Crop Land	5279.93	76.15
2	Fallow Land	13.94	0.20
3	Plantation	43.19	0.62
4	Aquaculture	3.98	0.06
5	Core Urban	38.10	0.55
6	Peri-Urban	37.44	0.54
7	Rural Village Settlement	133.25	1.92
8	Industry / Factory	13.39	0.19
9	Mining Activity	22.51	0.32
10	Forest	317.63	4.58
11	Forest Plantation	5.41	0.08
12	Saline Salt Affected Land	120.96	1.74
13	Scrub Land	565.56	8.16
14	Barren Rocky	49.07	0.71
15	River/Stream	138.12	1.99
16	Main Canal	21.84	0.31
17	Lake / Pond	5.24	0.08
18	Reservoir / Tank	104.79	1.51
19	Road Network	13.37	0.19
20	Railway Network	6.28	0.09
	Total	6934.01	100.00



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Geographical Study of Crop Concentration and Crop Diversification in Tungabhadra River Basin of Kurnool District, Andhra Pradesh

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Abstract

The aim of the Present study is to analyze the spatial distribution of agricultural crops in the Tungabhadra River basin of Kurnool district using statistical techniques such as Crop Concentration and Crop Diversification. The study focuses on the mandal level, covering a total of 30 mandals within the basin. The data used in this study is secondary data obtained from the Chief Planning Office of Kurnool District (C.P.O) and the Handbook of Statistics, Kurnool District, for the year 2019-20. A total of seventeen crops were considered for this study. The Bhatia's Location Quotient method (1965) was employed to calculate the crop concentration, while the Gibbs and Martin's Quantitative technique (1962) was used to compute the crop diversification index. To visually represent the cropping patterns across the entire basin, the mandal was chosen as the base unit for areal mapping. Among the seventeen crops analyzed, Cotton (37%), Groundnut (15%), Bengal gram (13%), and red gram (9%) were found to be the most widely cultivated crops in the basin. The diversification of crops was found to be high in three mandals, moderate in fourteen mandals, and low in thirteen mandals.

***Key words*:** Cropping pattern, Crop concentration, Crop diversification, Bhatia's location quotient method, Gibbs and Martin's quantitative technique, Arc GIS 10.4

The Tungabhadra River basin, located in the western part of the Kurnool district, is characterized by its unique agricultural landscape. More than 75% of the region comprises Pedi plains, with 45% of the soil being cotton-rich black soils and 30% being red soils due to its geological connection to granite and gneisses. The primary mode of agriculture in this region is rain-fed, and agriculture stands as the predominant land use. Over 70% of the population relies on agriculture for their livelihoods. However, the agricultural system here is primarily based on traditional practices and operates at a subsistence level due to the limited availability of irrigation facilities and the prevalence of marginal and small landholdings. A significant portion of the working population is engaged in agricultural labour.

In this context, the study of crop concentration and diversification becomes essential to assess the state of crops in terms of their distribution across the area, the number of crops grown, spatial variations, and agricultural practices. [1] brought out the patterns of Crop concentration and Diversification in India. This information is critical for regional agricultural planning [2-3]. Crop concentration refers to the density variation of a particular crop in a specific area at a given point in time, while crop diversification represents the opposite, indicating a balanced mix of crops within a region [4]. Both these aspects not only provide insights into areas dominated by specific crops but also play a pivotal role in bolstering the agrarian economy and aiding in land-use planning [5]. The spatial variations in the degree of crop concentration in the area are influenced by various factors, including topography, climate, hydrology, socio-economic conditions, and technological factors. These interactions shape the agricultural landscape of the region, making it crucial to consider these factors when devising strategies for sustainable agricultural development [6]. The studies Crop concentration and crop diversification has been widely studied and mapped by various researchers in India. Among them who have studied crop concentration and diversifications are [7-17].

MATERIALS AND METHODS

Study area

The study area of the Tungabhadra River basin is in the north-western region of the Kurnool district in the state of Andhra Pradesh, India. It lies Between North Latitude 15° 15ˈ00” to 16° 0ˈ00” and East longitude 77° 0ˈ00” to 78° 15ˈ00”. The area falls within the survey of India (SOI) Toposheet No 57E/ 1 to 57E/16 and 57I/1 to 57 I/5. The total area of the basin is 6,934 square kilometers. The basin consists of 30 mandals, with 21 mandals fully covered and the remaining 9 mandals partially covered. The basin receives an average annual rainfall of 670 mm and experiences temperatures ranging from 26°C to 46°C in the summer and 12°C to 31°C in the winter. The northwestern portion, which includes Adoni, Peddakadubur, Alur, Aspari, Chippagiri, Halaharvi, Holagunda, Pathikonda, Devanakonda, Krishnagiri, Veldurthy, Kodumur, and Kallur mandals, has a desolate appearance with vegetation mostly limited to small pockets of reserve forests. This portion of the basin covers an area of 41,712 hectares, which accounts for

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4.46% of the total geographical area. The terrain in this region slopes from south to north and is drained by the river Hundri, which joins the river Tungabhadra at Kurnool. The soils in the north-western parts traversed by the river Hundri are black cotton, while the south-eastern parts are predominantly pure red soils. Geologically, the basin is underlying by the crystalline rock of the Peninsular Gneissic complex (PGC), which includes the Granitic Gneisses and Granite in the western and southern parts of the basin.

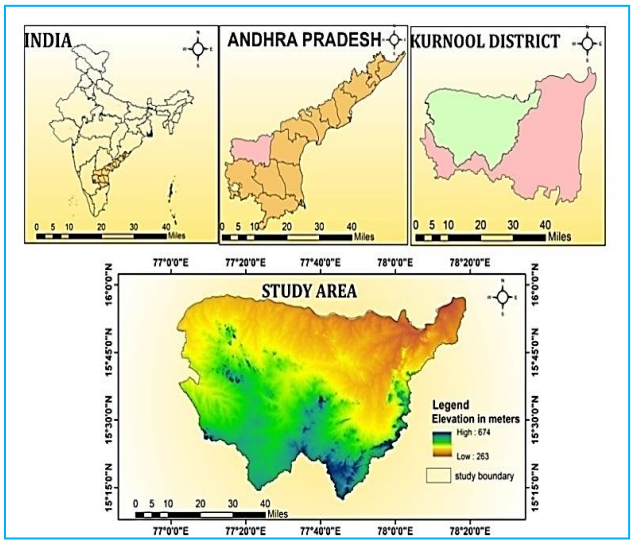


Fig 1 Location map of the study area

The present study utilized secondary data obtained from the Chief Planning office of Kurnool District (C.P.O) and the Handbook of Statistics, Kurnool District, 2019-20. Additionally, relevant information pertaining to physiographic, climate, and soil characteristics was collected from the Andhra Pradesh Satellite Application Centre (APSAC) Manuals and survey reports. To analyze the crop concentration index at the mandal level and its regional variations, Bhatia's Location Quotient Method was employed. This method considers the index values to be directly proportional to the levels of crop concentration.

$$\text{Crop concentration index (CCI)} = \frac{a/b}{a'/b'}$$

Where, a is the area of particular crop in the unit area
b is the total cropped area in the unit area
a' is the area of crop in the entire region
b' is the area of all crops in the entire region

(B). for the delineation of Crop Diversification regions in the study area, Gibbs and Martin Technique (1962) has been used which is Expressed as follows:

$$\text{Crop diversification index} = 1 \frac{\Sigma X^2}{(\Sigma X^2)}$$

Where;
X is the percentage of total cropped area occupied an individual crop.

RESULTS AND DISCUSSION

Spatial patterns of crop concentration in Tungabhadra River Basin of Kurnool district in 2019-20

The index of concentration of paddy, jowar, bajra, maize, total minor millets, red gram, Bengal gram, other pulses, chillies, condiments and spices, fruits and vegetables, cotton, ground nut, sunflower, castor, other oil seeds, tobacco crops for the year 2019-20 has been worked out adopting Bhatia method. The basin comprises of 30 mandals, out of which 21 mandals are fully covered while the remaining 9 mandals are partially covered. Consequently, we have collected complete data from the 9 mandals that were fully covered. so, the total geographical area is 935665 ha [18-19].

Paddy

The total cultivated land area within the basin for the given year amounts to approximately 643,521 hectares, representing 68.77% of the basin's total geographical area. Amongst this, 16,696 hectares are specifically allocated for the cultivation of Paddy, accounting for 2.59% of the overall cropped area. The crop concentration index reveals that there are fourteen mandals with a high concentration of crops, three mandals with a medium concentration, and eleven mandals with low concentration and two mandals are no concentration. Spatial distribution analysis indicates that the northern and north western mandals within the basin exhibit a high concentration of crops. In contrast, the eastern and southern regions of the basin demonstrate a low concentration. Notably, three mandals, namely Orvakal, Miduthur, and Krishanagiri, display a medium level of crop distribution. The Spatial distribution of crop concentration is shown in the (Fig 2, Table 1).

Jowar

The Jowar crop encompasses a total cropped area of approximately 15,319 hectares, representing 2.38% of the overall cropped area. Analysis of the crop concentration index reveals that there are eleven mandals exhibiting a high concentration of Jowar cultivation, while ten mandals display a medium concentration, and nine mandals exhibit a low concentration. Spatial distribution patterns indicate that Jowar cultivation is predominantly concentrated in the north-eastern and south-eastern regions of the basin, with a medium concentration observed in the western and southern areas. Conversely, the central and north-western mandals of the basin exhibit a low concentration of Jowar cultivation. The Spatial distribution of crop concentration is shown in the (Fig 3, Table 1).

Bajra

The present study reveals that the total cropped area under bajra cultivation in the basin is approximately 7023 hectares, which accounts for 1.09% of the total cropped area. The concentration index analysis indicates that the bajra crop concentration is high in eight mandals, medium in seven mandals, and low in twelve mandals of the basin. Notably, the concentration is found to be nil in Kurnool, Miduthur, and J. Bunglow. The spatial distribution analysis further reveals that the concentration of bajra cultivation is high in the north-central and a few mandals in the south, while it is of medium concentration in the central part of the basin. Conversely, the low concentration of bajra cultivation is observed in the eastern, north-western, and south-western mandals of the basin. The Spatial distribution of crop concentration is shown in the (Fig 4, Table 1).

Maize

The present study reveals that the total cropped area dedicated to Maize cultivation in the basin is approximately 24,263 hectares, which accounts for 3.77% of the total cropped area. The concentration index analysis indicates that there are nine mandals with high concentration, two mandals with medium concentration, and fourteen mandals with low

concentration. Additionally, five mandals exhibit no concentration. The spatial distribution analysis reveals that the Maize cultivation concentration is high in the north-eastern part of the basin. Furthermore, the medium concentration is observed in two mandals, namely Kodumur and Yemmiganur mandals, while the low concentration is found in the north-western, central, and western parts of the basin. The spatial variation in maize cultivation within the Tungabhadra River basin indicates significant differences. The Spatial distribution of crop concentration is shown in the (Fig 5, Table 1).

Table 1 Mandal wise crop concentration Iin Tungabhadra River basin of Kurnool district

S.no	MANDAL	RICE	JOWER	BAJRA	MAIZE	MINOR MILLETS	RED GRAM	BENGAL GRAM	OTHER PULSES	CHILLIES	CONDIMENTS AND SPICES	FRUITS AND VEGITABLES	COTTON	GROUND NUT	SUNFLOWER	CASTOR	OTHER OILSEEDS	TOBBACCO
1	Kurnool	1.28	1.85	0.00	2.30	0.67	0.53	2.26	0.33	0.85	0.60	2.40	0.61	0.15	1.43	0.61	0.00	6.67
2	Kallur	0.23	3.46	0.08	1.79	1.39	0.93	1.23	0.14	0.02	0.95	1.44	1.04	0.21	5.25	0.70	3.38	1.79
3	Orvakal	0.61	2.26	0.03	1.51	1.15	1.40	2.04	0.60	0.12	1.37	1.38	0.64	0.09	4.60	0.60	1.12	10.03
4	Kodumur	0.36	1.69	0.94	0.53	2.08	0.70	1.90	0.04	0.00	0.51	1.33	1.04	0.55	2.87	0.78	0.22	0.06
5	Gudur	0.03	2.05	0.32	0.02	0.20	0.14	1.70	0.01	0.25	0.26	0.51	1.72	0.16	0.28	0.12	0.06	0.31
6	C.Belagal	1.75	0.74	0.59	1.56	0.54	0.22	0.29	0.02	0.86	0.58	3.53	1.32	0.38	0.44	0.08	0.61	0.00
7	Dhone	0.14	0.51	0.92	0.00	1.88	4.42	0.21	0.21	0.05	0.22	1.39	0.06	2.25	0.93	2.53	0.35	0.00
8	Bethamcherla	0.42	0.72	2.76	0.44	11.52	6.25	0.57	0.69	0.00	0.80	1.06	0.04	0.30	6.61	0.53	3.75	0.00
9	Veldurthy	0.09	1.66	0.15	0.24	2.27	3.14	0.50	0.15	0.79	0.80	0.56	0.78	1.06	1.44	2.09	0.17	0.17
10	Krishnagiri	0.51	0.35	1.11	0.11	0.27	1.25	0.25	0.00	0.00	0.18	0.76	0.58	3.07	0.34	3.36	0.84	0.02
11	Peapully	0.11	1.04	3.84	0.04	2.14	3.87	0.14	0.23	0.00	0.56	1.01	0.18	2.20	0.92	2.13	0.56	0.00
12	Nandikotukur	1.59	0.25	0.01	9.66	0.53	0.66	2.69	4.44	0.00	0.45	1.16	0.05	0.06	0.36	0.02	0.50	2.48
13	Miduthur	0.81	1.17	0.00	3.69	1.37	0.88	2.18	1.34	3.20	1.35	0.61	0.63	0.01	0.04	0.08	1.03	12.48
14	Pagidayala	5.44	0.35	0.02	11.98	0.07	0.58	1.10	9.31	0.68	0.32	0.36	0.09	0.11	6.35	0.01	0.18	0.95
15	J.Bunglow	1.78	0.53	0.00	9.62	0.14	1.34	1.38	6.17	0.31	0.36	0.89	0.33	0.06	0.94	0.03	0.00	0.93
16	Adoni	1.51	0.75	0.67	0.01	0.28	0.09	0.30	0.25	1.99	1.26	0.50	1.71	0.97	1.06	0.19	1.50	0.00
17	Kowthalam	2.25	0.70	0.28	0.01	0.21	0.07	0.12	0.17	3.18	1.13	0.33	2.07	0.17	0.26	0.14	0.08	0.00
18	Kosigi	2.90	0.24	0.82	0.03	0.08	0.12	0.01	0.31	2.46	0.89	1.36	1.63	0.84	0.00	0.75	0.05	0.00
19	Peddakadubur	3.34	0.01	0.30	0.18	0.22	0.08	0.04	0.20	4.76	1.24	0.95	1.56	0.95	0.00	0.31	0.32	0.00
20	Yemmiganur	1.26	0.63	1.49	0.62	0.83	0.16	0.17	0.48	2.53	0.98	1.29	1.63	0.61	0.18	1.02	0.00	0.00
21	Nandavaram	2.98	0.41	1.46	0.49	1.11	0.15	0.42	0.43	2.14	1.58	0.72	1.76	0.13	0.00	0.18	0.05	0.00
22	Mantralayam	2.59	0.43	0.27	0.02	0.12	0.17	0.27	0.49	1.74	0.56	0.59	2.08	0.07	0.00	0.11	0.00	0.00
23	Alur	0.01	1.94	0.31	0.00	0.45	0.04	3.28	0.20	0.27	1.67	0.21	1.08	0.32	0.28	0.15	0.03	0.00
24	Aspari	0.08	0.93	0.65	0.03	0.76	0.09	1.91	0.44	0.32	1.38	0.74	1.25	0.77	0.13	0.14	8.68	0.00
25	Holagunda	2.64	2.77	0.20	0.01	0.04	0.04	0.67	0.06	1.46	0.34	0.08	1.88	0.24	1.70	0.00	0.52	0.00
26	Pattikonda	0.00	0.73	0.36	0.00	0.10	0.34	1.61	1.52	0.37	0.77	1.01	0.88	1.85	0.00	1.12	0.87	0.00
27	Devanakonda	0.16	0.34	0.89	0.01	0.32	0.27	0.17	0.97	0.28	0.39	1.18	1.06	2.63	0.04	1.75	0.03	0.00
28	Tuggali	0.00	0.61	3.15	0.00	0.16	1.30	0.63	3.83	0.24	0.17	0.37	0.52	2.69	0.00	3.44	0.00	0.00
29	Maddikera	0.05	1.04	3.57	0.00	0.21	0.73	2.79	2.83	0.27	5.45	0.47	0.17	1.23	0.05	1.40	0.16	0.00
30	Gonegandla	1.15	0.42	1.72	1.08	0.93	0.36	0.21	1.62	1.64	0.94	2.45	1.11	1.04	0.07	1.73	0.31	0.00

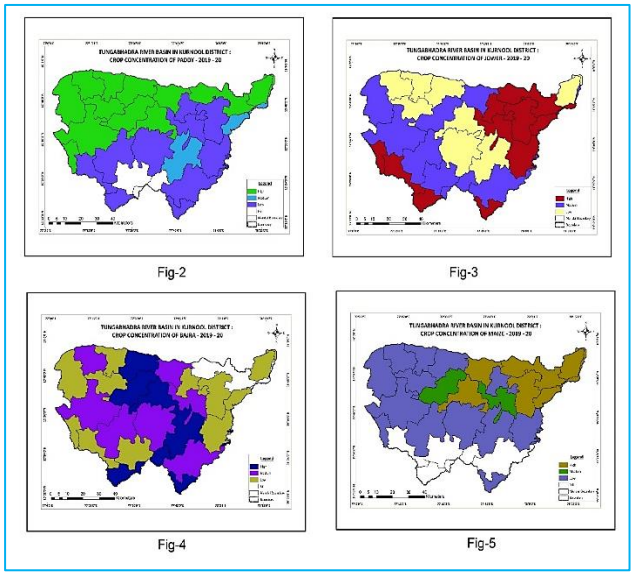


Fig-2 Fig-3

Fig-4 Fig-5

Minor millets

The minor millets exhibit a total cropped area of approximately 3,888 hectares, representing a mere 0.60% of the overall cultivated land. The concentration index analysis reveals a significant concentration of minor millets in nine mandals, a moderate concentration in six mandals, and a low concentration in fifteen mandals within the basin. Spatially, the eastern mandals of the basin exhibit a high concentration of minor millets, while the western and central mandals display a lower concentration. The Spatial distribution of crop concentration is shown in the (Fig 6, Table 1).

Red gram

The red gram crop encompasses a total cultivated area of approximately 60,564 hectares, representing 9.41% of the overall cultivated land within the basin. The concentration index reveals that red gram cultivation exhibits high concentration in eight mandals, medium concentration in seven mandals, and low concentration in fifteen mandals across the basin. Spatial analysis further indicates that the highest concentration of red gram cultivation is observed in the eastern and south-eastern regions of the basin, while the north-eastern region exhibits a medium concentration. Conversely, the western, northern, and central mandals of the basin display a low concentration of red gram cultivation. The Spatial distribution of crop concentration is shown in the (Fig 7, Table 1).

Bengal gram

The Bengal gram crop covers a total area of approximately 82,620 hectares, which accounts for 12.84% of the overall cropped area. The index of concentration reveals that this crop exhibits a high concentration in thirteen mandals, a medium concentration in four mandals, and a low concentration in thirteen mandals within the basin. The spatial distribution analysis indicates that the highest concentration of Bengal gram is observed in the north-eastern and south-western regions of the basin. Additionally, a medium concentration is observed in four specific mandals, namely Bethamcherala, Veldurthy, Holagunda, and Tuggali, within the basin. Conversely, the concentration of Bengal gram is low in the northwestern central and south-eastern parts of the basin. The Spatial distribution of crop concentration is shown in the (Fig 8, Table 1).

Other pulses

The total cultivated area dedicated to other pulses amounts to approximately 6,553 hectares, representing 1.02% of the overall cultivated area. The concentration index reveals that a significant concentration is observed in eight mandals, while a moderate concentration is found in three mandals, and a low concentration is recorded in eighteen mandals within the basin. Notably, no concentration is observed in the Krishanagiri mandal. The spatial distribution analysis indicates that the concentration is high in the mandals located in the north-east and southern regions of the basin. Additionally, a moderate concentration is observed in three mandals, namely Orvakal, Bethamcherla, and Devanakonda, with in the basin. Conversely, the concentration is low in the mandals situated in the north-western and eastern areas of the basin. The Spatial distribution of crop concentration is shown in the (Fig 9, Table 1).

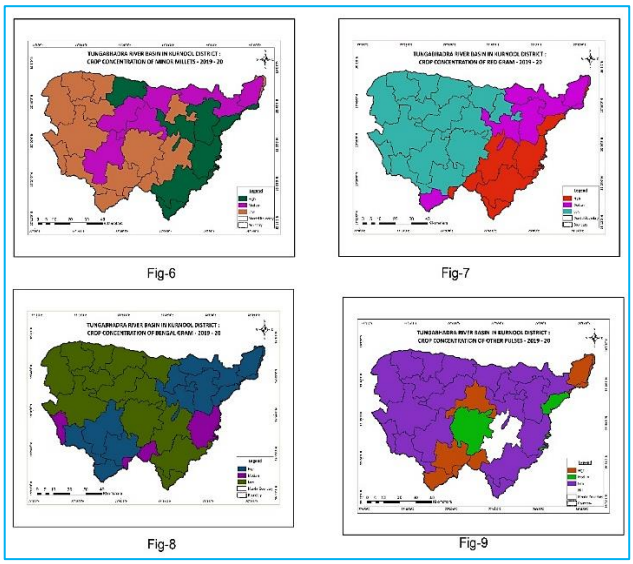


Fig-6 Fig-7

Fig-8 Fig-9

Chillies

The total cultivated area dedicated to chillies crops in the studied region amounts to approximately 7,427 hectares, representing 1.15% of the overall cultivated area. The concentration index reveals that chillies cultivation is highly concentrated in ten specific administrative divisions, moderately concentrated in four divisions, and minimally concentrated in ten divisions within the basin. Furthermore, the spatial distribution analysis indicates that chilli cultivation is predominantly concentrated in the western region of the basin. Additionally, moderate concentrations of chillies cultivation are observed in the mandals of Kurnool, C.Belagal, Veldurthy, and Pagidayala within the basin. Conversely, chili cultivation exhibits low concentrations in the southern and a few mandals in the eastern part of the basin. The Spatial distribution of crop concentration is shown in the (Fig 10, Table 1).

Condiments and spices

The total cultivated area dedicated to the cultivation of Condiments and Spices amounts to 19,230 hectares, representing 2.99% of the overall cultivated area. The distribution of this crop exhibits a high concentration in nine mandals, a medium concentration in twelve mandals, and a low concentration in nine mandals within the basin. Spatially, the condiments and spices crop concentration are notably high in the western and a few eastern mandals of the basin. Additionally, the concentration of this crop is of medium intensity in the northern, north central and southern mandals of the basin. Conversely, the southern mandals of the basin display a low concentration of Condiments and Spices cultivation. The Spatial distribution of crop concentration is shown in the (Fig 11, Table 1).

Fruits and vegetables

The aggregated cultivated land area dedicated to the cultivation of fruits and vegetables amounts to 41,850 hectares, representing 6.50% of the overall cultivated land area. The concentration index reveals that a significant concentration is observed in fourteen mandals, while a moderate concentration is found in ten mandals, and a low concentration is recorded in six mandals within the basin. Geographically, the concentration is spatially prominent in the mandals situated in the north-east, central, and southern regions of the basin. Conversely, the concentration is moderate in the mandals located in the western and eastern parts of the basin. Furthermore, the concentration is relatively low in the western and south-western mandals of the basin. The Spatial distribution of crop concentration is shown in the (Fig 12, Table 1).

Cotton

The total cultivated land area dedicated to Cotton is 40,182 hectares, representing 37.32% of the overall cultivated land area. The concentration index reveals that this crop exhibits a high concentration in sixteen mandals, a medium concentration in seven mandals, and a low concentration in seven mandals within the basin. Spatial analysis indicates that the highest concentration of Cotton is observed in the western, northern, and central regions of the basin. In the eastern mandals, the concentration of this crop is moderate. Conversely, the north-eastern and southern mandals of the basin exhibit a low concentration of cotton cultivation. The Spatial distribution of crop concentration is shown in the (Fig 13, Table 1).

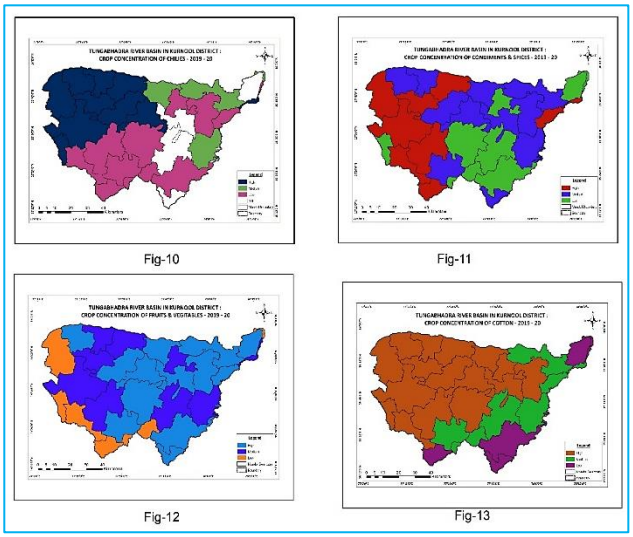


Fig-10 Fig-11

Fig-12 Fig-13

Groundnut

The cumulative cultivated land area within the Ground is measured at 95,239 hectares, representing 14.80% of the overall cultivated land area. The distribution of this crop exhibits a high concentration in nine mandals, a medium concentration in six mandals, and a low concentration in fifteen mandals within the basin. Spatial analysis reveals that the southern and central regions of the basin exhibit a high concentration of ground nut cultivation. Conversely, the western mandals of the basin demonstrate a medium concentration, while the northern, north-eastern, and select south-western mandals exhibit a low concentration of ground nut cultivation. The Spatial distribution of crop concentration is shown in the (Fig 14, Table 1).

Sunflower

The total cultivated area dedicated to sunflower cultivation amounts to 925 hectares, representing a mere 0.14% of the overall cultivated area. The distribution of sunflower cultivation exhibits a high concentration in nine mandals, a medium concentration in three mandals, and a low concentration in twelve mandals within the basin. However, sunflower cultivation is completely absent in six mandals. The spatial analysis reveals that the eastern and certain western mandals exhibit a high concentration of sunflower cultivation, while the central and north-eastern regions of the basin display a low concentration. Furthermore, sunflower cultivation is nonexistent in the north-western and certain southern mandals of the basin. The Spatial distribution of crop concentration is shown in the (Fig 15, Table 1).

Castor

The total cultivated area dedicated to castor is 16,067 hectares, representing 2.50% of the overall cropped area. The distribution of Castor cultivation varies across the basin, with high concentrations observed in ten mandals, medium concentrations in six mandals, and low concentrations in thirteen mandals. Notably, the mandal of Holagunda does not engage in Castor cultivation. Spatially, the southern and central mandals of the basin exhibit a high concentration of Castor cultivation, while the north-eastern part of the basin demonstrates a medium concentration. Conversely, the western and northern regions of the basin display a low concentration of Castor crop cultivation. The Spatial distribution of crop concentration is shown in the (Fig 16, Table 1).

Other oil seeds

The total cultivated area dedicated to other oil seeds is 2,078 hectares, which accounts for 0.32% of the overall cultivated area. The index of concentration reveals that this crop exhibits high concentration in six mandals, medium concentration in five mandals, and low concentration in fourteen mandals within the basin. Approximately five mandals do not cultivate this crop at all. The spatial distribution analysis indicates that the highest concentration of other oil seeds is found in the mandals of Kallur, Orvakal, Bethamcherla, Miduthur, Adoni, and Aspari within the basin. On the other hand, the concentration of other oil seeds crops is medium in C. Belagal, Krishnagiri, Peapully, Holagunda, and Pattikonda mandals of the basin. The concentration of other oil seeds crops is low in the central, north-western, and a few mandals in the eastern and south-western regions of the basin. The Spatial distribution of crop concentration is shown in the (Fig 17, Table 1).

Tobacco

The total cultivated area dedicated to tobacco cultivation in the basin amounts to 3,595 hectares, representing a mere 0.56% of the overall cultivated area. The index of concentration reveals that tobacco cultivation is highly concentrated in five mandals, moderately concentrated in two mandals, and has a low concentration in four mandals within the basin. Approximately nineteen mandals do not engage in tobacco cultivation. The spatial distribution analysis indicates that tobacco cultivation is highly concentrated in the mandals of Kurnool, Kallur, Orvakal, Nandikotukur, and Miduthur. The concentration of tobacco cultivation is moderate in Pagidayala and J.Bunglow mandals. Conversely, the mandals of Kodumur, Gudur, Veldurthi, and Krishnagiri exhibit a low concentration of tobacco cultivation within the basin. The Spatial distribution of crop concentration is shown in the (Fig 18, Table 1).

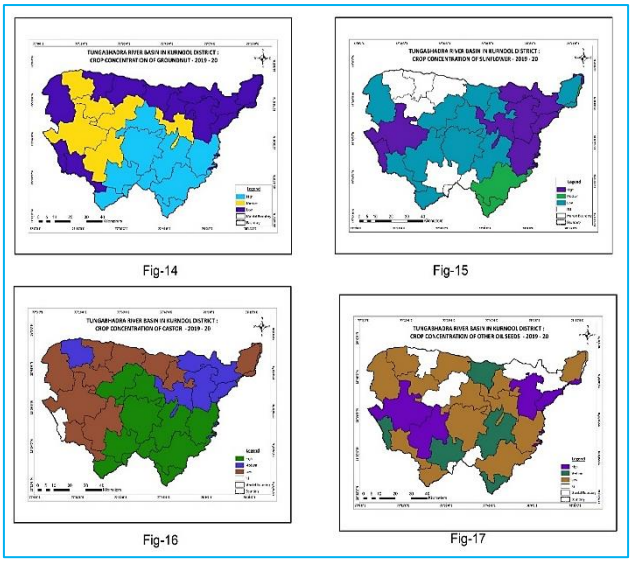


Fig-14 Fig-15

Fig-16 Fig-17

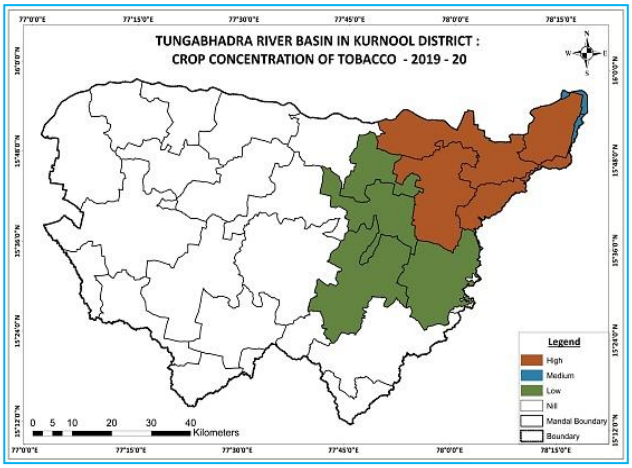


Fig 18

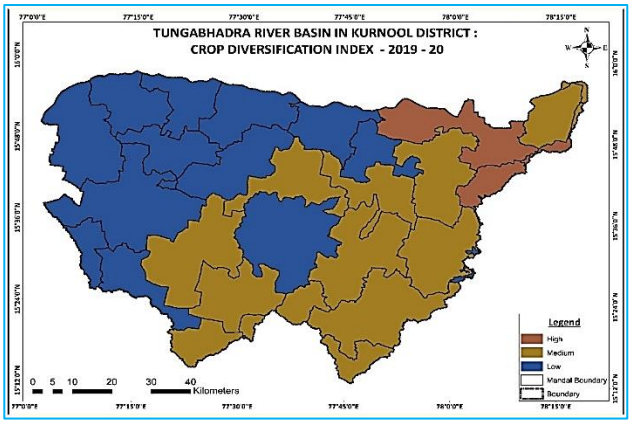


Fig 19

Crop diversification

Crop diversification plays a crucial role in enhancing agricultural productivity and sustainability. Identifying areas with high, moderate, and low levels of diversification can help policymakers and farmers implement targeted strategies to promote diversification and improve overall agricultural outcomes.

Areas with high crop diversification (> 0.80)

High level of crop diversification is found in Kurnool (0.82), Orvakal (0.84) and Miduthur mandal (0.83). Spatially these mandal are in North eastern part of the basin. The Spatial distribution of crop concentration is shown in the (Fig 19, Table 2).

Moderate crop diversification (0.70-0.80)

The mandals in the index exhibit a moderate level of diversification, ranging from 0.70 to 0.80. These mandals include Maddikera (0.80), J.Bunglow (0.80), Kallur (0.79), Veldurthi (0.79), Kodumur (0.77), Pattikonda (0.77), Tuggali(0.77), Gonegandla (0.77), Peapully (0.75), Pagidayala (0.74), Nandikotukur (0.73), Dhone (0.70), Krishnagiri (0.72), Aspari (0.70). The spatial distribution reveals that moderate diversification is observed in the eastern, southern, and a few mandals in the central part of the basin. The Spatial distribution of crop concentration is shown in the (Fig 19, Table 2).

Low crop diversification (>0.70)

The observation of a low level of crop diversification has been made in thirteen mandals, namely Gudur (0.54), C. Belagal (0.69), Devanakonda (0.68), Alur (0.65), Bethamcherla (0.63), Peddakadubur (0.62), Yemiganur (0.61), Mantralyam (0.61), Kosigi (0.60), Adoni (0.57), Nandavaram (0.55), Holagundra (0.49), and Kowthalm (0.39). The spatial distribution of these mandals indicates that they are situated in the north-western and western regions of the basin. The Spatial distribution of crop concentration is shown in the (Fig 19, Table 2).

Table 2 Mandal wise crop diversification index in Tungabhadra River basin of Kurnool district (2019-20)

S. No.	Name of the mandal	CDI	S. No.	Name of the mandal	CDI	S. No.	Name of the mandal	CDI
1	Kurnool	0.82	11	Peapully	0.75	21	Nandavaram	0.55
2	Kallur	0.79	12	Nandikotkur	0.73	22	Mantryalam	0.39
3	Orvakal	0.84	13	Midthur	0.83	23	Alur	0.65
4	Kodumur	0.77	14	Pagidayala	0.74	24	Aspari	0.70
5	Gudur	0.54	15	J. Bunglow	0.80	25	Holagunda	0.49
6	C.Belagal	0.69	16	Adoni	0.57	26	Pattikonda	0.77
7	Dhone	0.70	17	Kowthalam	0.39	27	Devanakonda	0.68
8	Bethamcherla	0.63	18	Kosigi	0.60	28	Tuggali	0.77
9	Veldurthy	0.79	19	Peddakadbur	0.62	29	Maddikera	0.80
10	KrishnaGiri	0.72	20	Yemmiganur	0.61	30	Gonegandla	0.77

CONCLUSION

The spatial variation of major crops in the basin indicates that the contrast is due to topography, climate, socio-economic, and technological factors. It can be observed that the cropping pattern in the Tungabhadra River basin is primarily focused on commercial crops, particularly cotton and groundnut, with food grains such as Bengal gram, red gram, fruits, and vegetables also being cultivated. Cotton is the dominant crop in this region, limiting agricultural diversification. As a result, most of the mandals in the area have a low to moderate index of diversification, with only three mandals, namely Kurnool, Orvakal, and Miduthur, exhibiting high crop diversification. More than 75% of the basin area consists of pediplains, and 70% of the population relies on agriculture for their livelihood. Therefore, crop diversification can be utilized as a tool to improve the economic conditions of small and marginal farmers. The traditional cropping pattern can lead to issues such as decreased productivity and soil fertility. To address these problems, crop rotation, intercropping, and the implementation of micro irrigation technologies such as drip, trickles, and sprinklers are effective measures to enhance soil health, minimize water usage, and reduce soil and water pollution. It is important to carefully manage surface and subsurface water resources and improve irrigation facilities by constructing check dams, percolation ponds, and interlinking canals and tanks to promote good agricultural production. Tungabhadra River basin's agricultural landscape is currently dominated by cotton and groundnut, with limited diversification. By adopting crop rotation, intercropping, and advanced irrigation techniques, and by improving water management infrastructure, the region can enhance its agricultural sustainability and improve the economic conditions of its farming community.

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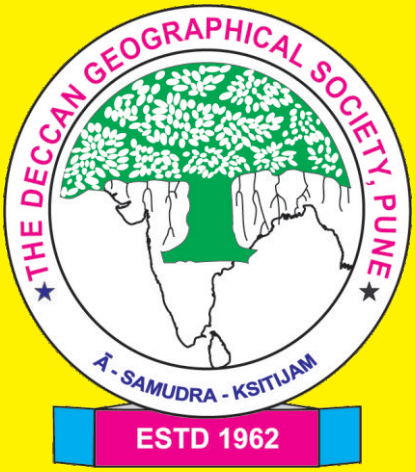
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HUMAN VULNERABILITY AND RISK OF LANDSLIDE HAZARD IN UPPER RAVI RIVER CATCHMENT- A SPATIAL APPROACH

Pooja Sharma, Vishwa B.S. Chandel, Simrit Kahlon, and Som Nath Thakur

Abstract

The paper examines landslide hazard in relation to human vulnerability and risk in River Ravi catchment. The work is built on the understanding that slope failure processes are inherent to mountainous regions, however, vulnerability and risk potential to such a hazard is rooted in human attributes of the landscape. Therefore, an attempt has been made to address the local contexts of landslide vulnerability to highlight human risk using a spatial approach. By taking into account the elements at risk and their exposure levels and vulnerability (physical, social, economic and environment), the research highlights significant variations in risk potential. Chamba town and its surroundings emerge as the most risk prone area on all accounts while remotely located areas on account of low development exhibit relatively low risk. The analysis establishes a positive relation between landslide risk and anthropogenic activities; high degree of risk in populated and developed areas underscores seriousness of problem that requires proactive mitigation strategies.

Introduction

The burgeoning risk of disasters is a testimony to the severity of undesirable events of both natural and human origin. The mounting impact and devastations observed globally is attributed to increasing frequency and magnitude of disasters. However, occurrence alone does not define disaster risk. It is the combined effect of hazards coinciding with vulnerability of exposed elements and lack of societal capacity to cope with adverse situations that yields disturbance and stressors on human population. Disasters in the 21st century has paralyzed the world (Ismail-Zadeh and Cutter, 2015) especially in the Asia-Pacific region where according to number of disaster events, death toll and people affected was maximum in recent years. The contemporary thinking places disaster risk analysis at the center of sustainable development practices. Risk reduction has become the most advocated initiative after the adoption of Sendai Framework for Disaster Risk Reduction (2015-2030).

The framework specifically focuses on understanding risk and strengthening risk governance for building resilience against the impacts of disasters. The recent catastrophic events in India, viz. cyclones in the Indian Ocean, floods in Uttarakhand in 2021, landslides and flash floods in Himachal Pradesh in 2023 have further highlighted the necessity of coordinated efforts to lessen disaster risk and human vulnerability. It has been estimated that risk due to disasters is likely to increase by 40 per cent by 2030 (UNDRR, 2022). In this context, vulnerability and risk assessment, therefore, becomes instrumental in ensuring effective disaster mitigation. Disasters and disaster risk have spatial specificities and locational predisposition. The nature, type, mechanisms, and impacts of disasters are guided by geographical and locational attributes. For mountainous areas, landslide is amongst the devastating processes causing tremendous loss of lives and infrastructure. In India, 48 major landslides recorded in the recent past has killed over 5000 people, affected 4 million and caused loss of US$ 55 million (EM-DAT, 2016). Such events have the propensity to occur in mountainous landscapes where risk factor is amplified by geo-tectonic attributes in association to accelerated human-induced landscape transformations (Sharma & Kumar, 2008; Chandel, Brar, & Chauhan, 2011). The geo-tectonic characteristics certainly make an area susceptible to slope failures, however, it is the human-induced changes that adds to the problem by making such fragile unstable slopes vulnerable (Barnard et al., 2001) risking human population and infrastructure. Therefore, contemporary research must address the local contexts of hazard, human vulnerability, and risk for appropriate solution to multidimensional problem of disasters.

Study Region

Ravi River catchment in Himachal Pradesh extends over four tehsils, viz. Chamba, Bharmour, and Holi of Chamba district and Multhan tehsil of Kangra district. Situated between the Pir-Panjal range in the north, and the Dhauladhar mountains in the south, a high altitudinal range (700-6100 meters above the mean sea level) has produced diverse micro-climates in this catchment. Summers are mildly warm whereas winters are severely cold. The mean annual precipitation is more than 1300 mm; a significant decrease in rainfall takes place to the north-eastern and eastern parts. Winter precipitation is driven by the western disturbances that also cause heavy snowfall in areas above 2000 meters elevation. Ravi is the main river fed by glacial melt and several tributary streams. The geomorphology of the areas is carved by tectonic and fluvioglacial processes. Active faults, joints, and lineaments have dislocated slopes thus making the landscape susceptible to slope failure.

A number of landslides observed along roads indicate human alteration of slopes (Chandel, Brar, & Chauhan, 2011; Sharma, Chandel, & Kahlon, 2018) for infrastructure and developmental activities in recent years (Thakur, Kahlon, & Bhutani, 2016). In such a scenario, it is likely that risk to human life and livelihood may get amplified posing serious challenges in times to come.

Objectives

The paper intended to examine the exposure, spatial vulnerability and risk to landslide hazard in the catchment of Ravi River in Chamba district of Himachal Pradesh. The key objectives were (a) to analyse the elements of risk and their exposure to landslides in the catchment and to analyse the vulnerability and risk potential to landslide hazard in the study area

Database and Methodology

This work offers an insight to human vulnerability and exposure of elements at risk. Primary data involved identification of past landslides through field survey wherein an inventory template was designed to record information on location, type, size, material involved, and key terrain characteristics of landslide sites. The researcher logged 100 sites of slope failures during the fieldwork out of which debris slides, rock slides, slumps, and rock & debris fall were the most common slope failure (75 per cent) type; the subsidence and lateral spread was observed mainly along road edges adjacent to river Ravi. It was noticed that rock fall sites are associated with exposed slopes in proximity to road construction sites. Similarly, earth flow, mud flow, and debris flow were spotted at numerous places. Almost every site of earth flow revealed reactivated landslides. Debris flows were noticed near streams, roads, and in areas where toe erosion by streams is prevalent. In addition to physical factors, anthropogenic activities have significantly triggered slumps in agricultural areas and slides along road construction and widening sites. The inventory on landslide sites and types formed the basis to evaluate risk factor by taking into account exposure, vulnerability, and the amount of elements-at-risk. The level of exposure (association between elements-at-risk and landslide hazard) was computed via spatial overlay of susceptibility (landslide probability under given set of terrain conditions) and vulnerability of elements-at-risk. This paper examined vulnerability in terms of 17 elements of risk. The index value closer to 1 indicate very high potential for damages and vice a versa. The risk assessment involved vulnerability calculation using Spatial Multi-Criterial Evaluation (SMCE) method using AHP model. The reliability of assessment was verified through

consistency index (CI) and consistency ratio (CR); its values for all elements-at-risk did not exceed the threshold value (0.1) which confirms the reliability of weightages assigned by the research. The study focussed on four vulnerability subgroups. Physical vulnerability expresses potential for physical impacts on built-up environment on account of landslide manifestation. Its indicators include settlements, roads (National, State, and Village roads), and helipads. Social vulnerability refers to potential impact on exposed societal groups. Here, we have defined social vulnerability in terms of population density (total, female and child population), essential and non-essential services (euclidean distance to healthcare facility, educational facility, postal facility, nutritional centers, and public distribution shops. Economic vulnerability is evaluated in terms of exposure to cropland, plantation, and forest cover whereas the environmental vulnerability is evaluated in terms of potential impacts on protected forests, reserved forests, and water bodies. The overall vulnerability was computed by aggregating physical, social, economic, and environmental vulnerability using weighted linear combination. Finally, the risk analysis was done through an indicator-based approach using input layers (landslide susceptibility, vulnerability, and amount of exposed elements-at-risk) via spatial overlay wherein risk factor was analysed for all elements-at-risk to produce the overall risk assessment.

Results and Discussion

Exposure of Elements-at-Risk

The 'elements-at-risk' represents people, assets, and things valuable to individuals or community that may get affected or suffers from loss due to hazard manifestation. For geographers, elements-at-risk (people, buildings, and infrastructure etc.) have locational stipulations; their exposure depends on proximity to hazard and degree of susceptibility. Here, we examined exposure of 17 elements of risk (Table-1). The physical element at risk defined in this work relates to settlements that being located in the vicinity of observed landslides have a potential to suffer from damages. Total area under settlements is 5007.53 hectare out of which majority area falls in Chamba (3927.45 hectare or 78.43%) tehsil. About 2313.81 hectare (46.20 per cent) has high to very high exposure (index value ≥ 0.6) to landslides while another 31.70 % has moderate exposure. The degree of exposure exhibits spatial variation; about 50 per cent settlements in Chamba especially around the town have high exposure and another 33 percent are moderately exposed to landslide hazard. Settlements in Bharmour (30%),

Table-1: Exposure of Elements-at-Risk

	Settlement Area		Total Population		Female Population		Child Population		Health Facilities	
Exposure Level	Hectare	%	Persons	%	Persons	%	Persons	%t	Number	%
Very Low (Below 0.2)	247.30	4.94	17649	8.59	8708	8.50	2527	9.11	23	10.18
Low (0.2 - 0.4)	858.76	17.15	72616	35.33	36056	35.20	9076	32.72	60	26.55
Moderate (0.4 - 0.6)	1587.66	31.71	58127	28.28	28890	28.20	8353	30.11	69	30.53
High (0.6 - 0.8)	1682.85	33.61	45051	21.92	22728	22.19	6176	22.26	54	23.89
Very High (0.8-1)	630.96	12.60	12085	5.88	6053	5.91	1609	5.80	20	8.85
Total	5007.53	100	205528	100	102435	100	27741	100	226	100

	Other Essentials*		Educational Institutions		Area under Roads		Helipad		Area under Cropland	
Exposure Level	Number	%	Number	%	Hectare	%	Number	%	Hectare	%
Very Low (Below 0.2)	120	13.06	79	9.43	724.78	8.85	0	0.00	716.08	5.38
Low (0.2 - 0.4)	253	27.53	249	29.71	1734.41	21.19	1	20.00	2162.06	16.25
Moderate (0.4 - 0.6)	273	29.71	242	28.88	2325.57	28.41	2	40.00	3680.16	27.67
High (0.6 - 0.8)	222	24.16	222	26.49	2407.29	29.41	2	40.00	4799.28	36.08

Contd...

Very High (0.8-1)	51	5.55	46	5.49	994.49	12.15	0	0.00	1944.09	14.62	
Total	919	100	838	100	8186.54	100	5	100	13301.67	100	
	Area under Plantations		Area under Forest Land		Area under Protected Forest		Area under Reserved Forest		Area under Water Bodies		
Exposure Level	Hectare	%	Hectare	%	Hectare	%	Hectare	%	Hectare	%	
Very Low (Below 0.2)	6.68	6.79	50705.32	79	8037.76	64.21	2189.38	34.26	112.62	9.38	
Low (0.2 - 0.4)	19.96	20.29	28205.25	249	3221.78	25.74	2304.54	36.06	121.85	10.15	
Moderate (0.4 - 0.6)	34.27	34.84	14237.51	242	961.1	7.68	1315.02	20.58	294.36	24.51	
High (0.6 - 0.8)	31.49	32.01	6018.01	222	263.65	2.11	515.81	8.07	412.03	34.31	
Very High (0.8-1)	5.97	6.07	1001.17	46	33.63	0.27	66.33	1.04	260	21.65	
Total	98.37	100	100167.3	838	12517.92	100	6391.08	100	1200.86	100	

*Other Essential Services includes three types of elements- Postal Services, Nutritional Centres and Public Distributional Services (PDS)

Holi (47.13%) and Multhan (21.5%) tehsils also shows a considerable area under high to very high exposure. The exposure of demographic elements (total population, female population and child population) reveals significant facts. The study area has a total population of 205528 residing in 537 villages (including 226 uninhabited). Population concentration exhibits influence of proximity to urban centre and roads. People of different ages, gender, and other demographic characteristics display distinct exposure levels. Females are amongst the most vulnerable due to social inequalities and lack of learning and economic opportunities. Similarly, exposure is also high for child population due to their dependency, lack of knowledge and ability to cope with disasters on their own. Over half of the total population (56.08%), female (56.30%), and child (58.17%) population is exposed to landslides hazard of moderate to very high level (index value ≥ 0.4). As much as a quarter (27.80 %, 28.10%, and 28.06 %, respectively) of these demographic groups has high-very high (≥ 0.6) exposure. In terms of absolute number, Chamba tehsil has the largest proportion of total population as well as female population and child population exposed to landslide hazard.

The provision of essential and non-essential services is vital to deal with disaster risk. The availability and accessibility to such services not only facilitate effective response but is crucial during disaster emergency. Health services are vital to ensure quick medical support for disaster-affected population. The study area has provision of medical services at 226 locations (Table-1), of which 142 are in Chamba tehsil, 59 in Bharmour, and 24 in Holi tehsil whereas Multhan tehsil has only one dispensary. The majority facilities are dispensary, primary health sub-centre, and primary health centre that provides basic health services only. However, lack of adequate doctors, staff, and medicines was observed during the field work. Moreover, these centers do not have adequate provisions for disaster emergency as in-patient care facility is absent except for a few locations. As per the exposure analysis, more than 63 per cent such services have moderate to very high exposure of landslides and one third fall in high to very high exposure class. Chamba tehsil has maximum number (142) of different medical services available of which 71.83 per cent falls in moderate to very high exposure; this proportion is 42.37 % and 62.50 % for Bharmour and Holi tehsils whereas Multhan tehsil being remotely located and having only one medical institution exhibits moderate exposure to landslides. Poor road connectivity is a challenge for providing emergency services in the area especially during the monsoon season and winters wherein landslides induced road blockades leads to delayed response of medical teams.

The study area is predominantly rural; life in such areas rely heavily on services such as post offices, sub-post offices, post telegraph offices, public distribution system, integrated child development scheme, Anganwadi centres, and nutritional centres. Any discontinuity in the availability of such services has serious impact on rural life. These services have locational bias; interior villages are either devoid of such provisions or services are inadequate, especially in Multhan tehsil. The exposure analysis shows that 29.71 per cent (Table-1) of such essential services has high to very high exposure. Chamba (33.65%) tehsil has the maximum proportion of these services under high to very high exposure followed by Bharmaur (23.30%) tehsil. The distribution of services is more in Chamba and Bharmour compared to other two tehsils where these are almost absent, particularly in Multhan. The exposure of educational institutions to landslide hazard is higher during the monsoons wherein several incidents in the past occurred in the proximity to such institutions. The study area has a total of 838 different educational facilities ranging from elementary schools to higher education institutes. Out of these, nearly a third (31.98%) have high to very high exposure of landslide hazard. The higher educational facilities are few and have low to moderate exposure. However, primary and middle schools have considerable exposure ranging from moderate to high level. As many as 214 (35.08%) such facilities in Chamba, 22 (26.19%) in Holi, and 32 (23.53%) in Bharmour has high to very high exposure. Multhan tehsil being a remote tribal region does not have higher educational institutes and number of schools is limited.

Therefore, its low to moderate exposure level is due to the unavailability of facilities and not because of the higher level of safety measures. Transportation is a crucial element in hilly regions that establishes links between sparsely and remotely located settlements and facilitates key services. Out of the total 537 villages, only 132 villages have access to all-weather roads. The total length of roads in the area is 951.49 km; however, road access is limited to certain villages. Moreover, many settlements have poor road conditions; most are unmetalled and in dilapidated conditions due to landslides, especially during monsoon and winter seasons. It was observed during the fieldwork that roads are highly vulnerable to landslides; frequent blockade restricts the movement of people and halts supply of key services. Nearly 41.55 % area along roads has high to very high exposure. The road network is denser in Chamba tehsil wherein 49.52 % land area along the roads has high exposure to landslides. Similarly, nearly 43.56 % and 24.09 % land along the roads in Holi and Bharmour tehsils have high to very high exposure of slope failure.

In addition to road transportation, there are 5 helipads out of which three are in Chamba and one each in Bharmour and Holi tehsil. Out of these, 2 helipads in Chamba are exposed to a high level and another 2 located in Chamba and Holi show a moderate level of exposure to landslides. A major source of livelihood in the area is agriculture and allied activities. Such activities are done on terraced farms and valley slopes susceptible to landslides during high intensity rainfall. This results in economic loss and stressed livelihood. Total cropland in the study area is 13301.67 hectare; more than 3/4th is in Chamba tehsil alone while other tehsils account for a much smaller area under cropland. Out of the total area of 98.37 hectare under plantation, Holi tehsil leads with 40.2 hectare followed by Chamba (33.25 hectare), and Bharmour (24.92 hectare). In contrast, people in Multhan tehsil so far are dependent on subsistence farming. Overall, a substantial land under agriculture (50.70%) and plantation (38.08%) displays high to very high exposure (Table-2). A significant level of exposure reflects from the fact that 81.45 % cropland in Chamba, more than 75 % in Holi, 66 % in Multhan, and 62 % in Bharmour shows moderate to very high exposure. Landslide inventory and field visits reveals several landslide sites in natural settings as well. In Holi tehsil, 31 hectares of protected forests have very high exposure. Approximately 108 hectares in Bharmour and 136 hectares in Chamba has very high to moderate exposure; the same is also observed for areas under reserved forests.

Vulnerability to Landslides

Vulnerability is a crucial component of disaster risk analysis; it is dynamic and determined by physical, environmental, social, and economic factors. Physical vulnerability has direct impact on population and infrastructure. Here, we have analysed physical vulnerability of key elements-at-risk, i.e., settlements, roads (national, state-highway, and village roads), and helipads on a relative scale of '0' (no damage) to '1' (total damage); their weightage were defined depending on each element's relative importance. The analysis shows only 0.75 % of the total area has very highly vulnerability (index ≥ 0.8) to landslides while another 14 % has moderate to high vulnerability (Table-2). Chamba (64.83 hectare) has the largest proportion under very high vulnerability followed by Holi (5.99 hectare) and Bharmour (3.93 hectare). Since population is concentrated in low altitude zones and along the roads, the physical vulnerability too is confined to such areas. It is higher in the western parts where settlements are more and larger. It has also been observed that vulnerability decreases towards higher altitudes and in the interior areas.

The other tehsils have low vulnerability that is confined to the valley floor and areas adjacent to roads and settlements.

Table-2: Vulnerability Assessment (Area in Hectares)

Physical Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	1373.36	4972.53	711.64	1.61	7059.14	71.02
Low (0.2-0.4)	194.05	1074.3	116	2.37	1386.72	13.95
Moderate (0.4-0.6)	74.75	817.78	92.19	1	985.72	9.92
High (0.6-0.8)	38.06	361.96	32.72	0.26	433	4.36
Very High (Above 0.8)	3.93	64.83	5.99	0	74.75	0.75
Total	1684.15	7291.4	958.54	5.24	9939.33	100
Social Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	26908.71	15221.49	15800.91	0	57931.11	32.97
Low (0.2-0.4)	14018.93	40084.71	17821.11	0	71924.75	40.94
Moderate (0.4-0.6)	3793.1	23521.11	817.55	0	28131.76	16.01
High (0.6-0.8)	1843.14	8464.67	54.95	0	10362.76	5.90
Very High (Above 0.8)	1311.12	6025.7	0.19	0	7337.01	4.18
Total	47875	93317.68	34494.71	0	175687.39	100.00

Contd...

Economic Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	19766.39	31325.82	17864.18	4376.77	73333.16	64.19
Low (0.2-0.4)	4493.72	22588.3	5560.65	1990.08	34632.75	30.32
Moderate (0.4-0.6)	790.9	3879.07	901.45	489.06	6060.48	5.31
High (0.6-0.8)	28.57	125.11	23.84	4.36	181.88	0.16
Very High (Above 0.8)	9.39	21.05	0.66	0	31.1	0.03
Total	25088.97	57939.35	24350.78	6860.27	114239.37	100.00
Environ. Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	1371.81	1949.25	14835.85	33.39	18190.3	89.71
Low (0.2-0.4)	73.55	487.31	743.1	33.63	1337.59	6.60
Moderate (0.4-0.6)	75.54	501.54	34.69	15.41	627.18	3.09
High (0.6-0.8)	11.02	97.33	7.89	1.71	117.95	0.58
Very High (Above 0.8)	0.18	0.91	2.5	0	3.59	0.02
Total	1532.1	3036.34	15624.03	84.14	20276.61	100.00

Contd...

Overall Vulnerability	Bharmour	Chamba	Holi	Multhan	Total Area	Area (%)
Very Low (Below 0.2)	71756.21	15689.08	40635.97	57848.37	185929.63	57.53
Low (0.2-0.4)	17284.34	39694.01	15313.73	3424.01	75716.09	23.43
Moderate (0.4-0.6)	7148.02	29427.98	6745.16	1730.32	45051.48	13.94
High (0.6-0.8)	1452.26	11320.48	1407.11	142.12	14321.97	4.43
Very High (Above 0.8)	175.4	1840.42	139.51	0.94	2156.27	0.67
Total	97816.23	97971.97	64241.48	63145.76	323175.44	100.00

Source: Computed by Authors Note: Area in hectares.

Social vulnerability expresses weakness in societal structure to deal with disasters. Its key markers include socially disadvantageous groups and essential services such as healthcare, educational facilities, postal facilities, nutrition centres, and PDS. These elements-at-risk examined via normalised vulnerability scores shows as much as 26 % area has moderate to very high vulnerability; about 4.18 % has very high vulnerability and another 6 % exhibits high vulnerability (Table-3). Chamba tehsil being the most populous has higher social vulnerability; more than 40 % area shows moderate to very high vulnerability while 15 % area is under high to very high vulnerability. About 14 % area in Bharmour too has moderate-very high vulnerability out of which 6 % is in high vulnerability class. The spatial distribution of social vulnerability shows concentration around certain pockets in the western and central parts of study area while eastern and northern areas have low vulnerability. The high vulnerability zone is apparent around Chamba town and other large settlements such as Sarol, Mehla, Dharwala, and Bharmour. The remaining areas are either uninhabited or have small size settlements with low population. Overall, about 26 % area exhibits high social vulnerability; such zones coincide with high population density in the study area. Economic vulnerability defines the threat of landslide to economic assets. The study area being an agrarian economy relies heavily on agriculture, horticulture, and other allied activities for livelihood and income. About 6 % area shows moderate to very high economic vulnerability.

Table-3: Risk Assessment of Upper Ravi River Catchment

Risk Elements	Risk Level (area in Hectare)					
	Very Low (Below 0.2)	Low (0.2-0.4)	Moderate (0.4-0.6)	High (0.6-0.8)	Very High (Above 0.8)	Total
Settlement Area (ha.)	1294.67 (25.85)	617.02 (12.32)	1237.32 (24.71)	1371.17 (27.38)	487.35 (9.73)	5007.53 (100)
Number of Villages	61 (19.81)	101 (32.79)	94 (30.52)	51 (16.56)	1 (0.32)	308 (100)
Total Population	22045 (10.73)	60696 (29.53)	61659 (30.00)	41195 (20.04)	19933 (9.70)	205528 (100)
Female Population	10790 (10.53)	30058 (29.34)	30813 (30.08)	20812 (20.32)	9962 (9.73)	102435 (100)
Child Population	3057 (11.02)	8642 (31.15)	8629 (31.11)	5549 (20.00)	1864 (6.72)	27741 (100)
Number of Education Facilitates	100 (11.93)	271 (32.34)	251 (29.95)	195 (23.27)	21 (2.51)	838 (100)
Number of Health Services	30 (13.27)	68 (30.09)	62 (27.43)	61 (26.99)	5 (2.21)	226 (100)
Number of Essential Services	155 (16.88)	311 (33.88)	275 (29.96)	177 (19.28)	0 (0)	918 (100)
Road Area (ha)	608.08 (7.43)	1838.57 (22.46)	2708.42 (33.08)	2921.31 (35.68)	110.16 (1.35)	8186.54 (100)
Number of Helipad	0 (0)	1 (20)	2 (40)	2 (40)	0 (0)	5 (100)
Cropland Area (ha.)	793.15 (5.96)	2786.36 (20.95)	4954.68 (37.25)	4723.93 (35.51)	43.55 (0.33)	13301.67 (100)
Area Under Plantation (ha.)	7.55 (7.68)	30.4 (30.9)	31.98 (32.51)	28.38 (28.85)	0.06 (0.06)	98.37 (100)
Forest Area (ha.)	51433.04 (51.35)	31074.12 (31.02)	13598.54 (13.58)	4039.27 (4.03)	22.29 (0.02)	100167.3 (100)
Protected Forest (ha.)	8656.37 (69.15)	3064.38 (24.48)	699.95 (5.59)	97.21 (0.78)	0 (0)	12517.91 (100)
Reserved Forest (Ha.)	2299.99 (35.99)	2585.18 (40.45)	1211.24 (18.95)	294.3 (4.6)	0.37 (0.01)	6391.08 (100)

Note: Values in the parenthesis are in percentp

In terms of spatial distribution, Chamba (146 hectare) tehsil has maximum area under high to very high vulnerability followed by Bharmour (38 hectare) and Holi (25 hectare) whereas less than 5 hectares in Multhan has high vulnerability (table-3). However, in terms of proportion, Multhan (7.19 %) has maximum area under moderate to very high vulnerability. It suggests that landslides have a higher potential to cause economic risk in remotely located areas. The proportion of moderate to high vulnerability in Chamba is 6.95 % while in other tehsils it remains below 4 per cent. The distribution pattern shows higher vulnerability along rivers and roads; it decreases with the altitude due to absence of arable land. A large part of study area is either uninhabited or sparsely populated with low infrastructure development. Such areas are covered with forests, highland pastures, and water bodies. An insignificant area (0.02 per cent) under such features has very high vulnerability. Holi tehsil has largest percentage of very high vulnerability; however, Chamba (97.33 hectare) and Bharmour (11.02 hectare) account for maximum area of high vulnerability. Holi tehsil has less than 10 hectares under high vulnerability; it is below 2 hectares in Multhan.

The two zones of vulnerability are most visible. First is the valley floor along the river Ravi in the western parts of Chamba tehsil and the other comprises of low to moderate vulnerability in the higher altitude areas of Holi and Multhan tehsils. The cumulative index derived by aggregating physical, social, economic, and environmental indicators shows a considerable area (19 %) under moderate to very high vulnerability (Fig.-1). Less than a per cent area falls in very high vulnerability. Out of the total 2156.27 hectare under this class, more than 85 per cent is in Chamba (1840.42 hectare) tehsil followed by Bharmour (175.4 hectare), and Holi (139.51 hectare). High vulnerability area accounts for 14321.97 hectare (4.43 per cent); Chamba is the leading vulnerable tehsil (11320.48 hectare) whereas Bharmour and Holi tehsils have a little over 1400 hectare under high vulnerability. Similarly, 45051 hectare (14 percent) display moderate vulnerability. In this category too Chamba (29427.98 hectare) has the largest proportion followed by Bharmour (7148.02 hectare), Holi (6745.16 hectare), and Multhan (1730.32 hectare). The analysis shows a visible spatial pattern of vulnerability in the catchment; clusters of high to very high vulnerability are confined to the western parts (Fig.1). The most critical sites include areas around Chamba town, Sarol, Mehla, Dharwala, and Bharmour. Moderate vulnerability surrounds these areas of high vulnerability. Chamba tehsil having more infrastructure, urban population, bigger rural settlements, and human activities display higher vulnerability especially at lower elevations and along the valley floor.

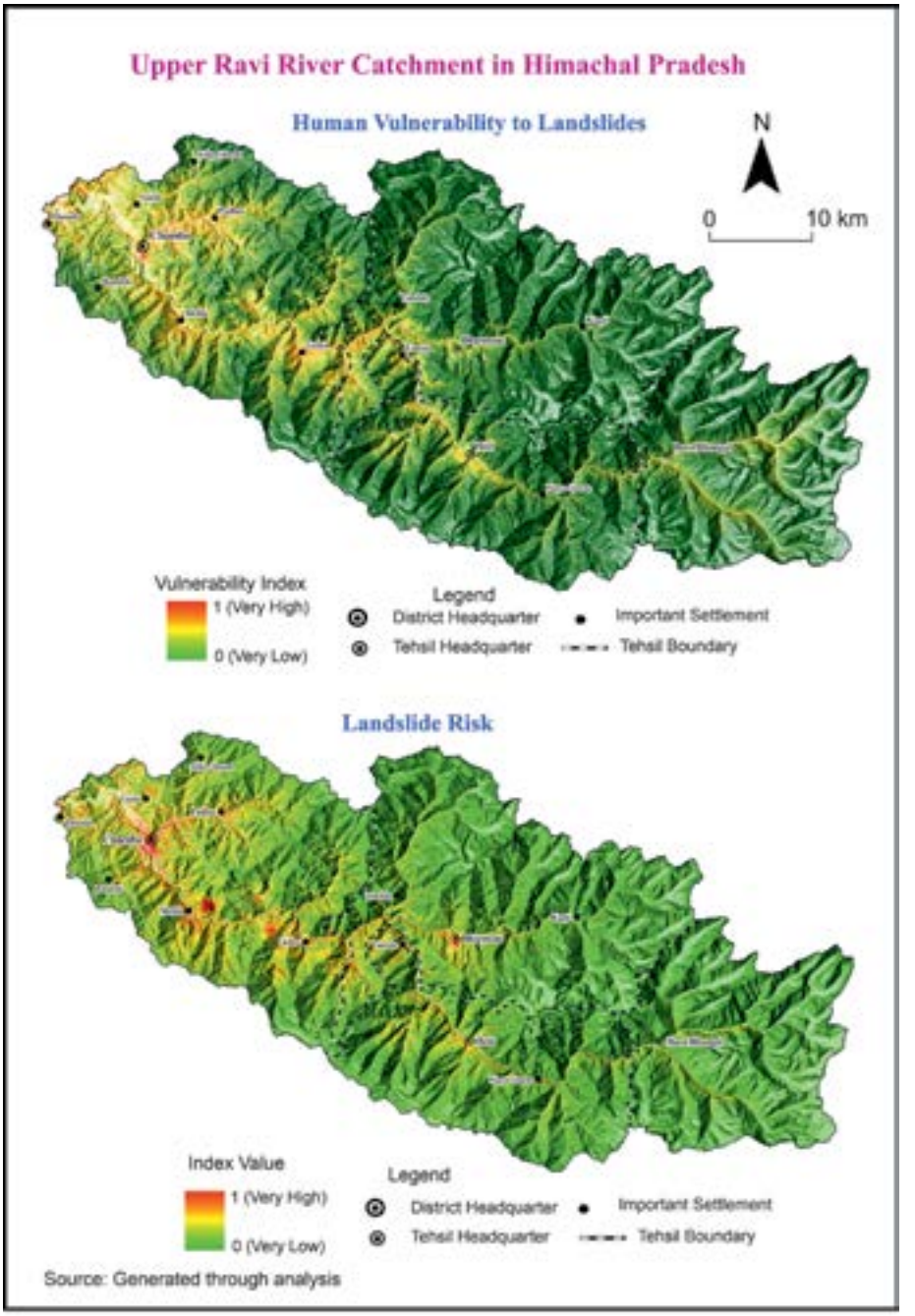

Upper Ravi River Catchment in Himachal Pradesh
Human Vulnerability to Landslides
N
0
10 km
Vulnerability Index
1 (Very High)
0 (Very Low)
Legend
District Headquarter
Important Settlement
Tehsil Headquarter
Tehsil Boundary
Landslide Risk
Index Value
1 (Very High)
0 (Very Low)
Legend
District Headquarter
Important Settlement
Tehsil Headquarter
Tehsil Boundary
Source: Generated through analysis

Fig. 1

Vulnerability pattern reveals higher damage potential in the narrow valley along the highway between Chamba and Bharmaur. Bharmour and Holi tehsils, where road development has taken place recently to boost hydropower projects also show moderate to high vulnerability.

Risk Assessment

Ravi River catchment demonstrate varying spatial patterns of vulnerability. These in conjunction with landslide susceptibility and the amount of elements-at-risk were further examined to analyse risk potential. The gravity of landslide risk reflects from the fact that out of the total 5007.53 hectare under settlements, more than 37 % has high to very high risk (index ≥ 0.6), and another 25 % in moderate risk category. Similarly, 17 % and 31 % villages are at high and moderate risk, respectively. In terms of population characteristics (Table-4), as much as 10 per cent, 20 per cent, and 30 per cent of the total population as well as female population is at very high (index above 0.8), high (0.6-0.8), and moderate (0.4-0.6) risk of landslides, respectively. Such proportions for child population too are of the same magnitude. The contribution of human-induced risk is therefore evident as majority of high-risk settlements are in the relatively developed parts of Chamba tehsil and its surrounding areas. The basic essential services like educational institutes under risk certainly emerge as a matter of concern since more than a quarter (25.78 per cent) are at high to very high risk alongside another 30 per cent at moderate risk (Table-4). The majority of such services are related to primary and middle schools wherein the young population do not have the skills to deal with hazardous situation. The state of affairs is no different for health services and infrastructure. A similar level of risk exists for health-related services. The areas of Holi and Multhan tehsils exhibiting low risks have no health facilities. Hence, low risk in these areas is not due to better facilities but because of its non-availability (Table-4).

Table-4: Overall Risk Assessment

Risk Class (Index Value)	Risk Potential (Area in Hectares)				
	Bharmour	Chamba	Holi	Multhan	Total
Very Low (Below 0.2)	81790.86 (38.08) (83.61)	34794.73 (16.20) (35.51)	47534.84 (22.13) (73.98)	50693.65 (23.60) (80.31)	214814.1 (100) (66.47)

Contd...

Low (0.2-0.4)	11011.63 (17.72) (11.26)	29808.65 (47.98) (30.43)	11434.78 (18.40) (17.80)	9875.02 (15.89) (15.64)	62130.08 (100) (19.23)
Moderate (0.4-0.6)	3742.81 (11.63) (3.83)	21965.36 (68.24) (22.42)	4189.14 (13.01) (6.52)	2292.27 (7.12) (3.63)	32189.58 (100) (9.96)
High (0.6-0.8)	1270.43 (9.17) (1.30)	11242.25 (81.11) (11.47)	1088.26 (7.85) (1.69)	259.3 (1.87) (0.41)	13860.24 (100) (4.29)
Very High (Above 0.8)	6.02 (3.52) (0.01)	162.29 (94.98) (0.17)	2.55 (1.49) (0.004)	0 (0.00) (0.00)	170.86 (100) (0.05)
Total	97821.75 (30.27) (100)	97973.28 (30.32) (100)	64249.57 (19.88) (100)	63120.24 (19.53) (100)	323164.8 (100) (100)

Note: Values in the parenthesis are in percent

The risk is high for road infrastructure as well; 37 % of areas have high-very high risk and another 33 % have moderate risk thus making over 70 % areas along roads at risk of landslides. The worse affected areas include Chamba and Holi tehsils. Such a high risk to road infrastructure also impacts other essential and non-essential services as these provisions are directly linked to road accessibility. As a result, these services get affected and become non-functional in case of roads blocked by landslides. Rural livelihood too is at risk as cropland, plantations, and forest resources display substantial risk. The cropland and area under plantation show 36 % and 29 % area under high to very high risk while another 37 % and 32% have moderate risk, (Table-6). With more than 70 % of the area that provides income and livelihood to people under persistent risk, it is but obvious that the catchment exhibits a high degree of uncertainty in the attainment of income and the well-being of its population. The analysis demonstrates uneven spatial distribution of landslide risk. About 14.30 % area has very high (above 0.8) to moderate (0.4-0.6) risk. A noteworthy variation in the spatial distribution of risk is discernible. Three areas, viz. Multhan (95.96%), Bharmour (94.87%), and Holi (91.78%) display minimal risk; the degree of moderate to high risk in these is limited. On the contrary, Chamba tehsil has about 12 % area under high to very high risk and additional 22.42% area has moderate risk (Table-3 and Fig. 2).

Here, it is important to acknowledge that this high-risk zone has the largest proportion of population. Looking at risk potential in terms of proportion of each tehsil to the total area under a specific risk class, it is evident that risk proportion in Chamba tehsil successively increase towards higher risk classes while the same diminishes in rest of the three tehsils. Out of the total 170.86 hectare under very high-risk class, nearly 94.98% falls in Chamba alone while other three cumulatively account for less than 5 %. The same is true for high and moderate risk classes wherein Chamba alone accounts for 81.11% and 68.24%, respectively whereas remaining tehsils have much smaller proportion in these risk classes. A higher risk in Chamba tehsil is due to greater concentration of population and infrastructure whereas remotely located areas despite a high susceptibility possesses far less risk of damages by landslides. However, as infrastructure development is gradually extending to remote areas, risk to landslides in these tehsils is likely to increase.

Conclusion

This paper intended to examine the likely threats of landslides to physical, social, economic, and environmental elements in the Ravi River catchment. Visualizing risk is crucial to envisage appropriate mitigation measures and capacity building to ensure safe development. Landslides are not life-threatening in all circumstances; however, these certainly impact human activities and crucial resources in mountainous regions. Landslide driven damage to life and property is exorbitantly high in the study area. This study evaluated landslide exposure, vulnerability, and risk via a blend of quantitative or qualitative approaches. Realizing the high degree of physical susceptibility to landslides in the Ravi River catchment, this paper outlined threat potential to human population and infrastructure. The study places Chamba as one of the most perilous tehsils in the catchment in terms of landslide risk to people, settlements, agriculture, infrastructure, essential services and economic activities. On the contrary, Multhan, a poorly developed tehsil displays the least risk on account of it being low development. It is evident that the area has high degree of susceptibility to slope failure, however, risk is the product of development coinciding with landslide potential. The more developed areas possess higher risk to landslides and vice versa. The risk assessment shows high-risk clusters around Chamba town and its surrounding areas mainly Sarol, Mehla, Dharwala, and Bharmaur. The very high to moderate risk exists along the roads and an inverse relation is evident between distance from the roads and degree of risk. A discernible spatial pattern emerges that shows clusters of higher risk in the western parts of the study area. High-risk zones exist at fewer locations that are surrounded by moderate risk.

The overall assessment shows maximum risk in Chamba tehsil followed by Bharmour, Holi, and Multhan tehsils. The higher risk to landslide in Chamba tehsil is attributed to clustered human population and economic activities whereas remotely located areas of Holi and Multhan despite high physical susceptibility show much less human risk and vulnerability to landslide hazard. The latter represents a landscape with limited anthropogenic meddling; low human occupancy, and underdeveloped roads and other infrastructure. Consequently, risk to human assets and resources is low. However, as the infrastructure development would proceed to such areas, landslide hazard may pose serious challenge. The spatial distribution of high-risk zones also establishes a positive association between landslide hazard and anthropogenic activities. The analysis points to the role of human transgressions in this tectonically and climatically sensitive area. It is clear that the large parts of the catchment, either habited or uninhabited, have high susceptibility to slope failure. However, high degree of risk in populated and relatively developed parts underlines the seriousness of existing threat to human life, property, and infrastructure. Landslides may not always be life-threatening but the ongoing process of infrastructure development is likely to escalate the degree of risk. This research contributes towards anticipating threat that the local community might face in the future. It provides a base to devise appropriate mitigation measures and build capacities to deal with the risk that landslides may pose.

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AN ASSESSMENT OF RAINFALL VARIABILITY ON GROUND WATER LEVEL IN TELANGANA USING LINEAR REGRESSION MODEL

Anupama Dubey and Sanjit Kumar

Abstract

Climate change will have a significant impact on freshwater supplies, as evidenced by a number of recent international studies. Groundwater is necessary for life as we know it. Global climate change can affect the availability of groundwater by influencing the amount and quality of water that is recharged, evaporated and transpired, and indirectly by affecting the amount of water pumped and abstracted. In regions where the water tables are relatively close to the surface, alterations to the groundwater system can also impact the surface water system. It is essential to comprehend the potential ramifications of climate change on groundwater systems in order to effectively and strategically manage the water supply. But it is not feasible to forecast the potential impact of climate change on groundwater systems. Forecasting impacts of climate change on groundwater systems is currently very difficult. The problem is exacerbated by the presence of uncertainty around future climate predictions.

Introduction

Climate change is expected to accelerate the hydrological cycle globally, aggravating regional and temporal differences in hydrological resource distribution (Huntington, 2006, Trenberth, 1999). Global warming is anticipated to increase the severity of extreme rainfall events in many places, even if the mean rainfall is decreasing (e.g., Wilby and Wigley, 2002). Climate adaption methods typically require accurate knowledge on the frequency of these catastrophic events. (Kumke, 2001). Many studies have been done on the issue of rainfall trends in India over the century. Others have studied changes in southwest monsoon/annual rainfall in India. According to Dash et al. (2009), Over the previous 50 years, moderate-to-heavy rainfall has decreased. India is seeing more frequent and longer monsoon

breaks with 100 mm per day rainfall in some locations, confirm this (Goswami et al., 2006). Alterations in precipitation, temperature, and evapotranspiration have a direct influence on the replenishment of groundwater. Precipitation and groundwater recharge are positively correlated. The thawing of permafrost will lead to an increase in groundwater recharge (Potter 2002; Kitabata et al. 2006). Modifying the rate of recharging will primarily result in adverse outcomes. Regions characterized by abundant rainfall are projected to experience an upward trend in precipitation, while regions with little rainfall and high rates of evaporation, which are now facing water scarcity, are anticipated to witness a decline (IPCC 2007; Issar & Zohar 2007). Immediate modifications to the existing infrastructure network are necessary in order to adapt to evolving circumstances (Potter 2002; Semadeni-Davies et al. 2007). The primary objective of this study is to investigate the impact of fluctuations in precipitation on local water resources and the accessibility of groundwater, as well as to identify significant risks and determine the most important measures for adaptation. Groundwater systems will also be affected by land use, surface water availability, human water needs, the distribution of native and cultivated plant communities, and climate change and rising carbon dioxide levels that affect native and crop plant water consumption. (Eckhardt & Ulbrich; Scanlon et al., Thomson et al.; Green et al.). Currently, there is a lack of adequate observation, understanding, and measurement of how groundwater resources respond to short-term climate variability, such as changes occurring within a year or decade. Climate change can affect groundwater systems in four ways: alterations in precipitation quantity and distribution, shifts in precipitation type (rain versus snow), and modifications in the rates of evaporation, transpiration, and groundwater extraction. Alterations in rainfall patterns can directly impact the replenishment of groundwater systems, while modifications in multiple other climatic factors can influence the different processes via which groundwater (and soil moisture) is discharged, either individually or in conjunction.

Study Region

Telangana was created on June 2, 2014, becoming the 29th state of India. Hyderabad is the capital of the state of Hyderabad. It is surrounded by four states: Maharashtra to the northwest and north; Andhra Pradesh to the south and east; and Karnataka to the west. From 15°46'N to 19°47'N is the latitude range, and from 77°16'E to 81°43'E is the longitude range. There are 1,12,077 square kilometers (43,273 square miles) in the expansion.

Objective

This paper is an attempt to correlate two variables of climate change, precipitation and ground water.

Database and Methodology

Data was compiled from various government reports, websites, census reports Telangana State Ground Water Boards, the Irrigation Department, CWC, the Ministry of Jal Shakti, and other relevant departments. The association between yearly mean rainfall and groundwater depth in the research area was determined using SPSS software. SPSS software enables us to run a linear regression model using a single dependent variable and a few independent variables. Groundwater depth was used as a dependent variable in this study, while the impact of rainfall was examined as an independent variable.

Result and Discussion

Even after mild rainfall, most of the districts in the research area had a deep groundwater level, according to the findings. The association between groundwater level and climate change is found to be similar in the state, highlighting the impact of climate change on groundwater levels. The irregularity in rainfall affects the depth of groundwater in all three states, as seen by the map of rainfall and groundwater depth. The average annual rainfall in Telangana varies between 650 m to 1200 m, depending on the region. Districts in the north and north-eastern region receive high rainfall, whereas southern districts near receive comparatively less rainfall hence coming under the first category. The coefficient of variation, on the other hand, is relatively high in southern districts and continues to decrease as one moves north-eastern in the state. This variation in rainfall has an impact on groundwater depth across the state, which may be shown on a map. Districts with substantial yearly rainfall fall into the group of districts with very shallow groundwater depths. Districts with minimal annual rainfall, on the other hand, reveal that the depth is extremely high in most part of the district. (Fig. 1)

Status of Ground Water Resources in Selected Sample States

Status of Ground Water resources in Telangana

Based on the data of Telangana district-wise average depth of ground water level data, the minimum water level is 5.43 meters below ground level (m bgl) in

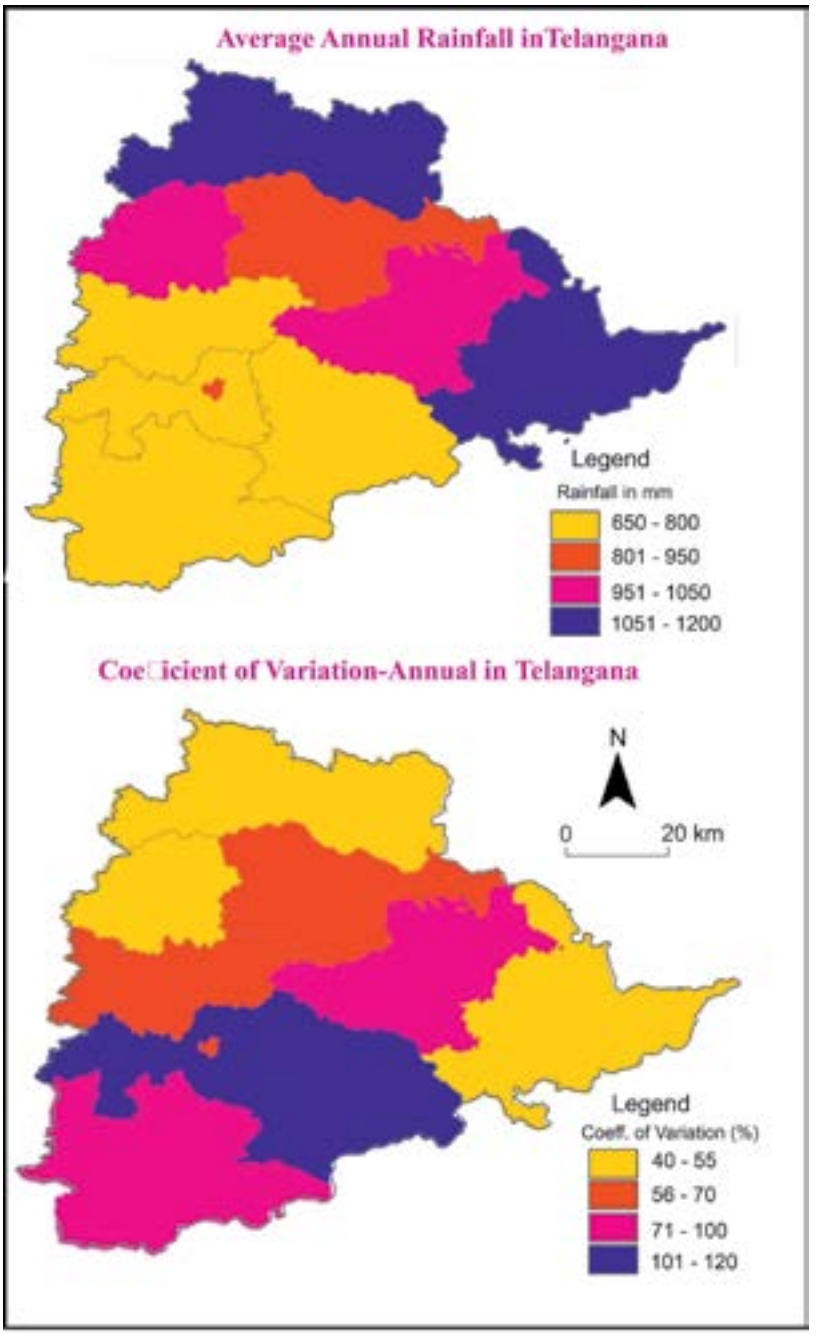

Average Annual Rainfall inTelangana
Legend
Rainfall in mm
650 - 800
801 - 950
951 - 1050
1051 - 1200
Coe icient of Variation-Annual in Telangana
N
0
20 km
Legend
Coeff. of Variation (%)
40 - 55
56 - 70
71 - 100
101 - 120

Fig. 1

Khammam district and the maximum is 20.84 m bgl in Medak district in 2018. Table-1 depicts the water index of ground water levels in Telangana. Ground water levels in the range of 5.43 to 8.51 m bgl in extremely shallow depth cover 33114.64 square kilometers in Telangana, with a percentage of 28.84. This area was covered on the east and north sides of Telangana in 2018, as well as a tiny part on the south side. This range includes the whole Bhadradri (Kothagudem), Komram Bheem, and Manchrial districts, as well as portions of Wanaparthy, Hyderabad, Jagityal, Warangal Rural, Adilabad, Mahabubabad, Khammam, and Peddapally districts. In Telangana, ground water levels in the low depth range of 8.52 to 11.59 m bgl cover 31188.27 sq km, with a percentage of 2.58. In 2018, this area was covered in the northeast and south to northwest parts of Telangana, as well as a tiny amount in the southwest. This range encompasses parts of the Medak and Sanga Reddy districts. Ground water levels in the intermediate depth range of 12 to 14.67 m bgl cover 33605.2 sq km in Telangana, with a proportion of 29.26. In 2018, this area was covered in Telangana from the northwest to the middle to the south and southwest. This range includes the whole Yadadri and Sircilla districts, as well as portions of Nizamabad, Kama Reddy, Jangaon, Medchal, Nalgonda, Nagarkurnool, Rangareddy, and Mahabubnagar (Fig. 2). In Telangana, ground water levels in the range of 14.68 to 17.75 m bgl (high depth) cover 13973.73 sq km, with a percentage of 12.17. This area was covered under Telangana's west side in 2018. This range comprised the entire Vikarabad district, as well as parts of the Kama Reddy, Medak, Sanga Reddy, Rangareddy, Mahabubnagar, and Siddipet districts. Ground water levels in the range of 17.76 to 20.83 m bgl, which is very deep, cover a total area of 2958.159 sq km in Telangana, with a percentage of 28.84. This area was covered under Telangana's west side in 2018. This range includes the whole Bhadradri (Kothagudem), Komram Bheem, and Manchrial districts, as well as portions of the Wanaparthi, Hyderabad, Jagityal, Warangal Rural, Adilabad, Mahabubabad, Khammam, and Peddapally districts.

Correlation and Variation

The SPSS linear regression was used to create (Table-4). Whereas average yearly rainfall serves as the independent variable in this model, groundwater depth serves as the dependent variable. Below is a table that summarizes the model. If the R-value exceeds 0.4, which is comparable to 40%, further inquiry is necessary to establish the correlation between the maximum groundwater depth and the quantity of rainfall received. Hence, the number is 0.664, which is equal to 66.4%,

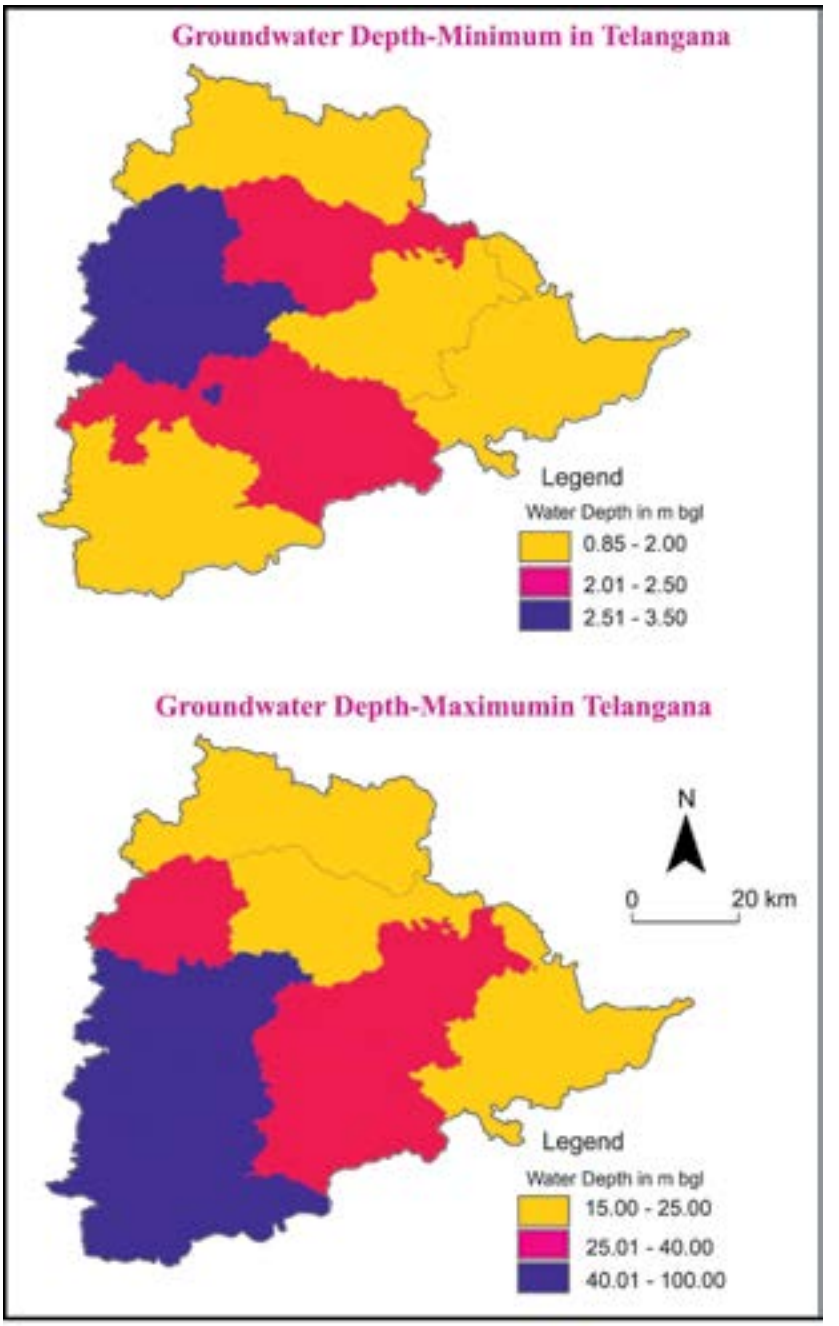

Groundwater Depth-Minimum in Telangana
Legend
Water Depth in m bgl
0.85 - 2.00
2.01 - 2.50
2.51 - 3.50
Groundwater Depth-Maximumin Telangana
N
0
20 km
Legend
Water Depth in m bgl
15.00 - 25.00
25.01 - 40.00
40.01 - 100.00

Fig. 2

indicates that model fits well under for the available data. The R-squared value rises above 0.4, indicating that more than 40% of the variable variance can be explained. The model accurately describes water usage, which is 0.440 or 44.0 percent. The decreasing R-square value indicates discovery frequency. The adjusted R-square number represents the generalizability of the results, which is also known as sample variation. The R-square and Adjusted R-square should have a marginal disparity, with both values being .390 or 39.0%, which is deemed satisfactory. Begin by referring to the model summary table. The P-value and 95% confidence level for this table were established in advance of conducting this research. As a result, statistical significance is defined as a p-value less than 0.05. As a result, the effect is substantial. As a result, the findings are critical. Similarly, the F ratio quantifies the accuracy with which a model predicts a given variable after accounting for the model's flaws. A model that is efficient can be developed with a F ratio of 8.659, which is greater than one. It explains the suitability of the sample for conducting the test. Based on these findings, there is a chance to reject the null hypothesis that there is no significant difference in groundwater depth and rainfall received, because the ANOVA's p-value is less than the tolerated level of significance. Annual rainfall and groundwater depth have a close link. This study established a relationship between the estimates (predictors) of the independent factors and the dependent variable. For each unit change in parameter estimates, the projected value increases or drops by the same amount. Univariate analysis of variance can employ effect size, parameter estimations, and cross-sectional approaches. The R square and adjusted R square values (0.440 and 0.390) remain unchanged from the previous technique, which employed a fixed effects dummy variable (t values, significant levels). The regression value of the dummy variable differs due to its interaction with a discrete dummy coexistence. The data is presented (Table-1, 2 and 3). Demonstrates a strong correlation between the depth of groundwater and the average annual precipitation.

Table-1: Variables Entered-Removed(b)

Model	Variables Entered	Variables Removed	Method
1	Mean Annual Rainfall(a)	.	Enter

(a) All requested variables entered.

(b) Dependent Variable: Groundwater Maximum Depth

Table-2: Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.664(a)	.440	.390	13.30672

(a) Predictors: (Constant), Mean Annual Rainfall

(b) Dependent Variable: Groundwater minimum depth

Table-3: ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1533.208	1	1533.208	8.659	.013(a)
	Residual	1947.758	11	177.069		
	Total	3480.965	12			

(a) Predictors: (Constant), Mean Annual Rainfall

(b) Dependent Variable: Groundwater Maximum Depth

Table-4: Coefficients and Residuals Statistics(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	81.316	18.132		4.485	.001
	R_M	-.055	.019	-.664	-2.943	.013
		Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value		1.1123	1.2111	1.1762	.03333	13
Residual		-.85496	1.41245	.00000	.71144	13
Std. Predicted Value		-1.915	1.049	.000	1.000	13
Std. Residual		-1.151	1.901	.000	.957	13

A Dependent Variable: Groundwater Maximum Depth

Evaluation of Telangana Government Schemes to Increase Water Storage

Mission Kakatiya – Telangana: The aim is to increase the storage capacity of minor irrigation water resources like tanks and ponds.

Methodology Adopted

(1) Desiltation of tanks, repair of bunds, re-sectioning of irrigation channels, restoration of tributary channels, and increasing water level to Full Tank Level (FTL).

(2) Villagers participated in Gramasabhas to discuss the action plan for managing water resources in containers and ponds. Farmers were motivated to incorporate the silt into their plots.

(3) Establishment of district-level Coordination Committees to ensure continuous village participation in irrigation management.

(4) Formation of Coordination Committees at the district level to activate the villagers continuously to participate in irrigation management.

Results

(1) Increase in the capacity of reservoirs and other bodies of water to store water. The availability of water extended to small and medium-sized producers.

(2) By tilling in sediment into the fields, the land's capacity to retain water was enhanced. Additionally, the incorporation of silts into fields increased their nutrient content, which reduced the need for chemical fertilizers and increased the value of crop diversification.

(3) Groundwater level elevation. Progression of livestock and fisheries.

Conclusion

Region-specific, the average annual precipitation in Telangana ranges from 650 to 1200 meters. Northern and northeastern districts experience substantial precipitation, while southern districts in close proximity receive comparatively less precipitation, thus falling within the first category. In contrast, the coefficient of variation exhibits a comparatively high value in the southern districts and progressively declines as one traverses towards the northeastern region of the state. This variation in precipitation affects the depth of groundwater throughout the state, which may be depicted on a map. Districts characterized by significant annual precipitation are

classified as having extremely shallow groundwater depths. Conversely, districts with negligible annual precipitation exhibit exceptionally deep water throughout the majority of the district. Realizing the urgent need of water storage and percolation, government of Telangana has implemented various schemes such as Mission Kakitya and Swar, depicting substantial productive outcomes of the plans. But still there is a long way to cover, for securing water for the upcoming generations.

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AVAILABILITY OF HOUSEHOLD AMENITIES AND ASSETS AMONG SCHEDULE CASTES AND NON-SCHEDULE CASTES IN RURAL HARYANA

K. V. Chamar and S. K. Chamar

Abstract

Availability of household amenities and assets reflects a household's quality of life among various social groups. For the present research work, primary data has been collected from 1365 households comprising 975 from scheduled castes category and 390 from non-scheduled castes from 39 selected villages of 15 blocks covering the five districts of Ambala, Panipat, Rohtak Rewari, and Sirsa that represent the northern, eastern, central, southern, and western parts of the Haryana state respectively. The surveyed households were represented by 37 castes comprising 24 castes from non-scheduled castes and 13 castes from scheduled castes. After that, caste-wise as well as among the scheduled castes and non-scheduled castes availability of household amenities and assets were worked out. Thereafter, caste-wise availability of amenities and assets of all the selected 16 indicators in the households were worked out in percent in proportion to total sample households. Furthermore, the weighted score has been assigned to selected amenities and assets depending upon their relative function and value to derive composite weighted scores. To find out the 'composite weighted scores' of availabilities of amenities and assets among select caste in respect to each of the indicator the 'weighted scores' have been added of all the selected indicators. Finally, to assess the levels in availability of household amenities and assets of each caste among scheduled castes and non-scheduled castes in rural Haryana, 'average composite weighted scores' have been identified by dividing the number of households of each caste among scheduled castes and non-scheduled castes of the total composite weighted scores. The analysis reveals marked variations in availability of amenities and assets among scheduled castes and non-scheduled caste in rural Haryana.

Introduction

Availability of household amenities and assets reflects a household's quality of life among various social groups. It plays an important role in our day to day life.

It also helps in the socio-economic importance of housing, improvement of housing and the condition of the households. "Safe drinking water and sanitation facilities reduce the prevalence of gastrointestinal diseases in any society. The availability of piped water, facility of electricity within the household and better electric appliances and furniture facilitate effective education among children. Likewise, availability of motor vehicles, communication and mass media strengthen the household's connection to the country as a whole. Access to these amenities thus reflects a household's quality of life. In modern era, they also act as symbol of social status among various social groups" (Desai et. al, 2010). Similarly, computer technology has also become an essential part of our daily lives. It can do complex tasks including data processing, storage and retrieval, and calculations fast, effectively and accurately. Many studies have been undertaken on the availability of household amenities or facilities and assets in different forms in India. Tiwari and Nayak, (2013) examined, "the drinking water and sanitation facilities in Uttar Pradesh.

They described the inter-regional disparity in Uttar Pradesh in the availability of drinking water and sanitation facilities. The study reveals that female literacy rate plays a significant role for improving access to sanitation facilities". Kaur and Sharma (2021) examined, "living conditions of POJK displaced persons in Jammu district by considering the various parameters such as demographic profile, family composition, family system, education, occupation, income, drinking water, house design, and housing facilities. The study reveals that the magnitude of loss of POJK displaced persons was very high. Hence, proper compensation, social security and political representation are very important issues and should be taken up seriously". Besides that few studies at micro level have also been conducted by the researchers in India. Some studies explore regional inequalities in the quality of living space in the rural areas of Haryana using tehsil level census data (Bairagai and Chamar, 2019; Chamar and Bairagi, 2019). Others are based on data collected through primary survey at micro level. Using a similar approach some studies have examined differentials in quality of living space among different clans in scheduled castes in different rural areas of Haryana at micro level (see Chamar and Rekha, 2016; Chamar and Chamar, 2018; Rani and Chamar, 2019: Dhanak and Chamar, 2021).

Study Region

Haryana is one of the most prosperous states of India. It is a landlocked state and located to the north-western part of India. It extends from 27º 39′ 0" to 30° 55′ 5" north latitudes and 74° 27′ 8" to 77° 36′ 5" east longitudes. It covers an

area of about 44,212 km2. Yamuna is the important perennial river of the state, which make its eastern boundary. Physiographically, the eastern sector of Haryana is largely plain, more fertile and featureless with better transport facilities, high literacy rate whereas the western sector is traversed by numerous sand dunes. Basically, Haryana is an agricultural state. It plays a vital role in the economy of Haryana and it is the main occupation of the people of the state. Its agriculture and manufacturing industries have experienced continuous growth after the formation of Haryana as an independent state. The economy of Haryana also relies on manufacturing, retailing and information outsourcing. Ambala, Yamunanagar, Sonipat, Gurgaon and Faridabad are the big industrial hubs of Haryana. On the other hand, Kurukshetra and Rohtak are important educational hubs. The location factor that is nearness to the National Capital (New Delhi) has helped the state to achieve the status of a leading industrialized state in India. As per 2011 census, it has 21 districts, 74 tehsils, 114 community development blocks and 6955 (6764 inhabited and 191 un-inhabited) villages. According to census 2011, out of total population of Haryana, about 165.09 lakh persons (65.12 %) live in rural areas comprising 87.74 lakhs males (53.15 %) and 77.35 lakh females ((46.85 %) persons. The total rural scheduled castes population in the study area is 37.20 lakh (22.53 %) persons, comprising 19.73 lakhs males (53.04 %) and 17.47 lakh females (46.96 %) persons, which reside in 7.23 lakh households.

Objectives

The major objective of the study is to analyze the levels in availability of household amenities and assets among scheduled castes and non-scheduled castes in rural Haryana.

Database and Methodology

The present study is based on the primary data collected on the basis of a well-structured schedule and personal interview conducted with the head/member of the household. The primary data has been collected from 1365 households comprising 975 from scheduled castes category and 390 from non-scheduled castes with the help of stratified random sampling from 39 selected villages of 15 blocks covering the five districts of Ambala, Panipat, Rohtak, Rewari, and Sirsa that represent the northern, eastern, central, southern, and western parts of the Haryana state respectively. To identify the levels in availability of household amenities and assets the following 16 indicators such as; Pipe water (X_1), Hand pump (X_2), Tube well (X_3), Toilet Facility (X_4), Electricity Facility (X_5), Chair (X_6), Fan (X_7),

Pressure Cooker (X_8), Refrigerator (X_9), Radio/Transistor (X_{10}), Television (X_{11}), Mobile only (X_{12}), Computer/Laptop (X_{13}), Bicycle (X_{14}), Scooter/Motorcycle (X_{15}), and Car/Jeep (X16) have been considered. After that, caste-wise total households have been bifurcated. The surveyed households were represented by 37 castes comprising 13 castes from scheduled castes and 24 castes from non-scheduled castes including seven from general castes and 17 from other backward castes. Initially, caste-wise availability of amenities and assets in the households were worked out in percent in proportion to total sample households. Furthermore, the weighted score has been assigned to selected amenities and assets depending upon their relative function and value (Table-1) to derive composite weighted scores. To find out the ‘composite weighted scores' of availabilities of amenities and assets among select caste in respect to each of the indicator the 'weighted scores' have been added of all the selected indicators. Finally, to assess the levels in availability of selected amenities and assets of each caste among scheduled castes and non-scheduled castes in rural Haryana, 'average composite weighted scores' have been identified by dividing the number of households of each caste among scheduled castes and non-scheduled castes of the total composite weighted scores.

Table-1: Selected Indicators and Weighted Scores

Selected Indicators	Weighted Score	Selected Indicators	Weighted Score
Pipe Water	1.0	Refrigerator	2.0
Hand Pump	0.5	Radio	0.2
Tube Well	0.5	Television	3.0
Toilet Facility	1.0	Mobile	2.0
Electricity Facility	1.0	Comp./Laptop	8.0
Chair	0.1	Cycle	0.5
Fan	0.2	Scooter/ Motorcycle	20.0
Cooker	0.2	Car/Jeep	100.0

Source: Compiled by Authors.

Results and Discussions

Based on data pertaining to 1365 sample households, the total population of 37 select castes is 6796 persons comprising 3582 males (52.71 %) and 3214 (47.29%) females in the study area (Photo-1 and 2). The data collected for study related to select 13 from scheduled castes and 24 non-scheduled castes.



Photo -1: Fieldwork Survey



Photo -2: Fieldwork Team

Population Characteristics

Based on 975 sample households, the Chamar, the Balmiki and the Dhanak are numerically dominant castes among scheduled castes which accounts for more than 84 percent population in the study area. The Odh and the Majhabi Sikh castes each shared by about four per cent. The other select castes namely the Meghwal, the Bazigar, the Khatik, the Sansi, the Doom, the Ramdasia Sikh, the Bawaria, and the Sapera accounts for nearly eight percent. The overall literacy rate among scheduled castes is about 76 percent, while the male and female literacy rates are 84 percent and 68 percent respectively. The average sex ratio is recorded 908 females per thousand males and the average size of the household is found 5 persons/household. Among the non-scheduled castes, it is noted that the Jat, the Brahman, the Ahir, the Jatt Sikh, and the Punjabi are dominant castes, which accounts for three-fifths of the total population at the time of survey. The literacy rates vary across among social groups. The highest literacy rate is observed among other backward castes (86 %) which are almost identical to that of among general castes but much higher as compared to that among scheduled castes with 76 per cent. The sex ratio is recorded 897 females/1000 males in rural Haryana. The highest sex ratio (909 females/ 1000 males) is recorded among other backward castes followed by scheduled castes (908 females/ 1000 males) and general population (841 females/ 1000 males). The average size of the household in rural Haryana is 5.0 persons, and there is not much of variation in the same across different social groups. It is recorded 4.8 persons per household among general castes, 4.9 persons among other backward castes and 5.0 persons in scheduled castes groups.

Availability of Household Amenities and Assets among Scheduled Castes

Based on sample survey, it is recorded that more than two-third households used pipe water for drinking; about 31 percent households used water from hand pump and nearly 15 percent households used tube well water for drinking. The facility of hand pump for drinking water is not available in any of the household in Odh caste. Pipe water is used by all the households belonging to the Doom and the Bawaria castes; hand pump is used by the Sapera caste and tube well is used by all the households belonging to the Ramdasia caste. About three-fifths households have the facility of toilet in the study area. Except the castes such as the Balmiki, the Dhanak, the Doom and the Sapera, all other castes have toilet facility above the average percentage. The facility of electricity is much better among all the households. About 92 percent of the households have the facility of electricity. Further, it is observed that more than two-third households have the asset of chair.

Fan is available in all the households belonging to the castes like the Khatik, the Sansi, the Ramdasia Sikh and the Sapera. Pressure cooker is used by about 46 percent of the total sample households, while little more than one-fifth households have the asset of refrigerator. The maximum availability of refrigerator is found in the Bawaria caste, followed by the Ramdasia Sikh and the Bazigar castes, while the refrigerator was not available in any of the household belonging to the castes such as the Khatik, the Sansi, the Doom and the Sapera at the time of field survey. Furthermore, it is found that about 12 percent households still fond of radio, but it is not available in any of the household belonging to the castes like the Khatik, the Sansi, the Bawaria and the Sapera. More than three-fifths households have the availability of television, and castes like the Balmiki, the Majhabi Sikh, the Sansi, the Doom and the Sapera have the asset of television below the average (62 %) in rural Haryana. On the other hand, about 73 percent households have mobile. The availability of mobile is found in all the households of the Sapera caste, followed by the Meghwal, the Odh, the Dhanak, the Ramdasia Sikh castes and the least is recorded in the Doom caste.

It may be noted that only three percent households among scheduled castes have the asset of computer and laptop, and only the Bazigar and the Chamar castes have such assets above the average that is 4.8 percent and 4.2 percent respectively. The other castes like the Odh, the Balmiki and the Dhanak have also asset of computer/ laptop. About half of the sample households have used the cycle, but it is not used in any of the household belonging to the Sapera caste. Further, about one-tenth households have scooter/motor cycle in the study area. The maximum number of households having such asset in the caste like the Bawaria, followed by the Doom and the Ramdasia castes. The lowest is recorded among the Majhabi Sikh and it is followed by the castes like Dhanak and Balmiki. Scooter/motor cycle is not found in any of the household belonging to the Sapera caste. Similarly, less than two per cent households have own car. The Odh caste has the highest number of households having own car (8.1 %), followed by the Bazigar, the Meghwal, the Majhabi Sikh and the Chamar castes, while the lowest is recorded among the Balmiki. On the other hand, the household belonging to the castes like the Dhanak, the Khatik, the Sansi, the Doom, the Ramdasia Sikh, the Bawaria and the Sapera have not their own car in the study area.

Availability of Household Amenities and Assets among Non-Scheduled Castes

Among the non-scheduled castes, it is recorded that about two-third households used pipe water for drinking; nearly one-third households used water from hand

pump and more than one-fourth households used tube well water for drinking. Pipe water is only used by all the households belonging to the Maniyar caste. On the other hand, the facility of hand pump is not available in any of the household belonging to the castes such as Rajput, the Kamboj, the Gujjar and the Muslim; and tube well water is not used by the Kumhar, the Sunar, and the Mali castes. Hand pump water is used by all the households of the Darji caste, and tube well water is used by all the households belonging to the Dhobi caste. Further, it is observed that, 86 percent households have the facility of toilet. All the caste belonging to general category and the castes belong to other backward castes such as the Jhinwar, the Kamboj, the Gujjar, the Sunar, the Darji and the Dhobi have the toilet facility above the average in the study area. All the households, except the castes like the Jhinwar, the Khati and the Lohar have the facility of electricity among the non-scheduled castes in rural Haryana.

Further, it is found that 87 percent households have the asset of chair. Except the caste like the Punjabi and the Rajput, all the households have chair among the general castes. Likewise, fan is available in nearly 97 percent of the surveyed households. The Rajput among general castes and the Jhinwar, the Khati, the Joginath, the Saini, the Kumhar and the Kashyap among other backward castes have the asset of fan below the average percentage. Pressure cooker is used by more than four-fifths of the total sample households. Little more than three-fifth households have the asset of refrigerator, while it was not available in any of the household belonging to the castes like Kashyap, the Maniyar and the Dhobi. It may be noted that a little less than one-fifth of the sample households have radio and half of the households belonging to the Rajput and the Gujjar castes still enjoying the voice of radio. Conversely, it is not available in any of the household belonging to the castes such as the Kashyap, the Mali, the Darji, the Maniyar and the Dhobi in the study area. Furthermore, about 85 percent of the surveyed households among non-scheduled castes have television and castes like the Mali and the Muslim have the asset of television less than half of the households. On the other hand, nearly 90 percent households have mobile and it is available in all the households belonging to the Bania, the Kamboj, the Gujjar, the Sunar, the Kashyap, the Mali, the Darji and the Dhobi castes and the least is found in the Maniyar caste. Only 16 percent households among non-scheduled castes have the asset of computer and laptop. However, nearly 24 percent and seven percent households have computer/laptop among the general castes and other backward castes respectively. It is not found in any of the household except the castes like the Ahir, the Kamboj, the Gujjar, and the Sunar at the time of survey in the study area.

It may be noted that more than three-fifth of the sample households still have used the cycle, but it is not found in any of the household belonging to the Maniyar and the Dhobi castes. About 48 percent households have scooter/motor cycle in the study area. All castes among the general castes and the Ahir and the Sunar among the other backward castes have scooter/motor cycle above the average percentage. Scooter/motor cycle is not found in any of the household among the caste like the Mali, the Darji, the Maniyar, the Dhobi, and the Muslim. Similarly, a little more than one-fifth of the households have own car. Half of the households belonging to the Rai Sikh caste has own car, followed by the Sunar and the Jatt Sikh castes, while the lowest is recorded among the Saini caste. On the other hand, car is not found in any of the household except the castes like the Sunar, the Ahir, the Kamboj and the Saini among the other backward castes in rural Haryana. In the preceding sections, the relative position in terms of individual variables of each of the castes among scheduled castes and non-scheduled castes of the selected variables has been discussed. In the present section, an attempt has been made to analyze the average composite weighted scores in the availability of amenities and assets of each of the caste among scheduled castes and non-scheduled castes in rural Haryana.

Caste-wise Average Composite Weighted Scores of Selected Amenities and Assets among Scheduled Castes

On the whole, based on sample households, the Odh caste has the highest average composite weighted scores in the availability of amenities like drinking water, sanitation and electricity, while the Ramdasia Sikh caste reports the lowest position followed by the Sapera and the Meghwal castes among the scheduled castes (Table-2). The castes like the Bazigar, the Khatik, the Sansi, the Majhabi Sikh and the Bawaria report above the average composite weighted scores that is 2.4. Table-2 also summarizes the caste-wise average composite weighted scores of selected assets among the scheduled castes in rural Haryana. It is found that the Odh caste has also obtained the highest average composite weighted scores of 15.8, followed by the Bazigar (13.4) and Meghwal (12.5) castes in the availability of various assets among the scheduled castes. Conversely, the Sapera caste reports the lowest position with average composite weighted scores of 3.8 and it is followed by the Sansi and the Doom castes with 5.2 scores. The other castes like the Dhanak, the Khatik, the Balmiki, and the Majhabi Sikh report below the average composite weighted scores (8.5) in the study area. Finally, it is also recorded that the first rank is obtained by the Odh caste with total composite average weighted scores of 18.5, followed by the castes like Bazigar (16.0) and Meghwal (14.6) in the availability

of various amenities and assets among the scheduled castes. On the other hand, the Sapera caste reports the lowest position with total average composite weighted scores of 5.8 and it is followed by the Doom and the Sansi with 7.4 and 7.8 scores respectively. However, the Bawaria, the Ramdasia Sikh and the Chamar castes have also better position in amenities/facilities and assets and obtained the total average composite weighted scores above from average scores in rural Haryana (Table-2).

Table-2: Average Composite Weighted Scores among Scheduled Caste

Castes	Based on Selected Amenities			Based on Selected Assets		Based on Selected Amenities and Assets	
	Total HHs	Total CWS	AC WS	Total CWS	AC WS	Total CWS	AC WS
Chamar	527	1283.5	2.4	4870.4	09.2	6153.9	11.6
Balmiki	184	0436.0	2.4	1138.6	06.2	1574.6	08.6
Dhanak	111	0268.0	2.4	0616.4	05.6	0884.4	08.0
Majhabi Sikh	39	0096.5	2.5	0262.9	06.7	0359.4	09.2
Odh	37	0098.5	2.7	0584.7	15.8	0683.2	18.5
Meghwal	23	0049.0	2.1	0287.3	15.5	0336.3	14.6
Bazigar	21	0055.0	2.6	0280.3	13.4	0335.3	16.0
Khatik	09	0023.0	2.6	0054.6	06.1	0077.6	08.7
Sansi	08	0020.5	2.6	0041.9	05.2	0062.4	07.8
Doom	05	0011.0	2.2	0025.9	05.2	0036.9	07.4
Ramdasia Sikh	05	0009.5	1.9	0049.5	09.9	0059.0	11.8
Bawaria	04	0010.0	2.5	0041.0	10.3	0051.0	12.8
Sapera	02	0004.0	2.0	0007.6	03.8	0011.6	05.8
Rural Haryana	975	2364.5	2.4	8261.1	08.5	10625.6	10.9

Source: ICSSR: ESCAC, Field Survey, 2012-14 (Haryana). Compiled by Authors.

Average Composite Weighted Score of Selected Amenities and Assets among Non-Scheduled Castes

Based on sample households, the average composite weighted scores has been recorded 2.9, 2.6 and 2.8 in the availability of amenities like drinking water, sanitation and electricity among the general castes, other backward castes and non-scheduled castes respectively. However, the Rai Sikh caste has the highest average composite weighted scores (3.3), followed by the Kamboj caste (3.0),

while the Kumhar caste reports the lowest position with 2.3 average composite weighted scores in the availability of amenities among non-scheduled castes. The study also reveals that only the Kamboj, the Sunar, the Jhinwar and the Saini castes have above the average composite weighted scores (2.6) among the other backward castes particularly. Further, it may be noted that except the castes such as the Rai Sikh, the Jat, the Bania, the Rajput among the general castes, and the Kamboj and the Sunar which includes in the category of other backward castes report above the average composite weighted scores (2.8) among non-scheduled castes (Table-3). The caste-wise average composite weighted scores of selected assets among general castes, other backward castes as well as non-scheduled castes in rural Haryana has also been summarized in Table-3.

The average composite weighted scores have been recorded 50.4, 23.7, and 38.6 in the availability of various selected assets among the general castes, other backward castes and non-scheduled castes respectively. The Rai Sikh caste has also obtained the highest average composite weighted scores of 75.6, followed by the Sunar and the Jatt Sikh with average composite weighted scores of 63.8 and 60.6 respectively in the availability of various assets among the non-scheduled castes in rural Haryana. On the other hand, the Maniyar caste reports the lowest position with average composite weighted scores of 2.9, and it is followed by the Muslim and the Mali castes with 3.6 and 4.3 scores. The Bania and the Brahman castes reports below the average composite weighted scores of 50.4 among the general castes. While except the castes such as Sunar, the Kamboj, the Ahir and the Dhobi, all other select castes belong to other backward castes have below the average composite weighted scores of 23.7 in the study area. Finally, it is also recorded that the households belonging to Rai Sikh caste has comparatively better condition in availability of amenities and assets with total average composite weighted scores of 78.9, followed by the Sunar (66.5) and the Jatt Sikh (63.3) castes among select non-scheduled castes in rural Haryana.

Table-3: Average Composite Weighted Scores among Non-Scheduled Castes

Selected Castes	Based on Selected Amenities			Based on Selected Assets		Based on Selected Amenities and Assets	
	Total HHs	Total CWS	AC WS	Total CWS	AC WS	Total CWS	AC WS
				General Castes			
Jat	99	291.0	2.9	5212.9	52.7	5503.9	55.6

Contd...

Brahman	57	160.5	2.8	2422.3	42.5	2582.8	45.3
Jatt Sikh	24	064.5	2.7	1454.2	60.6	1518.7	63.3
Panjabi	16	043.0	2.7	0818.9	51.2	0861.9	53.9
Bania	12	035.0	2.9	0438.4	36.5	0473.4	39.4
Rajput	06	017.5	2.9	0328.1	54.7	0345.6	57.6
Rai Sikh	04	013.0	3.3	0302.2	75.6	0315.2	78.9
General Castes	218	624.5	2.9	10977.0	50.4	11601.5	53.3
Other Backward Castes (OBC)							
Ahir	40	105.5	2.6	1954.3	48.9	2059.8	51.5
Jhinwar	14	038.0	2.7	0102.1	07.3	0140.1	10.0
Khati	14	035.5	2.5	0160.5	11.5	0196.0	14.0
Joginath	11	028.0	2.5	0094.9	08.6	0122.9	11.1
Kamboj	11	032.5	3.0	0547.6	49.8	0580.1	52.8
Lohar	11	028.0	2.5	0079.4	07.2	0107.4	09.7
Nai	11	028.0	2.5	0132.4	12.0	0160.4	14.5
Saini	10	027.0	2.7	0192.4	19.2	0219.4	21.9
Gujjar	08	020.0	2.5	0133.4	16.7	0153.4	19.2
Kumhar	08	018.5	2.3	0078.9	09.9	0097.4	12.2
Sunar	07	020.0	2.9	0446.5	63.8	0466.5	66.5
Kashyap	05	013.0	2.6	0041.7	08.3	0054.7	10.9
Mali	05	013.0	2.6	0021.3	04.3	0034.3	06.9
Darji	04	010.0	2.5	0024.2	06.1	0034.2	08.6
Maniyar	02	005.0	2.5	0005.8	02.9	0010.8	05.4
Dhobi	01	002.5	2.5	0025.5	25.5	0028.0	28.0
Muslim	10	025.0	2.5	0036.4	03.6	0061.4	06.1
Total OBC	172	449.5	2.6	4077.3	23.7	4526.8	26.3
Total Non-SC	390	1074.0	2.8	15054.3	38.6	16128.3	41.4

Source: ICSSR: ESCAC, Field Survey, 2012-14 (Haryana). Compiled by Authors.

On the other hand, the Maniyar caste reports the lowest position in availability of amenities and assets with total average composite weighted scores of 5.4 and it is followed by the Muslim (6.1), the Mali (6.9), the Darji (8.6) the Lohar (9.7), the Jhinwar (10.0), the Kashyap (10.9) Joginath (11.1) and the Kumhar (12.2) respectively have less than half of the total average composite weighted scores among the other backward castes particularly. However, it may also be noted that the households belonging to the Brahman, the Ahir, the Punjabi, the Jat and the Rajput castes have also better position in availability of amenities and assets among non-scheduled castes in rural Haryana.

Conclusion

It is concluded that the household's quality of life among various social groups is influenced by the availability of household amenities and assets and very large variations still exist among scheduled castes and non-scheduled castes in the study area. It is recorded that Odh caste has better access to the availability of amenities and assets as compared to other scheduled castes. The first rank is obtained by the Odh caste with total composite average weighted scores of 18.5, and followed by the castes like Bazigar and Meghwal, while the Sapera caste reports the lowest position with total average composite weighted scores of 5.8 and it is followed by the Doom and the Sansi castes. The Bawaria, the Ramdasia Sikh and the Chamar castes have also better position in amenities and assets and obtained the total average composite weighted scores above from average scores (10.9) among scheduled castes in rural Haryana. Likewise, among the backward castes except the castes such as the Sunar, the Kamboj, the Ahir and the Dhobi, all other select castes have below the average composite weighted scores (26.3) in the study area. Similarly, only Brahman and the Bania castes among general castes have below the average composite weighted scores of 53.3 in the study area. Further, it may be noted that very large difference (30.5) has been observed in the average composite weighted scores between the scheduled castes (10.9) and non-scheduled castes (41.4) in the study area. Finally, it is suggested that the government should provide incentives to enhance their income level for minimizing the inter castes variations in respect of availability of household amenities and assets among scheduled castes and non-scheduled castes in particularly rural areas of Haryana state. Secondly, proper implementation and regular monitoring of schemes and programmes launched by government for better housing conditions and poverty alleviations.

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WOMEN AT MARGIN: EXPLORING THE VILNERABILITY OF WOMEN IN UNORGANISED SECTOR OF JAMMU CITY

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Abstract

The unorganised sector also known as informal sector is an important stakeholder in Indian economy. It not only contributes a significant proportion to the GDP but also provides employment to large number of low and unskilled workers. However, despite its major contribution the unorganised sector is characterised by plethora of issues such as meagre wages, poor working conditions, lack of job security etc. Further, women in this sector are more vulnerable as they face various types of exploitation owing to both economic and social status. The present paper aims to analyse the condition of women in unorganised sector of Jammu city. For the purpose of study, the workers have been categorised into various categories such as domestic, agricultural, construction and others. The study is based on primary survey where 50 respondents have been interviewed. The collected data has been tabulated with the help of MS Excel. Simple statistical tools have been used to draw the analysis. Moreover, composite index has been used to examine the vulnerability of females in this sector. It has been found that the females in this sector are more vulnerable as they are exploited in various forms such as delayed payments, physical and verbal abuse.

Introduction

In India, the unorganized sector refers to economic activities that operate outside the scope of formal labour regulations and social protection programs. This industry is characterized by its informal nature, lack of fixed hours, lack of job security, and restricted access to benefits such as health insurance, pension, and paid vacations. It includes, among others, street vendors, domestic workers, construction workers, agricultural labourers, and artisans (Rani, 2016). Despite its informal nature, the unorganized sector employs a substantial portion of the country's workforce, including a large number of women. Women's participation in this sector is driven by various factors, including the need to contribute to household income, lack of formal education and skill opportunities,

and social norms that confine them to certain occupations (Monisha & Rani, 2016). The Periodic Labour Force Survey (PLFS) 2018-2019 data reveals that approximately 96 percent of employed women in India work in the informal or unorganized sector. This staggering statistic underscores the magnitude of women's presence in this vulnerable labour market segment (Masood, 2015). While women's participation in the unorganized sector is significant, they face numerous vulnerabilities and challenges. Indeed, in the unorganized sector, both male and female workers experience exploitation, but women are particularly vulnerable due to their gender (Manju, 2017). The lack of formal employment contracts often leads to lower wages and exploitative working conditions. The women situated at the lower end of the social and economic hierarchy rely on low-paying occupations that lack recognition and job security, commonly referred to as "informal" employment (Dubey, 2016). Many women in this sector work as daily wage labourers, facing uncertainty in income and job stability. Additionally, they often lack access to maternity benefits, paid leave, and safe working conditions. Women in the unorganized sector also confront social biases and gender discrimination. Women workers are more susceptible to the dangers of sexual harassment and exploitation (Saradamoni ,1995). In some occupations, they are paid less than their male counterparts for similar work. The lack of formal recognition and protection leaves them vulnerable to harassment and abuse, with little recourse to legal support.

Study Region

Because of its historic temples and Hindu shrines, Jammu is referred to as the "City of Temples". It is the biggest city in the Jammu division of Jammu and Kashmir's union territory. This city functions as both the administrative centre for the Jammu district and the winter capital of the J&K UT. Its longitudinal extension is from 740 24' E to 750 18' E, while its latitudinal extension is between 320 50' N and 330 30' N. Situated on the banks of the Tawi River, it occupies an area of 240 square kilometres. Jammu is tucked away among the jagged, lower-elevation slopes of the Shivalik hills (Kumari et al, 2019). It is bordered to the north, east, and southeast by the Shivalik Range, to the northwest by the Trikuta Range, and the south by the northern plains. Jammu is the second most populous city in the union territory, with a sizable population. Jammu city had 502,197 residents as of the 2011 census, with 8.47% of those under the age of six. 52.7 percent of the population was male, and 47.3 percent was female. Compared to the 940 national average sex ratio, there were 898 females for every 1,000 males in the city. With a male literacy rate of 93.13% and a female literacy rate of 85.82%, Jammu's average literacy rate was

significantly higher than the 74.4% national average literacy rate. It is located in the province of Jammu's largest urbanised district (Kumari & Singh, 2024). In J&K UT, almost 85% of the workforce is employed in the unorganised sector.

Objectives

(1) To assess the socio-economic status of women workers in the unorganised sector and conditions of their work environment.

(2) To understand and analyse the level of vulnerability among different categories of women workers in the unorganised sector and issues involved.

Database and Methodology

This study was purely based on primary data collected through well-prepared schedules. To achieve the objectives, 50 women respondents were selected from different categories of informal workers based on the categorization done by the Ministry of Labour, Government of India. They have categorized the unorganized labour force into four groups in terms of occupation, nature of employment, specially distressed categories and service categories. Under the Terms of Occupation, we had taken agricultural labourers and construction workers. Under the Terms of Nature of Employment and Terms of Service Category, migrant workers and domestic workers & vendors, had been taken respectively (Dhas & Helen, 2008). To find out the level of vulnerability among different categories of informal workers, different indicators were taken i.e., physical harassment, verbal harassment, sexual harassment, mental harassment, low wage, delayed payment and irregular payment. Scores have been assigned to the frequency of harassment faced by them. Based on the above criteria, the level of vulnerability has been calculated using the composite index

Results and Discussions

Socio-economic characteristics

Table-1 shows the socio-economic profile of the unorganised workers in the Jammu city. 42 percent of women working in the unorganised sector are between the ages of 30 and 40 years, 34 percent of the respondents were between 18-30 years of age, and 24 percent were above 40 years. The unorganised sector in Jammu city constitutes 90 percent of women respondents who are married. Only 6 percent of respondents have completed the 10th standard whereas 66 percent of respondents have studied only up to the primary level in this sector.

Low level of education is one of the factors responsible for engagement in the unorganised sector. Only 19 percent of women workers in the informal sector are domiciled in J&K and the remaining 81 percent are migrants from other states, thus, making them more vulnerable to abuse, exploitation, and discrimination in unfamiliar settings. Income varies for different categories of unorganised workers according to their average daily working time. Vendors have the highest average daily working hours of 11 hours and thus the highest average monthly income of Rs. 22,300 whereas domestic workers have the lowest average monthly income of Rs. 7000 because they work for only 5 hours a day (Table-1 and Fig.-1).

Table-1: Socio-economic Characteristics of Respondents (%)

Age			Domicile		Educational level			Marital status		
18-30	30-40	More than 40	Yes	No	Primary	Middle	Secondary	Married	Unmarried	Widow
34	42	24	38	62	65.7	28.6	5.7	90	2	8

Source: Primary Survey, 2022

People may be involved in informal work because of many reasons such as lack of formal job opportunities, limited education and skills, poverty and economic necessity, lack of legal documentation, seasonal and temporary work, etc. 38 percent of the respondents reported that they are forcibly involved in the informal sector while 62 percent comes in this sector willingly. Poor educational background is the most significant factor contributing to involvement in the informal sector as 60 percent of the respondents are involved in this sector due to this reason. This suggests that individuals with limited education may find it challenging to access formal job opportunities requiring higher qualifications, leading them to opt for informal work to earn a living. Family issues combined with poor educational background are responsible for 20 percent of the respondents for involvement in this sector. This indicates that family circumstances and responsibilities can compound the challenges faced by individuals with inadequate education, making it even more difficult for them to secure formal employment. The lack of jobs in the formal sector, combined with family issues, is responsible for another 10 percent of the respondents. This suggests that in some instances, individuals may be forced into the informal sector due to a lack of available formal job opportunities in their

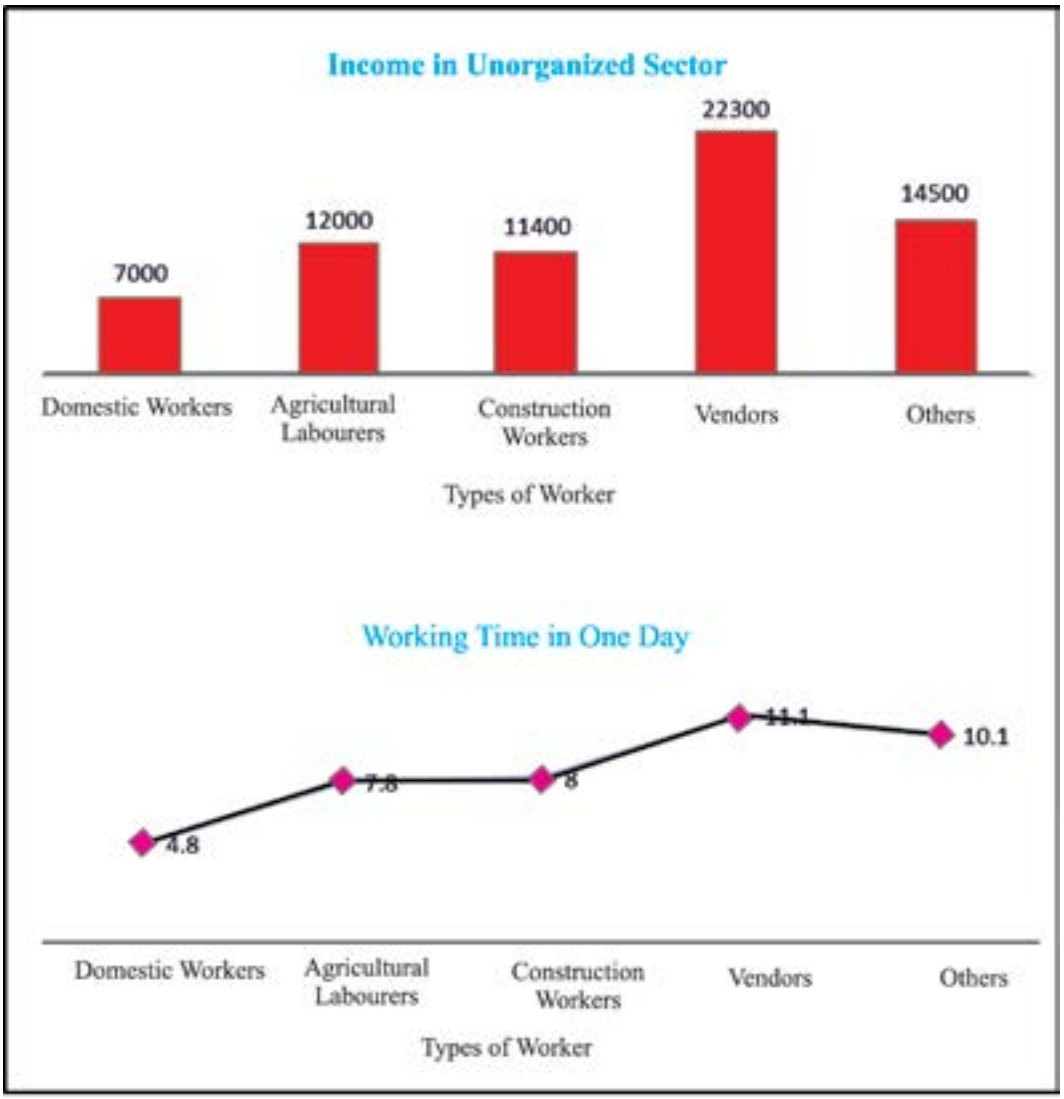

Income in Unorganized Sector
7000
12000
11400
22300
14500
Domestic Workers
Agricultural Labourers
Construction Workers
Vendors
Others
Types of Worker
Working Time in One Day
4.8
7.8
8
11.1
10.1
Domestic Workers
Agricultural Labourers
Construction Workers
Vendors
Others
Types of Worker

Fig. 1

region or sector of expertise. The involvement of the remaining 10 percent was attributed to other reasons such as lack of legal documentation, discrimination, and preferences for the flexibility and autonomy offered by informal work. Informal workers often face challenges when accessing different facilities such as loans or credit, medical, and child care facilities. The data reveals that 28 percent of women workers have access to credit facilities, 8 percent reported that they occasionally receive credit and 64 percent of them don't get credit in times of need. Moreover, these informal workers receive credit from either their employers or private lenders rather than from banks or any other financial institutions as loans. None of the respondents had access to on-site medical facilities or any kind of medical insurance. Also, all the respondents don't have access to basic amenities like toilets and child care. Only 12 percent of the respondents have child-care facilities at their workplace. It is important to mention here that they don't have proper child-care facilities but only they are allowed to bring their child to work. Additionally, 88 percent of the respondents have access to the toilet, and the remaining 12 percent that don't have toilet facilities at work mostly belong to agricultural labourers and vendors (Mishra, 2018).

Vulnerability among Different Categories of Workers in Unorganised Sector

The level of vulnerability was assessed among the five categories of informal workers based on different parameters such as physical harassment, verbal harassment, sexual harassment, mental harassment, low wage, delayed payment, and irregular payment. The index value ranges from 0.25 to 0.41, with vendors having the highest value (0.41), making them the most vulnerable group of informal workers, and agricultural labourers having the lowest value (0.25), making them the least vulnerable (Fig. 2).

Vendors

Vendors are the most vulnerable among the other categories of informal workers with an index value of 0.41. One of the major reasons that contribute to their vulnerability is that they have no fixed working hours (Vara & Subhashini, 2019). Vendors work an average of 11 hours each day, which is the most among all categories of informal workers. Firstly, the indicator which adds most to their vulnerability is the verbal harassment they face at their work being it from customers or fellow vendors, especially from male vendors (George, 2024). Vendors work in public spaces, such as streets or open markets,

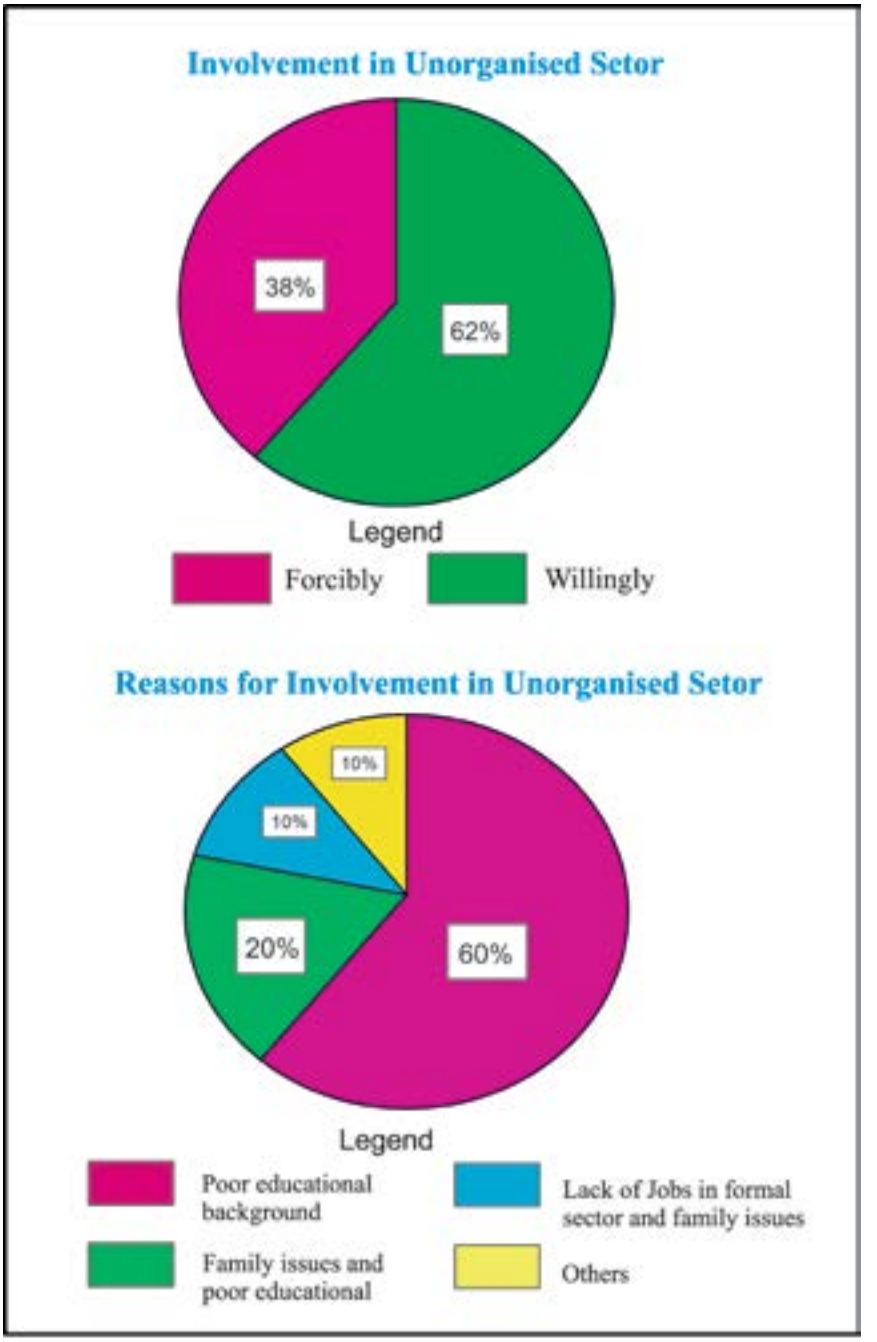

Involvement in Unorganised Setor
38%
62%
Legend
Forcibly
Willingly
Reasons for Involvement in Unorganised Setor
10%
10%
20%
60%
Legend
Poor educational background
Lack of Jobs in formal sector and family issues
Family issues and poor educational
Others

Fig. 2

where they are exposed to various risks, including accidents, theft, and harassment from local authorities or law enforcement, leading to constant fear and insecurity in their work environment. Secondly, irregular payments make them economically vulnerable. Although among the different types of informal workers, vendors earn the most money still they are the most vulnerable because their income is highly dependent on daily sales and fluctuations in demand.

Domestic Workers

Among the different categories of informal workers, domestic workers rank as the second most vulnerable category with an index score of 0.36. Domestic workers work in private homes, isolated from public view, which can lead to increased vulnerability to abuse, harassment, and exploitation (SEWA, 2014). The lack of visibility also makes it difficult to monitor working conditions and enforce labour standards (Neetha, 2023). The main indicators that make them vulnerable are low wages and delayed wages (Singh, 2023). They have the lowest average wages among all categories of informal workers. Domestic workers often depend entirely on their employers for their livelihood, accommodation, and often food and other basic necessities (Singh, 2023). This dependency can make it difficult for them to assert their rights or report abuses for fear of losing their jobs or being evicted. Additionally, the fact that they don't take enough breaks and off days makes their job more exploitative. They may be expected to be available 24/7, with little regard for their well-being.

Construction Workers

Construction workers are more vulnerable than agricultural labourers with an index value of 0.28. The indicator that adds the most to their vulnerability is mental harassment. Construction work can be physically demanding, and the strain on the body can take a toll on the mental health of workers, especially when they do not have access to proper healthcare or recovery time (Banu & Sampath, 2018). They got minimal time for rest and relaxation and thus fatigue and stress can build up, affecting the mental well-being of workers. Low wages and the uncertainty of finding continuous work can cause financial stress and job insecurity among construction workers, leading to anxiety and depression. Moreover, women involved in construction work are migrants who are away from their families and communities, feelings of isolation and loneliness can also lead to mental health challenges.

Agricultural Labourers

Agricultural labourers are the least vulnerable category among the other categories of informal workers with an index value of 0.25. They have fixed working hours in a day and fixed wages which at least ameliorates their vulnerability a little. Despite their low wages, they believe that they have stable incomes because of the timely disbursement of wages. Moreover, they are less prone to verbal and physical harassment as their interaction with their employer and fellow workers is quite less. Their work is of seasonal and temporary nature depending on the crop cycles which leaves them vulnerable because of lack of job security and income stability resulting from their uncertain employment (Dineshkumar, 2017), (Kiranekumar, 2022).

Others Workers

Other informal work categories include women working in shops, parlours, boutiques, etc. This category is also the second most vulnerable group among the other categories of informal workers. Like vendors, their job is also interactive which makes them vulnerable to verbal abuse. They work for an average of 10 hours every day. They work long hours with no set schedule, which leaves them with little time for rest. Additionally, they also face problems of delayed and irregular payments. Informal workers face a range of challenges and issues due to the nature of their employment and the lack of formal protections. They face issues such as difficulty in managing family life, not enough income, health issues, not enough time for rest, etc (Ansari, & Mehaboob, 2018). Different categories of informal workers face different issues due to their work as shown in Figure 3. 40 percent of domestic workers reported that they face issues of difficulty in managing family life, low income, health issues, and not enough time for rest. 10 percent of them reported that they feel their income is low and also face health issues especially backaches due to the nature of their work. Moreover, 10 percent of them don't face any such issues. In case of agricultural labourers, 40 percent of them reported issues of difficulty in managing family life and not enough time for rest. It is interesting to note here that agricultural labourers don't feel that their wages are low. This may be due to the reason that they get their wages timely. 20 percent of them reported that they don't get enough time for rest due to which they face health problems. 60 percent of construction workers reported that they face difficulties in managing family life, do not have enough income to meet their needs, and also do not have enough time for rest (Kumar & Banu, 2018).

Due to all these issues, 20 percent of these workers face issues related to their health. Moreover, construction sites are also not completely safe for work and if they meet any accident, they do even not get any insurance. Three main issues that are faced by 60 percent of vendors: low income, health challenges, and difficulty juggling family responsibilities. It is noteworthy to mention that all surveyed vendors have issues that make vendors the most vulnerable among the other categories of informal workers. The category of "Others" includes women working in shops, parlours, boutiques, etc. 50 percent of such workers stated that they face difficulty in managing their family with their work. This is due to their long and not fixed working hours. Thus, 10 percent stated that they don't get enough time for rest. Additionally, 10% of them believe that their income is insufficient given their long work hours and also, they face different health problems.

Conclusion

It has been found that the women working in unorganised sector face the dual pressure of balancing work and family life. Due to lack of security, women in this sector have to work for longer hours with limited wages. Moreover, women in this category are not skilled as a result they are employed in low-income jobs. The women in this sector do not get facilities for medical care and child care. Although the women working in this sector feel that they are willingly doing this job, still they are forced by external conditions such as poor educational background, family issues and lack of jobs in the formal sector. Currently, there is a lack of official statistics on this particular sector. The govt. has come out with a good initiative called the e-shram portal for collecting and organising the data of informal workers. Skill development programmes can be organised for women working in this sector so that they can get better remuneration. There should be some provisions for insurance and medical facility for workers in this sector.

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SPATIO-TEMPORAL ANALYSIS OF CROPPING PATTERN IN NILAKOTTAI TALUK OF DINDIGUL DISTRICT, TAMIL NADU

V. Parameswari and Dr. V. Emayavaramban

Abstract

The concept of agricultural regionalization is not dividing a land into different fragments but also a method of understanding the agricultural patterns. The existing patterns will strongly show the combinations of physical and socio-economic balance of an area. To map the cropping pattern the following analysis were required they include crop combination, crop diversification and crop combination. The results suggest that there are seven crops widely occupies in the study area. Among the Seven crops Flowers, Vegetables, cereals, e were the top three crops. (The high Crop diversification is observed in 23 Villages of the study area. Majority of villages are in Nilakottai block they are Kolladipatty (0.71), Nilakottai (0.75) Kullalakundu (0.71), the low crop diversification is observed Viralimayanpatti (0.17) and Kanavaipatty (0.34) in north and north eastern part of Batlagundu blocks shows lower crop diversification, other blocks in the study area have the index value more than 0.7 which indicates that the blocks have high diversification. The crop combination analysis also sight that Flowers, Vegetables, as fist ranking crop in several blocks, similarly cereals, paddy, founds as second ranking crop and paddy is found as third ranking crop in the study area. The cropping pattern analysis will provide the agricultural and agro-climatologist to suggest better land use planning of an area.

Introduction

Cropping patterns are defined as the sequence and spatial arrangement of annual crops on a piece of land. Knowledge of cropping patterns is crucial for crop production and land-use intensity. (Mahlayeye et al., 2022: Osama et al 2017). Crop concentration means the variations in the density of crop in an area/region at a given point of time (Mazid Hussain, 1965), Crop combination is a technique used to establish the boundaries of agricultural regions based on statistical comparison of acreages Florence (1948), Compared the share of a region with that of the

entire nation with the help of a location quotient method. Vivekananda M. and Sathyapriya V. S., (1994). Similarly, Bhatia (1965) used the quotient method to determine the regional concentration of crops. In the present work Jasbir Singh's (1976) technique has been adopted to identify the regional concentration of crops. Overall development depends on food production in service of existing or growing population with maximum benefits and optimal utilization of water and land resources. (Alabdulkader et al., 2012: Shreedhar et al., 2015: Vinothini et al 2019). The introduction of these crop combination methods by Bhatia (1960), Athawale (1966),). Vivekananda M. and Sathyapriya V. S., (1994). Kalaiselvi, V. (2009). In the present study Weaver's method of crop combination technique has been used to identify the temporal changes in the study area. The production has increasing trend for major crops. Productivity has increased and state agricultural growth rates are more satisfactory than national averages. (Goyal et al 20113: Peng et al., 2011: Aghajani et al 2013). The study of crop diversification is essential to the rotation of crops and the area under different crops. (Akhtar, R., & Acharya, 2015: Sun et al., 2015). . (Singh et al., 2001: Chen et al., 2018: Nematollahi et al., 2017,In order to identify the crop diversification, in present study, Gibb's Martin's Index has been applied and computed for Nilakottai Taluk ,This Journal also analysis the Nilakottai taluk ,Cropping pattern that happened between 2008-09 and 2017-18.

Study Region

The present study area Nilakottai taluk is in Dindigul district located between 1000'N to 100 17'North latitude and 77040'E to 770 68'East longitudes. Nilakottai taluk is found in the southern most part of Dindigul district. Nilakottai taluk shares borders with Kodaikanal, Aathur and Dindigul taluk in North and East Madurai district in the South of Nilakottai, Theni district is in the west. The NH 7 and state high passes through this taluk. The taluk is divided into two community block and 40 villages and 5 town panchayats of urban area for the implementation of development activities. The panchayats are grouped into two development Blocks.

Objectives

(1) To describe the crop concentration of the study are

(2) To bring out the crop combination

(3) To identify the crop diversification Disparity in Nilakottai taluk.

(4) To analysis farmers cultivated crops and their benefits

Database and Methodology

The present study is based on primary and secondary data sources. Primary data was collected at household surveys through questionnaires. A number of statistical techniques have been evolved and applied for the demarcation of crop concentration regions of which the location quotient method has been adopted by Bhatia (1965)

$$\frac{\text{Area of "x" Crop in a component aerial unit}}{\text{Area of all crops in a component aerial unit}}$$

Concentration Index of "x" Crop = Area of "x" Crop in entire region

The crop data has been computed with the help of Weaver's technique of crop combination. This is expressed as:

$$SD= \sum d2n$$

Where, d= Difference between actual crop percentage in the study region and the percentage in the theoretical distribution. n= number of crops in the given combination. The theoretical curve for the standard measurement was employed as follows; Monoculture = 100 % of the total harvested cropland in one crop. Two crop combinations = 50 % in each of two crops. Three crop combination = 33.3 % in each of three crops Four crop combination =25 % in each of four crops Five crop combination = 20 % in each of five crops Ten crop combination = 10 % in each of ten crops -Area of all crops in entire region. In present study, Gibb's Martin's Index has been applied and computed for Nilakottai Taluk. The formulas used to calculate area, as follows

$$\text{Index of Diversification} = 1-\sum x2/(\sum x)2$$

Here x is the one hundredth of total cropped area occupied by an individual crop. According to this method crop diversification varies between 0.1 - 0.9. This method is directly related to the magnitude of diversification. Here higher the index higher the diversification and lower the index lower the magnitude of diversification. where x is the percentage of total cropped area occupied by each crop under an individual crop ,if the index of diversification value close to I, the diversification is relatively high and the value not close to one ,it indicates the areal units have low diversification, If the total area in a region is devoted to one crop.

Result and Discussion

Crop Concentration in Nilakottai Taluk (2008 to 2018)

Cereals and Spices

When comparing the temporal years 2018 and 2008, it is to be noted that, the percentage of area occupied by cereals is varies from -6.50 to +37.64 per cent in that minimum is noted in Sevugampatty village of Bathalagundu block and maximum is noted in Kanavaipatty village of Bathalagundu block. Based on the data, it was observed that nearly 28 villages in the study area have decrease in area under cereals cultivation and 15 villages have notable increase in cereals cultivation. These cereals cultivation are high in Nilakkotai block than Bathalagundu block. Mean while decrease is also maximum in Bathalagundu block compared to Nilakottai block. The area under spices is not found in 5 villages in the study area, namely, Bodiakoundenpatti village of Nilakottai block, Kolladipatty village of Nilakkotai block, Kullichettipatty village of Nilakottai block, Mattaparai village of Nilakottai block and Pannaipatty village of Nilakottai block. The percentage of change is varies from -16.82 (Kanavaipatty village of Bathalagundu block to +23 per cent (Viralipatti village of Bathalagundu block). The area under cultivation of spices is decreased in 28 villages mainly distributed in the blocks of Nilakkotai and the area is increased in 10 villages distributed in the Bathalagundu blocks.

Sugar and Vegetables

Among the total 43 villages, the area under sugar crops is decreased in 22 villages and increase is noted in 5 villages namely (Nakkaluthu, pillyar natham, Malayagoundanpatti, Kullakundu, kolladipatty in southern side of Nilakotai block). The distribution of sugar crops is not found in 17 villages when comparing the temporal years. The area under change in sugar crops are varied from -16.71 per cent in Kullalakundu village of Nilakottai block to +44.8 per cent in Kanavaipatty village of Bathalagundu block. When comparing both the blocks, the sugar crops cultivation is increased in Nilakottai block than Bathalagundu block. The sugar crops cultivation is not found or no change is distributed mainly in Bathalagundu block. The cultivation of vegetables is increased in 21 villages in the study area when comparing both the years 2018 and 2008. Spatially these areas are distributed high in Bathalagundu blocks compared to Nilakottai block. The decrease is

noted in 22 villages mainly spread in the Nilakottai blocks than Bathalagundu blocks. The area under cultivation of vegetables is varies from -32.5 per cent in Ramarajapuram village of Nilakottai block to +23.73 per cent in Kanavaipatty village of Bathalagundu block.

Fibre Crops and Oil Seeds

Among the total of 43 villages, 21 villages in the study area have no cultivation of fibre crops. These villages are distributed high in Bathalagundu block than Nilakottai block. The area under fibre crops in the study area is varies from -12.02 per cent to +17.01 per cent. The minimum is noted in Viralipatti Batlagundublock and Ramarajapuram village inNilakkotai block. It is to be noted that 11 villages have increase and decrease of fibre crops in the study area. When comparing both the blocks the changes are high in Bathalagundu block than Nilakottai block. The change in area under cultivation of oil seeds is varies from -22.97 per cent in Viralimayanpatti village of Bathalagundu block to +16.63 per cent in kanavaipatty village of Bathalagundu block. From the changes data it has been observed that, increase in oil seed crop cultivation is noted in 21 villages and decrease is noted in 22 villages. The changes are noted high in Bathalagundu block compared to Nilakottai block in oil seeds cultivation during the two temporal years over the study area. (Table-1)

Flowers

The change in flower cultivation in the study area varies from -11.31 per cent in Chinnamanaickankottai village of Nilakottai block to +12.86 per cent in Musuvanuthu village of Nilakottai block. The increase in flower cultivation is noticed in 23 villages spread spatially high in _ Nilakkotai block compared to Bathalagundu block. The decrease is noted in 20 villages which are distributed high in Bathalagundu block than Nilakottai block. So, the changes in area under flower cultivation is high in Nilakottai block than block.

Crop Combination

The crop data has been computed with the help of Weaver's technique of crop combination. This is expressed as:

$$SD= \sum d2n$$

In the present study an attempt has been made to show the changes in the crop combination regions, during the period of 2008-09 and 2017-18.

Table-1: Changes in Crop Concentration (2008 to 2018 (Area in percent)

Sl. No	Village Name	Cereals	Spices	Sugar crops	Vegetables	Fibre crops	Oil seeds	Flowers
1	Bangalapatti	-0.618	-0.03	0	-1.99	0	-0.07	-0.02
2	Batalgundu	-2.4	5.77	-1.7	0.18	1.03	-7.93	0.05
3	Bodiakounden-patti	-0.369	0	0	0.35	0	-3.99	3.75
4	Chandaiyur	-0.817	8.91	-1.9	4.36	17.01	2.03	-0.58
5	Chinnammana-ickenkottai	-0.298	-2.86	0	-0.68	-2.55	-0.49	-11.31
6	Ethilode	0.413	-4.25	0	-0.42	0	2.16	4.42
7	Jampuduraikot-tai	0.936	-6.24	-1.49	2.12	0	-1.07	0.97
8	Kalladipatti	0.006	0	-9.28	0	0	-0.02	-0.58
9	Kanavaipatti	37.64	-16.82	44.8	23.73	-0.38	16.63	-3.32
10	Kodenginaick-enpatti	-2.216	-0.05	-4.89	-0.11	0	0.07	9.99
11	Kompaipatti	-4.739	-4.05	0	0.1	-0.41	1.68	-2.46
12	Koovanuthu	0.372	-0.31	0	-0.56	1.38	0.3	0.17
13	Kottur	-1.168	-5.05	-0.11	-2.46	-0.3	-0.97	0.93
14	Kullalakundu	-0.687	-0.13	-16.71	-0.71	0	0.91	-3.04
15	Kullichettipatti	-0.06	0	0	-0.51	0	-0.92	0.97
16	Kunruvarankot-tai	-1.54	2.38	0	0.01	0	3.63	-4.29
17	Malaiyakound-enpatti	0.12	-2.3	-10.91	-0.02	-5.9	-2.73	-0.33
18	Mallanampatti	-0.097	-0.27	0	0.53	2.78	-1.38	4.2

Contd...

19	Mattapparai	1.454	0	39.29	0.4	0	-10.9	-3.93
20	Musuvanuthu	-0.117	-0.28	0	1.26	0	-0.37	12.86
21	Nadakottai	-1.116	0.37	0	1.92	2.07	0.23	-1.28
22	Nakkaluthu	-0.022	-0.2	-10.13	-0.34	0	-0.22	3.41
23	Nariyuthu	-0.549	-5	0.32	-4.57	-5.91	-0.36	-2.43
24	Nilakottai	-0.105	-0.23	0	-0.03	0	0.6	-2.29
25	Nuthalapuram	-2.553	-0.53	0	4.37	0	1.91	0.53
26	Oruthattu	-2.59	-11.79	-1.41	0.58	0	4.47	-2.5
27	Pachamalay-ankottai	0.455	-1.62	0	0.27	0	0.15	-1.23
28	Pallapatti	0.034	-1.2	-1.4	3.39	0	5.19	-1.59
29	Pannaipatti	-0.943	0	-2.55	-0.37	2.76	-0.82	-5.04
30	Pillayarnatham	0.374	-0.79	-10.05	-0.16	0.14	1.81	0.26
31	Ramarajapuram	1.515	-0.18	3.02	-32.5	0	-0.78	1.69
32	Rengappanai-ckanpatti	-0.936	5.21	-0.51	7.8	2.76	0.94	-0.51
33	Sekkapatti	-3.092	4.75	-1.84	1.01	4.23	1.89	0.04
34	Senkattanpatti	-3.08	-0.94	-5.2	-1.45	13.8	0.64	3.95
35	Sevukampatti	-6.504	10.2	-0.15	-0.53	-12.02	11.51	-0.1
36	Silukkuvarpatti	1.72	-6.76	-1.23	-3.61	0	-0.04	-3.28
37	Sithrkalnatham	0.868	-0.72	-4.12	0.39	0	3.07	-2.77
38	Sivagnana-puram	0.205	-0.4	0	0.07	-1.53	0.93	-1.09
39	Veelinaicken-patti	-0.14	-0.2	0	-7.2	-5.39	-4.14	9.55
40	Vilampatti	1.97	-0.27	-0.4	-0.12	0	-0.38	0.15
41	Viralimayan-patti	-2.762	5.49	-0.04	5.03	4.82	-22.97	-0.52
42	Viralipatti	-4.854	23	-1.42	-0.5	-12.02	1.2	1.24
43	Viruveedu	-3.703	7.38	0	0.98	-1.21	-0.02	0.34

Source: Computed by Authors

Mono and Double Crop Combination

Crop combination is one of the important aspects in farming. It will help to rotate the crop and enrich the nutrients in the soil. Among the 43 villages in the taluk during 2008 and 2018, mono crop cultivation is dominated only in 5 villages of the study area. The major dominant groups of crops cultivated in the taluk are cereals, flowers and paddy. In cereals, the major crop cultivated is Bajra mainly found in Batlagundu village covering an area of 20.21sq.km constitutes 4.16 per cent of total land area of the taluk is noted in both the time periods. Among the flowers, Rottana flowers, Jasmine and Tuberose are cultivated widely in Ethilode, Malayagoundanpatti and Nadakottai villages respectively in 2008 but in 2018, Rose, Jasmine and Tulip rose are cultivated widely in Ethilode, Malayagoundanpatti and Nadakottai villages respectively. About, 31.55 sq.km of the land area was under flower cultivation covering 6.15 percent of the total land area of the taluk. The Ramarajapuram village is dominated by paddy cultivation covering the land area of 11 sq.km in both time periods. In the double crop combination, flowers, cereals, fruits, vegetables and cotton in 2008 and flowers, cereals, fruits, paddy and coconut are mixed widely in 2018 by the farmers in the study area.

It is to be noted that even though, varieties in flowers are dominantly cultivated as double crops, Rottana flowers and pitchy in Bangalapatti village, jasmine and pitchy in Kodainaickanpatti village where flowers are dominated covering the land area of 1.57 and 5.39 sq.km respectively, constitutes 1.43 per cent of the total land area of the taluk in 2008. But in 2018, along with the above said flower combinations, Charisanthiyam and Jasmine in Sivagnanapuram were also included and the total land area under flowers is 11.92 sq.km. The cereals and flowers combinations of crops cultivated in an area of 14.42 sq.km distributed in Chinnamanaickankottai and Kullalakundu villages are noted in both time periods. The double crop combination such as, flowers and fruits (Jasmine and Sapota) in Silukkuvarpatty village (9.23 sq.km), flowers and vegetables (Flag him and Olinder) combination in Koovanuthu (8.54 sq.km), paddy and vegetables (Paddy and Banana) combinations (24.02 sq.km) in Kunnuvarayan kottai and Mattaparai and Vegetables and cotton combinations (Cotton and Banana)is found in 3 villages namely Sithargal Natham, Sivagnanapuram and Pannaipatty cultivated in an area of 31.32 sq.km constitutes 6.45 per cent of the total land area of the taluk during the year 2008. But in 2018, the double crop combination such as, flowers and fruits (Jasmine and Sapota) in Silukkuvarpatty village (9.23 sq.km), flowers and fruits (Sapota and Olinder) combination in Koovanuthu (8.54 sq.km) are dominantly

found in the study area. The fruits and paddy group mainly banana and paddy are cultivated in Kunnuvarayan Kottai and Mattaparai village. The banana and coconut are cultivated in Sithargal Natham and Pannaipatty village of the study area.

Three and Four Crop Combination

The increase in the number of crops for cultivation indicates the diversification in crop combinations. The crop group under triple crops are, flowers, vegetables, fruits, paddy, cereals, cotton, oil crops and coconut are the combination widely distributed in the study area in the year 2008. But during the year 2018, the triple crop combinations are flowers, vegetables, fruits, paddy, cereals, cotton and coconut. In three crop combinations, most of the farmers cultivated flowers and vegetables as one of the mixed crops in most of the villages under triple crop in both the temporal years. The crop varieties such as, paddy, jasmine, bajra, cotton, coconut, millets, tomato, pitchy, Chrychantum, oleander, tupe rose, rose, mango, lemon, flag him and drumstick in 2008 and the crops such as paddy, jasmine, banana, coconut, lemon, tomato, millets, Chrychantum, pitchy, oleander, rose, mango, tulip, snake guard, pomegranate, flag him and drumstick are dominantly cultivated by the farmers in trip crop combinations in the study area by the year 2018. About 20 similar villages in both time periods have three crop combinations distributed in the total land area of 254 sq.km constitutes 52 per cent of total land area of the taluk but the combination of crops differs only in few villages during the study period. In the year 2008, in four crop combinations flowers, vegetables, cereals, cotton and mango are the dominant crops but in 2018, flowers, vegetables, cereals, fruits and coconut cultivated are the dominant crops by the farmers of the study area. The important crops cultivated in the four crop combinations are jasmine, oleander, drumstick, flag him, pitchy, Bajra, sorghum, mango, rose and coconut in both the time period meanwhile snake guard were added additionally in the year 2018. Only four villages in the study area have four crop combinations namely, Jambudurai kottai, Musuvanuthu, Nakkaluthu and Pallapatti. About 53.17 sq.km of the area under four crop combinations constitutes 11 per cent of the total land area of the taluk. Flowers are cultivated in four crop combinations in all the four villages of crop combinations in both time periods of study.

Five Crop Combination

Viralimayanpatti is the only village in the study area that has had five crop combinations in the past few years. The major crops group under five crop combinations are cotton, vegetables mainly tomato, paddy, cereals mainly sorghum

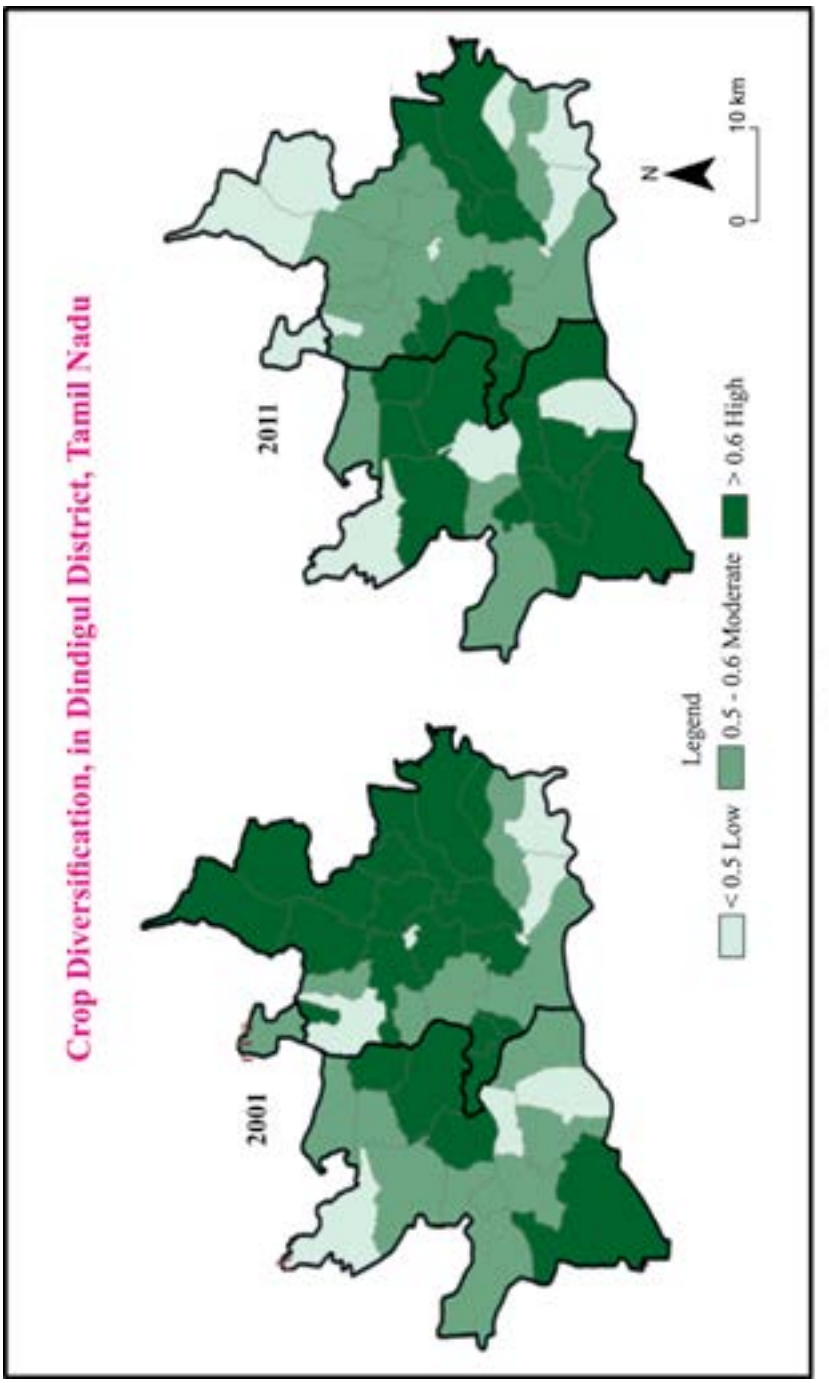

Crop Diversification, in Dindigul District, Tamil Nadu
2001
2011
N
0
10 km
Legend
< 0.5 Low
0.5 - 0.6 Moderate
> 0.6 High

Fig. 1

and fruits particularly banana. The total area under five crop combinations of 12.81sq. km constitutes 2.64 per cent of the total area of the taluk in both the time period. The application of Weaver's methods shows the realistic picture of crop combination. Three Crop Combination regions have found rice with a study area. Monoculture is in one village out of five villages in our study area. Two crop combinations are found in eleven villages. Three crop combinations are found in twenty villages in the study area .Four crop combinations are found in four villages in the study area. Five crop combinations are found in one village in the study area.

Crop Diversification

The whole study area is divided into three type of crop diversification regions, identified as (a) High crop diversification area, (b) Moderate crop diversification area and (c) Low crop diversification area (Fig. 1). The high Crop diversification is observed in 23 Villages of the study area. Majority of villages are in Nilakottai block they are Kolladipatty (0.71), Nilakottai (0.75) Kullalakundu (0.71), Pachamalayankottai (0.61), in southern side of Nilakottai block, Kottur (0.62), Ethilode (0.63), Pillaiyarnatham (0.65), Jambuduraikottai (0.65), Pallapatti (0.66), Bodiakoundenpatti (0.66), Silukkuvarpatty (0.66) in eastern part of the Nilakottai block, and the remaining five villages situated in south and south eastern side of Nilakottai block at Kulli Chettipatti (0.67), Koovanuthu(0.67), Malaiyakoundenpatti (0.68), Kompaipatti (0.68), Nariyuthu (0.69), Sivagnanapuram (0.69), Chinnamanaickankottai (0.70) and the Batlagundu block villages at eastern side of the study area in Rengappanaickanpatti (0.70), Mallanampatty (0.71), Kuruvankottai (0.64), Bangalapatti (0.66), Chandaiyur (0.60) ,Moderate Crop Diversification is found in 17 villages of both block, in that Nilakottai block only eleven villages identified in eastern side of Nilakottai block of Mattaparai (0.60), Vilampatti (0.42), Viralimayanpatti (0.42), Kanavaipatty (0.46), Nuthulapuram (0.47), Oruthattu (0.51), Sithargal natham (0.52),Veelinaickanpatti (0.53), Kodenginaickenpatti (0.53), Musuvanuthu (0.55), Viruveedu (0.58) in Nilakottai block south and south western side of cultivable land, remaining six villages were observed in Batlagundu block villages of Batlagundu (0.56), Viralipatti (0.57), Pannaipatty (0.58), in eastern side and Senkattanpatti (0.58), Nadakottai (0.59), Sevugampatty (0.59), in northern side of Batlagundu block, Ramarajapuram (0.09), Sekkapatti (0.32), Nakkaluthu (0.37) in southern side of Nilakottai block were observed low crop diversification region during the period. During the year 2017-18, the maximum crop diversification appears in Nadakottai (0.77) village of Batlagundu block, and the lowest crop diversification also identified in (Batlagundu block), where it is Senkattanpatti

(0.06) village. The region under high crop diversification is observed in 17 villages, Oruthattu (0.61), Kullalakundu (0.61), Sivagnanapuram (0.61), Veelinaickanpatti (0.61), Musuvanuthu (0.64), Ethilode (0.64), Bodiakoundenpatti (0.65), Pallapatti (0.66) Kompaipatti (0.69) and Bangalapatti (0.67) all these villages located at the south and south eastern part of the Nilakottai block. Pannaipatty (0.65), Batlagundu (0.66), Mallanampatty (0.70), Chandaiyur (0.71), Rengappanaickanpatti (0.72), Viruveedu (0.73) and Sekkapatti (0.74) villages are located in east and central part of the study area in Batlagundu block.

Moderate crop diversification is noted in 16 villages of Kolladipatty (0.43), Nakkaluthu (0.45), Chinnamanaickankottai (0.47), Silukkuvarpatty (0.52), Kottur (0.52), Nuthulapuram (0.52), Kullichettipatty (0.53), Nilakottai (0.53), Pillyarnatham (0.54), Mattaparai (0.54), Kodenginaickenpatti (0.56), Koovanuthu (0.56), Malaiyakoundenpatti (0.58), Sithargal Natham (0.59) and Nariyuthu (0.59) in all direction of the study area in Nilakottai block. Viralipatti (0.60) and Sevugampatty (0.60) are the two villages found in Batlagundu block that are noted as moderate crop diversification. The low crop diversification is observed four villages of Nilakottai blocks, it have identified in south and western part of Vilampatti (0.38), Ramarajapuram (0.38), Jambuduraikottai, Pachamalayankottai (0.28) and Senkattanpatti (0.06), Kunruvarankottai (0.08), Viralimayanpatti (0.17) and Kanavaipatty (0.34) in north and north eastern part of Batlagundu blocks (Fig No.3.19).

Conclusion

When comparing the temporal years 2018 and 2008, Spatial and temporal distribution crop indicates that increase in area under cultivation is noted These cereals, spices, sugar crops, oil seeds cultivation are higher in Nilakottai block than Bathlagundu block. Mean while decrease is also maximum in Batlagundu block compared to Nilakottai block, the decrease is noted in 22 villages mainly spread in the Nilakottai blocks than Batlagundu block the increase in flower cultivation is noticed in 23 villages spread spatially high in Nilakottai block compared to Batlagundu block. . Monoculture is in one village out of five villages in our study area. Two crop combinations are found in eleven villages. Three crop combinations are found in twenty villages in the study area. Four crop combinations are found in four villages in the study area. Five crop combinations are found in one village in the study area. The availability of irrigation facilities and the soil favoured more crop cultivation in this region. Crop diversification clearly denotes the low crop diversification area is decreased and high crop diversification is increased during

2017-18 especially in Nilakottai block in eastern side of the taluk than Bathalagundu block it clearly brought out that the cropping pattern, crop combination, crop diversification of the study area is highly influenced by the physical and socio-economic factors of the taluk.

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EXAMINING STATE'S ELECTORAL POLITICS THROUGH THE REGIONAL EYE- A CASE STUDY OF AHIRWAL REGION IN HARYANA

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Abstract

In Indian federal union, different states act as separate political arenas for both political parties and voters. For political parties these are the electoral battlegrounds to contest for gaining the seat of power and for the voters to make their choices felt in the elections either held for the parliament or state assemblies or local bodies. However, over the period of time, it is also being felt that state in itself is not a homogeneous unit for analyzing the electoral contests. States also constitute different regions, each come up with its own unique genesis and preference in favour of or against a political party. The bonds of liking or disliking for a particular party by majority of the voters of a region may remain stable or change with the passage of time. In the present research paper the above stated proposition is tested by taking a case study of Haryana wherein the electoral analysis was done at two levels, i.e. Haryana state and the Ahirwal region of Haryana. For analyzing the fact whether the Ahirwal region vote in favour/against a political party en masse and whether the voters in the region go as per the general trends in the state, the electoral analysis of two political parties in the last three assembly elections (2009, 2014, 2019) in Haryana vis-à-vis the Ahirwal region was done. The electoral performances of the selected parties were measured in terms of percent vote polled, and seats won in the selected elections.

Introduction

The Indian federal democratic structure permits electoral analysis to be carried out at various levels, viz., national, state and local. Although one can analyze the patterns of electoral politics independently on any of these levels or a combination of these levels, however, the fact remains is that the politics is being constructed as a consequence of innumerable events working in combination to each other from national to local level. To simplify the fact, the national politics (i.e. politics viewed at the national level) is not something which is being constructed at that level only;

rather it is an assemblage of politics constructed at various geographical levels. This argument, however, does not mean to underestimate the national level political happenings that play their own role in the making of national politics. In terms of electoral analysis in India, it was the analysis of electoral politics at the national level that was given pre-eminence for quite a long time, especially the decades that followed the independence. During the phase of the Congress System (i.e., the period when the Congress was at the centre of all levels of politics and the regional voices were subtle) even studies carried out at the state level were looked at from the national perspective (Yadav and Palshikar, 2003). This viewpoint had changed to some extent after the 1967 State Assembly elections, when in many states, non-Congress governments were formed. With this, the era of unchallenged supremacy of the Congress came to an end. This political change had led to advancement of the idea that state specific politics is different from the national politics. With this consideration, state specific election studies became important. Henceforth, various important state specific election studies were carried out and published (Weiner, 1968; Narain, 1976; Jenkins, 2004). In fact, as we scale down our analysis of understanding the Indian politics from the national level, we find construction of politics at varied scales. If we view politics at the level of state, each state emerges with its own distinct patterns of politics that is going on therein at a moment of time.

However, close analysis will further show that even state politics is not homogeneous in itself. Each state consists of various regions of unique political identities formed in the name of caste, language, religion etc. Recently we are witnessing this shift in electoral studies from national/state level to the study about construction and analysis of electoral politics at the level of region. This changeover came with the realization that states constitute different regions, each with its own unique genesis and preference about a political party. The way majority of the voters of a region vote in favour or against a political party may remain stable or change with the passage of time. The focus on study of electoral politics at the level of region is in tune with unique voices emerging from different social-cultural regions of the country, i.e. the emergence of identity politics. Historically, in some parts of the country these regional voices were so strong that had even led to the creation of separate states and many of such demands are still keeping alive. In fact, the "process by which subaltern groups have politicized has varied enormously from state to state" (Jenkins, 2004:2). In a large federal country like India, this construction of politics at the level of region takes place some way in-between the national/state politics on the one hand and locality politics on the other. It retains the characteristics of both higher and lower levels of politics without losing the regional identity.

This construction of politics at the level of region is unique in the sense that a region is constructed and re-constructed in social-political-economic terms in a time framework. It is a very slow and gradual process of developing a unique culture of politics. The regional identity may be dormant or active in political terms. It depends on the aspirations and participation of people living therein. How politics is being constructed and re-constructed at the unit of region is always going to be an imperative exercise for unraveling the complex nature of national and state level politics in India. However, despite having so much unique regional electoral politics in the country "there has been a dearth of literature that focuses on the region within states…" (Kumar, 2011:11). This is despite being the fact that cultural heterogeneity of the regions within states over the years has been sharpened as a result of unevenness of development and unequal access to political power (Sathyamurthy, 2000:33). The proposed study intends to fill this academic gap, especially by taking a case study from the state of Haryana. Despite being a small state in terms of geographical area, Haryana has its own socio-cultural regional framework wherein certain castes and religious groups are dominant and have their say in the electoral contests. One such socio-cultural region is the Ahirwal region of Haryana which was in news for having an important say in the formation of the BJP government in the state in 2019. There is hardly any study in terms of analyzing the electoral politics of the region. Yadav (2000) had discussed about the Ahirwal region in historical perspective. Similarly Yadav (2003) has briefly discussed about the Ahirwal region in his study on the social coalitions and power strategies made by different political parties to capture power in the state

Study Region

Despite Haryana being a small state in terms of geographical area, there are various specific regions where different religious/caste groups (Sikhs, Muslims, Jats, Ahirs etc.) dominate in terms of their numerical strength. One of such regions is the Ahirwal or the 'Land of the Ahirs'. Broadly it is a region which lies in both Haryana (southern parts) and neighbouring state of Rajasthan (north-eastern parts). It was described at length by Joseph E. Schwartzberg in his study of Folk Regions of Northwestern India as a 'folk region' (Schwartzberg, 1978, 1985). The history and culture of this region is mentioned in an exclusive study by K.C. Yadav (Yadav, 2000). It was also mentioned by Lucia Michelutti in her study as a 'cultural-geographical region' (Michelutti, 2008: 42). Broadly the region includes the districts of Alwar and Bharatpur in Rajasthan, and districts of Mahendragarh, Rewari and Gurgaon in the state of Haryana. In the present study,

Ahirwal region of Haryana only is undertaken for the study. It was on two accounts. One, assembly elections in the two states were held at different dates, and two, the issues that had emerged and affected the voters' preferences were different. Ahirs are commonly known with different names such as Hir, Yadav, Rao ji, Rao Sahib. In Haryana their area of concentration is known as Ahirwal region. Although Ahirs are one of the backward castes in the state but "they have the self-perception of being a Kshatirya upper caste" (Yadav, 2003:147). There are "three main categories among the Ahirs of Haryana and the neighbouring states" (Sangwan, 1994:14). These are Afaria Ahirs, Gwala Ahirs, and the peasants. The Afaria Ahirs belong to the category of big landlords and used to live in small fort like structures. They consider themselves as Rao Sahib and their fort like structures in Haryana are found in villages like "Kila Pathani, Ahi Bharwi, Tirpur and Jaitpur near Rewari…" (Sangwan, 1994:13). Gwala Ahirs are those whose main occupation is that of rearing of animals and related activities. The third category belongs to peasants who are in large number. Over the period of time, although this class division among the Ahirs has narrowed down but not diminished. In Haryana, the Ahirwal region has 11 assembly constituencies. Such a spatial concentration of a particular caste in a state assists the people in creating and retaining a kind of separate identity.

Till recently, the nature of electoral contests in the region largely remained between the Indian National Congress (the Congress) and the Indian National Lok Dal (INLD). However, the dramatic success of the Bharatiya Janata Party (BJP) in the last two assembly elections has changed the political scenario of the state and that of the region as well. Whereas, the BJP had failed to win any of the eleven assembly constituencies in the region in 2009 assembly elections, it won all the eleven assembly seats in 2014 elections. In 2019 assembly elections, when there was decline in the total number of seats won by the BJP in the state (47 in 2014 to 40 in 2019), it managed to retain eight seats (out of eleven) in the region. This was despite being the fact that the electoral scenario for the party was different in surrounding socio-cultural regions of the state in 2019 assembly elections. The party could win one (i.e. Hathin) of the four Meo-Muslims dominated seats of Nuh, Ferozepur Jhirka, Punhana, and Hathin. Similarly in the 14 assembly constituencies of the neighbouring districts of Bhiwani, Rohtak and Jhajjar (a part of the Jatland) the party seats tally declined from six in 2014 to three in 2019. The eight assembly seats that the party had won from the Ahirwal region were one of the main determining factors that the BJP was able to form the government in the state in 2019.

Objectives

(1) The electoral performance of selected political parties in Haryana state in general and Ahirwal region in particular; and,
(2) The impact of switching over of Rao Inderjit Singh on February 13, 2014 from the Congress to the BJP in Ahirwal region in general and Kosli assembly segment of the Rohtak Lok Sabha in particular.

Database and Methodology

For analyzing the electoral dynamics in Haryana state in general and Ahirwal region in particular, assembly constituency wise data for the last three assembly elections of 2009, 2014, and 2019 were taken. These elections were held as per the Delimitation Order of Constituencies, 2008. In the study, special focus is on the eleven assembly constituencies of the Ahirwal region: Ateli (68), Mahendragarh (69), Narnaul (70), Nangal Chaudhary (71) of district Mahendragarh; Bawal (SC) (72), Kosli (73), Rewari (74) of district Rewari; Pataudi (SC) (75), Badshahpur (76), Gurgaon (77) and Sohna (78) of Gurgaon district (Fig. 1). The assembly constituencies of Ateli, Mahendragarh, Narnaul and Nangal Chaudhary are part of the Lok Sabha seat of Bhiwani-Mahendragarh; and Bawal (SC), Rewari, Pataudi (SC), Badshahpur, Gurgaon and Sohna are part of Gurgaon Lok Sabh seat. Kosli is one of the assembly segments of Rohtak Lok Sabha seat .Two national parties, viz. the Congress and the BJP were chosen for the analysis. The justification behind selecting these two political parties was twofold. One, these were the only political parties which had contested all the ninety assembly seats in the state during the three elections taken for the analysis. Two, the contest for gaining the seat of power basically remained between these two political parties. The Congress formed the government after 2009 assembly elections, whereas, the BJP formed the government after the 2014 assembly elections and also after the 2019 assembly elections. The electoral performances of both the parties were measured in terms of percent vote polled, average vote, seats won and co-efficient of variation (CV). Assembly constituency wise data were taken from the reports published by the Election Commission of India.

Result and Discussion

Historical background of politics in Ahirwal region

To begin with, the politics in the region was divided among the followers of three political parties, viz. the Congress, the Unionist Party, and the Punjab Hindu

Mahasabha. The real contest, however, was between the latter two. In electoral terms, the Congress was comparatively stronger in the urban areas. The Unionist Party, on the other hand, was comparatively more popular in rural areas. It was led by Sir Chhotu Ram and Sir Fazl-i-Husain (for details see, Wallace, 1980; Chowdhry, 1991). Although Chhotu Ram "began his political career as a congressman but soon discovered that this organization had no agrarian programme worth the name and secondly it was dominated by the well-to-do urbanites who flourished on the exploitation of peasantry" (Choudhry, 1985:120). For the welfare of peasants he, along with Fazl-i-Husain had formed the Unionist Party and was able to enact various agrarian laws in their favour. This had, however, further deepened the rift between the urban and rural elites. This social rift started emerging during the Non-Cooperation Movement (1923). In fact, the "rural agriculturalist elite was not prepared to cooperate with the urban elite on the issue of non-payment of land revenue as they considered it very harmful to the interests of agriculturalists" (Singh, 1977: 65). At that time, the main contest for gaining the seat of power in the region was between the Punjab Hindu Mahasabha and the Unionist Party.

The prominent political leaders were Rao Balbir Singh (from Punjab Hindu Mahasabha), and Rao Pohap Singh and Rao Mohar Singh (from the Unionist Party). Presently, the political legacies of Rao Balbir Singh and Rao Mohar Singh are popularly known as Rampura House and Budhpur House. In addition to these two Houses, the Captain House has its own importance in the region's politics. The nomenclatures of these houses are based on either the family name or on the basis of ancestral villages of these political families. Members of these houses have remained at the helm of affairs in various governments formed by different political parties in the state as well as in the central government. However, there remains a sort of political rivalry between these houses for gaining more and more political space of the region. It is also important here to mention that of the persons representing these houses, many have changed their alignments with different political parties. The death of Sir Chhotu Ram on January 9, 1945 was disastrous for the Unionist Party. The number of seats won by the party in the British Punjab came down from 98 seats (out of total 175) in 1937 to 11 seats in 1946. The Congress on the other hand, improved its seats tally from 18 seats to 51 seats during the same time period. The Ahirwal region also went for this change. The Ahirs also shifted their alliance to the Congress as it was expected that once independence is achieved, it would be the Congress led government in India. An overview of the three Houses around which politics in the region revolves is as under:

Rampura House

The politics in the region is influenced by the family members of Rao Tula Ram, the hero of the revolt of 1857. Rao Balbir Singh, a descendant of Rao Tula Ram, was founder of Rampura House. He was the Head of the Election Board of the Hindu Mahasabha for the Punjab Legislative Assembly (see, Yadav, 2002:185). He was "the first Ahir to contest election to the provincial legislative council in 1916 against Ch. Lal Chand. The Ahirs solidly backed Balbir Singh…but being in a minority they failed in getting Balbir Singh elected" (Yadav, 1980:9). However, things changed after the introduction of the Montague Chelmsford reforms of 1919 under which the right to franchise was liberalized and constituencies were delimited separately as urban and rural. Now the chances of winning an Ahir candidate from a rural constituency got enhanced as Ahirs were mainly rural. And when the first election after these reforms was held in 1920, Rao Balbir Singh was elected to the Council from Gurgaon (Non-Mohammedan) Rural seat. He was colleague of Rao Mohar Singh (of Budhpur House) in the Punjab Legislative Council. Rao Balbir Singh remained member of the Punjab Legislative Council and Punjab Legislative Assembly on many occasions in the United Punjab from 1921 to 1941. In the mid, he was defeated by Rao Pohap Singh (a young lawyer and a big landlord) of the Unionist Party in 1923.

He, however, came back in 1926 and 1930 elections on the Hindu Mahasabha Ticket. He was elected again in 1937 from the same seat. The Unionist Party led by Sir Chhotu Ram could recover the lost ground in the region only after the death of Balbir Singh in 1941. Rao Balbir Singh was also instrumental in establishing Ahir Yadav Kshtirya Mahasabha in Rewari as early as 1910. After his death, it was in 1945 that Rani Nihal Kaur (wife of Rao Balbir Singh) had adopted Rao Birender Singh as Head of the Rampura House. Rao Birender Singh, a graduate from St. Stephen College, Delhi, was enrolled in the Territorial Army during the World War II. In 1947 he resigned from the Army as a Captain and returned back to Rampura. He established various educational institutions: Ahir College, Rewari; R.B.S. School, Rewari; Rao Tularam School, Rewari; Rao Tularam Technical College, Delhi; R.B.S. College of Education, Rampura. He became a member of the legislative council in 1954 and was a minister in the Punjab government. After the formation of Haryana as a separate state in 1966, he became the first speaker of the Haryana State Assembly. Owing to his differences with first Chief Minister of Haryana (Bhagwat Dayal Sharma) he left the Congress which ultimately led to fall of the government. He was instrumental in forming Samyukta Vidhayak Dal (SVD)

and became second Chief Minister of the state (March 24 to Nov. 2, 1967). After dissolving SVD, he formed his own political party as Vishal Haryana Party (VHP, first regional political party of Haryana) in 1967 (Singh, 1971). The party was, however, merged with the Congress (I) on September 23, 1978. "The Ahirs have mostly been voting for the Congress (I) after the merger…" (Singh, 2003:353). Thereafter he played his role in the central politics as a Member of Parliament on a few occasions. In 1989 he left the Congress and joined Janata Dal. He remained president of All India Yadav Mahasabha many a times. Another important personality of the House was great granddaughter of Rao Tula Ram, the then ruler of Rewari, and daughter of Rao Balbir Singh, Rajkumari Sumitra Dev (Bai Ji as popularly known). A Padma Shri awardee in 1968, she is still known for her untiring efforts for social service and especially for upliftment of women and children, and animal protection. She was President, District Congress Committee, and Vice President of Punjab Congress Committee (for details see, Government of Punjab, 1964:104). She was elected unopposed to the second Punjab Vidhan Sabha on the Congress ticket in 1957 from Rewari assembly constituency. In 1962 and 1967 she was re-elected from Rewari assembly seat as a Congress party candidate by huge winning margin of 33.81 and 16.27 percent vote respectively. In 1968, she contested the Rewari seat on VHP seat and won by a margin of 10.76 percent vote. For devoting all her time for the social cause, she remained unmarried. After the death of Rao Birender Singh, his political legacy was continued by his son, Rao Inderjit Singh, a product of Lawrence School, Sanawar and Delhi University. Like his father he has played his role both in the state and central politics as minister of different portfolios.

On September 23, 2013 he gave his decision of quitting the Congress and floated a non-political outfit Haryana Insaf Manch. His daughter Arti Singh Rao was also associated with this non-political outfit. The formation of this Manch was an attempt to raise the issues related to discrimination in development in the state. It was alleged that Bhupinder Singh Hooda led Congress government had favoured the districts of Rohtak, Jhajjar and Sonepat at the cost of other districts and there was discrimination in canal water allocation. He also stated that farmer's land was acquired forcefully by the state government and people were avoided in employment opportunities and development projects. On 13 February, 2014 in the presence of BJP National President, Sh. Rajnath Singh, he joined the BJP on the Martyrdom Day of Rao Tularam. He became a Member of Parliament on BJP ticket from Gurgaon parliamentary constituency.

Rao Inderjit Singh's two brothers (Rao Yadavendra and Rao Ajit Singh) and his daughter Arti Rao are also actively playing their role in the politics of the region. Although, Rampura House is now a divided house, as many of the extended members of the family are in different political parties, but Rao Inderjit Singh is the most important face of the house. It would be interesting to analyse the impact on voters of Rao Inderjit Singh quitting the Congress and joining the BJP. This is especially in regard to his public statement on April 3, 2014 that 'I know that people love me and not the flag I carry'. Interestingly Rao Inderjit Sigh joined the party he kept on criticizing for more than three decades. The impact of Rao Indejit Singh joining the BJP would be of special interest in the case of the electoral performance in the Kosli assembly constituency. Here it is important to mention that the Kosli assembly constituency is a part of the Ahirwal region of Haryana but if falls in the Rohtak parliamentary seat. Rao Inderjit Singh remained member of legislative assembly from Jatusana seat four times (1977, 1982, 1991, 2000).

Budhpur House

The Budhpur House was founded by Rao Mohar Singh (born in July 1903 in Budhpur village). His father, Rao Ramji Lal was the first person from Gurgaon district who cleared the Punjab Civil Services and became administrator of Nalagarh state during the British times. Rao Mohar Singh did his graduation from St. Stephen College, Delhi, and education of law from Lahore Law College in 1930. It was during his practicing day in Gurgaon that he came in close contact of Rao Pohap Singh and joined the Unionist Party (popularly known as Zamindara Party). However, it was only after the death of Rao Balbir Singh in 1941 that the Unionist Party could break the dominance of Punjab Hindu Mahasabha. Its candidate, Rao Mohar Singh won the North West Gurgaon General Rural seat in the by-election held in 1941 (due to death of Rao Balbir Singh). He won again in 1946 by defeating Rao Gajraj Singh (a member of Rao Balbir Singh's family). His son Rao Mahabir Singh was elected member of legislative assembly on three times and was minister in the state. He also contributed in the field of education by establishing Kamla Nehru College, Jatauli, and Rao Mohar Singh College of Education, Behrampur. The grandson of Rao Mohar Singh, Rao Narbir Singh is also in the field of politics and remained minister in the state government. Narbir Singh had defeated Rao Inderjit Singh from Jatusana assembly constituency in his debut election of 1987. In his turn, however, Inderjit Singh defeated Narbir Singh in 2009 Lok Sabha election from Gurgaon.

Captain House

To begin with, Rao Abhay Singh who became MLA three times was head of this house. However, this house is known after Captain Ajay Yadav, son of Rao Abhay Singh. Before joining politics, Ajay Yadav served the Indian Army as a Captain. He is playing a very important role in the politics of the region. It needs to mention here that he was elected on the Rewari assembly constituency consecutively for six times and that shows his popularity. Now his son, Chiranjeev Rao who is MLA from Rewari is leading his legacy. Among the three houses, the Rampura House is certainly the most important in terms of influencing the choices of voters in the region and there are certain reasons for that: one, this house belongs to the legacy of Rao Tula Ram and that legacy still works in the region. Two, this house had played an important role in the process of recruitment of local youth during the World War-I. In fact, this region belonged to arid/semi-arid climatic conditions with limited agricultural opportunities at least to begin with. In that scenario, the World War-I brought about a big change in improving the socio-economic conditions of the people here. The enrolment of local youth in the armed forces not only provided employment opportunities but also acted as a gateway to occupational mobility and modern world exposure. This had also awakened them as social and political being. At that time "Rao Balbir Singh, the second descendant of Rao Tula Ram acted as a recruiting agent of the British Government, and since then many Ahirs have joined the Army in increasing numbers" (Rao, 1964:1440). This had created a linkage of local people with this House. Even the big landlords were in favour of the British as they took the event as a means of future rewards. Three, many members of this house have remained on top positions both in the state and central governments. Four, the establishment of various educational and other social welfare institutions by the representative of this house have had worked at the grass root level in strengthening the people's bond with the house. Five, constant rise of voice by the representatives of this house at various platforms about the neglect of this area in development process has further built up their image as that of region's representative.

Electoral Performances of Congress and BJP

Assembly Election in 2009

In 2009 Lok Sabha elections that were held prior to assembly elections in the state, the Congress was the leading party in the Ahirwal region.

In terms of percent vote share, it was first ranking party in six of the total eleven assembly segments. It is interesting to note that of these six assembly segments, five were only from the Gurgaon lok sabha seat from where Rao Inderjit Singh of the Congress was the candidate (Fig.-1). The other lone assembly segment from where the Congress the leading party was the Kosli assembly segment of the Rohtak lok sabha seat. In the remaining four assembly segments which are part of Bhiwani-Mahendragarh lok sabha seat, in three assembly segments (Ateli, Mahendragarh, and Narnaul) the Haryana Janhit Congress Bhajan Lal (HJCBL) was the leading party, whereas, in Nangal Chaudhary, the INLD was the leading party. The BJP remained underperformer in the lok sabha elections. It did not contest the lok sabha seats of Bhiwani and Mahendragarh, and that of Rohtak. It had contested the Gurgaon lok sabha seat and of its six assembly segments falling in the region, it was second ranking party in three assembly segments (Pataudi—SC, Badshahpur, and Gurgaon) and in the remains three segments (Bawal—SC, Rewari, and Sohana) it was third ranking party. In 2009 assembly elections, the Congress had polled 35.08 percent vote in Haryana. Its average vote was 35.41 percent and CV was 33.32 percent. The party won 40 of the total 90 assembly seats, i.e. 44.44 percent. In its comparison, the party had polled 30.12 percent vote in the Ahirwal region. Its average vote in the region was 29.28 percent and CV was 26.50 percent (Table-1). It shows that although the average percent vote for the party was lower in the region but its votes were more uniformly distributed in the region. (Table-1)

The party vote in the region ranged from 17.23 percent in Narnaul assembly constituency to 40.35 percent in Rewari assembly constituency. In total the party had won six assembly seats (Ateli, Mahendragarh, Rewari, Badshahpur, Sohna and Kosli) (Fig. 2a). It shows that the party was able to confirm its dominance of lok sabha elections in the assembly elections in the constituencies of Rewari, Badshahpur and Kosli. It had further improved its performance of lok sabha elections in assembly elections and won the seats of Ateli, Mahendragarh, and Sohana. The party was not out of competition in rest of the five assembly seats of the region where it was defeated. It was runner-up in four constituencies (Nangal Chaudhary, Bawal—SC, Pataudi and Gurgaon) and third ranking party in Narnaul. In terms of percent seats won, the electoral performance of the Congress was better in the Ahirwal region (i.e. 54.54 percent) than the state (44.44 percent). In this election, three seats (Nangal Chaudhary, Bawal—SC, and Pataudi—SC) were won by the INLD, and one seat each by the HJCBL (Narnaul), an independent candidate (Gurgaon).

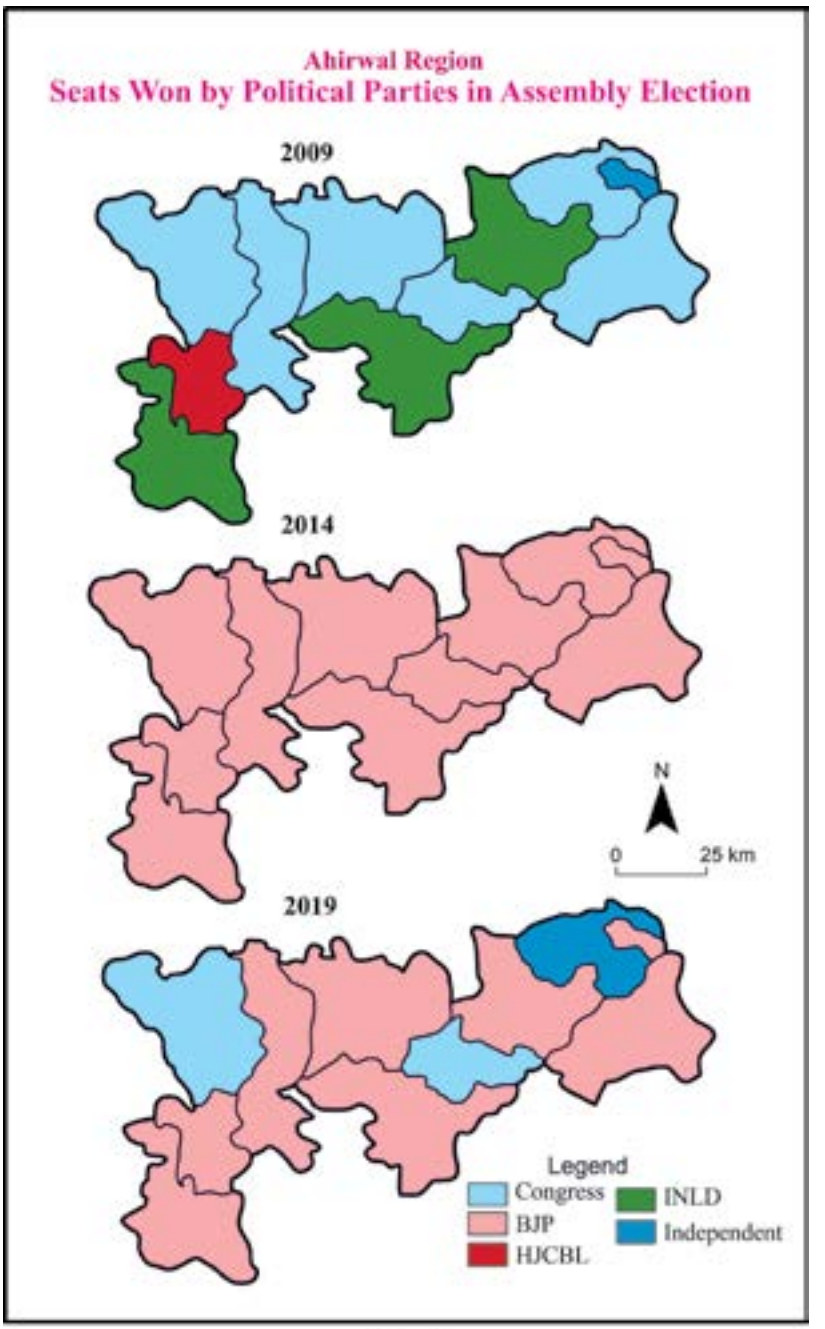

Ahirwal Region
Seats Won by Political Parties in Assembly Election
2009
2014
2019
N
0
25 km
Legend
Congress
INLD
BJP
Independent
HJCBL

Fig. 1

Table-1: Assembly Election: Electoral Performance of BJP and Congress in Haryana and Ahirwal Region

Political party	Electoral Statistics	2009		2014		2019	
		Haryana	Ahirwal	Haryana	Ahirwal	Haryana	Ahirwal
BJP	Seats Contested	90	11	90	11	90	11
	Seats Won	04	00	47	11	40	08
	Per cent Vote polled	9.04	12.80	33.20	46.75	36.49	41.37
	Mean vote (%)	9.44	12.50	32.92	46.25	36.52	41.79
	SD (%)	11.00	9.20	14.20	9.60	11.00	8.67
	CV (%)	116.52	73.60	43.13	20.76	30.12	20.75
INC	Seats Contested	90	11	90	11	90	11
	Seats Won	40	06	15	00	31	02
	Per cent Vote polled	35.08	30.12	20.58	11.81	28.08	16.41
	Mean vote (%)	35.41	29.28	21.07	12.08	28.51	16.97
	SD (%)	11.80	7.76	12.10	8.72	15.40	10.19
	CV (%)	33.32	26.50	57.43	72.18	54.02	60.05

Source: Election statistics, Haryana

The electoral performance of the BJP In this assembly election was very dismal. It had polled only 9.04 percent vote and won only 4 seats (4.44 percent) in the state. Its average vote was 9.44 percent and CV was 116.52 percent (Table-1). It shows large scale variations in the party's vote across the state. In comparison to the overall picture in the state, the vote share of the party vote in the region was marginally better. It had polled 12.80 percent vote in the region. Its vote share in the region ranged from 2.9 percent in Kosli assembly constituency to 21.53 percent in Ateli assembly constituency. The average vote for the party in the region was 12.50 percent and CV was 73.60 percent. The party, however, failed to win any assembly seat in the region. In terms of percent vote received, it was second ranking party in two assembly constituencies (Ateli, Mahendragarh), third ranking party in three

assembly constituencies (Bawal—SC, Rewari and Gurgaon), fourth ranking party in four assembly constituencies (Narnaul, Pataudi—SC, Badshahpur, and Kosli), fifth ranking party in one constituency (Nangal Chaudhary), and eight ranking party in one constituency (Sohna).

Assembly Election in 2014

Prior to the Lok sabha elections that were held in 2014, a political upheaval took place in the state with its serious implications in the state politics in general and that of Ahirwal in particular. Rao Inderjit Singh, one of the most powerful leaders of the Ahirwal, quit the Congress on September 23, 2013 and joined the BJP. He alleged the Congress for discriminating the region in all spheres of development. Keeping in view his political family background and his long standing in the politics of the region, there were all possibilities that his decision would make serious implications for the Congress. He has remained Member of Parliament from Mahendragarh lok sabha seat (1998, 2004), and Gurgaon lok sabha seat (2009), and Member of Legislative Assembly from Jatusana (now largely part of Kosli) in 1977, 1982, 1991, and 2000. Besides, he has also remained as Cabinet Minister, and Minister of State (various portfolios). In addition to the above, the political legacy of the Rampura House he is carrying clearly indicates that his decision could influence the voters across the length and breadth of the region. The other fact that might have influenced the voters of the region in favour of the BJP was that in 2013 the prime ministerial nominee of the BJP, Narendra Modi chosen the Ahir belt to start his national poll campaign. He addressed a rally of ex-servicemen. The political show and the place were rightly chosen as the region is dominated by villages having large number of persons in defense services. Amit Shah followed Narendra Modi when he held his first rally in Mahendragarh on August 14, 2013. The elections results of the lok sabha elections in different assembly segments of the region showed a complete transformation in the electoral fortunes of different political parties.

The BJP had emerged as the first ranking party in all the eleven assembly segments of the three lok sabha seats. The Congress was either pushed to either second place (Nangal Chaudhary, Rewari, Badhahpur and Kosli), or third place (Ateli, Mahendragarh, Narnaul, Pataudi—SC, and Gurgaon) or fourth place (Bawal—SC, and Sohana). In the 2014 assembly elections, the electoral scene in the region had changed completely for both the Congress and the BJP. In fact, the assembly election results broadly followed the patterns of lok sabha election results. From no seat in the assembly elections from Ahirwal in 2009 assembly election, the BJP won all the eleven assembly seats in 2014 assembly elections. As mentioned above,

the BJP was the first ranking party in all the assembly segments of the region. It clearly indicates that the BJP was able to transfer its electoral success of lok sabha elections completely to assembly elections in the region. In this assembly election, in the Ahirwal region, the percent vote share for the Congress had experienced a negative swing of 18.31 percent in its vote share (from 30.12 percent in 2009 to 11.81 percent in 2014). The BJP, on the other hand, had gained a positive swing of 33.95 percent (from 12.80 percent in 2009 to 46.75 percent in 2014) in the region (Table-1). It was basically as a consequence of this change in the vote percentage received that the Congress failed to win any seat, whereas, the BJP won all the eleven assembly seats. There was negative vote swing for the Congress in all the assembly constituencies of the region. It ranged from 2.55 percent in the case of Mahendragarh assembly constituency to 29.54 percent in the case of Badshahpur assembly constituency. Barring Mahendragarh and Narnaul wherein the party had recorded a negative swing of less than three percent, in all the remaining nine assembly constituencies, the negative vote swing for the party was huge. In this assembly election, the percent vote polled by the party was much higher at the state level (i.e. 20.58 percent) than at the level of region (i.e. Ahirwal) (i.e. 11.81 percent). The CV in the party vote was much higher at the level of region (72.18 percent) than at the state level (57.43 percent). It shows much heterogeneity in the party vote at the level of region. On the other hand, it was the otherwise picture for the BJP. The party's percent vote share at the state level was 33.20 percent, whereas, it was 46.75 percent in the case of Ahirwal. The CV for the party vote was lower at the level of region (20.76 percent) than at the state level (43.13 percent) (Table-1). It indicates much homogeneity in the party vote in Ahirwal region.

Assembly Election in 2019

In the 2019 lok sabha elections that preceded the assembly election, the BJP again emerged as the first ranking party in all the assembly segments of the Ahirwal region. The Congress, on the other hand, had improved its electoral performance than the previous lok sabha elections. It had emerged as the second ranking party in all the assembly segments. Despite emerging as the first ranking party in all the assembly segments of the region, the BJP, however, was not able to transfer its huge electoral success completely in the subsequent assembly election. In 2019 assembly elections, the party won eight of the eleven seats in the region, i.e. Ateli, Narnaul, Nangal Chaudhary, Bawal—SC, Pataudi—SC, Gurgaon, Sohana, and Kosli. The party, however, was not out of battle in the three seats it was defeated (Mahendragarh, Rewari and Badshahpur) and was runner-up in all the three.

Two seats (Mahendragarh and Rewari) were won by the Congress and on one seat (Badshahpur), an independent candidate was elected (Fig. 2c). Whereas, at the state level, the BJP had recorded a positive swing of 3.29 percent (from 33.20 percent in 2014 to 36.49 percent in 2019), there was a negative swing of 5.38 percent (from 46.75 percent in 2014 to 41.37 percent in 2019) for the party in the region in 2019 assembly elections (Table-1). In the case of the Congress, on the other hand, there was a positive swing at both state level and that of the region, i.e. Ahirwal. At the state level, its vote rose from 20.58 percent in 2014 to 28.08 percent in 2019—a positive swing of 7.5 percent) and in the case of Ahirwal, it rose from 11.81 percent in 2014 to 16.41 percent in 2019—a positive swing of 4.6 percent). The CV in the case of the BJP, however, was much lower than the Congress at both state and at the level of region.

Impact of switching over of an important political leader and its impact on the electoral performances of the Congress and the BJP

The impact of switching over of an important political leader, Rao Inderjit Singh, from the Congress to the BJP and its impact on the preferences in favour of or against a political party by majority of the voters of an area/region can be judged on two accounts: one, the electoral performances of the two selected parties in the six assembly segments of Gurgaon Lok Sabha seat (Bawal, Rewari, Pataudi, Badshahpur, Gurgaon and Sohana) from where Rao Inderjit Singh contested the seat on the Congress ticket in 2009 lok sabha election, and on the BJP ticket in 2014 and 2019 lok sabha elections; and two, the Kosli assembly segment, one of the assembly segments of Rohtak Lok Sabha seat, from where Deepender Singh of the Congress was the contestant. In 2009 lok sabha elections, the Congress was the first ranking party in five assembly segments of the Gurgaon Lok Sabha seat when Rao Inderjit Singh had contested the seat from the Congress party, however, when in 2014 and 2019 Lok Sabha elections, Rao Inderjit Singh contested the same seat on the BJP ticket, in all the six assembly segments falling in the region, the BJP became the first ranking party.

The Kosli assembly segment is a part of the Rohtak Lok Sabha seat, however, it is a part of the Ahirwal region and majority of the voters are Ahirs. In the last three Lok Sabha elections, Deepender Singh was the candidate from Rohtak Lok Sabha seat on the Congress ticket. In 2009 Lok Sabha elections, Deepender Singh won the Lok Sabha seat by a huge margin of 4,45,736 votes. He had polled 53.30 percent vote from the Kosli assembly segment. During the subsequent assembly election, the Kosli seat was won by the Congress.

However, things took a dramatic shift during the last two Lok Sabha elections. In the 2014 Lok Sabha elections, although Deepender Singh from the Congress won the seat but the margin of victory was reduced from 4,45,736 votes in 2009 lok sabha election to 1,70,627 votes in 2014 lok sabha election. More importantly, in Kosli segment his percent vote share was reduced from 53.30 percent in 2009 Lok Sabha election to 27.32 percent in 2014 Lok Sabha election. In the assembly election of 2014 that followed the Lok Sabha election, the BJP won all the seats of the Ahirwal region (including that of Kosli) and in terms of percent vote polled, the Congress was shifted to third place with 12.14 percent vote. In 2019 Lok Sabha elections, Deepender Singh of the Congress was defeated by the BJP candidate, Arvind Kumar Sharma by a margin of 7,503 votes. At aggregate level in eight assembly segments, Deepender Singh was leading with a margin of 72,344 votes (excluding postal), however, the difference of 74,980 votes alone in the Kosli assembly segment led to his defeat. The analysis at booth level data for Deepender Singh in Kosli assembly segment alone explains the story. Of the 199 booth in Kosli, in 2009 Lok Sabha elections, there were 89.53 percent booths where the Congress percent share was 40 percent and above. However, the number of such booths was reduced to 18.50 percent in 2014 Lok Sabha elections, and 17.65 percent in 2019 Lok Sabha elections. This is all about the fact that how in adverse conditions only one assembly segment can change the fortunes of a political party in a Lok Sabha seat.

Conclusion

The study concludes with the fact that electoral politics in a federal country like India is constructed at different geographical scales. Even the states constitute different regions, formed with time, on the basis of their unique socio-economic characteristics. This constructs a different kind of electoral politics at the level of region. In the study, this proposition was tested by analyzing the electoral performances of the Congress and the BJP during the last three assembly elections in Haryana (i.e. state level) in general and Ahirwal (i.e. regional level) in particular. The study finds the fact that the Ahirwal region not only retains a different kind of electoral-political character but also plays its own role in the formation of state electoral politics. The study also concludes the fact that the electoral preferences of majority of voters changes if an influential leader of the region changes his alignment from one political party to another. The impact of Rao Inderjit Singh switching over from the Congress to the BJP was certainly one of the crucial factors that had improved the electoral performance of the BJP in Haryana in general and

Ahirwal in particular. It would be an academically enriching exercise if a field-based study is conducted to further analyse the impact of Rao Inderjit Singh's on the voters' choices in the Ahirwal region.

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GEOSPATIAL ANALYSIS OF HOUSING AMENITIES IN INDIA

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Abstract

A housing unit refers to a physical structure in which people can live (e.g., a house, apartment, condo, mobile home, etc.), whereas a household refers to a group of people who occupy a housing unit as their residence. The National Family Health Survey (NFHS) sample describes key housing characteristics of the household population. Information on household characteristics and housing amenities provides context for understanding socio-economic status of the population. The research paper aims at examine some of the housing characteristics in India and its states based on secondary data collected from NFHS-3 and NFHS -5. The results shows that the housing characteristics such as electricity, improved source of drinking, toilet/latrine facility and using fuel for cooking had significantly augmented in India and its states over a period of 15 years and the housing characteristics are found considerable variations in India and its states.

Introduction

Every family has basic, physiological, and additional needs. Food, clothing and shelter are basic necessities. Of his three basic needs of a human being, protection is one of the basic needs of human existence. It protects us from the vagaries of nature and threats, natural or otherwise. Housing with better characteristics not only provides socio- economic status/condition in society, but also a sense of security and well-being, and high-quality housing provides safeguard. Housing with better amenities are important to mankind because, it provides residents with a safe place and makes it easier to achieve life goals. For centuries, people have been creating homes for themselves, which is a basic need for everyone. Access to basic amenities such as adequate housing, electricity, clean drinking water and sanitation/toilet, and clean cooking fuel is not only an important indicator of a household's socio-economic status, but also an important indicator of the health condition of household members. Improving water supply and sanitation, as well as better management of water resources, can boost economic growth and make a significant contribution to poverty reduction in countries.

Clean water is essential for healthy life among the people. From drinking water to disinfection to modern technology such as gowns, it's so important. Humans and animals require water every day for survival and well-being. Without safe water for just three days, we would all suffer greatly. According to the World Health Organization, more than 2 billion people lack access to safe drinking water and more than 8,00,000 people die from water-related diseases each year (Comer et al, 2018).The National Family Health Survey (NFHS) provides information on a variety of household characteristics that represents living conditions. This research paper describes the housing characteristics of households, including access to electricity, improved source of drinking water, sanitation/toilet /latrine facilities, and fuel used for cooking. Information on household characteristics is based on questions that household survey respondents are required to answer when surveyed by enumerators. Housing provides physical safety and protection from the elements and plays a central role in determining a person's physical and social risk environment (Weir BW et al., 2007). Research results by Soebiyan. V and Bsakina (2021) showed that the main factors influencing household electricity consumption are floor area, number of family members, household income, and number of air conditioners. Access to water is one of the main goals of the United Nations Millennium Development Goals (UN-MDGs) and one of the main goals of the Sustainable Development Goals (SDGs). Fundamentally, everyone needs access to sufficient amounts of clean water for drinking, cooking, personal hygiene and hygiene without putting their health or dignity at risk. Therefore, access to safe and reliable (clean and fresh) water is a fundamental human right (Samra SCJ and Fawzi SCM, 2011). According to the study by Swachh Survekshan Grameen 2022, 95.4 percent of surveyed households have access to a toilet, and 95.4 percent of households with a toilet use it regularly. The 2030 Agenda of Sustainable Development Goals (SDGs) emphasizes the importance of sanitation and sets Goal-6 to "Ensure the availability and sustainable management of water and sanitation for all." Although India's rural households have seen modest improvements in access to toilet facilities in recent decades, they still face high levels of disadvantage, spatial and socio-economic inequality, and exclusion.

Study Region

India is a country that occupies the greater part of south Asia. It is consisting of 28 states and eight union territories, in addition to its national capital is New Delhi, built in the 20th century just south of the historic hub of old Delhi to serve as India's administrative centre. It lies completely in the Northern hemisphere and

Eastern hemisphere between latitudes 84′ N and 37°6'N and longitudes 68°7′ E and 97°25′ E. Prior to independence, Indian mass was under British rule for centuries and neglected the vital housing amenities, which are essentials for survival of humankind. After independence, there is remarkable improvement in basic housing amenities in majority of the states, but in some of the states the condition of housing amenities is still poor. In the present study, all the states were considered in panorama perspective which will be guide administrators to focus on framing the policies decisions on housing amenities. The present study area is Indian union and its 28 states excluding National capital of Delhi. However, the Telangana state value is included in Andhra Pradesh because; the state was not formed at the time of N.F.H.S-3 survey period. Hence, the averages of the amenity value aspects in N.F.H.S-3 and 5 contain combined Andhra Pradesh.

Objectives

The aim of the research paper is to study dynamics of some of the housing characteristics such as electricity, improved source of drinking; toilet/latrine facility and solid fuel used for cooking in India and states between N.F.H.S-3 of 1992-93 and from NFHS-5 of 2019-21.

Database and Methodology

The research paper is based on descriptive research design and data collected from of NHHS-3 (1992-93) and from NFHS-5 of phase-I (2019-20) covers states such as Andhra Pradesh, Assam, Bihar, Goa, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim, Tripura and West Bengal and NFHS-5 of Phase-II (2019-21) for India and 11 States (Arunachal Pradesh, Chhattisgarh, Haryana, Madhya Pradesh, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand and NCT Delhi). NFHS-3 collected information from a nationally representative sample of 109,041 households, while, in NFHS-5 phase-I and phase-II, data gathered information from 6,36,699 households. However, the NFHS-5 survey in of phase-II got delayed because of sever COVID-19 pandemic. Arc GIS 10.5 version is applied to trace the dynamics in household amenities in India and its states.

Results and Discussion

The housing characteristics/ amenities in India and its states during the period of NFHS-3 and NFHS-5 have been presented briefly hereunder.

Households with Electricity

Electricity is an essential energy for day today human life. Power shortages not only cause inconvenience to individual consumers due to malfunction of electrical appliances. In the residential sector, it is very important for all consumers to properly manage their daily electricity consumption. Therefore, electricity is an important aspect of modern life and economy. It is used to operate home appliances such as room lighting, fans, electric stoves, air conditioners, computers, electronic devices, and machinery. All these things bring comfort to people. Yunqing Lu et al (2022) focused on studying energy consumption and household characteristics through a dynamic price experiment in communal housing in a smart community in Japan. An interstate comparison of households with electricity amenity is presented (Table-1). In NFHS-3, Delhi being capital city of the nation, the highest per cent (99.3) is noticed, while lowest (27.7) household electricity is observed in Bihar. Based on the highest and lowest house hold electricity amenity the Indian states are grouped into three categories as less than 45 per cent, 45-80 per cent and above 8 per cent More than 90.0 per cent of households have electricity in eight states (Delhi, 99.3, Goa, 96.4; Punjab, 96.3; Jammu & Kashmir, 93.2; Mizoram, 92.3; Haryana, 91.5; Sikkim, 92.1 and Kerala, 91.0) and in the highest category (>80 per cent) there are 16 states showing the high percentage of household amenity. (Table-1 and Fig.-1)

In second category, there are 9 sates distributed in central and northeastern part of the country. There are four states where fewer than half the households have electricity (Uttar Pradesh, 42.8; Jharkhand, 40.2, Assam 38.1 and Bihar, 27.7 per cent) and these states are categorically located in north and northeastern part of the country. The analysis shows that, the physiographic and socio-economic conditions of the states influenced the low rate of electricity amenity. However, in NFHS-5, except Arunachal Pradesh (94.7), Jharkhand (93.8), Assam (92.7), Meghalaya (92.0) and Uttar Pradesh (89.8), all other states possess more than 97.0 percent of the households with electricity amenity and Goa state achieved cent per cent electrification. Country's average household electricity facility also rapidly enhanced from 67.9 to 96.5 per cent which encountered the remarkable improvement in electricity amenity. Thus, rapid improvement in households with electricity found from the period of NFHS -3 of 2005-06 to NFHS -5 of 2019-21, which reflecting within fifteen years.

Households with Improved Source of Drinking Water

Safe drinking water means clean water that does not cause any harm to humans if it comes into contact with it (Fig. 1 and Table-1 and 2).

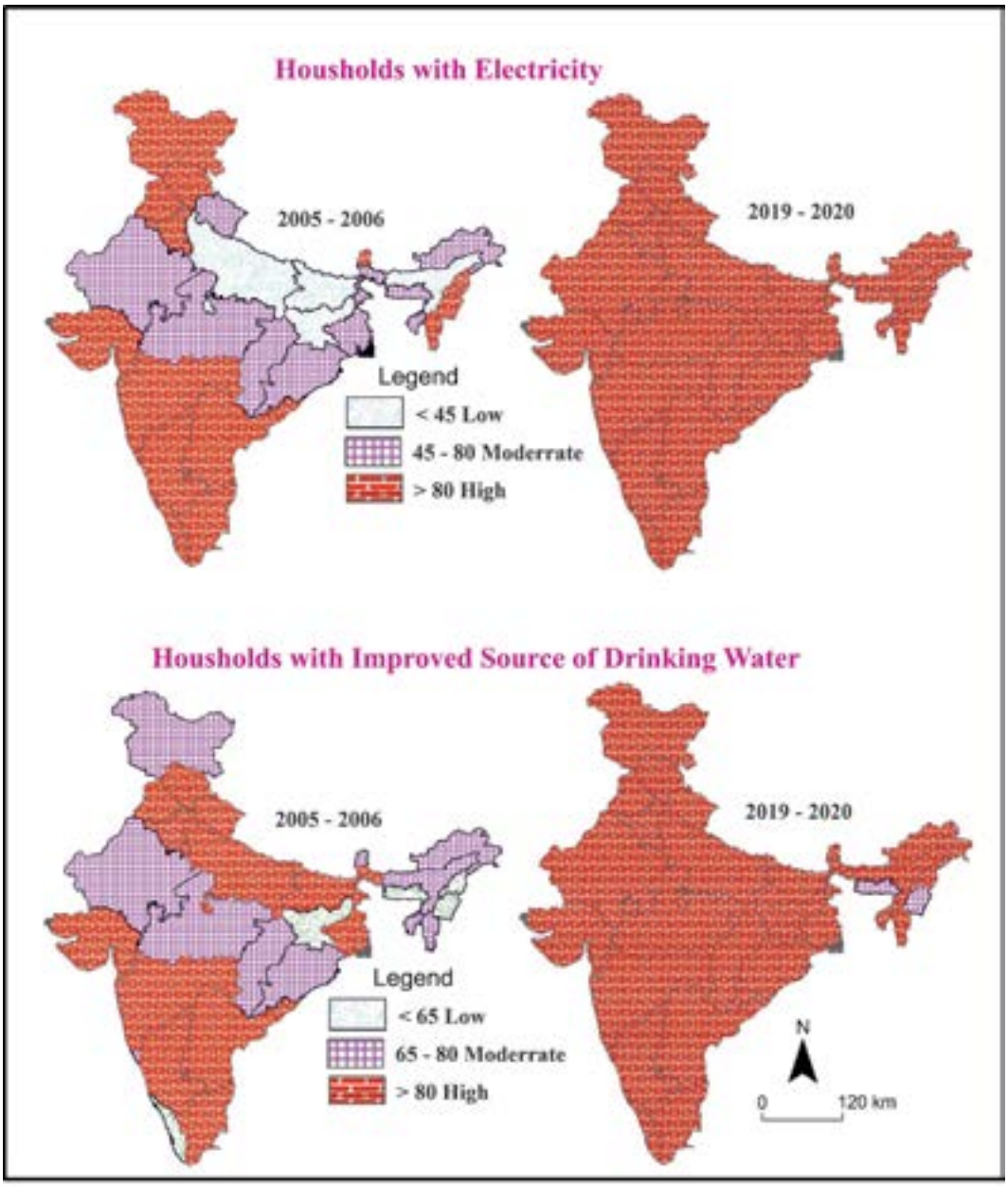

Housholds with Electricity
2005 - 2006
2019 - 2020
Legend
< 45 Low
45 - 80 Moderrate
> 80 High
Housholds with Improved Source of Drinking Water
2005 - 2006
2019 - 2020
Legend
< 65 Low
65 - 80 Moderrate
> 80 High
N
0
120 km

Fig. 1

Table-1: Percent of Households Having Electricity

Sr. No	India/State	NFHS-3	NFHS-5
(1)	NCT of Delhi	99.3	99.9
(2)	Haryana	91.5	99.5
(3)	Himachal Pradesh	98.4	99.4
(4)	Jammu & Kashmir	93.2	99.3
(5)	Punjab	96.3	99.6
(6)	Rajasthan	66.1	97.9
(7)	Uttarakhand	80.0	99.4
(8)	Chhattisgarh	71.4	98.5
(9)	Madhya Pradesh	71.4	98.1
(10)	Uttar Pradesh	42.8	89.8
(11)	Bihar	27.7	95.6
(12)	Jharkhand	40.2	93.8
(13)	Odisha	45.4	96.3
(14)	West Bengal	52.5	97.0
(15)	Arunachal Pradesh	76.9	94.7
(16)	Assam	38.1	92.7
(17)	Manipur	87.0	97.8
(18)	Meghalaya	70.4	92.0
(19)	Mizoram	92.3	98.0
(20)	Nagaland	82.9	98.6
(21)	Sikkim	92.1	99.3
(22)	Tripura	68.8	97.9
(23)	Goa	96.4	100
(24)	Gujarat	89.2	97.2
(25)	Maharashtra	83.5	97.4
(26)	Andhra Pradesh	88.4	99.1
(27)	Karnataka	89.3	98.8
(28)	Kerala	91.0	99.5
(29)	Tamil Nadu	88.6	99.0
	India	67.9	96.5

Source: National Family Health Survey-3 and 5

Table-2: Improved Source Drinking Water

Sr. No	India/State	NFHS-3	NFHS-5
(1)	NCT of Delhi	92.1	99.5
(2)	Haryana	95.6	98.6
(3)	Himachal Pradesh	88.4	96.4
(4)	Jammu & Kashmir	80.4	92.3
(5)	Punjab	99.5	98.8
(6)	Rajasthan	81.8	96.4
(7)	Uttarakhand	87.4	95.5
(8)	Chhattisgarh	77.9	95.6
(9)	Madhya Pradesh	74.2	88.9
(10)	Uttar Pradesh	93.7	99.2
(11)	Bihar	96.1	99.1
(12)	Jharkhand	57.0	86.8
(13)	Odisha	78.4	90.8
(14)	West Bengal	93.7	97.5
(15)	Arunachal Pradesh	85.0	94.2
(16)	Assam	72.4	86.4
(17)	Manipur	52.1	77.0
(18)	Meghalaya	63.1	79.2
(19)	Mizoram	85.0	95.7
(20)	Nagaland	62.8	91.0
(21)	Sikkim	77.6	94.0
(22)	Tripura	76.1	88.5
(23)	Goa	80.1	98.2
(24)	Gujarat	89.8	97.5
(25)	Maharashtra	92.7	93.8
(26)	Andhra Pradesh	94.0	96.7
(27)	Karnataka	86.2	95.6
(28)	Kerala	69.1	94.9
(29)	Tamil Nadu	93.5	98.6
	India	87.9	95.9

Source: National Family Health Survey-3 and 5.
Note: Improved sourse drinking water for households.

To be safe, water must have sufficiently low concentrations of harmful contaminants. Safe and readily available water is important for public health, whether used for drinking, domestic use, food production, or recreational purposes. In India, widespread access to safely managed drinking water could prevent nearly 14 million Disability-Adjusted Life Years (DALYs) from diarrheal diseases, resulting in an estimated cost of up to $101 billion. It is estimated that this will lead to a reduction in drinking water, which is one of the most important and basic needs of humans. It is the most basic and important element necessary for humans to survive. Access to safe and clean drinking water is critical to maintaining health and well-being. Drinking water has many important functions in the body, including regulating body temperature, maintaining healthy skin, and promoting digestion (Amend, Sarah R et al., 2016). As per NFHS improved safe drinking water means "tap water in the apartment/garden/property, pipes to neighbors, public taps/standpipes, tube wells or boreholes, protected boreholes, protected springs, rainwater, tanker trucks, small tanker trucks, bottled water, and local communities, reverse osmosis (RO) system ". An interstate comparison of households with improved source drinking water is presented (Table-2 and Fig.-1).

The household access found to improved highest source of drinking water (piped water or water from hand pump) is found highest in Bihar (96.1) state and lowest percentage of drinking water amenity is observed in Manipur (52.1). By considering the highest and lowest household drinking amenity the Indian states have been grouped into three categories as less than 65, 65-80 and above 80 per cent and the same range group is adopted for NFHS-5 also. In this amenity, three states (Bihar 96.1, Haryana, 95.6 and Punjab, 99.5) exceed 95 per cent. In lower category, there are four states (Manipur, 52.1; Jharkhand, 57.0; Meghalaya, 63.1; and Nagaland, 62.8) in low category in which more than one-third of households obtain water from an unimproved sources like cannels, rivers, streams, ponds, lakes tanks and open dug wells. In seven states such as the available amenity is moderate ranging from 65-80 percent and remaining percent of households obtain their drinking water from unsafe sources, which in many cases declaim the health conditions. Majority of Indian states possess with high percent of improved source of drinking facility around 18 states come under this category. While in NFHS-5, majority of states have access to improved source of drinking water (Table-3). Therefore, substantial raise in the household access to improved source of drinking from NFHS-3 of 2005-06 to NFHS-5. Thus, in NFHS-5 the least percent improved source of drinking water facility is found in Manipur (77.0) and highest per cent (99.50) is noticed in NCT of Delhi state.

Table-3: Households having Toilet/Latrine Facility

Sr. No	India/State	NFHS-3	NFHS-5
(1)	NCT of Delhi	92.4	98.7
(2)	Haryana	52.4	96.6
(3)	Himachal Pradesh	46.4	93.5
(4)	Jammu & Kashmir	61.7	94.3
(5)	Punjab	70.8	97.2
(6)	Rajasthan	30.8	77.5
(7)	Uttarakhand	56.8	93.6
(8)	Chhattisgarh	18.7	84.7
(9)	Madhya Pradesh	27.0	73.8
(10)	Uttar Pradesh	33.1	77.1
(11)	Bihar	25.2	61.1
(12)	Jharkhand	22.6	66.4
(13)	Odisha	19.3	66.1
(14)	West Bengal	59.6	88.0
(15)	Arunachal Pradesh	80.6	98.5
(16)	Assam	76.4	95.8
(17)	Manipur	95.6	99.5
(18)	Meghalaya	71.3	95.8
(19)	Mizoram	98.0	99.9
(20)	Nagaland	85.6	99.6
(21)	Sikkim	89.0	99.6
(22)	Tripura	96.7	98.9
(23)	Goa	76.0	96.3
(24)	Gujarat	54.6	80.7
(25)	Maharashtra	52.9	82.6
(26)	Andhra Pradesh	42.4	83.7
(27)	Karnataka	46.5	82.3
(28)	Kerala	96.1	99.7
(29)	Tamil Nadu	42.9	77.5
	India	44.6	80.6

Source: National Family Health Survey-3 and 5.
Note: Figures are given in percent.

It is interesting to present that possess above 90 per cent and about achieved more than 95 per cent in possessing improved source of safe drinking water. Geographically, all the sates achieved tremendous achievement except a few states which located in hilly terrain.

Households with Toilet/Latrine Facility

Sustainable Development Goal (SDG) 6.2 calls for universal access to safely managed sanitation by 2030. Ensuring universal access to safe sanitation by 2030 is a development priority for India. It helps to achieve better physical and mental health results. While, the proportion of people in India with access to safe sanitation has been increased dramatically over the past three decades. However, in some of the Indian states are at the highest risk of not having access to safe sanitation during this period. The most disadvantaged and excluded are households from backward areas belonging to weaker sections of society, such as Poor wage earners, Scheduled Tribes and Scheduled Castes. Therefore, in addition to accelerating rural sanitation development efforts to achieve the SDGs, there is an urgent need for complementary measures that focus on the socio-spatial conditions of backward areas, vulnerable groups, and households in rural India. According to Jain, A et al. (2023), the prevalence of zero hygiene (defined as people defecating in the open due to lack of access to a household toilet) across India has increased. During NFHS-5, considered uses an improved sanitation facility (toilet facility) as "flush to piped sewer system, flush to septic tank, flush to pit latrine, flush to don't know where, ventilated improved pit (VIP)/biogas latrine, pit latrine with slab, twin pit/composting toilet, which is not shared with any other household". State wise comparison of households with any toilet/latrine facility is presented (Table-3 and Fig. 2).

Table-3 reveals that, the substantial variations across states in access to any toilet/latrine facility. As per NFHS-3, the proportion of households with access to any toilet/latrine facility ranges from 25.0 per cent or less in four states (Bihar, 25.2; Jharkhand, 22.6; Odisha, 19.3 and Chhattisgarh, 18.7) to over 95.0 per cent in Manipur, Kerala, Tripura and Mizoram. Based on these observations, the Indian states have been grouped as less than 45, 45-70 and more than 70% classes. The analysis designates that, majority households with low toilet facility are found in central part of the country and interestingly high facility is noticed in north eastern states except Rajasthan. However, the Swachh Bharat Mission, Swachh Bharat Abhiyan, or Clean India Mission is a country-wide campaign initiated by the Government of India on 2nd October 2014 to eliminate open defecation and improve solid waste management and to create Open Defecation Free (ODF) country.

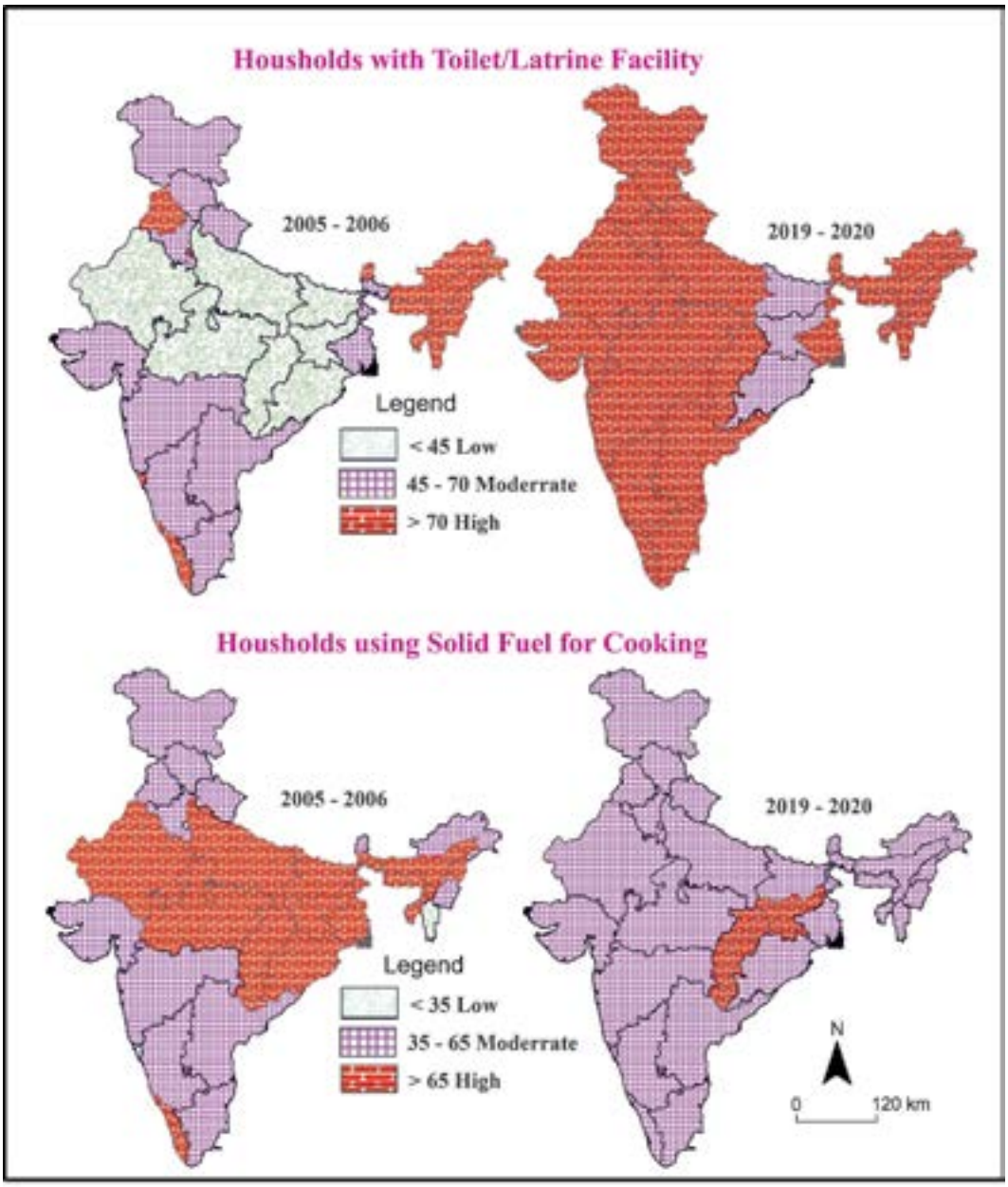

Housholds with Toilet/Latrine Facility
2005 - 2006
2019 - 2020
Legend
< 45 Low
45 - 70 Moderrate
> 70 High
Housholds using Solid Fuel for Cooking
2005 - 2006
2019 - 2020
Legend
< 35 Low
35 - 65 Moderrate
> 65 High
N
0
120 km

Fig. 2

As a result, the improved sanitation/toilet/latrine facility India and its states significantly improved. The NFHS-5 reveals that in sixteen states (NCT of Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Uttarakhand, Chhattisgarh, Arunachal Pradesh, Meghalaya, Mizoram, Nagaland, Sikkim, Goa, Andhra Pradesh, Karnataka and Kerala) over 70.0 percent (high) of households have access to improved sanitation facility and no state falls under low percent group and only three states namely Bihar, Jharkhand and Odisha have come in moderate group. Even though, 22 states possessed above national (80.6) average percentage, there is dire need to a take steps to achieve open defecation free country by 2030.

Households Using Solid Fuel for Cooking

A fuel is a type of substance that burns to produce heat or electricity. It can be in solid, liquid, gaseous or natural form. Reliance on cheap and dirty solid fuels such as firewood and other dry biomass, cow dung and coal for cooking exposes millions of Indians to dangerous air pollution, leading to significant health risks. Clean cooking fuels provide access to energy for the country's poor. This will minimize health problems and premature deaths especially among women and children, and help India reach its net-zero targets by reducing carbon emissions. As far as India's energy scenario is concerned, the most commonly used fuels in India are LPG, PNG, coal, kerosene, dung meal, firewood, crop residue, and to some extent electricity. As per NFHS, solid fuels used for cooking considered such as “coal/lignite, charcoal, wood, straw/shrub/grass/crop waste, and dung cakes”. Balakrishnan et al. (2019) found that of the 1.24 million deaths caused by air pollution in India in 2017, 6,70,000 were due to ambient particulate pollution and with an additional of 4,80,000. This is due to household air pollution as point out by people. Although the main sources of particulate pollution in the environment are external, domestic air pollution is primarily caused by the combustion of solid fuels for cooking and heating. An interstate comparison of households with using solid fuel for cooking is presented in Table-4 and Fig 2.

The smoke from solid fuels poses a health hazard when inhaled. As per NFHS-3, the proportion of households relying on solid fuels for cooking range from a lowest in Delhi (9.3 per cent) to a highest in Bihar (89.7 per cent) and over 85.0 per cent observed in four states: Chhattisgarh, Orissa, Jharkhand, and Bihar. Other states with particularly low use of solid fuels are: Mizoram and Goa, where around one-third of households rely on solid fuels for cooking. In fact, with the exception of Delhi, in all other states, significant per cent of households relies on solid fuels for cooking.

Table-4: Households having Using Solid Cooking Fuel

Sr. No	India/State	NFHS-3	NFHS-5
(1)	NCT of Delhi	9.3	0.8
(2)	Haryana	69.1	40.1
(3)	Himachal Pradesh	68.9	47.7
(4)	Jammu & Kashmir	59.5	30.2
(5)	Punjab	54.9	22.1
(6)	Rajasthan	77.2	58.5
(7)	Uttarakhand	61.7	40.5
(8)	Chhattisgarh	86.7	66.4
(9)	Madhya Pradesh	80.3	59.3
(10)	Uttar Pradesh	81.7	50.3
(11)	Bihar	89.7	62.0
(12)	Jharkhand	89.1	67.8
(13)	Odisha	88.6	64.9
(14)	West Bengal	79.2	59.1
(15)	Arunachal Pradesh	67.7	46.6
(16)	Assam	75.8	56.4
(17)	Manipur	64.7	29.6
(18)	Meghalaya	72.2	63.4
(19)	Mizoram	34.1	16.0
(20)	Nagaland	76.0	56.5
(21)	Sikkim	52.4	20.7
(22)	Tripura	80.4	53.0
(23)	Goa	33.3	2.8
(24)	Gujarat	52.3	32.2
(25)	Maharashtra	48.1	18.2
(26)	Andhra Pradesh	66.3	15.6
(27)	Karnataka	63.8	19.4
(28)	Kerala	71.4	27.4
(29)	Tamil Nadu	60.5	15.4
	India	70.8	40.6

Source: National Family Health Survey-3 and 5.
Note: Figures are given in percent.

By considering the lowest and highest solid fuel consumption the states were grouped as less than 35, 35-65 and more than 65 per cent. In low category, only two states namely NCT of Delhi, Mizoram and Goa represented less than 35 per cent, which shows, high dependency on other than solid fuels for cooking (i.e. clean fuel such as Electricity, LPG/natural gas, biogas). However, in NFHS-5, nearly all of the households in NCT of Delhi (99.2 percent) and Goa (97.2 percent) are relying on clean fuels for cooking. In seven states (Punjab, Mizoram, Sikkim, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu) over 75.0 per cent of households using clean fuel for cooking. Only in the states of Chhattisgarh and Jharkhand, more than 65 per cent (high category) households using solid fuel and in rest of the states, households are using clean fuel. Thus, findings reveal that substantial change has been noticed in the use of solid fuel (coal/lignite, charcoal, wood, straw/shrub/grass/ crop waste, and dung cakes) to clean fuel (electricity, LPG/natural gas, and biogas) indicates country's advancement in cooking fuel and in a line to conserve natural vegetation and minimize the air pollution which has been leading to overcome from health hazardous conditions to safe health positions.

Conclusion

Based on the findings, it can be concluded that, a substantial variation exists across states in the basic housing characteristics such as electricity, improved source of water, toilet facility and using solid fuel for cooking. However, a significant increase in housing characteristics such as households with electricity, an improved source of drinking water, sanitation/toilet facility and clean fuel for cooking has been noticed from NFHS-3 of 2005-06 and NFHS-5 of 2019-21 in India and its states, which resembles the government initiations and societal transformation from traditional to modern and health hazardous to safe and leading comfortable life.

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ASSESSMENT OF LANDUSE AND LANDCOVER CHANGES USING GIS ANALYTICS OF RIVER KALJANI BASIN IN DOOARS, NORTH BENGAL

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Abstract

The need of studying Land use and the existing Land Cover situation has got tremendous impetus after Second World War conditions and was highly geared during the 1960s though a handful of methodological approaches started flourishing from 1980s. With the advent of satellite imageries and legacies of air photographs resulted in precise computation of land use patterns. The novelty of such studies lies in the fact of assessment of human civilization and development. The present work has been framed taking the Kaljani river basin in the Sub-Himalayan North Bengal plains of Duars of West Bengal (India) and to compute the changes in view of environmental loss and alterations of land using GIS techniques for a 20 years temporal frame and satellite imageries especially to document the facts. The authors have used Landsat 8 OLI/TIRS, Landsat 5 TM, and also Landsat 5 TM for situations of 2019, 2010 and 2000 periods respectively. Supervised classification has been used as a user guided approach involving selection of training sites as reference for the class categorization associated with pixel selection. Authors followed four types of accuracy evaluations for land use class derivations like User accuracy, Producer accuracy, Overall accuracy and Kappa coefficient (K) and thereby to frame the Error matrix calculations to assess the overall condition and in all cases the Kappa coefficient qualified the degree of accuracy becoming more than 80% for all the three time series data. As a major finding seven types of land use classes were derived and the authors have tried to find out the socio-environmental implications. The study may be fruitful to document the land use variations within the basin and identify the land cover alterations.

Introduction

Land is a valuable natural resource on which human activities have taken place and is highly influenced by the management practices. Although the words "landuse change" and "landcover change" are sometimes employed interchangeably, they

have distinct meanings. The 'human activity or economic function connected with a site specific section of earth's surface' is referred to as land use (Lillesand et al., 2013; Das et al., 2019), they are typically not visible immediately on satellite photos' (Bhatta, 2011), while land cover alludes to "the vegetation, water bodies, and man-made structures that cover the earth's surface" (Alam et al., 2019; Burley, 1961). Multiple changes in land use are the result of rising human population and the associated demand for more resources, the most important of which are minerals, soil, and water. The long-term sustainability issue is more significant than climate change, yet it is amplified by it (Das et al., 2019). The rate (temporal) and geographical scale modifications of land surface, mostly in the form of LULC change, are unprecedented and, influence some components of earth systems like-biodiversity, physical components of biosphere, lithospheric characteristics etc. Two basic features of land transformation are Land Use Alteration (LUA) and Land Use Intensification (LUI) (Das et al., 2019). LULC change has a great impact on even biogeochemical cycle. Humans' ability to influence the rate and pattern of LULC change is largely determined by their social, economic, and political traits (Ojima et al., 2019). Land Use Land Cover Change (LULCC) is an important component of global environmental change studies now (Jensen, 2009).

Landuse and landcover is a local and site-specific system that focuses on global environmental issues as a whole. These changes have negative implications on loss of biodiversity (at three levels: genetic, species, and ecosystem), desertification, climate change, and changes in human behaviour, among others. LULC change studies attempt to interpret (i) where change is occurring, (ii) what types of land cover are changing, (iii) the types of transformation occurring, (iv) the rates or amounts of land change, (v) the driving forces and proximate causes of change, (vi) the adverse effects on lithosphere, biosphere and atmosphere if over use of land is questioned commissioning excessive cropping practices and (vii) what are the sustainable management practices with spatio-temporal changes on the earth surface (Lillesand et al., 2015; Loveland et al., 2000; Reddy, 2008). The future change patterns or trends of the LULC, which are generally generated by simulation modelling, are also an important aspect of such analyses. Models frequently include empirically fitting the evaluation system to a historical pattern of change, then extending that pattern analysis for future projections to determine when, where, and why LULC changes occur (Brown et al., 2000). That’s why more reliable/accurate LULC data for time points will be a very crucial need for imposing any local or regional and consistent policy in respect to sustainability and to initiate accurate monitoring of LULC change (Belward et al., 1999).

There are many scientific ways to monitor or detect LULC changes on the earth surface over time (Bhatta, 2011; Campbell & Wynne, 2011; Jensen, 2009; Li et al., 2014; Lillesand et al., 2013; Nelson, 1983). In the past, academies mapped LULCC over smaller areas using field data and aerial images but less suitable for larger areas. As satellite images have high temporal coverage, remote sensing (RS) has become a more dependable one for spectrally sensitive changes of the planet since the last decade of the twentieth century especially inevitable for inaccessible places. The information executed through the digital technology (Space based technology) is also crucial for model building and other natural and cultural processes (Jensen, 2009). Such Remote sensing data with varying resolutions and descriptive models, provide a unique opportunity to record past and present LULC patterns for detail study (Bhatta, 2011; Lillesand et al., 2013; Lillesand et al., 2015; Reddy, 2008). Over the years, LULC switch assessment has been accomplished efficiently and cost-effectively using satellite data (Landsat OLI/ETM+/TM/MSS). Assessing LULC changes has been the most widely used and well adopted application of satellite data from an operational standpoint (Nelson, 1983; Singh, 1989; Turner & Meyer, 1994). The present study is taken up to delineate LULC zones over a volatile riverine trajectory.

Study Region

The research area is mainly situated in the newly formed Alipurduar district (25th June, 2014). This is the northeast corner of the state bordering Assam on the East, Bhutan on the North and Bangladesh on the south of West Bengal and comprises some part of Jalpaiguri district (West Bengal) and a little bit of portions of Southern Bhutan which covers an area of 1,190 km2. Kaljani basin is the sub-basin of Torsa drainage system (sub-basin of Brahmaputra drainage system). Areal extension of Kaljani basin is 26o16/30// N to 26o55/20// N and 89o21/17// E to 89o37/10// E. Kaljani basin is the part of Darjeeling Sub-Himalaya and comes under piedmont tract of North Bengal Dooars. Upper catchment of this basin comes under hilly areas (highest elevation approximately 2,200 m above M.S.L.) and lower catchment comes under plain areas known as Tarai-Dooars region (lowest elevation approximately 50 m above M.S.L.). The total basin area sub-divided into three geomorphic units i.e. upper hilly or mountain area; middle piedmont area and lower plain area. In every part of the basin distinct hydro-geomorphologic characteristics are visible.

Objectives

This research work aims to examine the land use and land cover changes in the Kaljani River Basin (KRB) between the time periods from 2000–2010–2019 and its impact on the river.

Database and Methodology

In this study three satellite images have been taken from 2000 to 2019 with a 10 years interval. It is required to have at least two time periods of data to compare in order to monitor LULC change. For assessing LULC changes in any area, a remote sensing technique generally requires the use of satellite images from two or more dates. The imageries used in this investigation were chosen based on their spatial resolution compatibility (30 x 30 m). The LANDSAT data archive, which contains pictures that are sufficiently consistent with data from previous missions, enables for long-term regional and global LULC change analysis (Irons et al., 2012). For LULC change analysis in the Kaljani basin, we employ cloud free scenes from LANDSAT-TM (2000 and 2010) and LANDSAT-OLI (2019). Because the imagery had previously been pre-processed, no radiometric calibrations or atmospheric adjustments were needed. (Table-1)

Table-1: Characteristics of Satellite Imageries

Sl. No.	Satellite Data	Path	Raw	Date of acquisition	Spatial resolution
1	Landsat 8 OLI/TIRS	138	41,42	November 14, 2019	30 x 30
2	Landsat 5 TM	138	41,42	October 12, 2010	30 x 30
3	Landsat 5 TM	138	41,42	November 17, 2000	30 x 30

Source: USGS Earth Explorer

Error Correction before Utilizing Raster Data

Multi-spectral satellite imagery (raster data) having various kinds of error like cloud cover, sun inclination, poor reflectance etc. Therefore, error correction (radiometric and atmospheric correction) is very essential before utilizing the data. In this context, the researchers have been proceed system provided atmospheric correction, raster image enhancement (linear), high pass filtering with edge sharpening (filter level size: X=3 and Y=3) for better identifying the pixel character.

Results and Discussion

LULC Classification

Through the digital process of feature recognition and classification, the changing nature of LULC was acquired from multiband raster imageries. Spectral information such as colour band is one of the main types of information used for the purpose of image classification as well as interpretation. In this context, image conversion from FCC (False colour composite) to TCC (True colour composite also called natural colour composite) map has been developed through the systematic image classification technique. Image classification is designed for an automatic categorization of pixels with a common reflectance range into a specific LULC class (Lillesand et al., 2015). It is noticed that image classification method has been used as a tool in mapping from remotely sensed data. Supervised classification is a user-guided classification technique that involves selecting training sites as category references (Lillesand et al., 2015). Many approaches, such as parallelepiped classification, K-nearest neighbour, minimal distance to mean classification, Gaussian maximum likelihood, linear discriminant, features space, and others, are used to accomplish supervised image classification (Lillesand et al., 2015; Reddy, 2008; Bhatta, 2011). Using ArcMap (10.5) software, we employed a frequently used maximum likelihood classifier (Foody et al., 1932) for LULC classification in this work. The maximum likelihood/Bayesian classifier method examines both the variance and covariance of spectral response patterns quantitatively, and each pixel is allocated to the class with the highest likelihood of connection (Alam et al., 2019; Shalaby & Tateishi, 2007). A total of 7 LULC classes i.e. water body, sand deposit, dense forest, open forest, agricultural land, bare soil and settlement area were determined. Post-classification of the LULC raster layer was cross verified with the help of Google Earth pro software in a systematic statistical way. (Table-2)

Accuracy Checking

Any map is nothing more than a model or a generalization, so it has some oversight (Dicks & Lo, 1990; Maling, 2016; Smits et al., 1999) because primarily derived LULC map from satellite data is not standard one due to error in remote sensing data (Hord & Brooner, 1976; Congalton, 1991). Because LULC classification is prone to mistakes, the output (maps) must be submitted to the test for correctness using a trustworthy statistical approach (Foody, 2002).

Table-2: Description of LULC Categories

Class	Description
Agricultural land	This class represents the cultivated land (Rabi and kharif crops).
Settlement area	The residential areas are represented under this class, road, bridge, industrial area and other paved surface.
Dense forest	This classification refers to the coniferous forest that covers the surrounding mountains.
Open forest	This class includes tea plantation (Tea garden), small deciduous forest and sparse vegetation etc.
Sand deposit	This class represents the dry river channel with full of sand, gravel and boulders etc.
Bare soil	This class represents the bare land and other soil surface that are bare of greenery throughout the entire year, bank soil, landslide area etc.
Water body	This class represents the open water bodies such as river, ponds, cutoffs, pools etc.

Source: Prepared by Authors

As a result, LULC maps frequently come with an accuracy assessment index that includes a detailed description of the sampling design (including sample size and, if applicable, stratification details), an error matrix, the area or proportion of area of each category according to the map, and descriptive accuracy measures like user, producer, and overall accuracy (Congalton, 1991; Lillesand et al., 2015; Olofsson et al., 2013; Trodd, 1995). Cohen's kappa (k) is a frequently used statistical measure for determining inter-rater concurrence between categorical variables that was introduced by Cohen in 1960 (Alam et al., 2019). The accuracy of all raster layers (2000, 2010, and 2019) was evaluated in this study by the production of an error-matrix (Stehman, 1997; Lard, 1995; Foody, 2002; Congalton, 1994). The sample design used in accuracy testing has an impact on the accuracy assessment's dependability (Muller et al., 1998; Stehman, 2001). In order to test accuracy, a stratified random sample design was used (Stehman & Czaplewski, 1998). Geo-statistics has been used to design an efficient sample (Atkinson et al., 2000). For this purpose, 50 samples for each LULC category have been selected.

Sample points have been selected with proper care and significant ways to provide a representative and meaningful basis (Hay, 1979). So, ground truth validation is the main standpoint (Campbell & Wynne, 2011). The generated maps of the time periods - 2000, 2010 and 2019 revealed an overall accuracy of 85.14%, 89.14%, 89.14% and kappa coefficient of 0.8267, 0.8733 and 0.8732 respectively. The precision of all three raster layers is satisfactory in general. The overall accuracy of LULC maps is estimated to be between 85 and 90% (Anderson, 1976; Shalaby & Tateishi, 2007). In case of Kappa coefficient, results are also reliable and standard one (Lillesand et al., 2015). As a result, the acquired results can be regarded as more dependable to a greater extent. The Eq. was used to calculate the overall accuracy and kappa coefficient (4) (for details see Table-6).

UA (%) = No. of correctly classified pixels in each category/Total no. of classified Pixels in that category (Row total) × 100 (Eq. 1)

PA (%) = No. of correctly classified pixels in each category/Total no. of Reference pixels in that category (Column total) × 100 (Eq. 2)

$$OA = \frac{\sum_{=1} xii}{x} \text{(Eq. 3)}$$

Note: Where xii is the diagonal elements in the error matrix, x is the total number of samples in error matrix.

$$\text{Kappa coefficient } (\text{K}) = \frac{n\sum_{i=1}^{r} xii - \sum_{i=1}^{r} xi + x + i}{n^2 - \sum_{i=1}^{r} xi + x + i} \text{(Eq. 4)}$$

Note: where r is the number of rows in the matrix, r_ii is the number of observations in row i and columni, xi+ x_(i+) and x_(+i) are marginal totals for row i and column i respectively and n is the total number of observations. (Table-3, 4, 5 and 6 and Fig. 1)

Table-3: Error Matrix Resulting from Classifying Randomly Sample Test Pixels, 2019

2019	WB	DF	AL	SD	BS	OF	SA	RT	UA (%)
WB	50	00	00	00	00	00	00	50	100.00
DF	00	47	00	00	00	03	00	50	94.00
AL	00	00	44	01	02	02	01	50	88.00

Contd...

SD	00	00	01	48	02	00	00	50	96.00
BS	00	00	03	03	43	01	00	50	86.00
OF	00	05	02	00	01	41	01	50	82.00
SA	00	00	03	01	03	04	39	50	78.00
CT	50	52	53	53	51	51	41	350	
PA (%)	100.00	90.38	83.01	90.56	84.31	80.39	95.12		

Source: Calculated by Authors

Table-4: Error Matrix: Randomly Sample Test Pixels, 2010

2010	WB	DF	AL	SD	BS	OF	SA	RT	UA (%)
WB	50	00	00	00	00	00	00	50	100.00
DF	00	43	01	00	02	04	00	50	86.00
AL	00	00	47	00	02	01	00	50	94.00
SD	00	00	00	48	01	01	00	50	96.00
BS	00	01	04	02	41	02	00	50	82.00
OF	00	02	00	01	01	45	01	50	90.00
SA	00	01	03	02	03	03	38	50	76.00
CT	50	47	55	53	50	56	39	350	
PA (%)	100.00	91.48	85.45	90.56	82.00	80.35	97.43		

Source: Calculated by Authors

Table-5: Error Matrix: Randomly Sample Test Pixels, 2000

2000	WB	DF	AL	SD	BS	OF	SA	RT	UA (%)
WB	49	00	00	01	00	00	00	50	98.00
DF	00	44	01	01	02	02	00	50	88.00
AL	00	00	41	02	03	02	02	50	82.00
SD	01	00	01	45	01	01	01	50	90.00
BS	00	00	02	05	41	01	01	50	82.00
OF	00	02	02	01	01	42	02	50	84.00
SA	00	01	04	02	03	04	36	50	72.00

Contd...

CT	50	47	51	57	51	51	42	350
PA (%)	98.00	93.61	80.39	78.94	80.39	82.35	85.71	

Source: Calculated by Authors

Note: WB=Water body, DF= Dense Forest, AL= Agricultural land, SD= Sand deposit, BS= Bare soil, OF= Open forest, SA= Settlement area, RT= Row total, UA= User's accuracy, CT= Column total, PA= Producer's accuracy Diagonal Italic numbers represent correctly classified samples for each LULC class.

Table-6: Overall Accuracy and Kappa coefficient of LULC Maps (2019, 2010 and 2000)

Satellite data	LANDSAT 8 OLI/ TIRS C 1 Level-1	LANDSAT 5 TM C1 Level-1	LANDSAT 5 TM C1 Level-1
Year	2019	2010	2000
Sum of Diagonal	312	312	298
Total	350	350	350
Overall accuracy (%)	89.14	89.14	85.14
Kappa coefficient (K)	0.8732 (87.32%)	0.8733 (87.33%)	0.8267 (82.67%)

Source: Calculated by Authors

In remote sensing, primarily obtained multi-spectral raster data is associated with several errors (Both radiometric as well as atmospheric error) (Lillesand et al., 2013; Bhatta, 2011) (Fig. 1). The egregious disadvantages of remote sensing include the incapability of many sensors to acquire data and information over the earth surface due to cloud cover, inclined sun angle, distinct phenomena can be pixelated (Bhatta, 2011) if they appear the same to the sensors, and satellite imagery resolution may be too coarse for detailed mapping and exclusive tiny contrasting areas; on the other hand, high-resolution satellite imagery is more cost effective. Despite these disadvantages, remotely sensed satellite data (LANDSAT OLI/ETM+/TM/MSS) have been used to identify changes on the earth surface over time in a variety of land use (crop land, building construction, paved surface etc.) and land cover (Forest, water body etc.) attributes (Bhatta, 2011; Lillesand et al., 2015; Reddy, 2008). This is especially true in distant areas, which are frequently inaccessible and hence difficult to obtain data from using standard approaches.

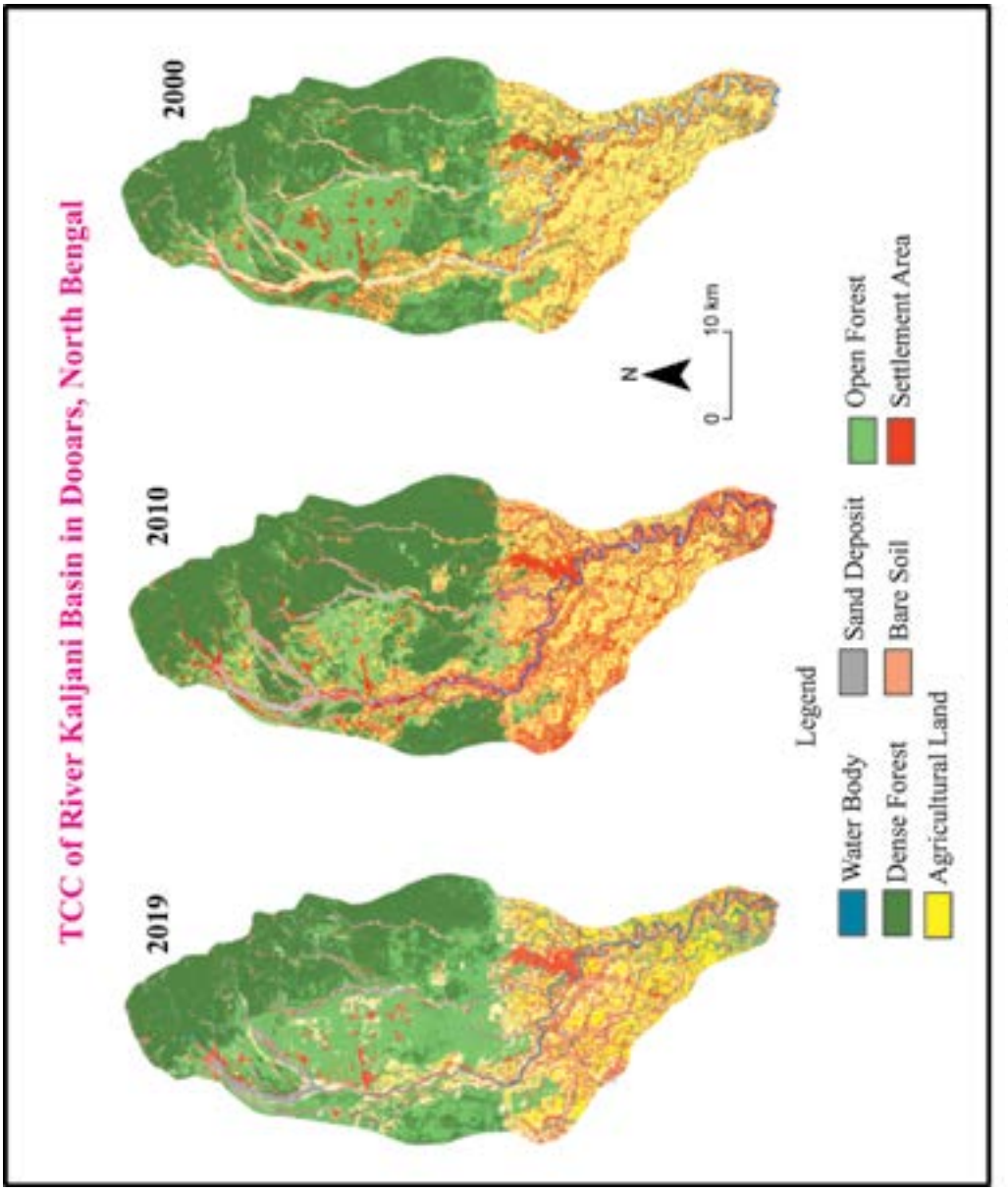

TCC of River Kaljani Basin in Dooars, North Bengal
2019
2010
2000
N
0
10 km
Legend
Water Body
Sand Deposit
Open Forest
Dense Forest
Bare Soil
Settlement Area
Agricultural Land

Fig. 1

In this situation, researchers/learners/planners frequently employ remotely sensed data in a scientifically sound manner to give data on resource inventory and land use, as well as to discover, monitor, and quantify evolving landscape patterns.

Landuse Change Analysis

Over the last three decades, the Kaljani basin has seen significant changes in LULC over its length and width. Figure 2 shows the changes in LULC within the research region across the specified time periods (2000–2010–2019). (Fig. 2)

Dense Forest

The research area's dense forest is the biggest of all the recognized classifications. Dense forest is very common in hilly/mountain areas. Upper catchment of Kaljani basin is mainly covered up with dense forest (like Buxa forest, Buxa hill forest, Gabour Bachhara forest, Dakshin Barajhar forest). The result shows that this LULC category shared 35.38% area of the basin in 2000 and decreased in 2019 (33.69%) but an exceptional case happened in 2010 (2.58%), resulting in a positive change. The present trend is normal due to population pressure, may be illegal logging and lack of sustainable management techniques in forest areas are the two reasons. Local people experienced such kind of LULC changes in their daily life. To be specific Forest is the house of primitive tribal people and must be saved. But over time they are losing their traditional forest based lifestyle due to destruction of forest land and it is very common in Buxa and surrounding forest areas. Figure 3 clearly stated that 144.93 sq.km areas have vanished in between 2010 to 2019 and also showed 38.35 sq.km area totally disappeared during the selected time periods (2000-2019).

Agricultural Land

The agricultural land revealed a continuously declining trend in the Kaljani basin area. The total area under this category has been 24.88 %, 23.71% and 16.60% of the total area in 2000, 2010 and 2019 respectively. There has been a decreasing trend of 13.81 sq.km area from 2000 to 2010, 93.47 sq.km from 2010 to 2019 and a collective reduction of 107.28 sq.km from 2000 to 2019 in agricultural land. It is noticeable that, considerable portion of agricultural land was lost and reduced due to rapid population growth with increasing demand for settlement areas and urbanization.

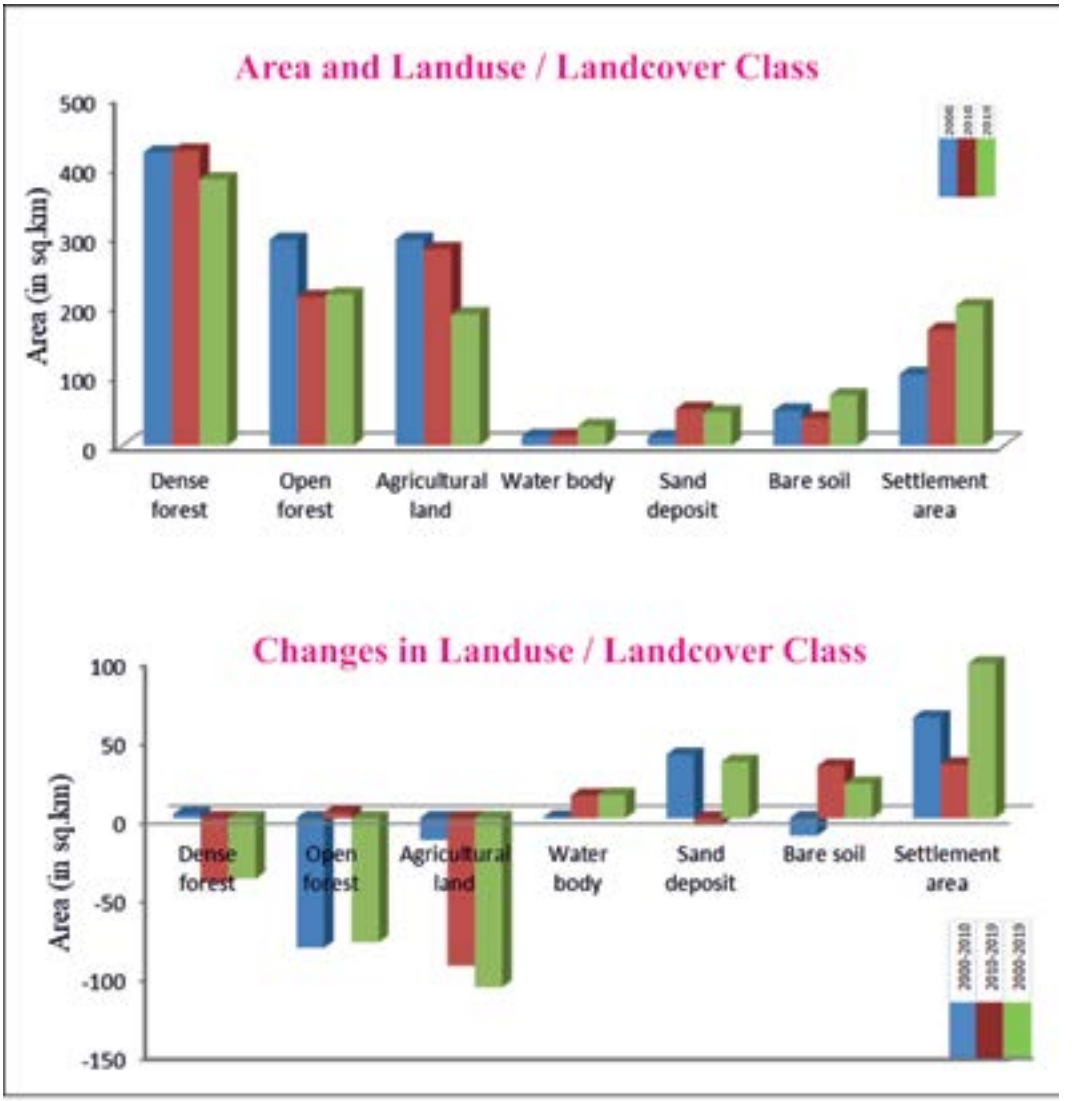

Area and Landuse / Landcover Class
Area (in sq.km)
500
400
300
200
100
0
Dense forest
Open forest
Agricultural land
Water body
Sand deposit
Bare soil
Settlement area
Changes in Landuse / Landcover Class
Area (in sq.km)
100
50
0
-50
-100
-150
Dense forest
Open forest
Agricultural land
Water body
Sand deposit
Bare soil
Settlement area

Fig. 2

Sand Deposit

Piedmont areas, even foothill plains have witnessed huge concentration of sand, boulders, cobbles, pebbles etc. throughout the year. In the studied basin, the upper part of Kaljani drainage network has been filled up with different sizes of particles and gradually increasing its bed elevation. The result shows 0.99% of total basin area covered with sand deposits and has been increased in 2010 (4.37%) and 2019 (4.19%). There has been increased of 40.18 sq.km from 2000 to 2010, little bit reduced from 2010 to 2019 (4.47 sq.km) but has witnessed net increase of 55.71 sq.km from 2000 to 2019. Unplanned circumstances (like population pressure and building construction in mountain regions, rudimentary practices of cultivation along the mountain slopes etc. are the main reasons for the supply of load and high concentration of sand and other types of particles in river bed. And various natural events e.g. torrential rainfall, earthquakes though very less, landslides etc. are also responsible for such a changing scenario. Excessive bed deposition and avulsions are the ecological problems of Kaljani River. It is noticeable that all the major rivers of North Bengal like Teesta, Torsa, Kaljani, Raidak, Lish and Ghish are suffering from unnatural siltation. Deforestation, civil construction, and several other increased human activities in hills are causing loosening of the top soil and increasing discharge of debris. Therefore, residential areas alongside the Kaljani River have witnessed worse flood events almost every year due to low carrying capacity of monsoon runoff.

Bare Soil

This class of LULC represents open uncovered fallow land. It may be unfertile agricultural land; wipe away lands by landslide or unplanned cutting process, bank soil etc. In the study area lands under this category have been found with 4.20%, 3.27% and 6.34% in 2000, 2010 and 2019 respectively. Statistics show that the amount of bare soil gradually increased in Kaljani basin over time, it's about 33.00 sq. km from 2010 to 2019 and 21.94 sq. km from 2000 to 2019. Deforestation in the Piedmont area, as well as an expansion in industry and building sites such as brick kilns and highways, have all contributed to the growth of this class.

Open Forest

Open forest especially in the form of plantation (Tea garden), social forestry and scattered vegetation is a LULC class of such a category that has reduced slowly. It is mapped through satellite data of 24.84%, 17.93% and 19.09% in 2000, 2010 and 2019 respectively under this category in Kaljani basin.

Open forest area has decreased about 82.17 sq.km in between 2000-2010 and increased by 3.57 sq.km from 2000 to 2019, encroaching the agricultural land, bare soil areas side by side, little bit of portion added from dense forest.

Waterbody and Settlement

Water body represents the open water surface (Table-2) area on the earth surface. This LULC category revealed a positive growth in the basin area. In 2000 total covered area of the water body was 13.12 sq. km (1.14%) and over time gradually increased about 1.14% and 2.45% in 2010 and 2019 respectively. In the Kaljani basin, LULC fluctuations are more obvious; one of them is the expansion of the settlement area. The majority of the structures are residential, although there are a few commercial ones as well, the total area under settlement has been 8.61%, 13.98% and 17.65% in 2000, 2010 and 2019 respectively, registering a total growth of 63.85 sq.km from 2000 to 2010, 34.12 sq.km from 2010 to 2019 and total net growth of 97.97 sq.km in the selected time period (2000 to 2019). The settlement areal expansion has been mostly encroaching the agricultural land, bare land, open forest areas etc. particularly expanding along the road and around the core area (e.g. Hamiltonganj and Alipurduar in Alipurduar district); the increasing settlement area adversely affects the environment quality, loss of biodiversity etc.

Conclusion

The study reveals some exodus results especially reduction of all three types of forest cover and which is indicative of probable misuse and natural loss of forest resources during the last 20 years period. More overwhelming scenario is probating the fact that agricultural lands have declined to a remarkable percentage and which is actually attributing to the volatile nature of seasonal submergences and pocket floods within the basin and that might be due to avulsion and an branching of the channels. Furthermore, huge bed filling scenarios and negligible bed slope characteristics have been attributed to the spate of the channel and occasional deluges. As a fact of provenance, the sand deposits and their percentage share is contravening influence of bank side submergences and diluvia of land under marginal cropping usage. Contextually development of settlement areas is also increasing keeping an incremental trend and dependency on land cum man-land share is turning into challenges over time especially agricultural production point of view. Increasing trends of water bodies are almost pointing out reappearances of channel off shoots and paleo channel features but excessive replenishments are reasonably resulting in their disfigurations for every next year from the year of appearance.

Multi thread channel patterns with anastomosing character or pattern is viewable in Kaljani basin and seriously approves the factuality of occasional flood scenarios.

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GROWTH PROFILE AND SIGNIFICANCE OF HERITAGE-RELIGIOUS TOURISM IN EASTERN REGION, UTTAR PRADESH

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Abstract

Growth and development of tourism primarily hinges on cultural factors including heritage and religious sites. Modern tourism is driven by and at the same time contributes towards the conservation and preservation of heritage-religious centers of tourism attraction. Drivers which affect influx of tourists at heritage sites include its cultural, religious, monumental significance and infrastructural improvements. There are many historical and heritage sites in state of Uttar Pradesh which attract a significant and few of them a majority of tourists including both domestic and foreign tourists. There are marked geographical variations in the tourists flow across the districts of the state. However, with a changing policy planning, a few of them are going through revitalization and redevelopment stages to further promote culture and tourism consequently contributing to economy of Eastern region. Based on secondary data, the present research paper focuses on to study trends, growth and spatial-temporal pattern of tourism in Uttar Pradesh especially in its Eastern region. Present study unravels and highlights the emerging challenges in tourism sector and why they need to be tackled for a sustainable tourism strategy in the state.

Introduction

Tourism has emerged as one of the most promising economic activities in modern times. It is now being actively integrated with economic development planning in most of developing countries (Rasool et al., 2021). A policy shift can be sensed in terms of developing all such potential places which can attract more tourists and consequently contribute to overall economy. The United Nations World Tourist Organisation (UNWTO) stated that "Tourism comprises the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes". In 2019, the global tourism peaked to 1464 million (UNWTO).

Tourism is well established part of heritage (Light, 2015) and it is interconnected since heritage is blend of cultural, social, historical and architectural image of a society. Heritage, being both tangible and intangible, has always been the point of attraction for tourists around the globe and "heritage tourism is a major economic activity in almost all countries of the world" (Light, Ibid). Thus, heritage places include ancient monuments, religious and spiritual sites, and places of cultural amalgamation which always remained preferred sites for tourists. Hall and McArthur (1998) illustrated that "[H]heritage is a part of a region's resource base, but only exists as such when it has been determined to have some utility function" (cited by Boyd 2002:212). The Organisation for Economic Co-operation and Development (OECD, 2009) highlighted that "[C]cultural tourism is one of the largest and fastest-growing global tourism markets. Culture and creative industries are increasingly being used to promote destinations and enhance their competitiveness and attractiveness." In a developing country like India, the rich and diverse cultural heritage and resources can act as the axle of tourism development. In India, cultural tourism is a sector that focuses on those geographical areas which reflect the art, architecture, religion and associated elements. Menon et al. stated that "cultural tourism is one of the biggest attractions for the tourist and it is a known fact that many travellers who plan to visit India focus their trip on cultural tourism" (2021). The fact is that the tourism industry thrives on the needs, tastes and perceptions of visitors.

Study Region

The study primarily focuses on the tourism development in Uttar Pradesh with special emphasis on its eastern region. The study also analyses the domestic and foreign tourism in India and the Empowered Action Group (EAG) States which include Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttaranchal, and Uttar Pradesh. Uttar Pradesh is one of the largest states in India which has a diverse cultural heritage. Uttar Pradesh comprises seventy-five districts with a population of 199.58 million as per the Census of India 2011. It's a fact that a few states in a country play an important role in attracting tourists for various purposes. Uttar Pradesh is one such state in the country which draws a huge number of tourists not form domestically but globally as well. The state has seen some sort of transition in tourism profile as tourists now turn to several places of religious and cultural importance rather than visiting recreational sites only. Thus, the share of religious places in attracting tourists has increased over the past few years in the state. In terms of tourist footfalls, the state is consistently ranked among the top five states in the country. Uttar Pradesh has emerged as the top destination for

attracting the highest number of domestic tourists in the year 2019. State's tourism significantly contributes to the state's economic growth and employment generation both direct and indirect, making it an important focus area for the government.

Objectives

The focus of the paper is to study the growth and development of tourism in eastern region of Uttar Pradesh (a) to analyse trends and growth of tourism in India and EAG states; (b) to study spatial concentration of tourism growth in districts of Uttar Pradesh; (c) to examine the growth pattern of tourism in Eastern Uttar Pradesh; (d) to critically discuss recent developments in tourism development policy and planning in Uttar Pradesh and their implications for sustainable tourism.

Database and Methodology

The present research adopts a descriptive and analytical framework. The entire study is based on secondary data collected from various sources such as published books, journals, reports, documents and websites. The secondary data is taken from Indian Tourists Statistics at a Glance-2020, Ministry of Tourism, Government of India; Annual Report 2019-2020/Annual Report 2020-2021, Ministry of Tourism, Government of India; Uttar Pradesh Tourism Statistics, Department of Tourism, Government of Uttar Pradesh; Statistics of Tourists Visits at Important Historical Places/Monuments in Uttar Pradesh (2014-2017/2015-2018), Department of Tourism, Government of Uttar Pradesh; Statistical Abstract Uttar Pradesh (Multiple Years), Economic and Statistic Division, State Planning Institute, Planning Department, Uttar Pradesh; Uttar Pradesh Statistical Diary (2019, 2022); Tourism Data Dashboard, UN World Tourism Organization (2018, 2019); Annual Research Highlights, World Travel and Tourism Council (WTTC, 2020); and Economic Survey of India and Uttar Pradesh Tourism Policy, 2018. The paper calculates the annual growth rate of multiple years and the share of tourists in each region to the total tourists influx in the country.

Results and Discussions

Tourism has a spatial and cultural difference in the way it takes place in different societies and regions. It is often known as the temporary movement of people to destinations outside their normal place of work and residence. India has a long tradition of people moving for various pilgrimage and religious sites. Thus, travel and tourism have been a part of Indian tradition and culture. The modern mass tourism is more organized and it adds significantly to the economic development.

The tourism industry in India plays a significant role in significant economic multiplier and it has more potential for the growth in employment sector. At a broader level "India accounts for a majority of South Asia's travel and tourism gross domestic product (GDP) and has also been the preferred destination for tourists from within the region" (Sinha and Sharma, 2020). The foreign exchange earnings from tourism in 2010 were Rs. 648.89 billion as compared to Rs.549.60 billion during 2009. The approach paper of the Twelfth Five Year Plan (2012-17) of the Planning Commission of India highlighted the need to adopt "proper tourism" to increase net benefits to the poor and ensure that tourism growth contributes to poverty reduction. India is divided into five tourist zones: northern, southern, eastern, western and central. Under the Ancient Monuments and Archaeology Sites and Remains Act, of 1958, the Archaeological Survey of India has declared three thousand six hundred and seventy-five monuments or sites to be of national importance which includes twenty-one properties that are inscribed as World Heritage Sites by UNESCO. By 2015, there were thirty World Heritage Sites in India, six were natural and the rest of the others are cultural wonders. The country India is endowed with rich physical landscapes including mountains, beaches, deserts, mangroves, rivers etc.

The celebration of fairs, festivals and manifold religious fabric gives support to wider tourism in India. In India, more attention is now being paid to the protection and conservation of the monuments including their cultural heritage such as performing art, visual art, festivals, languages, folk art and handicrafts. The major schemes in India are being aimed at Product/Infrastructure and Destination Development at certain places of tourism importance. Thus, to make these places as most tourist attractions, major redevelopment works and rejuvenations are being carried out at such heritage places of social, cultural and spiritual importance. Studies suggested that heritage can act as an important holistic development tool for the overall community development in India (see, Sharma and Sharma, 2017). The Uttar Pradesh Tourism Policy has the mission "to drive a sense of inclusive tourism development in the local community and make optimum use of tourism experiences across vibrant cities, attractions, nature, wildlife, adventure, food, heritage, religion and culture of state" (2018). Analysis of trends of domestic tourism in India over the past years offers an insight into the flow. In 2005, 392.04 million domestic tourists visited India which increased to 747.70 million in 2010. The number of domestic tourists further increased to 1431.97 million by 2015. It reached 2321.98 million in 2019. In terms of annual growth rate, it was 17.96% in 2006. It showed a decline in 2007 being at 13.90% and further declined to 6.90% percent by 2008.

However, there was a drastic growth of 18.79% in 2009, but it declined to 11.8% in 2010. Then there was a sudden growth in 2011 at 15.63% and it further grew to 20.88% growth rate in 2012. Then afterwards there has been a decline over the next year. The years 2014 and 2016 showed an increase in annual growth rates. It declined later in 2015 and grew in 2018. There was a drastic fall in growth rate in 2017 when it dropped to 2.61%. However, the year 2019 showed an annual growth rate of 25.26%. Thus, one can see that the trends of domestic tourist growth in India have been erratic during this period. The trend of foreign tourist arrival in India is similarly encouraging. The number of foreign tourists in India increased from 9.94 million in 2005 to 17.91 million in 2010. The period from 2005 to 2009 registered a declining trend in the annual growth rate of foreign tourists as the annual growth rate of 18.07% in 2006 declined to -0.06% in 2009. In 2010, the annual tourism growth rate bounced back to 24.62%. This further declined to -6.33% in 2012. The number of tourists visiting the country increased to 23.32 million in 2015. In 2019, this further increased to 31.40million. Though there was an overall growth in the number of tourists visiting the country, the annual growth rate pattern is very irregular.

The annual growth rate of domestic tourists in Empowered Action Group (EAG) states of India. The annual growth rate (AGR) of domestic tourists in Assam was 5.2% in 2010 which declined to 3.3% in 2014. It anyhow increased to 13.75% in 2015 but it again dropped to -6.03% in 2016. The growth rate further improved to 15.65% in 2019. The state of Bihar had an annual growth rate of tourism at -0.51% in 2011, which increased to 24.33% in 2015. The domestic AGR of Bihar reached 1.1% in 2019. Chhattisgarh had a domestic AGR of 13.8% in 2011, which declined to 5% in 2012. It drastically increased to 51.64% in 2013. It again declined sharply to 7.4% in 2014 and -25.16% in 2015. It dropped to -10.48% in 2019. The domestic AGR of Jharkhand was highest being at 62.97% in 2014. It declined and reached to 0.49% in 2019. Madhya Pradesh had the highest domestic AGR in 2010 with 64.8% of the domestic Annual Growth Rate. The domestic AGR of Odisha remained almost the same till it drastically dropped to 0.65% in 2019. Rajasthan had the lowest domestic AGR of -0.1% in 2010. It depicted an erratic pattern and reached 3.95% in 2019. Uttarakhand had a domestic AGR of 37.7% in 2010. It witnessed the lowest of ten years in 2013 with a domestic AGR of -25.67%. A gradual rise was reported later and it reached 5.55% in 2019. The annual growth rate of foreign tourists in Empowered Action Group (EAG) states of India. Overall, the growth rate of foreign tourists in EAG states has been fluctuating over the

years in the country. The Foreign AGR of Assam in 2010 was 1.4% which declined to -48.69% in 2016. It witnessed a sharp increase of 69.33% and 72.38% in 2018 and 2019 respectively.

The state of Bihar has a record of the highest foreign AGR of 52.97% in 2011 from 50.3% in 2010 and it declined to -30.18% in 2013. It grew by 11.36% in 2015. Its annual growth rate declined and reached 0.48% in 2019. In Chhattisgarh, the annual growth rate of foreign tourist arrivals has been showing signs of fluctuation over the years from 2010 onwards. The highest foreign growth rate of Chhattisgarh was recorded at 114.88% in 2018, which dropped sharply to rate of -52.66% in 2019. Jharkhand had the highest jump in foreign tourist growth rate at 361.72% in 2011 which declined again in the next two years. It suddenly jumped to 236.41% in 2014. It further went down and reached 0.14% in 2019. Madhya Pradesh had a lower growth all through the past years from 2010 onwards. The State's foreign tourist growth rate was lowest at -13.8% in 2016 and again it grew at -12.66% in 2019. Odisha had a lower growth rate in 2010 and 2011 compared to the EAG average. It showed signs of fluctuations over the next few years. The highest foreign tourist arrival growth in Odisha was recorded at 31% in 2017 and it again declined and grew at 3.89% in 2019. Uttarakhand in 2010 had an annual growth rate of 19.5%. Then afterwards it declined while growing at -2.05%, -0.08%, -21.57% in 2011, 2012 and 2013 respectively. It jumped to 14.2% in 2017 but declined later to 13.16% and 0.63% in 2018 and 2019 respectively. The state of Uttar Pradesh has not seen an impressive growth rate in foreign tourist arrivals in the initial years since 2010. It jumped in 2014 and grew at 41.63%, however, it declined in later years It again in 2017 grew at a 12.7% rate higher than the EAG average and declined later. Its growth rate was reported at 25.51% in 2019, again it was higher than the EAG average.

Heritage-Religious Tourism in Uttar Pradesh

Uttar Pradesh is popular for many historical monuments such as the Taj Mahal, Fatehpur Sikri, Dhamek Stupa, Bada Imambara etc. and also religious and spiritual places such as Varanasi, Prayagraj, Ayodhya, Kushinagar, Vrindavan, Mathura and others. Agra is one of the most populous cities in Uttar Pradesh and a major tourist destination because of its many Mughal-era buildings, most notably the Taj Mahal (one of the Seven Wonders of the World), Agra Fort and Fatehpur Sikri. It is included in the Golden Triangle tourist circuit, along with Delhi and Jaipur. Lucknow is a multicultural city that flourished as a North Indian cultural and artistic hub,

and the seat of power of Nawabs in the 18th and 19th centuries. Shravasti, located near the West Rapti River, is closely associated with the life of Gautama Buddha who is believed to have spent 24 Chaturmases here. Kushinagar is an important Buddhist pilgrimage site, where it is believed that Gautama Buddha attained Parinirvana after his death. The followers of Buddhism, especially from Asian countries, wish to visit this place at least once in their lifetime. Of course, Varanasi or Kashi situated on the banks of the Ganges is a major religious hub in India. It is the holiest of the seven sacred cities (Sapta Puri) in Hinduism and Jainism and played an important role in the development of Buddhism. Vindhyanchal is a renowned religious city in Mirzapur District. The city is a Hindu pilgrimage site with the Vindhyavasini Devi temple situated on the banks of the holy river Ganga. It is one of the most revered Shakti Peeths of the presiding deity, Vindhyavasini Devi. There are also physical and natural scenic attractions including the Ganga, the Yamuna, Dudhwa National Park, Chandraprabha Wildlife Sanctuary and other places. Unique archaeological sites such as Sinauli and Sarnath are also located in the state. They all offer a plethora of options to tourists who visit the state and attract tourists of domestic and foreign origin as well.

Table-1 shows the domestic tourist arrivals pattern in Uttar Pradesh. The domestic tourism arrival has seen an increasing trend in Uttar Pradesh. In 2005, 95.44 million domestic tourists visited Uttar Pradesh which further increased to 144.75 million in 2010The number of domestic tourists kept growing and reached 204.88 million in 2015 and 535.85 million in 2019. The annual growth rate of domestic tourists has been an erratic trend. The annual growth rate of domestic tourists was 8% in 2005, which increased in the next few years but came to 7.36% in 2010. Since then, the annual growth rate gradually accelerated over the next few years and highest ever recorded in 2013. The lowest growth rate was in 2014 at -19.3%. It reached to 12.07% in 2015. Further, it declined and reached 3.33% in 2019. In terms of the share of the state in total domestic tourists in India, it has been remarkable from 2005 to 2010, later showing signs of declining share. It was reported 23.08% in year 2019. Foreign tourism in Uttar Pradesh witnessed a different trend. In 2005, some 1.17 million foreign tourists visited Uttar Pradesh. The number of foreign tourists visiting the state increased to 1.67 million in 2010 and further increased to 3.10 million in 2015. The number of foreign tourists increased to 4.74 million in 2019. The annual growth rate was recorded at 13.24% in 2005. The lowest growth rate was in 2009 being at -3.71%/. It jumped and reached at 9.67% in 2010. It has grown over the next few years, the highest being recorded in 2014, it came to

Table-1: Share of Domestic and Foreign Tourists of Uttar Pradesh in India

Years	Domestic Tourists (%)	Foreign Tourists (%)
2005	24.34	11.81
2006	22.82	11.31
2007	22.07	11.49
2008	22.17	11.2
2009	20.16	10.79
2010	19.36	9.67
2011	17.98	9.68
2012	16.11	10.92
2013	19.83	10.3
2014	14.25	13.03
2015	14.31	13.31
2016	13.11	12.77
2017	14.12	13.23
2018	15.38	13.1
2019	23.08	15.11
2020	14.11	12.42
2021	16.19	4.24
2022	18.37	7.56

Source: India Tourism Statistics, Ministry of Tourism, Govt. of India

6.68% in 2015. It again showed fluctuation in the next few years reaching 12.65% in 2016. It came down to 6.31% in 2018 and a sudden jump was recorded in 2019 where it grew to 25.51%. Whereas the share of the state in overall foreign tourists in the country is concerned, it has been somehow constant over the years since 2005 onwards and showed a declining trend in 2010 and 2011. It further maintained its course and gradually bounced back over the next years and had 15.11% in 2019. The COVID-19 pandemic and subsequent lockdowns impacted tourism in the country. The number of domestic tourists dropped to 86.12 million registering a sharp decline of -83.93% in 2020. Similarly, foreign tourists also dropped by -81.22% to 0.89 million in this. The tourism industry showed resilience and tourism started growing again in 2021 with an increase of 27.89% in 2021. Although,

due to air restrictions, foreign tourism dropped further by -94.98% in 2021. In the year 2022 they witnessed rapid growth in terms of both domestic and foreign tourism. In Uttar Pradesh, the tourist destinations are grouped into nine Regional Tourist Office (RTO) Zones. These RTO zones include Agra, Jhansi, Bareilly, Prayagraj, Varanasi, Lucknow, Meerut, Ayodhya and Gorakhpur. Thus, the trend of tourism in all RTO zones over the past few years has been analyzed. The percentage share of domestic tourists in various RTO zones of Uttar Pradesh. Here Agra zone received the highest number of domestic tourists in Uttar Pradesh. The percentage share of domestic tourists in the Agra RTO zone was 19.8% in 2013, which increased to 25.27% in 2014 and 29.55% in 2015. Afterwards, the zone has shown signs of decline having come down to 29.09%, 28.16%, 26.82% and 15.20% in 2016, 2017, 2018 and 2019 respectively. Agra zone is followed by Prayagraj RTO zone with a 37.7% share in 2013 in total domestic tourists in Uttar Pradesh. It declined to 20.08% in 2014 and remained almost the same at 20.08%, 19.9%, 19.3% and 17.3% in 2015,2015,2017 and 2018 respectively. It increased to 53.8% in 2019. The next zone which received a higher share of domestic tourists is Ayodhya followed by Meerut, Jhansi and then Varanasi zones. Fig. 1 depicts the percentage share of domestic tourists in various RTO zones of Uttar Pradesh. Here Agra zone received the highest number of domestic tourists in Uttar Pradesh. The percentage share of domestic tourists in the Agra RTO zone was 19.8% in 2013, which increased to 25.27% in 2014 and 29.55% in 2015. Afterwards, the zone has shown signs of decline having come down to 29.09%, 28.16%, 26.82% and 15.20% in 2016, 2017, 2018 and 2019 respectively. Agra zone is followed by Prayagraj RTO zone with a 37.7% share in 2013 in total domestic tourists in Uttar Pradesh. It declined to 20.08% in 2014 and remained almost the same at 20.08%, 19.9%, 19.3% and 17.3% in 2015,2015,2017 and 2018 respectively.

It increased to 53.8% in 2019. The next zone which received a higher share of domestic tourists is Ayodhya followed by Meerut, Jhansi and then Varanasi zones (Fig. 1). It is quite clear here that a major share of foreign tourists visited the Agra and Varanasi zones in Uttar Pradesh. This trend is followed by Prayagraj and others. In 2013, 48.4% of total foreign tourists visiting the state of Uttar Pradesh visited Agra. It further increased to 50.7% in 2014, and 53.04% in 2015. It declined to 51.16% in 2016 but again bounced back and increased to 53.63% in 2017. However, it declined later to 53.4% in 2018 and 43.21% in 2019. This zone was followed by Varanasi which had 20.77% foreign tourist's share in 2013. It further jumped to 23.38% in 2014. The share of Varanasi in total foreign tourists

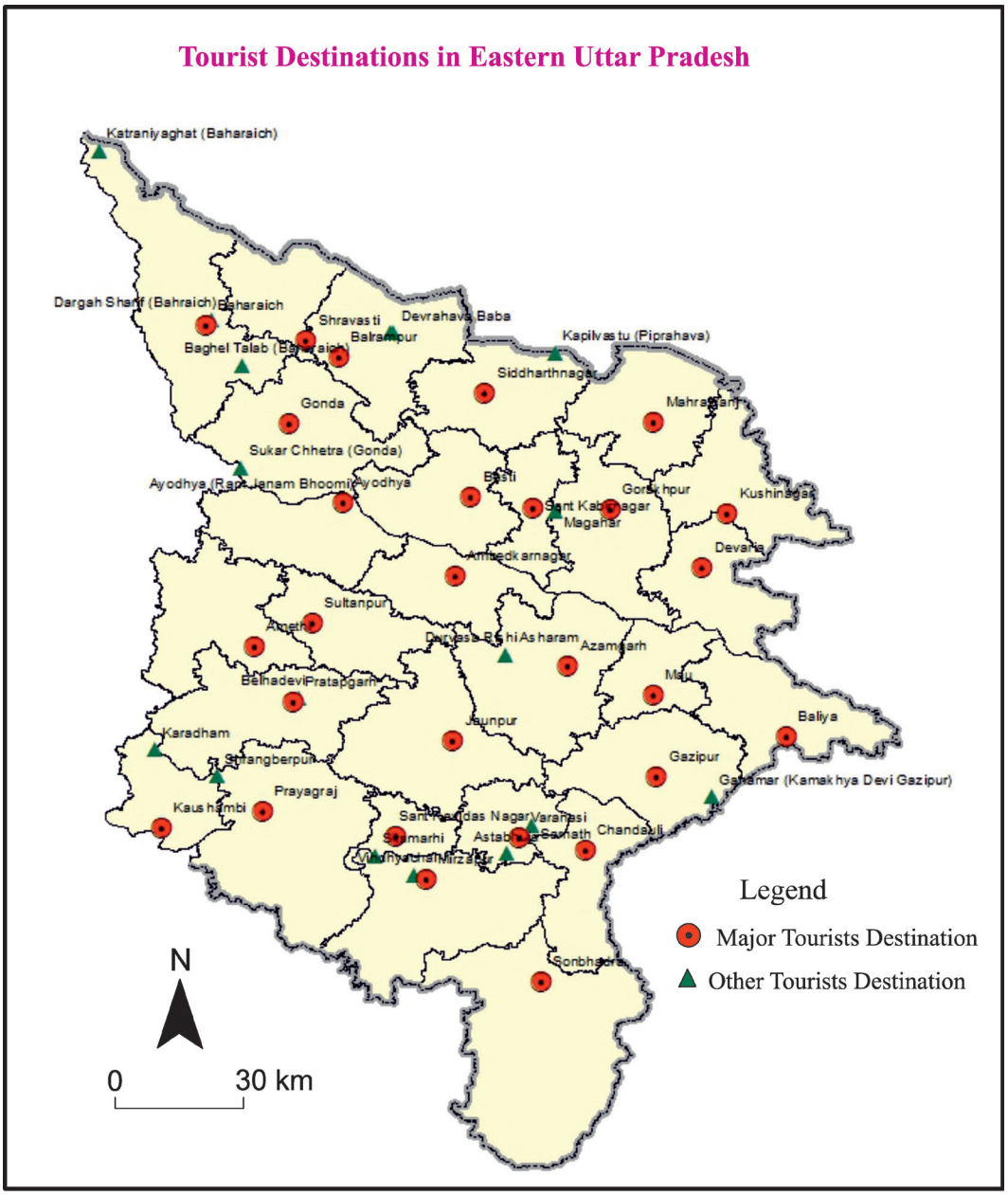

Tourist Destinations in Eastern Uttar Pradesh
Katraniyaghat (Baharaich)
Dargah Sharif (Bahraich)
Baharaich
Shravasti
Devrahava Baba
Balrampur
Baghel Talab (Baharaich)
Kapilvastu (Piprahava)
Siddharthnagar
Mahrajganj
Gonda
Sukar Chhetra (Gonda)
Ayodhya (Ram Janam Bhoomi)
Ayodhya
Basti
Gorakhpur
Kushinagar
Sant Kabir Nagar
Maghar
Devaria
Ambedkarnagar
Sultanpur
Amethi
Azamgarh
Belhadevi
Pratapgarh
Mau
Jaunpur
Baliya
Karadham
Shringerpur
Gazipur
Gahmar (Kamakhya Devi Gazipur)
Prayagraj
Kaushambi
Varanasi
Sitamarhi
Sarnath
Chandauli
Mirzapur
Legend
Major Tourists Destination
Other Tourists Destination
Sonbhadra
N
0
30 km

Fig. 1

visiting Uttar Pradesh remained at 22.84%, 23.45%, 22.06% and 21.30% in 2015, 2016, 2017 and 2018 respectively. Further, it declined by the year 2019. This zone is followed by Gorakhpur, Ayodhya, Jhansi, Prayagraj, Lucknow and the remaining zones. Prayagraj occupies a unique position in the tourist flow pattern in the state. Prayagraj zone received a higher share of foreign tourists in 2013, which was 12.6%. Afterwards, it slipped down more than fifty percent of this share reaching 4.1% in 2014, 4.19% in 2015, 4.1% in 2016, 3.7% in 2017 and 4.5% in 2018. However, with a congregation of Kumbh, the foreign tourist share shot up again and increased to 25.19% in 2019.

Growth Pattern of Tourism in Eastern Uttar Pradesh

The state of Uttar Pradesh has been divided into four sub-regions- Western Uttar Pradesh, Central Uttar Pradesh, Bundelkhand and Eastern Uttar Pradesh. The Eastern Uttar Pradesh sub-region is also known as 'Purvanchal'. The eastern portion comprises of Allahabad, Ambedkar Nagar, Amethi, Azamgarh, Ayodhya, Bahraich, Ballia, Balrampur, Basti, Chandauli, Deoria, Ghazipur, Gonda, Gorakhpur, Jaunpur, Kaushambi, Kushinagar, Maharajganj, Mau, Mirzapur, Pratapgarh, Sant Kabir Nagar, Sant Ravi Das Nagar, Shravasti, Siddharth Nagar, Sonbhadra, Sultanpur, and Varanasi. These RTO zones include Varanasi, Prayagraj, Gorakhpur and Ayodhya. At present, Eastern Uttar Pradesh has eight prominent tourist destinations where both domestic/local and foreign tourists visit to see and experience a blend of historical, cultural and heritage places. Here, Varanasi is believed to be the one of oldest cities- the ancient- of the world. Since her origin, the city has grown in the rich tradition of Hindufold. Now, it has a unique amalgamation of several religions such as Hinduism, Buddhism Jainism and other cultures. The city is famous for its region-cultural significance. The city is well known for the great Ganga Ghats (river fronts) and is known as the "City of Salvation". (Table-2)

The Lord Buddha gave his first sermon at Sarnath, a place located close to the city of Varanasi. The Ayodhya is located at the bank of river Sarayu and it is believed to be the birthplace of Lord Rama. The Prayagraj is considered as a holy city due to the confluence of sacred rivers such as Ganga, Yamuna and Saraswati. Gorakhpur is well known for the Gorakhnath Temple. Shravasti is believed to be where the Buddha taught many of his Suttas (sermons). Buddha attained his mahaparinirvana (salvation) in Kushinagar located in the region. Kaushambi is an important Buddhist tourist destination in Eastern Uttar Pradesh. Sant Kabir Nagar has a blend of natural, cultural and historical places to visit and attracts tourists. Table-2 shows the annual growth rate of tourists to the important tourist destinations

Table-2: Annual Growth Rate (%) of Tourist Destinations of Eastern Uttar Pradesh

Years	Varanasi	Ayodhya	Prayagraj	Gorakhpur	Shrawasti	Kushinagar	Kaushambi	Sant Kabir Nagar
2001	2.89	16.64	23.14	-0.7	-2.33	-2	32.61	6.25
2002	-0.85	-12.26	13.21	1.42	80.95	-17.69	1.64	5.88
2003	4.58	0.99	8.72	4.2	0	1.65	8.06	150
2004	5.02	0.04	12.27	28.86	14.47	0.81	10.45	53.33
2005	8.23	0.11	9.99	3.65	8.05	101.61	10.81	10.14
2006	5.1	6.02	7.17	718.09	82.98	110.8	8.54	68.42
2007	9.5	2.75	14.44	3.13	0.58	3.42	11.24	15.63
2008	5.88	2.38	18.11	14.06	8.67	3.3	10.1	4.73
2009	5.01	41.8	19.51	5.22	2.66	20.96	22.94	16.13
2010	6.63	20.23	6.84	6.7	-5.18	10.57	6.72	10.56
2011	8.12	20.63	3.91	2.14	10.93	2.92	4.2	12.06
2012	7.41	8.38	10.93	2.5	11.82	2.84	3.36	14.35
2013	3.75	8.12	143.07	1.78	-8.37	1.88	20.13	7.84
2014	4.53	0.68	-58.04	1.4	0.96	3.45	3.78	1.09
2015	4.14	7.46	14.83	1.12	1.9	4.05	7.81	2.88
2016	3.43	0.34	0.6	1.36	3.74	2.75	7.73	3.15
2017	6.34	13.35	1.5	2.52	16.22	4.34	873.54	-66.1
2018	2.5	9.51	7.02	14.38	338.76	4.27	0.23	11
2019	5.48	4.7	536.46	9.28	12.28	12.18	0	15.32
2019	67.97	201.49	2852.28	30.51	12.71	10.96	21.76	1.28
2020	-85.55	-70.11	-88.8	-	-	-	-76.24	-
2021	206.21	156.73	-64.89	-	-	-	11.03	-

Source: Statistical Abstract Uttar Pradesh, (Multiple Years) Economic and Statistics Division, State Planning Institute, Planning Department, Uttar Pradesh).

Note: Data is not available for a given destination is shown by symbol.

located in Eastern Uttar Pradesh. Some of these tourist places have witnessed the highest record of annual growth rates over the past two decades (Fig. 1). Ayodhya had an unusual growth, the highest ever, in 2009. Prayagraj recorded first highest annual growth rate (143.07%) in 203 and second highest (536.46%), ever recorded, recorded in 2019. Gorakhpur had a higher annual growth rate (718.09%) in 2006 after 2004 when it was 28.86%. Shravasti experienced the highest annual growth rate (338.76%) in 2018. Kushinagar had a high growth rate (873.54%) in 2017. Sant Kabir Nagar had a higher annual growth rate of tourists in the year 2006. These changes in some years are the result of many initiatives of state governments such as organizing fairs or other cultural and religious activities.

Development Policy, Planning and Recent Initiatives

Eastern Uttar Pradesh has seen a kind of revival of several historical, religious and heritage sites in the context of their religious and touristic importance in recent years. The political dynamics of the nation over the last few years have focused on that "destroying the existing structures is not the way but the emphasis should be on rejuvenation and preservation. This should be done in accordance with the requirements of modern times" (Kamal Sandesh, 2022). Primarily, Varanasi, Ayodhya, Prayagraj, Gorakhpur, Shravasti, Kushinagar, Kaushambi and Sant Kabir Nagar dominate the tourist landscape of the region. Efforts are being made towards several other places to be developed in the region. Of the many places, only a small number of places have been figuring in the tourist-destination profile of the state. There are many more places, found in almost every district, as identified by the Department of Tourism of Uttar Pradesh (see, Statistical Diary 2020, Annexure 24), where future tourism development can be directed in the eastern region. Initially, the state policy for tourism development is reflected in Uttar Pradesh's industrial policy. The two main objectives that came to light were: increasing employment in the region; and targeting high growth. In this context, there was a realization that the service sector must be promoted for the industrial and economic growth of the state. It was here that mention of imperatives for the preservation of the environment and cultural heritage as well as the need to promote specific geographic areas/corridors are highlighted (Uttar Pradesh Development Report, Vol.2, 2007).

A report on "20 Years Perspective Plans for Uttar Pradesh" by the Department of Tourism, Government of India (2002) highlighted the corollary objectives which focused on: i) promoting tourism development in harmony with local community involvement and employment, ii) protecting, preserve and conserve the monuments that a testimony to the past and are to be bequeathed to future generations; and

iii) to promote the highest possible standards of cleanliness, sanitation, and landscaping elegance. The report listed the following hubs of tourism in the state of Uttar Pradesh: Varanasi, Jhansi, Agra, Lucknow, and Greater Noida. The fact is that Uttar Pradesh has tremendous potential to attract both foreign and domestic tourists. The government of Uttar Pradesh has enacted Tourism Policy 2018 for the holistic development of tourism in the state. It aims to achieve the target "to become the most preferred tourist destination of the country by 2023" (Uttar Pradesh Tourism Policy 2018). This policy laid down six pillars to successfully achieve the targets of the policy: Strengthening Tourism Infrastructure; Promoting Investment and Employment Generation; Augmenting Brand Uttar Pradesh; Focus on Religious/Spiritual Tourism; Promoting Theme Based Tourism; and Sustainable Tourism through Community growth and upgradation of local skills.

The state has taken key steps to ensure better connectivity of districts and tourist places in the eastern region. Recently, Kushinagar International Airport has become operational, which will connect many countries especially South Asian and South East Asian countries where Buddhism is prominent. Now two international airports are functional in Eastern Uttar Pradesh in Varanasi and Kushinagar. Along with Taj Mahotsav at Agra, various events such as Rangotsav at Barsana, Dev Deepawali at Varanasi and Deepotsav at Ayodhya have contributed to transforming the state's image as an attractive tourist destination for both religious and leisure tourism. Religious and spiritual tourism contributes a prominent part of tourism in the state. Strengthening and upgradation of civic amenities, the establishment of shrine boards to manage religious places, creation of accommodation facilities has been the aims. The centrally launched schemes such as HRIDAY (Heritage City Development and Augmentation Yojana) under the Ministry of Urban Development, Government of India, and the objectives are heritage conservation, beautification, cleanliness, safety, accessibility and service delivery. Another scheme is the PRASAD (Pilgrimage Rejuvenation and Spiritual Augmentation Drive) scheme under the Ministry of Tourism, Government of India. It aims to integrate pilgrimage destinations in a prioritized, planned and sustainable manner to provide a complete religious tourism experience. There are two cities in Uttar Pradesh under these schemes: Mathura and Varanasi.

The former scheme focuses on infrastructure that preserves the heritage character, while the latter goes beyond this to include vocational training programmes and other things that make up the tourism ecosystem. The Kashi Vishwanath complex in the city of Varanasi has been undergoing an unprecedented transformation and

the site is being connected to the river Ganges. The project comprises of Shri Kashi Vishwanath Dham, Manikarnika Ghat and its Beatification. The operation of the project will provide value addition to the existing infrastructure, as due to the development of the project, the commercial facilities such as public transport, water supply, telecommunications, power lines, road maintenance etc. all to be upgraded. The growth of domestic tourism hugely depends on pilgrimage tourism. In Uttar Pradesh, heritage tourist circuits are being developed which would lead to holistic development of all the places sharing cultural or spiritual importance. Some of these tourist circuits in the state and the Eastern region are: i) the Buddhist Circuit connecting Kapilvastu, Kaushambi, Kushinagar, Sankisa, Sarnath, and Sravasti; ii) The Heritage Arch connecting Agra, Lucknow and Varanasi; iii) Braj Circuit connecting Agra, Vrindavan and Mathura; iv) Awadh Circuit connecting Lucknow, Devasharif, Naimisharanya, Ayodhya, Faizabad; v) Vindhya Varanasi Circuit connecting Varanasi, Chunar and Vindhyanchal; vi) Ramayana Circuit connecting Ayodhya with important places related with Lord Ram; vii) Bundelkhand Circuit connecting Bithoor, Chitrakoot, Jhansi, Kalinjar and Mahoba; viii) Mahabharat Circuit connecting Hastinapur, Kampilya, Barnava, Mathura and Gonds; ix) The Aadhyatmic Circuit connecting Gorakhpur, Balrampur, Ghazipur, Goriya and Sant Ravidas Nagar; and x) The Sufi/Kabir Circuit connecting Amethi, Maghar, Salim Chishti Dargah and Barabanki (see, Uttar Pradesh: A conglomeration of Culture, Religious and Heritage Tourism, FICCI-MRSS, 2018). Beautification of places has also been on the agenda of the government to promote tourism.

The new tourism policy also takes this into account and aims to promote theme-based tourism such as eco-tourism, agri-tourism, caravan tourism, adventure tourism, sports tourism, rural tourism, etc. In this way, the state aims to create a 'Brand Uttar Pradesh'. Uttar Pradesh is rich in handicrafts and handlooms. Gorakhpur's Terracotta, Varanasi's Silk, Bhadohi's Carpet, Agra's Zardoji, Khurja's Pottery, Firozabad's bangles, etc. have global demand and repute. The 'Hunar Se Rojgar' scheme of the Government of India and the 'One District One Product' initiative of the Uttar Pradesh government a medium to promote crafts and handloom in the tourism sector. The new Tourism Policy advances the idea of 'Weekend Tourism', under which potential tourist spots have been identified, where people living in and around the area can visit the place. These tourist sites can also act as major tourist attractions for foreign tourists. These weekend tourist spots have only been identified for a few districts. It is essential to identify such places in all the districts of Uttar Pradesh and connect these locations with major tourist

destinations. The Pro-Poor Tourism Growth Project of Uttar Pradesh is projected to offer far-reaching social, economic and environmental benefits at local and regional levels. The project aims to meet the expectations of both low and high-spending domestic and foreign tourists visiting each such destination by enhancing their overall experience. (Table-3)

Table-3: Features of Drivers-Pressures-State-Impacts-Responses Framework

Elements	Major Features
Drivers	Tourist attendance, urban traffic, hospitality structures, urbanization, status of environment etc.
Pressures	Air quality, production of urban solid waste, use of land, presence of tourists in protected areas etc.
State	The concentration of pollutants in the air, change of land use, state of the local host community tourist satisfaction etc.
Impacts	Adverse impact on heritage structures, local host community, profile of tourism industry etc.
Response	Awareness about sustainable tourism activities, promoting eco-friendly transport, promoting eco-tourism activities etc.

Source: EEA 1998: Guidelines for Data Collection and Processing, EU State of Environment Report

Emerging Challenges and Prospect of Sustainable Tourism

There are many grey areas which need to be identified and improved for the holistic development of tourism in the state. The major challenge is still the connectivity issue and availability of transport networks. The tourist concentration is only in a few districts and geographical regions of the state, other tourist places remain the least connected. The dedicated heritage or tourist corridors can also be made to cater for the specific needs of tourists and provide a seamless experience. The important tourist sports need to be connected by other important but now so well-known tourist spots of the state. Heritage tourism is usually promoted around tangible heritage and monumental sites. Though monument protection and conservation are important, the promotion and protection of intangible heritage such as folk art, dance and music forms, traditions and customs are equally important. Special attention should be paid towards intangible heritage also because if they are not supported, they may not be passed on to coming generations.

The intangible heritage is a unique feature of the place and can act as a major tourist attraction. Skill upgradation of people involved in the formal hospitality sector should be done periodically. The government can provide subsidies and incentives for opening accommodation facilities at tourist places. The government has planned to convert heritage buildings into hotels. This can also help to attract tourists but while doing this, the conservation of these heritage buildings must be assured. Uttar Pradesh is rich in water resources. The rivers can be used to promote tourism by promoting water transport. State Waterways can be developed on the theme of National Waterways. Identifying the opportunity and feasibility of water-based adventure sports and their promotion can help boost tourism in the region (Table-3). The feasibility of connecting various cities located at the bank of rivers by river cruise service should be analyzed. These steps can help to strengthen the position of Uttar Pradesh in the tourism sector (Jaiswal, 2021). To make tourism more sustainable and integrated in Uttar Pradesh, the DPSIR framework (European Environment Agency, 1999) can play an important and strategic part in tourism development and management. The tourism industry thrives on the kind of environmental, ecological and social-cultural conditions present at tourist destinations. Thus, an assessment of physical, accommodation, environmental and economic carrying capacity is inevitable for further planning of tourist destinations.

Conclusion

Study shows that tourism in India is growing in the terms of arrival of domestic and foreign tourists. The growth rate pattern indicates an erratic fluctuation in the country and state of Uttar Pradesh as well. Tourism and its growth rate in Empowered Action Group (EAG) states are relatively promising and at certain times it is found higher as compared to that of the country. This indicates the fact these states have immense opportunities in the tourism sector. Among them all, the state of Uttar Pradesh offers a hybrid experience to tourists. However, a few tourist destinations and places dominate the tourism flow in the state. Only a few places in the Eastern part of Uttar Pradesh have a cultural, historical, and heritage edge in tourism over the other places. Only a few of them are hubs for religious and spiritual tourism and attract a significant number of domestic and foreign tourist arrivals in the country and state. There is a need to work in the direction of making a shift from the conventional tourism development approach towards more inclusive tourism development in the state. This will create more economic opportunities in tourism in

the state and eastern region. For comprehensive planning for tourism development, there are certain factors such as a sense of security, affordable accommodation, better connectivity perception building etc. should be given place in further tourism development planning.

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SPATIAL ANALYSIS OF REGIONAL DISPARITY IN INDIA BASED ON NSSO 78TH ROUND DATA ON MULTIPLE INDICATORS OF DEVELOPMENT

Dr. Chhering Tandup and Sheezan Khursheed Kichloo

Abstract

Understanding regional disparities is crucial for addressing social and environmental factors that contribute to inequality and poverty. The study aims to analyze regional disparities in India using secondary data from the 78th round of the National Sample Survey (NSS) Multiple Indicator Survey (MIS) conducted in 2020–2021. The study has focused on state-wise disparities across multiple indicators as well as comparing disparities in urban and rural areas. The coefficient of correlation matrix has been used to determine the relationship between different socio-economic development indicators in both rural and urban areas. The Kandell Ranking Coefficient Method is also used to identify high-, medium-, and low-developed states or union territories based on socio-economic development indicators. GIS mapping and spatial analysis have been utilized to visualize and investigate regional disparities in India through a mixed-method approach.

Introduction

India is a country with vast diversities in terms of geography, culture, and economic development. Regional disparities refer to the differences in economic growth, social development, infrastructure, and living standards in different regions of the country. These disparities arise due to various factors, such as historical legacies, natural resource distributions, government policies, and infrastructure. The regional disparities in India are pronounced and can be seen in various aspects. Firstly, there are significant variations in economic growth and development between regions. States like Maharashtra, Tamil Nadu, Gujarat, and Karnataka have seen significant economic growth, while many states in the eastern and northeastern regions are still struggling with poverty and underdevelopment. Secondly, there are differences in social development indicators such as education, health, and gender equality. Southern states like Kerala and Tamil Nadu have high literacy rates and

good health indicators, while many states in North India have poor literacy rates and health indicators. Thirdly, there are also infrastructure disparities between regions. Cities like Delhi, Mumbai, and Bangalore have modern infrastructure and good connectivity, while smaller cities and towns in rural areas lack basic infrastructure like roads, electricity, and water supply. The reasons for regional disparities can be attributed to various factors. One of the major factor is the historic legacy of colonialism, which led to the concentration of economic and administrative power in certain regions. Additionally, natural resources like minerals and fertile land are unevenly distributed across the country, leading to disparities in economic growth. Sastry and Tripathi (2013) argue that MIS is an essential tool for data collection and analysis in the field of health research. Seneviratne, S. I., & Wickramasinghe, R. (2018). Regional disparities in Sri Lanka: A multidimensional perspective. Journal of Development Studies, 54(1), 1–16. This study uses MIS to analyze regional disparities in Sri Lanka across various dimensions, including economic, social, and environmental indicators. The authors highlight the importance of addressing social and environmental factors in reducing regional disparities. Kabeer, N., & Mahmud, S. (2019).

Study Region

India is surrounded by Bay of Bengal in the east, the Arabian Sea in the west, and the Indian Ocean to the south. Lying entirely in the Northern Hemisphere, the Country extends between 8° 4' and 37° 6' latitudes north of the Equator, and 68° 7' and 97° 25' longitudes east of it India is a vast and diverse country with a population of over 1.3 billion people. The country is located in the Indian subcontinent and is bordered by Pakistan, China, Nepal, Bhutan, Bangladesh, and Myanmar. The study region of India is vast and includes various geographical regions such as the Himalayas in the north, the Gangetic Plain in the north and northeast, the Deccan Plateau in the center, and the coastal regions in the south, east, and west. The climate varies significantly across these regions, with extreme temperatures and weather conditions in some areas. The economy of India is rapidly growing and is the fifth-largest economy in the world by nominal GDP and the third-largest by purchasing power parity (PPP). The country has a diverse mix of industries, including agriculture, manufacturing, services, and technology. The study region of India is significant due to its large population, rapid economic growth, and diverse geography, making it an important area for research in various fields such as economics, geography, politics, and culture.

Objectives

To examine regional disparities and analyze state and UT wise level of development in India based on NSSO 78th round data on multi-indicator basis at the rural and urban level for 2020-2021.

Database and Methodology

The present study relies solely on secondary data. In this dissertation, the secondary source of data was acquired from the 78th round of the National Sample Survey (NSS) Multiple Indicator Survey, which was conducted during the period of 2020–2021. The data included a wide range of variables and indicators related to socio-economic factors such as income, education, employment, health, etc. The main indicators are access to piped water, access to improved sources of drinking water, access to latrine, clean fuel as the primary source of cooking, heating, and lighting, the percentage of rural households reporting the availability of all-weather roads within 2 km from their place of residence, public transport facilities within 500 m from their place of residence, access to bank accounts, financial institutions, or mobile money services, and access to mass media. Indicators were categorized into rural and urban areas to compare disparities in different environments. The technique of analysis of the coefficient of correlation matrix has been used to determine the relationship between different socio-economic development indicators in both rural and urban areas. This technique has been used as a tool for quantifying the relationship between variables and has been an important part of the methodology used in this study. The Kandell Ranking Coefficient Method was used to identify high-, medium-, and low-developed states or union territories based on socio-economic development indicators. ArcGIS 10.8 software was utilized to create maps and visualize data, while MS Excel was used for charting and analysis.

Results and Discussion

Table-1 provides data on the percentage of rural and urban persons having access to an improved source of drinking water for each state or UT of India. The data highlights the regional disparity between rural and urban areas among different states and UTs in terms of access to clean and safe drinking water.

Rural Areas

The percentage of rural households with access to an improved source of drinking water ranges from as low as 54.4% in Kerala to as high as 99.3% in Uttar Pradesh. States like Kerala, Manipur, Nagaland, and Jharkhand have relatively low

percentages, indicating limited access to safe and clean drinking water in rural areas. States like Uttar Pradesh, Bihar, and Haryana have high percentages, indicating better access to clean drinking water in rural areas. (Fig 1)

Urban Areas

The percentage of urban households with access to an improved source of drinking water ranges from 55.9% in Kerala to 100% in many states and UTs such as Delhi, Chandigarh, Daman & Diu, and Lakshadweep. Urban areas generally have a higher percentage of households with access to improved sources of drinking water compared to rural areas. States like Kerala and Tamil Nadu have relatively low percentages in terms of urban access to clean drinking water, indicating a need to improve access in urban areas. Overall, the data demonstrates a significant disparity in access to clean and safe drinking water between rural and urban areas in different states and UTs of India. While some states have achieved relatively high percentages of access to clean drinking water, many states and UTs still face significant challenges in this regard. (Fig. 1)

Table-1: Percentage of Rural Access for Rural and Urban Population and Improved Source of Drinking Water

State/UT	Rural	Urban	All
Andhra Pradesh	96.8	99.2	97.5
Arunachal Pradesh	97.9	100.0	98.3
Assam	90.8	97.8	91.6
Bihar	99.2	99.9	99.3
Chhattisgarh	94.8	99.8	96.0
Delhi	100.0	100.0	100.0
Goa	99.6	100.0	99.8
Gujarat	94.8	100.0	98.0
Haryana	100.0	99.8	99.9
Himachal Pradesh	98.0	99.8	98.2
Jharkhand	86.5	97.2	88.8
Karnataka	95.6	98.3	96.6
Kerala	54.4	55.9	55.2
Madhya Pradesh	88.4	99.5	91.4

Contd...

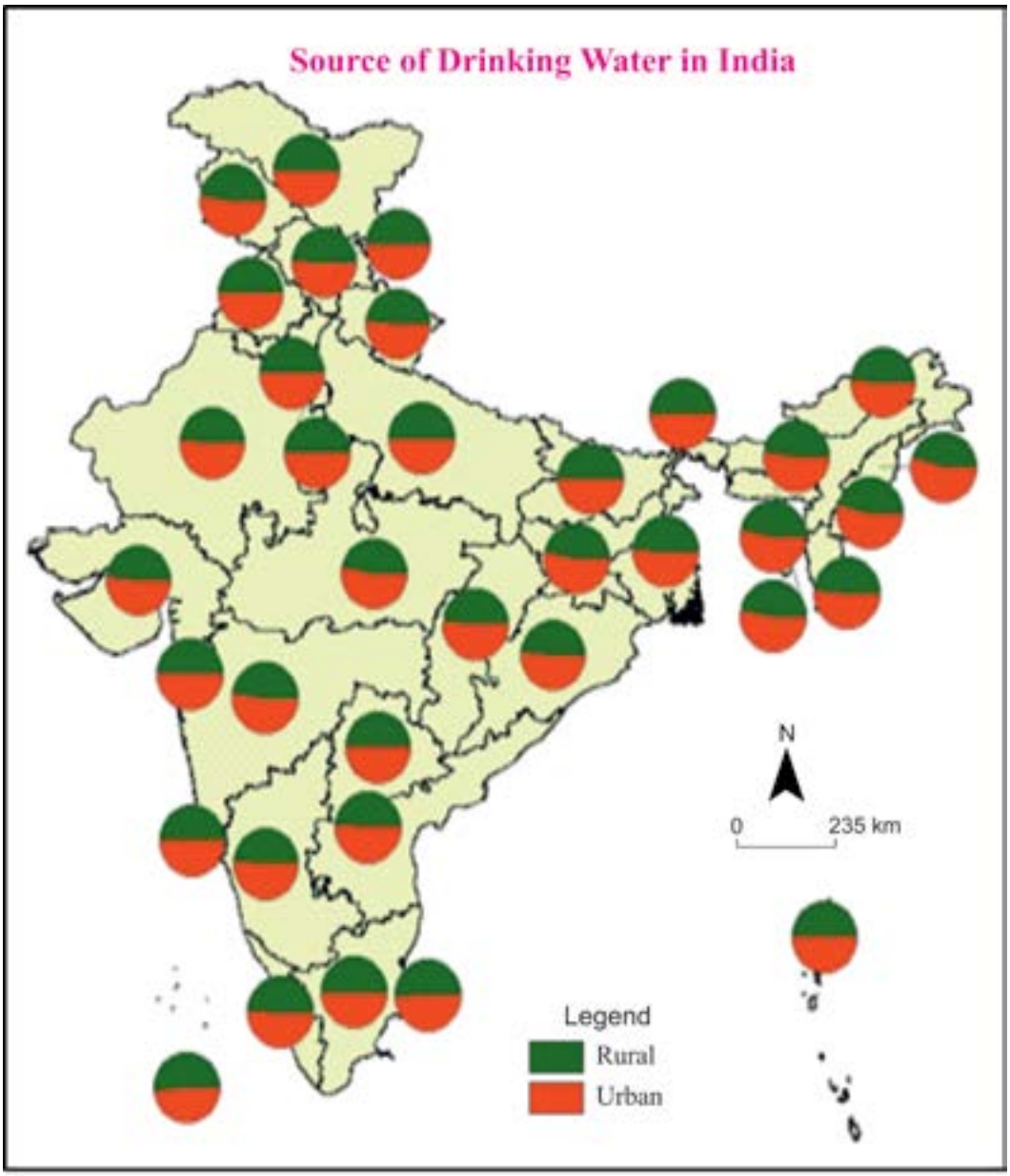

Source of Drinking Water in India
N
0
235 km
Legend
Rural
Urban

Fig. 1

Maharashtra	92.7	99.9	95.6
Manipur	72.4	82.5	75.6
Megahlaya	88.2	99.4	90.0
Mizoram	94.5	99.0	96.5
Nagaland	81.0	96.3	85.3
Odisha	91.8	98.4	92.8
Punjab	100.0	99.8	99.9
Rajasthan	93.7	98.5	94.8
Sikkim	98.5	100.0	98.9
Tamil Nadu	99.7	99.6	99.6
Telengana	98.3	99.7	98.9
Tripura	89.6	99.3	91.7
Uttarakhand	95.1	100.0	96.3
Uttar Pradesh	99.3	99.8	99.4
West Bengal	98.4	99.3	98.7
A & N Islands	98.1	99.7	98.7
Chandigarh		100.0	100.0
Dadra & Nagar Haveli and Daman & Diu	99.6	100.0	99.8
Jammu & Kashmir	92.5	99.7	94.1
Ladakh	99.8	100.0	99.8
Lakshadweep	76.5	72.8	73.8
Puducherry	100.0	98.7	99.2
All-India	95.0	97.2	95.7

Sources: NSS Report No. 589(78th Round 2020-2021): Multiple Indicator Survey in India

Sanitation Facility

The data highlights significant regional disparities in terms of access to sanitation facilities across different states and UTs.

Rural Areas

The percentage of rural households reporting access to a latrine ranges from as low as 58.7% in Jharkhand to 100% in Kerala, Manipur, Mizoram, and Nagaland.

States like Bihar, Odisha, and Rajasthan have a relatively low percentage of rural households with access to a latrine, reflecting inadequate sanitation facilities in these areas. States like Arunachal Pradesh, Assam, Himachal Pradesh, and Sikkim have relatively high percentages of rural households with access to a latrine, indicating better access to sanitation facilities in these areas. The all-India percentage of rural households reporting access to latrines is 78.7%.

Urban Areas

The percentage of urban households reporting access to a latrine range from 91.9% in Jharkhand to 100% in many states and UTs such as Arunachal Pradesh, Mizoram, Nagaland, and Sikkim. Urban areas generally have a higher percentage of households with access to a latrine than rural areas, reflecting better sanitation facilities in urban areas. Some states, such as Odisha and Tamil Nadu, have relatively low percentages of urban households with access to a latrine, indicating a need to improve access to sanitation facilities in these areas. The all-India percentage of urban households reporting access to latrines is 97.1%. Overall, the data shows that there are significant regional disparities in terms of access to sanitation facilities in India, particularly in rural areas. A lower percentage of rural households have access to a latrine compared to urban households.

Use of Clean Fuel

The national average for households using clean fuel as a primary source of energy is 16.4% in rural areas and 75.9% in urban areas. There is a wide variation in the percentage of households using clean fuel across different states and union territories. For instance, in Delhi, 91.4% of rural households and 82.6% of urban households use clean fuel. On the other hand, in Nagaland, only 0.8% of rural households and 24% of urban households use clean fuel. States and union territories with higher urbanization levels generally have higher percentages of households using clean fuel, with the exception of Mizoram, where 80.9% of rural households use clean fuel, compared to 13.9% of urban households. Puducherry has the highest percentage of urban households using clean fuel at 93.5%, and Sikkim has the highest percentage of rural households using clean fuel at 25.6%. Jharkhand has the lowest percentage of rural households using clean fuel, at only 3.8%. Overall, the data suggests that there is a significant disparity in access to clean fuel across various parts of India, with rural areas and some states having much lower usage rates.

Facilities for Connectivity

Overall, 92.5% of rural households in India have access to all-weather roads within 2 km from their place of living, while 89.6% of rural households have access to public transport facilities within 500 m from their place of living. There is a lot of variation in the availability of these facilities across different states and union territories. For instance, in Chandigarh, 100% of rural households have access to all-weather roads, and 99.5% have access to public transport within 500 m from their place of residence. On the other hand, in Meghalaya, only 64.7% of rural households have access to all-weather roads, and 82.6% have access to public transport facilities. States with higher levels of development and urbanization, such as Delhi, Goa, and Kerala, have higher percentages of rural households reporting the availability of these facilities. Surprisingly, some states with a lower level of urbanization, such as Manipur and Mizoram, also have high percentages of rural households reporting the availability of all-weather roads and public transport. In general, the data suggests that there is a significant disparity in the availability of facilities like all-weather roads and public transport across various parts of India, with some states and union territories having much better access than others.

Financial Institutions

Goa has the highest percentage of individuals with an account in both rural (97.9%) and urban (97.3%) areas. Nagaland has the lowest percentage of financial services in rural areas (66.5%), while Meghalaya has the lowest percentage in urban areas (79.5%). There are some States and Union Territories where the percentage of individuals with an account is higher in rural areas than in urban areas, such as Andhra Pradesh, Chhattisgarh, Himachal Pradesh, Jharkhand, Karnataka, Odisha, Rajasthan, Tripura, and Uttarakhand. On the other hand, there are some states and union territories where the percentage of individuals with an account is higher in urban areas than in rural areas, such as Assam, Gujarat, Telangana, and Uttar Pradesh. Overall, this table provides insights into access to financial services across different areas of India, highlighting the differences in account ownership between rural and urban areas and across different regions. Overall, the table highlights the disparities in access to mass media in different parts of India and can be a useful tool for policymakers and development practitioners to identify areas where interventions may be needed to improve access and reduce inequalities.

Coefficient of the Correlation Matrix of Indicators

The coefficient of correlation matrix has been analyzed to find out the relationship among various parameters of socio-economic development indicators in both rural and urban areas. It can be inferred from the coefficient correlation matrix in Figure 2 that access to piped water is positively correlated with access to improved sources of drinking water in both rural and urban areas, and the values lie at 0.88. It is very significant and highly correlated. It is natural that more access to pipe water will provide more sources of drinking water. Similarly, access to latrines is positively correlated with access to improved sources of drinking water; the value is 0.77, which highlights the importance of basic sanitation facilities for maintaining good health. However, access to a latrine is negatively correlated with all other indicators, which suggests that people who lack access to latrines tend to have worse socio-economic indicators overall. This highlights the importance of investing in basic sanitation facilities, particularly in rural areas where access may be limited. Access to clean fuel is positively correlated with access to improved sources of drinking water, which suggests that people who have access to clean fuel may also have access to other basic amenities. However, the correlation between clean fuel usage and other indicators is mixed, with positive correlations in some cases (e.g., access to improved sources of drinking water) and negative correlations in others (e.g., not in education, employment, or training).

The percentage of people who are not in education, employment, or training is negatively correlated with most indicators, particularly in rural areas. This indicates that people who are NEET tend to have worse socio-economic indicators overall and may require additional support to improve their standard of living. Access to facilities like roads and public transport is positively correlated with other socio-economic indicators in both rural and urban areas. Particularly, people who have access to transportation facilities may be more likely to have access to other amenities such as schools and markets (Table-2). The distribution of people with bank accounts is positively correlated with most other indicators in both rural and urban areas. This highlights the importance of financial inclusion in improving people's socio-economic status. Overall, this correlation matrix provides valuable insights into the relationship between various socio-economic indicators in both rural and urban areas. It may be useful for policymakers and development practitioners to identify areas for intervention and target resources towards improving access to basic amenities and promoting financial inclusion and education for all.

Table-2: Ranks of Selected Development Indicators for States/UT of India and Ranking Co-efficient according to Kendell's Method

State/UT	Access to piped water	Access to improved source of drinking water	Access to latrine	Clean fuel as primary source of cooking, heating and lighting	NEET	Percentage of rural households reporting availability of all-weather roads within 2 km from the place of living	Public transport facility within 500 m from place of living	Bank account	Access to mass media	Ranking Coefficient (Composite score)	Level of Development
	R1	R2	R3	R4	R5	R6	R7	R8	R9		
Andhra Pradesh	23	19	28	19	14	23	8	10	18	162	Low deloped
Arunachal Pradesh	13	16	1	33	35	35	12	25	28	198	Low developed
Assam	35	29	14	31	4	29	16	31	31	220	Least developed
Bihar	32	10	34	27	8	20	26	27	34	218	Least developed
Chhattisgarh	27	23	23	32	23	33	35	14	26	236	Least developed
Delhi	5	1	11	2	13	4	32	24	14	116	Medium developed

Contd...

Goa	3	5	12	3	19	12	26	2	3	85	Highly developed
Gujarat	8	18	29	18	8	31	28	33	23	196	Low developed
Haryana	14	3	16	9	15	19	34	30	17	157	Low developed
Himachal Pradesh	4	17	15	28	27	17	7	4	4	123	Medium developed
Jharkhand	34	32	36	30	18	32	33	25	35	275	Least developed
Karnataka	17	20	27	17	28	30	22	5	12	178	Low developed
Kerala	26	36	4	15	17	8	19	15	5	145	Low developed
Madhya Pradesh	24	30	33	25	12	22	24	20	30	220	Least developed
Maharashtra	10	24	25	11	24	18	23	22	19	176	Low developed
Manipur	21	34	4	35	33	15	3	34	10	189	Low developed
Meghalaya	29	31	13	34	30	36	31	35	21	260	Least developed
Mizoram	16	21	1	14	36	10	4	32	12	146	Low developed
Nagaland	25	33	10	36	34	26	11	36	24	235	Least developed
Odisha	31	27	35	24	3	25	21	17	32	215	Least developed
Punjab	9	3	18	7	10	8	18	28	8	109	Medium developed
Rajasthan	19	25	32	25	20	21	29	12	29	212	Least developed
Sikkim	7	12	4	13	21	24	36	19	7	143	Low developed
Tamil Nadu	22	8	30	10	16	11	17	11	6	131	Low developed

Contd...

Telangana	11	12	20	7	11	28	8	20	16	133	Low developed
Tripura	28	28	4	22	25	14	6	9	25	161	Low developed
Uttarakhand	18	22	16	21	7	34	25	23	20	186	Low developed
Uttar Pradesh	33	9	31	29	6	16	20	28	33	205	Least developed
West Bengal	30	14	26	20	5	13	8	18	27	161	Low developed
A & N Islands	6	14	19	5	2	7	2	1	11	67	Highly developed
Chandigarh	1	1	4	1	29	1	1	6	2	46	Highly developed
Dadra & Nagar Haveli and Daman & Diu	20	5	21	6	31	6	12	7	22	130	Low developed
Jammu & Kashmir	15	26	24	23	26	5	12	16	N/A	147	Low developed
Ladakh	12	5	4	16	32	27	4	13	15	128	Medium developed
Lakshadweep	36	35	1	12	1	3	15	8	1	112	Medium developed
Puducherry	2	11	22	4	21	2	30	3	9	104	Medium developed

Sources: NSS Report No. 589 (78th Round 2020-2021): Multiple Indicator Survey in India

Level of Development

It is one of the simplest and quickest methods of computing composite score involving multivariate data with different units of measurement. Kendall (1939) used this technique for finding out agricultural efficiency in England and Wales using productivity data of different crops. The composite score, called ranking coefficient, in this case is found out for each spatial unit by simply adding the corresponding rank values of all the indicators. Table-2 provides information on various development indicators for different States and Union Territories (UTs) in India. These indicators include Access to Piped Water, Access to Improved

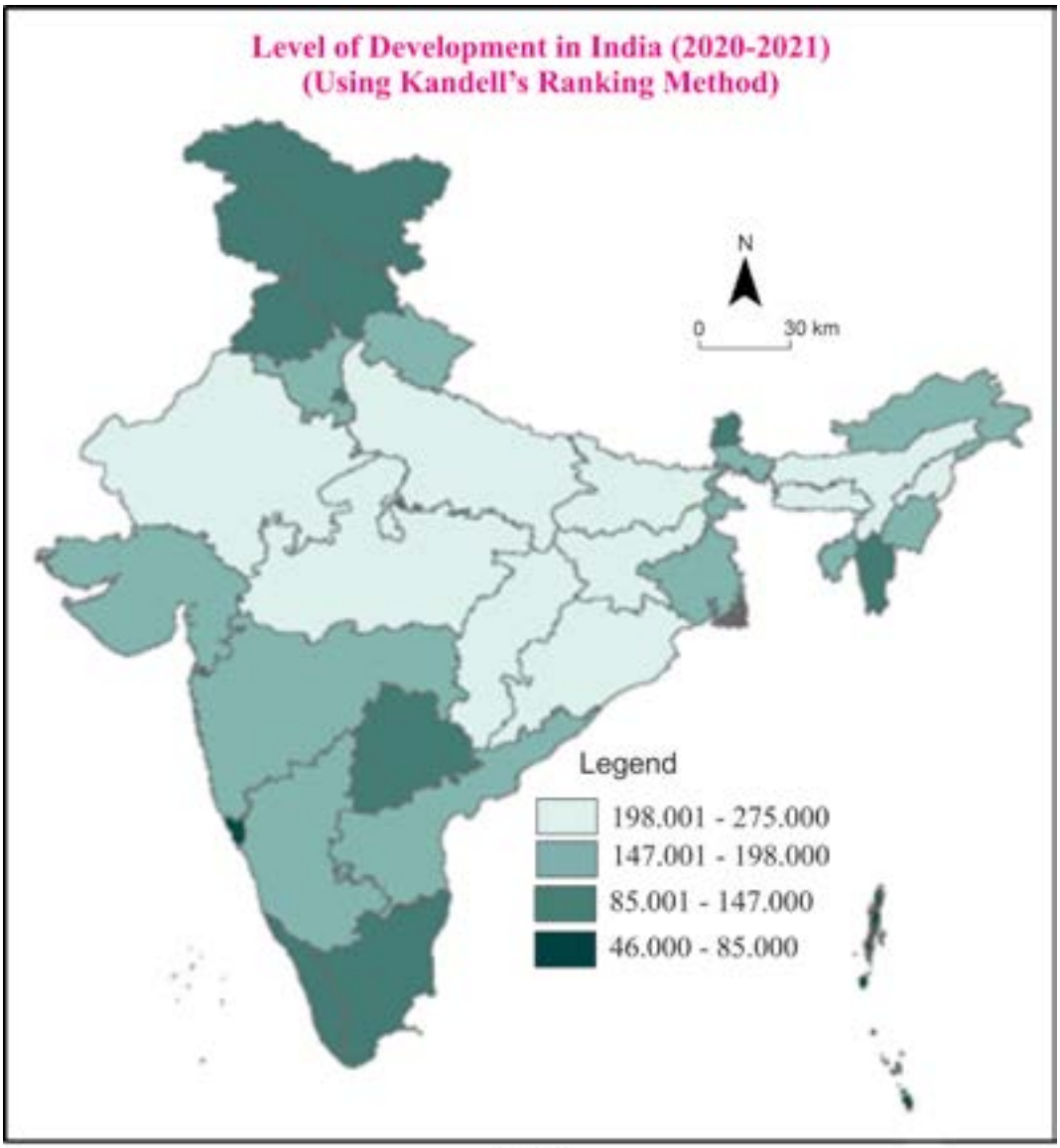

Level of Development in India (2020-2021)
(Using Kandell's Ranking Method)
N
0
30 km
Legend
198.001 - 275.000
147.001 - 198.000
85.001 - 147.000
46.000 - 85.000

Fig. 2

Source of Drinking Water, Access to Latrine, Clean Fuel as Primary Source of Cooking, Heating and Lighting, NEET, Percentage of Rural Households Reporting Availability of All-Weather Roads within 2 km from the place of living, Public Transport Facility within 500 m from Place of Living, Bank Account Access, and Access to Mass Media. In Andhra Pradesh, the state ranks 23rd in terms of access to piped water, while it ranks 19th in terms of access to improved source of drinking water. In addition, it ranks 8th in terms of having access to a public transport facility within 500 m from the place of living and 18th in terms of having access to a bank account.

The best ranking for any development indicator is found in Chandigarh, which ranks 1st in access to piped water, improved source of drinking water, latrine, and bank account access. The worst ranking for any development indicator is found in Arunachal Pradesh, which ranks 36th in access to clean fuel as a primary source of cooking, heating, and lighting and in Nagaland, which ranks 36th in access to latrine. Now, the Composite Score Value is calculated for each State/UT by adding up their rank values for each of the indicators. The State/UT with the highest composite score value is considered to be the least developed, while the State/UT with the lowest composite score value is considered to be the most developed. For example, the State/UT with the highest composite score value is Meghalaya with a score of 260, indicating that it is the least developed in terms of the indicators we have considered. On the other hand, Chandigarh has the lowest composite score value of 46, indicating that it is the most developed. Other states/UTs can also be ranked based on their composite score value; for instance, Jharkhand has a score of 275, which is the second highest, followed by Nagaland with a score of 235, and Chhattisgarh with a score of 236. Table-2 also showing the level of development of various States/UTs in India based on their composite score.

The States/UTs are categorized into four categories i.e highly, medium, least and low level of development (Fig. 2). The States/UTs with the highest composite score are Jharkhand, Meghalaya, Nagaland, Chhattisgarh, Bihar, and Odisha and are categorized as Least Developed. On the other hand, the States/UTs with the lowest composite score are Chandigarh, Puducherry, A&N Islands, Delhi, Ladakh, Goa, Lakshadweep, and Punjab and are categorized as Highly Developed. The other States/UTs with composite scores between the highest and lowest are categorized as Low and Medium Developed. The table gives an overview of the current state of development in different areas of the country and provides useful information for policymakers to identify areas for further development.

Conclusion

Based on the data presented in the tables, maps, and figures, it is evident that there are significant regional disparities in India, particularly in terms of access to basic necessities such as water, sanitation, education, and financial services. Rural areas tend to lag behind urban areas in terms of access to these necessities, with lower percentages of rural households having access to piped water, all-weather roads, public transport, bank accounts, and mass media. Similarly, rural areas have higher percentages of people not in education, employment, or training (NEET) compared to urban areas. These disparities are particularly pronounced in states such as Assam, Bihar, Jharkhand, Odisha, and Uttar Pradesh, which report lower levels of access to basic necessities across various indicators. It is therefore imperative for policymakers to prioritize and invest in improving access to basic necessities in rural areas, especially in states with high levels of regional disparities. This may involve providing infrastructure such as all-weather roads and public transport, promoting education and employment opportunities, improving access to financial services, and ensuring access to clean water and sanitation. Addressing these regional disparities can contribute to inclusive and sustainable development in India. In addition to regional disparities, the data in the tables also highlights other important issues. For example, the low percentage of households using clean fuel as a primary source of energy for cooking, lighting, and heating is a cause for concern, as this can have negative impacts on air quality and health. Similarly, the percentage of households reporting access to latrines by the majority of household members is relatively low in some states, highlighting the need for greater investment in sanitation facilities. Overall, the tables provide a useful overview of the various challenges and opportunities facing India. Addressing regional disparities and promoting greater access to basic necessities and financial services can contribute to inclusive and sustainable growth, improve the quality of life, and promote greater social and economic inclusion for all citizens.

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A GEOGRAPHICAL ANALYSIS OF TRIBAL EDUCATION IN JHARKHAND

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Abstract

Although the rate of literacy among the tribal population is only 59.1% in India, it is lower than the national average of 74.4% (Census 2011). Education is one of the main forces behind a society's transformation. The literacy rate of Jharkhand's tribal population (57.1%) is still lower than the country as a whole, which is 59 percent (Census 2011) of India's tribal population. Upon reviewing a variety of literature, it has been found that factors such as cultural customs, poverty, the absence of educational institutions in rural areas, the medium of instructions, parental education, and school location all significantly contribute to the low enrolments of tribal students. According to the 2011 Census, in Jharkhand, 20.4% of the tribal population 46.4% of male and 53.6% of Female (6-15 age group) had never attended an educational institution. The objective of the study is to address the factors preventing tribal children from access to education and also to know the percentage who never attended educational institutions in Jharkhand. Coefficient correlation method is used to analysis the factors which is affecting the educational attainment of a tribal children. The present paper is mostly based on secondary data from various research studies including census data, Annual reports of tribal welfare ministry, Districts report card 2011, Jharkhand economic survey 2021, UDISE-2011.

Introduction

Education for the tribal population in India has been challenged due to historical marginalization and geographical isolation. (Brahmanandam T & Bosu T.2016:70). Education plays a significant role in overall development of an individual in a holistic way. Tribal people often called as Adivasi, Aboriginal, Indigenous people, first nation, Hunter-gatherers are the original inhabitants of a particular region or a country. (Michael A. Peters & Carl T. Mika 2017:1). The term ‘Adivasi', is used in the Indian context which is refer to as the tribal community (Xaxa, V. 1999:1).

There is significant percentage of tribal population in India, which contribute about 8.6 per cent population. Tribal population's literacy rate (58.96%) which is 14% lower than the national average (72.99%). The female literacy rate of India is 64.6% while the ST female literacy rate is only 46.4% (Census 2011). But however tribal population's literacy rate increased significantly from 8.53 percent in 1961 to 58.96 percent in 2011. In India, the total dropout ratio (DoR) of the tribal population of India (class I-VIII) stood at 69 % in 2001, but it subsequently decreased to 55% in 2011. (Educational Statistics at A Glance, 2012). The most common causes of school dropouts among tribal children in primary school are identified as household work, lack of parental guidance in studies, family socioeconomic status, school discipline (Soren, D. 2010:1). In term of education, health and economy concern tribal communities are still deprived as compared to general population. (Z. A. Bhat and M. A. Khan 2021 :659). More than 20–30% of India's tribal population, aged 6 to 15, has never attended school in the states of Madhya Pradesh, Himachal Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Uttar Pradesh. (census of India 2011). In the year, 2007-08, Five states namely Rajasthan, Jharkhand, Odisha, Chhattisgarh, and Madhya Pradesh together accounted 48 percent of STs in India but together accounted for 55 per cent of illiterate among STs (India human development report 2011:184). In Jharkhand, 20.4 per cent of the tribal population (age group 6-15) has never attended school in which 46.4 per cent are male and 53.6 per cent are female. Factors such as household income, caste, location, gender, and the level of education of the head of the household can significantly influence a parent's decision to send their child to preschool (Choudhury, P.K., Joshi, R. & Kumar,2021: 21). Tribal representation is very low in the nation's human development index and high in the human poverty index when compared to other social groups. (Patil, R. R. 2020:1).

To ensure the overall development and integration of tribal population into the mainstream of the society, it is necessary to educate them which directly contribute economic upliftment, empowerment, cultural preservation, social inclusion, health and hygiene, awareness of right, and gender empowerment. Literacy is one of the basic parameters for the overall development which encompass societal progress, economic growth and the overall wellbeing of communities. But in Jharkhand, Education sectors depicts a very poor situation particularly in term of enrolment and dropout of tribal students. The GER for school education in Jharkhand for ST was 106 percent in primary level which decreases to 87 percent in upper primary and 38 percent higher level of education. (Jharkhand economic survey 2021). We can see the trend of declining of enrolment ratio of ST students as when they grow in the higher level of education.

Study Region

Jharkhand is a state is eastern India lies on the Chhota Nagpur plateau, part of a vast deccan plateau that occupies most of the peninsular India. Major rivers like Koel, Damodar, Brahmani, Kharkai, Subarnarekha etc. flow over it. The average elevation of the area is approximately 1000ft. The state has total five divisions, (North Chhota Nagpur, South Chhota Nagpur, Santhal Pargana, Kolhan and Palamu) and 24 districts with total population of 32,988,134 total tribal population of 86,45,402 (26.2%). (census 2011). The total ST population is highest in the district like Ranchi 10,42,016 (12.05%) followed by Paschimi Singhbhum 10,11,296 (11.70%) Gumla 7,06,754 (8.18%) and then Purbi Singhbhum 6,53,923 (7.56%).The tribal communities like Santhal, Oraon, Munda, Kharia and Ho constitute the majority of the total tribal population and they speak Austroasiatic and Dravidian language. District wise distribution of tribal population shows that Khunti district has the highest percentage tribal population (73.3%), followed by Simdega (70.8%), Gumla (68.9%), Paschimi Singhbhum (67.9%).

Objectives

(1) To determine the percentage of tribal children (age group 6-15) who have never attended educational institution in the states of India and the districts of Jharkhand.
(2) To identify the factors preventing tribal children from having access to an education.

Database and Methodology

The paper used Census of India 2011 C-series data for the analysis of educational status of ST population in India with special focus on Jharkhand state. Beside these several reports and Jharkhand state database like Unified Districts Information for Education System 2011, Educational statistics at glance, 2012, National Sample Survey Organization 2010. Jharkhand economic survey 2021-22, District report card 2011, Tribal committee report 2014, Statistical profile of scheduled tribes 2013, Ministry of tribal affairs Annual report 2021-22, District elementary education report card 2011-12 (UDIES 2011) data have been used for analysis purpose. Pearson's correlation coefficient is most efficient common method to use for statistical technique for examining the linear relationship between the variables.

Result and Discussion

The Tribal population for the age group (6-15) who has never attended an educational institution is given in the table 1. More than 20% of the tribal population in states like Rajasthan, Madhya Pradesh, Odisha, and Jharkhand, Bihar, Uttar Pradesh has never attended an educational institution. An analysis of data by gender reveals that the proportion of female than male has never attended school. The primary reason for never attending an educational institution is indicated by the cost of school fees, and a lack of interest in learning, school far away, education not necessary are some reasons behind not enrolling themselves in the school. (National family health survey, 1998-99). The factors such as household income, caste, location, gender, and the level of education of the head of the household can significantly influence a parent's decision to send their child to preschool (Choudhury, P.K., Joshi, R. & Kumar, 2021:21). There is a severe teacher shortage in areas where tribal people predominate, affecting both tribal and non-tribal schools (Choudhary. K 2018:6). Less than 10% of the population in states and union territories like Himachal Pradesh, Uttarakhand, Sikkim, Mizoram, Kerala, Lakshadweep, Goa, Daman and Diu has never attended school. These states and territories show a positive picture of school enrolment.

Thus, the enrolment of tribal population in these states is good as compared to other states. Numerous initiatives, such as the introduction of midday meals, the opening of alternative schools, encouraging the involvement of Parent Teacher Associations (PTAs), and large-scale enrolment drives, have all contributed to the rising enrolment rate (Singh, P. 2017:817). An important feature of schooling in India is that despite of high enrolment rate, attendance is much lower than enrolment, and the difference between the two increased at higher level of education. (India human development report 2011: 180). The tribes' emphasis on educating boys, interpersonal issues like child marriage, a lack of family support, pressure from peers, and a personal lack of value for education have all contributed significantly to the high school dropout rate among tribal girls (Sucharita, V. 2023). The students of India do not attend elementary school for a variety of reasons, including poverty, lack of funds, discriminatory mindset, lack of planning, and ignorance on the part of their parents (Table-1). The educational background and family background of parents significantly impact their children's performance (Li, Z., Qiu, Z. 2018:3). It is important to note that both Punjab and Haryana have a predominantly non-tribal population compared to some other states in India so there is no data been found regarding these states. The north eastern states like Nagaland, Manipur, Mizoram,

Tripura and Meghalaya showing good enrolment of children (age 6-15) whose population of school attending is above 80 percent. In comparison to other regions of India, the tribal population in the northeastern state is more literate, and these regions are also more urbanized. Among the states with the highest ST literacy rates Mizoram, Meghalaya, Nagaland, Sikkim, and Manipur rank first, second, fourth, sixth, and eighth, respectively. (NSSO, 2010). Ministry of tribal affairs, Government of India has introduced special educational schemes and residential facilities such as Ashram school, Eklavya mode, Kasturba Gandhi Balika Vidyalaya, Jawahar Navodaya Vidyalaya and various vocational training centers were open in the tribal areas.

Table-1: Scheduled Tribes and Educational Institutions in 2011

States	Age Group (6-15)					
	Population attending Educational institutions (%)			Population never attended Educational institutions (%)		
	Person	Male	Female	Person	Male	Female
India	75.8	77.2	74.28	18	16.5	19.6
Jammu & Kashmir	69.7	74.3	64.77	27.8	23.4	32.5
Himachal Pradesh	88.9	89.9	87.87	8	7.5	8.6
Uttarakhand	89.4	89.8	88.91	7.2	7.1	7.3
Rajasthan	69.1	74.4	63.24	24.6	19.7	30.0
Uttar Pradesh	69.6	71.1	67.98	24.9	23.0	27.0
Bihar	68.7	70.6	66.67	27.3	25.1	29.7
Sikkim	90.9	90.6	91.21	5.5	5.4	5.6
Arunachal Pradesh	79.8	80.8	78.81	18.5	17.4	19.5
Nagaland	82	82.0	81.92	13.9	13.8	13.9
Manipur	83.6	84.0	83.04	13.4	13.0	13.9
Mizoram	87.8	88.8	86.87	9.4	8.6	10.2
Tripura	84.8	85.9	83.69	10.8	9.8	11.7
Meghalaya	77.7	75.9	79.48	18.1	19.4	16.8
Assam	81.8	82.2	81.33	13.8	13.3	14.4
West Bengal	75.1	75.8	74.39	17.4	16.2	18.6
Jharkhand	74.8	76.2	73.27	20.4	18.7	22.3

Contd...

Odisha	70.3	71.9	68.81	20.7	18.7	22.7
Chhattisgarh	79.4	80.4	78.46	15.7	14.5	16.9
Madhya Pradesh	73.9	74.0	73.71	20.5	20.0	20.9
Gujarat	75.8	77.1	74.53	15.1	14.1	16.2
Daman & Diu	88.1	88.2	88.00	7.2	7.4	7.0
Dadra & Nagar Haveli	86.1	88.9	83.24	8.2	6.5	10.1
Maharashtra	79.6	81.0	78.02	13.4	12.2	14.6
Andhra Pradesh	78.4	80.4	76.36	14.8	12.9	16.7
Karnataka	80.1	81.6	78.59	12.3	11.2	13.5
Goa	90.2	90.4	90.02	6.4	6.3	6.5
Lakshadweep	94.4	94.4	94.31	4.1	4.2	3.9
Kerala	88.5	87.8	89.20	6.2	6.4	6.0
Tamil Nadu	81.5	82.1	80.83	10.5	9.7	11.3
Andaman & Nicobar Islands	82.2	80.6	79.38	13.4	11.5	13.0

Source: Census of India, 2011

These initiatives make easier for the tribal children to access to schools. One fifth of the children in the age group of 6-15 years were out of the school and financial constraint was an important reason for discontinuation of education. (India human development report, 2011:180). In order to provide the children with a high-quality pre-school education, the Anganwadi are inadequately trained in early childhood development techniques. As a result, most children are insufficiently ready to start school and pursue their education. As a result, learning standards are still low and dropout rates in the early grades of primary school remain extremely high. (India human development report 2011: Planning commission 2014:194). (Table-2)

Table-2 displays the proportion of the population in the district of Jharkhand that attends or has never attended an educational institution. The proportion of scheduled tribes who has never attended educational institution is higher than that of non-tribal population in Jharkhand. The districts like Koderma (41.9 %), Godda (30.5%), Sahibganj (30.1%), Pakur (31.5%) and Paschimi Singhbhum (28.8%) have higher percent of tribal population who has never enrolled in any educational institutions (6-15 age group). (Fig. 1) Less than 20% of the tribal population in districts like Ranchi, Ramgarh, Simdega, Lohardaga, Khunti,

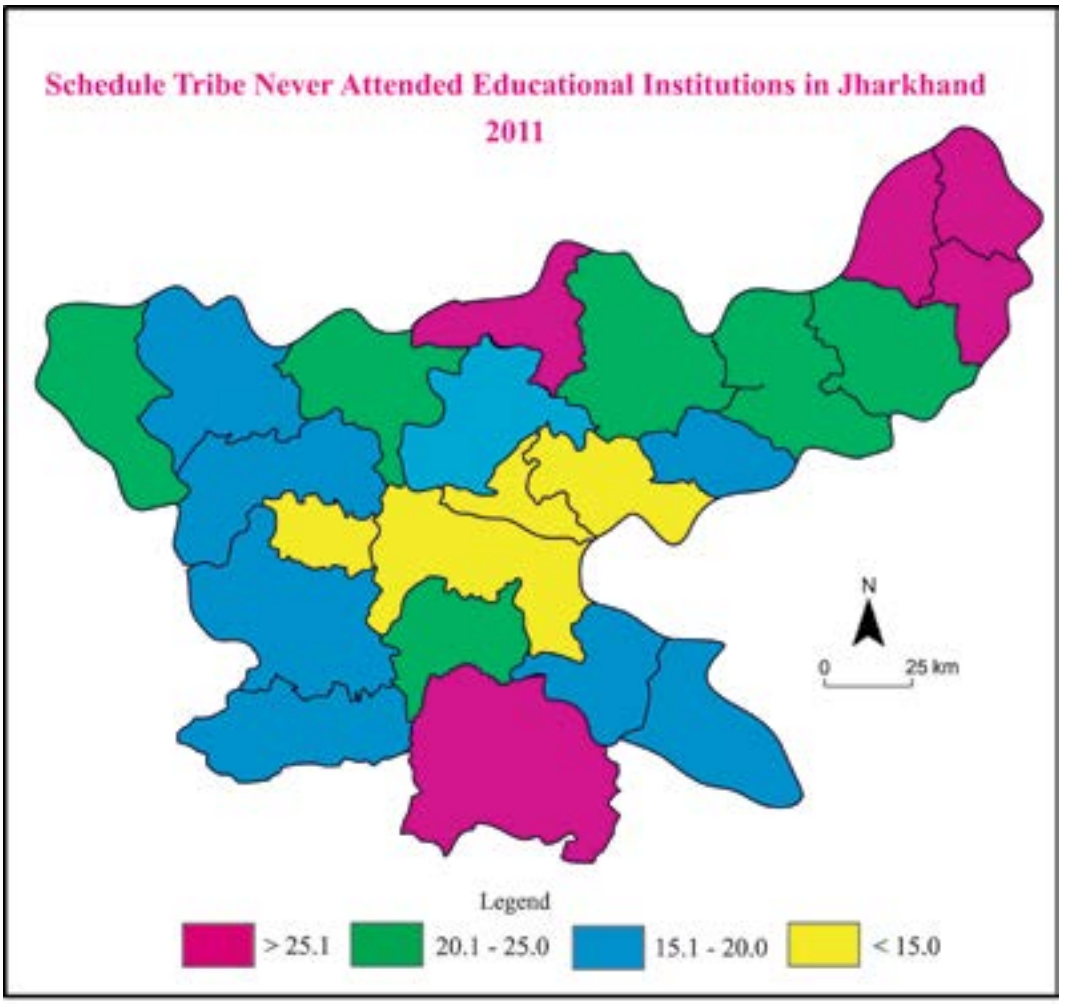

Schedule Tribe Never Attended Educational Institutions in Jharkhand
2011
N
0
25 km
Legend
> 25.1
20.1 - 25.0
15.1 - 20.0
< 15.0

Fig. 1

Table-2: Scheduled Tribes and Educational Institutions in Jharkhand

(Age 6-15 years)						
State/ Districts	Population Attending Educational Institutions (%)			Population Never Attended Educational Institutions (%)		
	Person	Male	Female	Person	Male	Female
Jharkhand	74.76	76.21	73.27	20.43	18.66	22.28
Garhwa	70.89	72.46	69.27	24.05	21.96	26.20
Chatra	71.92	74.09	69.61	22.16	19.95	24.51
Kodarma	53.15	59.23	45.51	41.91	34.76	50.90
Giridih	71.39	75.20	67.46	24.17	20.14	28.32
Deoghar	71.63	75.17	67.94	23.53	19.62	27.60
Godda	64.76	67.39	61.93	30.46	27.37	33.79
Sahibganj	66.34	68.78	63.74	30.14	27.48	32.98
Pakur	64.20	65.80	62.50	31.48	29.50	33.58
Dhanbad	77.98	80.35	75.54	17.45	14.87	20.10
Bokaro	81.50	83.40	79.59	15.00	12.77	17.25
Lohardaga	83.22	83.86	82.56	13.52	12.51	14.56
Purbi Singhbhum	79.02	80.18	77.78	15.70	14.31	17.19
Palamu	78.21	80.06	76.29	19.02	16.97	21.14
Latehar	76.21	77.65	74.75	19.73	17.94	21.56
Hazaribagh	78.38	80.15	76.62	17.26	15.50	19.01
Ramgarh	83.32	83.23	83.41	12.93	12.40	13.46
Dumka	73.68	74.62	72.71	21.08	19.79	22.42
Jamtara	69.81	71.70	67.80	23.10	20.92	25.41
Ranchi	83.73	84.07	83.39	12.14	11.48	12.80
Khunti	74.34	75.98	72.64	20.06	18.18	22.01
Gumla	79.61	80.29	78.91	16.59	15.57	17.63
Simdega	73.91	73.82	74.01	19.75	19.58	19.92
Paschimi Singhbhum	64.49	66.85	62.04	28.81	25.97	31.76
Saraikela-Kharsawan	78.26	80.20	76.22	17.22	15.04	19.51

Source: Census of India, 2011

and Purbi Singhbhum has never attended school and rest of the districts lies in between 20- 30 percent of tribal population who never enrolled in school. We can see the regional wise differences in the districts of Jharkhand who has been attended the school. The students' learning process was complicated by the teacher's unfamiliarity with the tribal dialect. A few of the difficulties faced by first-generation learners include fear of teachers, difficulty understanding subjects like Mathematics, Hindi, and English, and a nonfunctional parent teacher association that hampered learning and increased dropout rates (Ottaplackal, J. J., & Anbu, K. 2022:26). Appropriate early childhood education in tribal communities will undoubtedly contribute to fostering a love of learning at an early age and lowering the school dropout rate (Asha, C. M. 2020:1396). Most of the tribes live in steep terrain, forested areas, and remote areas. The tribal children live in remote areas, which makes it difficult for them to receive an education (Majumder, A. 2018:102). Additionally, among the social groups, the majority of SC/ST children attend government schools, which lowers the number of children who do not attend school. Girls outnumbered boys in the group of kids who were not attending school because "education was not considered necessary (Sankar, D. 2008:5). Positive attitude towards education and tribes living standard are strongly corelated, that is families with stronger economic background tend to have a higher proportion of literate member to families with weaker backgrounds. (Gupta, S., & Nanda, P. 2008:65). Tribal girls are prevented from attending and remaining in school by widespread gender-specific discrimination and stereotyping in Indian society (Sucharita, V. 2023:11). The majority of schools in tribal areas lack even the most basic facilities. Tribal areas typically have poorly maintained school buildings. Many tribal schools lack even blackboards and proper teaching and learning procedures (Jai Prabhakar, S. C. 2018:73).

After analyzing Pearson coefficient correlation by using data from the Census of India 2011, and UDIES 2011, Here several variables have taken like literacy of a family, socio-economic condition of a family, poverty, level of urbanization are the factors which effect the educational attainment of a children. we conclude that a family's socioeconomic status and level of education of parents effect the educational attainment of children. The correlation coefficient (r) value of tribal population never attended (6-15 age) and household using river as a source of drinking water is .499 which shows moderate positive association between both the variables. The P value is <0.05 (0.013) which means the relationship is statistically significant. So, we can say that increases in the dependence on river water also increases the population of never attended educational institutions.

Similarly, household using firewood and cow dung as a source of cooking showing (r) value of .415 showing moderate positive and P value is <0.05 (.044) which shows a significant relation. When we taking Electricity as a source of lighting in a household, it showing a negative relation with population never attended educational institution. The P value of <0.05 (.011) showing a significant relation. Lighting with electricity reduces the number of never-attended educational institutions. The social and economic aspects of any community have a big impact on education. (Lagravinese, Liberati, & Resce, 2019:18). Appendix 3 shows the strong negative relation of literacy with population never attended educational institutions. The (r) value of literacy is (-.850) with p value of <0.01 (0.000) showing a significant relation. It is evident that high literacy rates are correlated with high school enrolment rates and the population having low level of education are associated with a high proportion of the population that has never attended an educational institution. When compared to ST female literacy, there is also a clear negative correlation with the population that has never attended school with (r) value of -.584 and P value <0.01 (0.003) significant at 0.01 level. Poverty is again a significant factor in affecting education of a child. The correlation matrix shows a moderate positive correlation of poverty with (r) value of .405 with person never attended educational institutions. It is significant at 0.05 level with P value of 0.050. The percentage of population who have never attended an educational institution rises along with the level of poverty. Higher the level of poverty also increases the number of children who has never attended the educational institutions. Taking urbanization into consideration, which is strongly negative corelated with population never attended educational institutions with (r) value of -4.30 which is significant at 0.05 level with p value of 0.036. It demonstrates that the proportion of tribal people who have never attended an educational institution is lower in urbanized areas. The One of the most economically disadvantaged and marginalized groups in India is represented by the ST (Sahu 2014:1). The It is likely that the socioeconomic status of the family influences the decisions made by parents regarding whether or not to send their children to preschool (Ghosh, S. 2019:148).

Conclusion

This paper shows a descriptive analysis of the Indian states and the districts of Jharkhand that have never attended educational institutions of age group (6-15). Although the literacy rate among tribal population is increasing, it is doing so at a slower pace than it is among non-tribal people. According to census 2011, 18% of

the tribal population in India, comprising 46.4 % of male and 53.2 % of female, are not enrolled in school. In Jharkhand, 20.4 percent of tribal population (6-15 age group) 46.4% of male and 53.6 % of female have never attended school. The data indicates a percentage of females are high as compared to male counterpart who have never been sent to school. More than 20% of the tribal population (6-15 age group) in the states like Rajasthan, Rajasthan, Madhya Pradesh, Bihar, Uttar Pradesh, and Jharkhand, have not enrolled in the schools. However, in the southern Indian states, like Kerala, Karnataka, Andhra pradesh, Tamil Nadu the percentage of never enrolled tribal students is low as compared to north Indian states. The ignorance and neglect of parents regarding their children's education is a serious problem as well. Poverty is a major barrier to educational access because it keeps underprivileged households from funding their children's education with money for supplies like books, school supplies, uniforms, meals, and transportation. Another challenge in providing elementary education to tribes is their geographic location. Undoubtedly, a number of factors can have a significant impact on the educational attainment of children of Scheduled Tribes (ST) in Jharkhand and many other regions. These factors include poverty, socioeconomic status, literacy, and school facilities. Consequently, Tribal education is very important because it is essential to the growth and well-being of indigenous communities worldwide and also tribal education must be taken into consideration as a way to support the population's growth and integration into society at large.

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POPULATION DENSITY AND URBANIZATION EFFECTS ON AGRICULTURAL LANDUSE IN LUCKNOW DISTRICT

Vivek Kumar and Dr. S.P. Asthana

Abstract

This research paper is a comprehensive exploration of the intricate interplay between population density, urbanization trends, and their profound repercussions on agricultural land use patterns within Lucknow District, Uttar Pradesh. Against the backdrop of Lucknow's rich historical, cultural, and economic heritage, the study investigates the transformative impacts of rapid urbanization on the allocation and utilization of agricultural land. The findings, spanning the decade from 2001 to 2011, reveal notable changes in various land use categories, including a substantial decrease in forest land, cultivable wasteland, and current fallows. The increase in areas other than agricultural land use underscores diverse transformations beyond traditional agricultural activities. The research emphasizes the need for sustainable land management practices, considering the challenges posed by urban expansion to traditional farming practices. The conclusions drawn from this study provide valuable insights for policymakers, land managers, and urban planners, offering a nuanced understanding of the challenges and opportunities at the intersection of urban development and agriculture. The research aspires to contribute to the academic discourse on evolving land use dynamics, offering practical implications for sustainable land management and informed decision-making processes, specifically tailored to the unique context of Lucknow District.

Introduction

The research endeavours to conduct a comprehensive examination of the intricate interrelationships among population density, urbanization trends, and their profound impacts on agricultural land use patterns within Lucknow District, Uttar Pradesh. As urbanization undergoes unprecedented growth, it exerts significant pressure on the allocation and utilization of agricultural land, posing challenges to traditional farming practices. Lucknow District, with its rich historical, cultural, and economic heritage, provides a compelling backdrop for this study.

The rapid urbanization witnessed in recent years has transformed the landscape, necessitating a closer examination of how these changes influence the agricultural sector. The research aims to unravel the nuanced dynamics of this interaction, exploring how increasing population density and urban expansion reshape the agricultural land use mosaic. Through a meticulous geographical analysis, the study seeks to identify the specific effects of urbanization on the distribution, quality, and productivity of agricultural lands in the district. This investigation becomes particularly crucial given Lucknow's significance as a major urban center within the state of Uttar Pradesh. The findings of this research are anticipated to provide valuable insights for policymakers, land managers, and urban planners, fostering a deeper understanding of the challenges and opportunities that arise at the intersection of urban development and agricultural sustainability. In essence, the study aspires to contribute to the academic discourse on the evolving dynamics of land use in the face of urbanization, offering practical implications for sustainable land management and informed decision-making processes tailored to the unique context of Lucknow District.

Study Region

Lucknow district is a district located in the state of Uttar Pradesh in northern India. The city of Lucknow is the district headquarters and the district is part of Lucknow Division. It also is the capital of Uttar Pradesh. Lucknow is Bounded on the east by Barabanki district, on the west by Unnao and Hardoi districts, on the south by Raebareli district and in the north by Sitapur district. It is geographically located between latitude 26° 30' North and longitude 80° 30' East. Lucknow district covers an area of 2,528 square kilometers, centrally located in both the central Ganges plain as well as Uttar Pradesh as a whole. The climate of Lucknow district is predominantly subtropical in nature, and it experiences the effects of the South Asian monsoon. Lucknow district is divided into 4 tehsils: Lucknow, Malihabad, Mohanlalganj, and Bakshi Ka Talab. These tehsils are then divided into 8 community development blocks. According to the 2011 census Lucknow district has a population of 4,589,838. This gives it a ranking of 31st in India (out of a total of 640). The district has a population density of 1,815 inhabitants per square kilometre (4,700/sq. mi). Its population growth rate over the decade 2001-2011 was 25.79%. Lucknow has a sex ratio of 906 females for every 1000 males, and a literacy rate of 79.33%. 66.21% of the population lived in urban areas. According to the 2001 census Lucknow district had a population of 3,681,461.

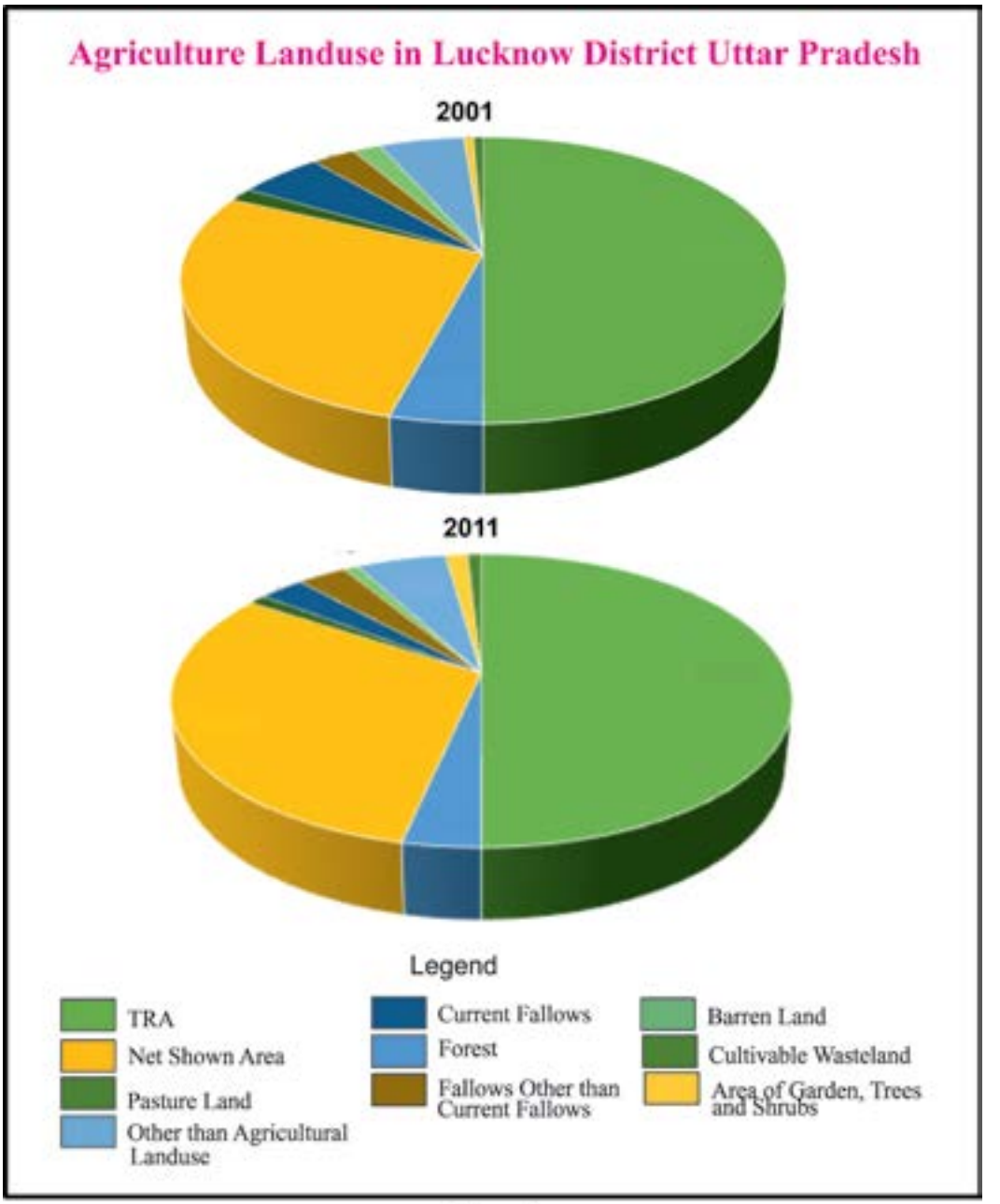

Agriculture Landuse in Lucknow District Uttar Pradesh
2001
2011
Legend
TRA
Net Shown Area
Pasture Land
Other than Agricultural Landuse
Current Fallows
Forest
Fallows Other than Current Fallows
Barren Land
Cultivable Wasteland
Area of Garden, Trees and Shrubs

Fig. 1

Objectives

(1) Examine the specific effects of urbanization on agricultural land use, including changes in landscape, land conversion, and potential loss of arable land.
(2) Analyze the dynamics of land conversion and its consequences for the overall agricultural landscape.
(3) Identify challenges and opportunities arising from the interplay between population density, urbanization, and agricultural land use.
(4) Highlight the need for sustainable land use practices in the face of a growing population in Lucknow District.

Database and Methodology

This research paper is based solely on secondary data. The approach involves a systematic and structured process for collecting, analyzing, and interpreting existing information. Secondary data from reliable sources such as government reports, statistical databases, academic journals, and research publications has been used for collection of data. Demographic data, urbanization statistics, and agricultural land use information has been collected. A comparative analysis of urban and rural areas within Lucknow District to discern differences in agricultural land use patterns has been done. By relying on secondary data, this research methodology aims to provide a comprehensive understanding of the complex relationships between population density, urbanization, and agricultural land use in Lucknow District.

Result and Discussion

Urbanization and Population Density in Lucknow District

In 2001 Lucknow District had a total population of 3,681,461, the population density was 1453 persons / sq. km. The urbanized population was 63.3%. In 2011, the total population of Lucknow District increased to 4,589,838 and the population density increased to 1815 persons / sq. km. The urbanization was 66.21%. The decadal population growth rate between 2001 to 2011 was 25.79%. (Fig. 1) The uptick in urbanization from 63.3% to 66.21% underscores the transformative impact of urban expansion on the district's landscape. This demographic shift is crucial in the context of the research paper, as heightened urbanization tends to exert substantial pressure on agricultural land. As the population grows and urban areas expand, agricultural land faces challenges such as conversion, potential loss of arable land, and changes in land use patterns (Table-1, 2 and 3).

Table-1: Blockwise Agricultural Landuse in 2001

Blocks	TRA	Forest	Net sown area	Cultivable Waste Land	Current Fallows	Fallows other than current fallows	Barren Land	Other than agricultural landuse	Pasture Land	Areas of Garden, Trees & Shrubs
Maliha bad	23056	1410	15917	729	1049	1439	452	1739	271	50
Mall	24503	685	13659	586	1927	2333	342	4241	304	426
Bakshi Ka Talab	38209	2808	23133	934	3982	2241	610	3794	432	275
Kakori	22159	812	14269	826	495	1702	1431	2224	235	165
Chinhat	19831	882	8605	919	4913	1684	270	2359	87	112
Sarojini Nagar	36871	2082	22614	682	3842	925	2576	3625	146	379
Gosain Ganj	34876	1271	20072	990	6345	996	1662	2291	489	760
Mohan Lal Ganj	38209	5946	20068	1034	2941	1789	1425	2973	1137	896
Total	251853	20967	139772	7734	26737	14164	8963	27278	3104	3134

Source: Up Statistical Bulletin, Lucknow (2001) Note: Area is in hectares

Table-2: Blockwise Agricultural Landuse in 2011

Blocks	TRA	Forest	Net sown area	Cultivable Waste Land	Current Fallows	Fallows other than current fallows	Barren Land	Other than agricultural landuse	Pasture Land	Areas of Garden, Trees & Shrubs
Maliha bad	22231	889	15575	474	965	1674	364	1934	257	99
Mall	23736	60	18002	568	759	1018	590	2360	326	53
Bakshi Ka Talab	34882	1307	22018	626	2618	2542	600	4302	467	402
Kakori	20652	240	13806	450	1691	1482	657	1955	224	147
Chinhat	12700	3	5328	665	1646	1260	492	3143	72	91

Contd...

Sarojini Nagar	30432	1172	17781	791	3640	2164	1353	3214	206	111
Gosain Ganj	27043	386	16610	741	2295	2262	814	3143	435	357
Mohan Lal Ganj	37766	2584	23359	776	2124	2336	679	4219	1048	641
Total	251596	12000	135737	5501	16224	15358	6775	55014	3051	1936

Source: Up Statistical Bulletin, Lucknow (2011)

Table-3: Changes in Landuse for 10 Years

Landuse Category	2001	2011	Change (in %)
TRA	251853	251596	-0.10
Forest	20967	12000	-42.76
Net Sown Area	139772	135737	-2.88
Cultivable Wasteland	7734	5501	-28.87
Current Fallows	26737	16224	-39.32
Fallows Other than Current Fallows	14164	15358	8.4
Barren Land	8963	6775	-24.41
Other than Agricultural Landuse	27278	55014	101.67
Pasture Land	3104	3051	-1.70
Area of Garden, Trees and Shrubs	3132	1936	-38.22

Source: Calculated by Authors Note: Area is in hectares

TRA

The total agricultural land in Lucknow District showed a marginal decrease from 251,853 hectares in 2001 to 251,596 hectares in 2011, reflecting a slight decline of 0.10% over the decade.

Forest

Forests in cities play a crucial role in enhancing air quality by absorbing pollutants, providing essential green spaces for recreation and mental well-being, and contributing to overall biodiversity (Fig. 1). They act as urban lungs, mitigating the impact of pollution and fostering a healthier, more sustainable urban environment. Additionally, urban forests contribute to temperature regulation and act as a natural habitat for diverse flora and fauna, promoting ecological balance within cityscapes. Forest land witnessed a substantial reduction from 20,967 hectares in 2001 to

12,000 hectares in 2011, indicating a significant decrease of 42.76%. This decline suggests potential urbanization effects, changes in land management, or alterations in forest policies.

Net Sown Area

Net sown area refers to the total cultivated land excluding fallow land. It represents the portion of agricultural land actively used for sowing crops during a specific agricultural season. Calculated by deducting the fallow land from the total cultivated area, net sown area provides insights into the actual land under cultivation, essential for assessing agricultural productivity and planning resource allocation. Net sown area in the study area slightly decreased from 139,772 hectares in 2001 to 135,737 hectares in 2011, reflecting a decline of 2.88%. Possible influences include changes in agricultural practices, land use priorities, or urbanization effects.

Cultivable Wasteland

Cultivable wasteland refers to land with potential for cultivation that is currently unused or underutilized. It encompasses areas suitable for agriculture but left fallow or abandoned. Rehabilitating cultivable wasteland can significantly contribute to expanding agricultural productivity and addressing food security concerns by bringing additional arable land into cultivation. Cultivable wasteland in Lucknow experienced a notable decrease from 7,734 hectares in 2001 to 5,501 hectares in 2011, indicating a substantial decline of 28.87%. Possible causes include changes in agricultural methods, land reclamation, or urban development.

Current Fallows

Current fallows refer to agricultural land left uncultivated for one or more regular crop-growing seasons. These fallow periods are intentional and part of the crop rotation system to allow the land to regenerate fertility. By allowing fields to remain fallow temporarily, farmers can manage soil health, prevent depletion, and enhance overall agricultural sustainability. Current fallows decreased significantly from 26,737 hectares in 2001 to 16,224 hectares in 2011, reflecting a substantial decline of 39.32%. This suggests changes in agricultural practices, land utilization patterns, or increased cultivation efficiency.

Fallows Other Than Current Fallows

Other fallows, apart from current fallows, include: Fallow land left uncultivated for an extended period beyond the regular crop cycle, known as "fallow land other than current fallow, temporary fallows where land is intentionally left unused

for a shorter duration to manage crop rotation effectively and in some cases, fallow lands are left to regenerate naturally, aiding soil recovery and preventing degradation for improved long-term agricultural productivity. The category of fallows other than current fallows increased moderately from 14,164 hectares in 2001 to 15,358 hectares in 2011, in the study area, indicating growth of 8.4%. Possible interpretations include changes in fallow land management strategies or shifts in agricultural planning.

Barren Land

Barren land refers to areas that are unproductive and unsuitable for cultivation due to factors like extreme aridity, poor soil quality, or environmental degradation. These lands lack the necessary conditions to support plant growth and agricultural activities. Barren lands contribute to challenges such as desertification and are often targeted for conservation or reclamation efforts to mitigate environmental impacts. In the District, Barren land decreased from 8,963 hectares in 2001 to 6,775 hectares in 2011, indicating a decline of 24.41%. Potential factors contributing to this decrease include urbanization, land reclamation, or improved land management practices.

Other Than Agricultural Landuse

Other than agricultural land use in cities includes various categories such as residential, commercial, industrial, and institutional land uses. Residential areas cater to housing, while commercial zones are designated for businesses and trade. Industrial zones accommodate manufacturing activities, and institutional areas include spaces for schools, hospitals, and other public facilities, collectively contributing to the diverse urban landscape and functionality. Other than agricultural landuse saw a substantial increase from 27,278 hectares in 2001 to 55,014 hectares in 2011, indicating significant growth of 101.67%. This emphasizes the need for understanding diverse transformations, potentially beyond traditional agricultural activities.

Pasture Land

Pasture land is open land used for grazing livestock, providing a natural environment for animals to feed on grass and other vegetation. These areas support the husbandry of livestock like cattle, sheep, or goats, promoting sustainable agriculture and animal husbandry practices. Pasture lands play a crucial role in maintaining ecological balance, preventing soil erosion, and supporting the livelihoods of pastoral communities. Pasture land decreased slightly from 3,104 hectares in 2001 to 3,051 hectares in 2011, reflecting a decline of 1.70%.

Possible causes include changes in livestock management practices or alterations in land use priorities.

Area of Garden, Trees and Shrubs

The area of garden, trees, and shrubs refers to the collective space dedicated to cultivated ornamental plants, trees, and bushes. This encompasses landscaped areas within residential, commercial, or public spaces, contributing to aesthetic beauty, environmental benefits, and recreational value. The careful planning and maintenance of these green spaces enhance urban aesthetics, air quality, and overall well-being. The area of garden, trees & shrubs notably decreased from 3,132 hectares in 2001 to 1,936 hectares in 2011, indicating a substantial decline of 38.22%. Implications may include changes in landscaping preferences, urban development, or altered land use priorities.

Conclusion

This research paper has provided a comprehensive examination of the intricate interrelationships among population density, urbanization trends, and their profound impacts on agricultural land use patterns within Lucknow District, Uttar Pradesh. The study elucidates the evolving dynamics of land use in the face of unprecedented urbanization, particularly focusing on the changes witnessed over the decade from 2001 to 2011. The findings reveal significant transformations in various land use categories, emphasizing the intricate balance between urban expansion and agricultural sustainability. Notable trends include the decrease in forest land by 42.76%, reflecting potential impacts of urbanization and changes in forest policies. Additionally, the decline in cultivable wasteland by 28.87% suggests alterations in agricultural practices or land reclamation efforts. The substantial decrease in current fallows by 39.32% indicates shifts in agricultural practices and increased cultivation efficiency. Importantly, the considerable increase in areas other than agricultural land use by 101.67% underscores the diverse transformations occurring beyond traditional agricultural activities. The findings highlight the need for sustainable land management practices and informed decision-making processes tailored to the unique context of Lucknow District. As urbanization exerts pressure on agricultural land, the study emphasizes the importance of striking a balance to ensure the coexistence of urban development and agricultural sustainability. The research contributes valuable insights for policymakers, land managers, and urban planners, fostering a deeper understanding of the challenges and opportunities at the intersection of urban development and agriculture.

In essence, this research aspires to contribute to the academic discourse on the evolving dynamics of land use, offering practical implications for sustainable land management and decision-making processes in the context of rapid urbanization. The insights gained from this study can inform future policies and initiatives aimed at ensuring a harmonious coexistence between urban development and agricultural resilience in Lucknow District and similar regions facing similar challenges worldwide.

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RESEARCH ARTICLE

A Perspective on Ecological View and Ecodevelopment Approach for Land Use Planning in The Drought Prone Areas: A Case Study of United Anantapur District, Andhra Pradesh

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Abstract

Land is a basic natural resource. It forms the basis for all the biological, human and economic activities. In the developing countries like India, where agriculture is the main source of economy and livelihood for more than two-thirds of the working population, proper utilisation of land resource is vital.

Introduction

In recent years, serious concern has been shown on ecological management and optimum utilization of land resources for the benefit of mankind. Hence the use of land resource is "central to all discussions of land problems and policies [(1)] . Land use at any region is a complex, diversified and dynamic concept. It is due to the operation of whole range of environmental factors but modified by socio-economic and historical elements. In dry areas, the use of land resources is virtually associated with climatic and edaphic conditions, besides the socio-economic needs of the mankind. Undoubtedly, the erratic behaviour of the monsoon, frequent occurrences of drought and prolonged dry spells have had a devastating and debilitating effect on land use pattern and as a result, the landscapes in dry areas gets continuously varied and modified. Since land itself is one of the important components of the ecosystems, a critical study on landscape ecology and its planning calls for greater attention to be paid to the drought prone areas to keep the ecological balance between the environment and the socio-economic needs of the region.

Ecological View of Landscape

In the sense of ecology, land carries ecosystems, but is itself also a part of these ecosystems. Although the use of land resource may be considered from abroad view of human welfare, its use is always a process of modifications of ecosystem. The idea that land use is a process of modification of ecosystem was well explored by Simmons [(2)] .

He suggested that land use ecology might form a central theme in biogeography. It is also mentioned that the ecosystem concept provides the necessary modern scientific framework to the study of land use. The form and function of land use is a human enterprise, while the development of landscape is the continuous efforts of man for his needs and sustenance under every possible combinations of terrain, climatic, edaphic and vegetative conditions. By all means, it suggested that any scientific and rational land use planning should see that the ecological balance was not disturbed and that proper equilibrium between the environment and the socio-economic needs of the area be maintained.

Ecological Problems of Land Use

In the process of land use management and optimisation, ecological problems are becoming a most serious concern. The ever increasing pressure of population and decreasing man-land ratio are posing challenging problems to the land-use planners. Structurally, a land-use system consists of three interacting spheres namely, ecological (environmental), economic and social. Each sphere has its own unique set of human-ascribed goals. Ecological problems are those, which appear in connection with human socio-economic needs, change the quality of the physical environment and indiscriminate use of natural resource base. Ecological problems appear in different types of physical environment and various socio-economic, technological and political conditions.

The negative ecological effects like degree of decertification, land degradation, soil erosion, soil salinisation, chemical contamination and water pollution are frequent in the dry areas but taking place in different intensities and degree of criticality. The other problems related to land use are under-utilisation, over-utilisation and mis- utilisation of land resources. So the question is what are the reasons for the appearance of negative ecological effects in different environmental and socio- economic conditions. Off all, undoubtedly, man's indiscriminate use of land resources has resulted in the creation of negative ecological effects. His failure to recognise the long term implications of deforestation, faculty methods of cultivation, overgrazing, massive application of fertilisers and pesticides, practice of single crop monocultures, imbalances in the input and output factors and large scale exploitation of land and soil resources throughout an entire ecosystem. Results in widespread degradation.

The practice of monoculture was accompanied subsequently by great losses of genetic varieties in the fields, involving high risks of large hectarages being destroyed by single drought or pest. To cultivation of the same crop continuously and their synthetic fertilisation year after year has resulted in the disruption of the soil balance. With diminishing organic matter in the soil, its ability to retain moisture is also reduced and as a consequence, the soil becomes sterile and dry. To circumvent some of these problems a critical examination of landscape ecology is essential for a more rational approach to land use planning and conservation of resources.

Eco-development and Ecological Planning of Land Use

Generally speaking, ecological planning is a fundamental tool for landscape and regional planning, such that many landscape ecological studies are now done as integral parts of landscape and regional planning projects[3] . It offers an effective means of helping mankind to adapt to the dynamic changing environment of which he is but one integral part. Mc Harg[4] has defined ecological planning as "an instrument for revealing regions as interacting and dynamic natural systems having intrinsic opportunities and constraints for all human uses.

The goals of such planning are derived from the region and its people as proffered by locations where all or most advantageous (safe, healthy and beautiful) factors exist with none or few detrimental factors for any and all anticipated future uses. What constitutes 'detrimental' or 'advantageous' is derived from the use itself and the value system of the initiating person or group. The concept of eco-development forms the main strategy of 'Habitat Ecology'. It helps in explaining the form of planned growth which is concerned with the development of local available land resources within the constraints of local environment with a view to optimise the local capacities of the biosphere to support the welfare of life. The eco-development approach is very close to ecological and environmental planning to balance and harmonise the various enterprises of land use which man for his own benefit has superimposed on physical environment.

The eco-development approach related to land use rests on (i) rational utilisation, (ii) development of mankind pertaining to their well-being rather than in economic sense, and (iii) advancing a true symbiosis between man and environment. To activate and regulate the harmony between landuse development and environment both the demand and supply side of the equation must be acted upon. In the eco-development and ecological planning sense, any land use planning should not be considered merely from the agricultural point of view and bringing more land under the plough making it viable for cultivation, but should include rational utilisation of land resource, conservation of land from erosion, development of nutrients and soil cover through multiple vegetative systems, improving the potential capacity of land, application of modern scientific technology and lastly the preclusion of over exploitation of land.

Study Region

Anantapur district is one of the chronically drought-prone areas in the country. It is located in the rain-shadow region of

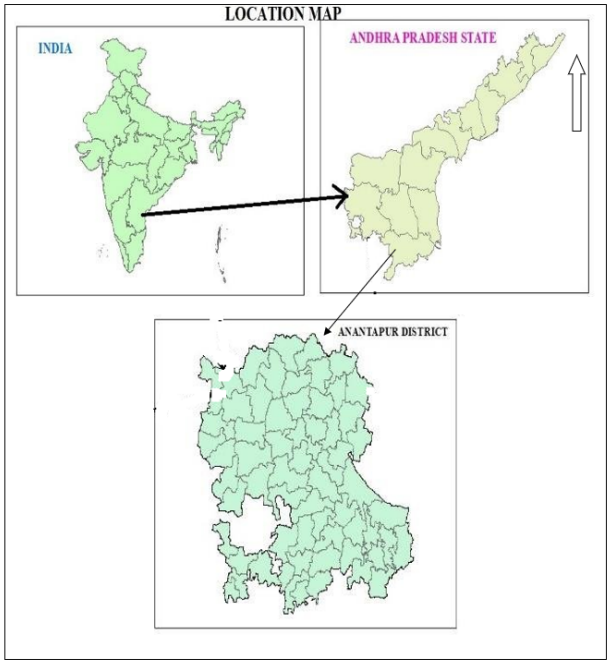


Fig. 1. Location map

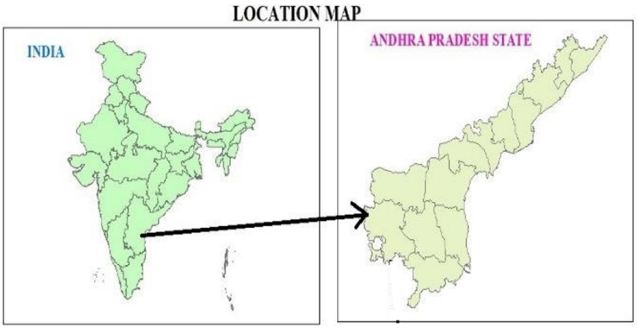


Fig. 2. Location map

the Western Ghats in Andhra Pradesh. It is the largest district in terms of area in the State. The population spread is very sparse with a density of population of 166 persons per Sq.Km. Agriculture is the predominant occupation of the people. The average annual rainfall of the district is 544 mm. with the lowest number of rainy days of 35 in the State. The district has been experiencing a drought once in every two years which is really serious and detrimental to stable agriculture.

Methodology

The spatial distributional pattern and changes in important land use types namely, forest land, fallow land and crop-land are examined and delineated with the help of both quantitative and cartographic techniques. The quantum of change is determined through percentages, regression trend and growth rates The impact of rainfall on land use types is measured with correlation testing.

Forest Land Use

Forests form distinct ecosystems. In fact, Anantapur district is very poor in forest cover with only 10.3% of the total geographical area of the district. The nature and character of forests in the district does not indicate any dense growth of tree population with different variety of plants. The forests of the district may be described as dry mixed deciduous and thorny open scrub types.

The distribution of forest-cover in the district is not only very low in proportion but also most uneven. Relatively, higher concentrations (15.1-20% and >20%) of forest-cover are found in southern, south-eastern and north-eastern parts of the district. In these areas, the amount of rainfall is comparatively higher than the other parts of the district. The western part of the district is found with very thin forest cover with discontinuous thorny thickets and scrub woodlands whose vegetative growth is stunted due to poor edaphic and very low isohyetal conditions.

During the three decades under consideration (1960-90) total area under forest has not shown any substantial change but showed a small increase of 0.1 per cent or 2000 hectares. The regression analysis has also revealed that the trend of forest land is marginally positive with 2 per cent of the goodness of fit. The annual compound growth rate has also shown a negligible rate of increase of 0.003 per cent.

Planning for the Development of Forest Land

In drought-prone areas, maintenance of ecological balance is one of the most important considerations to build-up the humus contents in the soil, avert soil erosion, increase the moisture in the atmosphere, raise the ground water level and heap in ground water recharge and storage besides other economic purposes. However, the poor quantity of forest cover in the district is too short to fulfil the requirement of ecological balance and is seriously jeopardizing the ecosystem of the region it is necessary to take up massive efforts on war-footing to develop forest-cover in the district

The development of forest-cover in the district heavily depends upon the (i) plantation of drought resistant species in large parts of the reserve forest areas, which are devoid of any vegetative cover, (ii) there are number of tanks in the district which are silted and do not fill up with meagre rainfall The foreshore of these tanks can be planted with eucalyptus and subabul plantations., (ii) depending upon the suitability of site and topography, particularly in the slopy agricultural lands and cultivable wastelands and all along the road sides the species like tamarind, neem, gulmohar, eucalyptus, fruit and flowering plants can be planted extensively. Agave species

can be planted in 'estate concept' mainly to yield raw material for fibre extraction and to put otherwise unproductive areas to productive use and (iv) pasture development can be taken up on the barren hills, slopy soils, community lands and village poramboke lands. Having all the afforestation schemes, it is utmost necessary to convert this dry belt gradually into a green belt for balancing the ecosystem.

Fallow Land Use

Land under fallows accounted for 17 per cent of the geographical area of the district. which is indeed a high proportion. More than one fifth of the geographical area under fallows is found in 17 mandals mostly located in western and north-eastern parts of the district.

During thirty years period, the proportion of fallow land has increased by 5.6 per cent amounting to about 106 thousand hectares. The increase is found in many parts of the district. The regression analysis has also confirmed this trend of increase of fallow land but is accounted by 22 per cent of co-efficient of determination. It indicates that the increase in the area under fallows is not perpetual from year to year but highly fluctuating. The annual average rate of increase is 0.6 per cent.

It is suggested that an increasing trend of fallow land should be controlled and utilised at optimum level through scientific land use management systems. If possible all the fallow lands should be brought under dry farming cultivation with suitable drought resistant rain-fed crops like millets, pulses, fodder crops and agro-forestry A considerable change in the outlook of farmers is to be brought out from traditional practices to new methods of dry farming for optimum use of fallow lands with multi-tier vegetations in different ecological systems and the sound management of Sylvi-Agri-Pastoral Systems.

Agricultural Land Use

The district has vast agricultural land resource base but suffers from instability due to vagaries of monsoon. The net area sown in the district accounted for 49.9 per cent of the total geographical area which is significantly. Higher than the average proportion of net sown area in Andhra Pradesh State (41.3 per cent)

The quantum of change in the proportion of net area sown during 1960- 1990 showed a significant decline of 5.5 per cent amounting to 105 thousand hectares. The trend of net area sown in the district has been negative. The goodness of fit of the regression trend states that the present negative trend is to the tune of 11 per cent only. It means that the negative trend of the net area sown is not exactly perfect but it is highly fluctuating from year to year depending on the variation of rainfall On an average, the annual compound growth rate declined at 0.03 per cent.

Impact of Rainfall on Arable Land

In the drought-prone region, where rain-fed farming is predominant and irrigation development is very low, it is a common assumption that the increase or decrease in either cropped area or fallow land will be in close association with the success or failure of monsoons. In the present study, the correlation analysis has revealed that there has been a positive correlation between rainfall and net area sown in the district to the tune of 0.55 Co-efficient value and negative correlation between rainfall and fallow land to the tune of 0.62 co-efficient value. A high negative correlation of 0.85 is found between net area sown and fallow land. It shows that if there is an increase in rainfall, the land under cropping may increase or if there is decrease in rainfall, the land under fallows may increase. It indicates that these two land use types are inversely correlated and functionally related with each other.

Strategy for the Development of Suitable Cropping Pattern

The present cropping pattern dominated by groundnut, cannot be treated as inappropriate and it appears to be a more or less natural consequence of the poor natural resource endowments of the district. Now that it required all the more is the optimisation and strengthening of present cropping pattern without further spatial extension of mon-crop groundnut. In view of varying drought conditions and agricultural drought which differs from one crop to another crop in an area, an extending monoculture groundnut farming to wider area may not be advisable, as a wide-spread drought may adversely affect the agricultural economy of the district. In such circumstances, all rainfed crops which are of high value and low water consuming must be preferred. The risks from droughts could be reduced by popularising suitable inter-cropping methods. If there is failure of rain, at least one of the component crops will yield something and thereby minimise the risk of total loss. The non-traditional crops like sunflower, safflower and castor etc. should also be grown in the suitable soil and moisture conditions.

Soil Characteristics and Problems

The soil is a dynamic layer which immediately reacts to the pattern of its use or changes in the soil forming environment. The district has 82 per cent of red soils and 18 per cent of black soils. The phosphorus and organic matter 3 content is poor in 82 to 90 per cent of the soils. But more than 90 per cent of the soils are moderately rich in potash more than 95 per cent of the soils are neutral or weakly alkaline. Less than 5 per cent of the soils are having severe saline and or alkaline problems.

The results of studies made by different organisations reveal that the soil characteristics are being changed in a short span of time by such activities of man like (i) removal of vegetation cover, (ii) application of heavy irrigation, (iii)

change of cropping pattern and (iv) change of morphology. The conclusions are that (1) in the undulating piedment regions where dry farming is practiced there is an increase of rill and gully erosion, (2) there is steady increase in the salinity and alkalinity problems in the canal irrigated mandals like Rayadurg, Gooty. Tadipatri and Anantapur, (3) there is a decreasing tendency in the potassium content of the soils particularly in the paddy cultivated areas and (4) with the shift from millet oriented to groundnut oriented cropping pattern, the soils have shown sulphur and zinc deficiency. Iron deficiency is also predicted in the near future.

Soil Management

The soil management programme in a semi-arid region like Anantapur district should be comprehensive and integrated one. First and foremost adequate importance should be given to the extension programmes to create the awareness in the farming community about the dangers of the mismanagement of the soil ecosystem and to motivate them to follow proper soil management 2 guidelines. The soil forming environment could be improved by managing catchments at t micro-level Construction of check dams and watersheds on small catchments serves as a multi-purpose schemes in this direction Both agronomic and engineering measures of soil conservation should be implemented in a complementary manner to achieve better results. The alkalinity and salinity problems of the soils have to be solved with suitable measures like zypsum application and leaching of excessive salts with suitable dosage of irrigation respectively Proper care should also be taken to minimise water sepage from the irrigation canals which will lead to the problems of salinity and alkalinity.

Conclusion

It has been observed that man, rather than the nature is bringing considerable change in the quality of land in a short span of time. The short- sighted and unplanned commercial and subsistence gathering of resources from the nature's bounty have caused considerable damage to the land system Many of his activities though fetching short-term gains, are causing long-term and sometimes irreversible damages to the quality of landscape system in this dry region. In view of very low proportion of forest cover, high proportion of fallow land, instability in agriculture land followed by mono-cultures and poor nature of soil cover, the landscape ecosystem of this region is delicate and is being easily disturbed.) The maintenance of ecological balance is one of the most important 4 considerations and is to be looked into it very seriously. To achieve the required goals, "Sustainable Land Use Development" is the way of environmental feature. Jacobs [5] has referred to sustainable development as "the offspring of ecological planning". To understand both and carry them out, environmental education is essential at all levels and in all sectors of the population.

It is also often emphasised that the transformation of rural habitat is the fundamental lead for the eco-development of the region the integrated Rural Development (IRD) is to be concerned with ecological and environmental issues in addition to the integration of sectors and policies in space-time dimensions. The IRD concept is also to be conceived as strategic design of problem solving planning process for the effective involvement of local human and physical resources to improve the socio-economic and ecological situation of the rural habitat.

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GEOGRAPHICAL ANALYSIS

RESEARCH ARTICLE

The Female Child Deficit: Its Causes and I mpending Consequences in Indian Perspective

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Abstract

The female children are equally important apart from male children of any country. It donated as Sex composition of Child population (0-6 Years), which is basic demographic characteristics. The deficit in girl children will have many implications, the most fundamental being to define the limits of the society's reproductive potentials. Further, the existing sex composition of children is also the basic demographic determinants of births, deaths and marriages in future. Moreover, future migration rates, work force and all other population characteristics can be influenced by the ratio between the sexes of children at present. The present aims to examine deficit of girl children and its causes along with upcoming consequences in India based on secondary data collected from census apart from others and suggestions are given for advocacy as well as policy matters.

Keywords: Gils Child; Discrimination; Son Preference; Neglect of Girls; Sex Selective Abortion

Introduction

In a "normal world," the female population equals or slightly surpasses the number of males. Except in India, that is, where the situation is just the opposite, where the gender ratio- or the number of females to males- is known to be among the most imbalanced in the world. Child Sex Ratio is defined as "number of females per 1000 males in the ages of 0-6 years" in given period in an area. Although China has the most severe shortage of girls compared to boys of any country in the world today, in India, the 2011 census revealed disturbing news: the proportion of girls aged 0-6 years dropped from 927:1000 to 914:1000 since the previous census done 10 years earlier. The census also revealed that the phenomenon has reached high proportions in states which had no prior history or practice of female infanticide, or where forms of discrimination against girls were not strongly evident earlier. The reasons behind this mistreatment of girls crosses the spectrum of Indian regions, economic classes, and castes and are due to a complex mix of economic, social, and cultural factors. In India, the changes in education, employment, nutrition, work patterns, religion, and culture, as well as family concerns such as marriage, property, inheritance, and continuity are the causes for imbalance sex ratio.

Though the population growth rate in respect of males was lower at 17.1 per cent, when compared with 18.3 per cent for females-implying some correction in the overall sex ratio- the child sex ratio (for the age group from zero to six years) deteriorated over the decade, from 927 to 919 females for every 1000 males. This should set off alarm bells in the government, civil society groups and the law. This ratio is mainly man-made through selective sex determination with the aim of getting rid of the girl child, early death due to neglect and infanticide. As per census of India, 2011 the declining sex ratio in India is due to "neglect of the girl child resulting in their higher mortality at younger age, high maternal mortality, sex selective female abortions, female infanticide, change in sex ratio at birth"[1] . The deficit of Girl Children is an unique feature of India over the decades as compared to developed nations, which has been highlighted in respective census repots and also studies by many authors viz,[2–4] , but many were examined the trends and causes for deficit of girl children population by examine the child sex ratios, while some[5,6] and IDRC and Action Aid India, 2011 with some efforts made on its impending consequences.

Objective

The objectives of the present paper are to examine deficit of girl children in India, it causes and future repercussions extensively along with suggestions to overcome the issues.

Methodology

The present paper based on secondary data collected from census of India and other published documents. Here the Girl Children is considered as number of female children per 1000 male children in the age group of 0-6 years in given area in a period of time.

Results and Discussion

The sex ratio worked out for population of all ages is not indicative of any clear picture to know whether it is favourable to females or otherwise. The child sex ratio generally affected by two factors namely mortality differentials and extent of medical interferences, which influence overall sex ratio also. Hence, child sex ratio is always considered as the best indicator to understand the sex ratio at birth when the data on births by sex are not easily available. Differentials in child sex ratio explain changes girl child population over period of time in India.

Table 1 depicts that Over all Sex Ratio(Number of females per 1000 males) was 945 in 1951, comedown to 934 in 1981 and recorded as 943 in 2011, implying some improvement in the overall sex ratio in recent decade; while, the child sex ratio (0-6 years of ages) deteriorated over the decade, from 983 in 1951 to 927 in 2001, thus declined sharply with 56 points in five decades and it further declined to 914 in 2011, such least had never recorded after independence.

Table 2 shows that in 1961 census, the child sex ratio at the National was 976; whereas the rural child sex ratio stands at 957 and urban child sex ratio was 951. The corresponding figures in 2011 census are 914, 919 and 902 respectively. Further, the gap in rural-urban child sex ratio was 6 in 1961, rose to 17 in 2011. Thus, the child sex ratio had been drastically declined and gap had been widened. The main causes for low child sex ratio and further decline, gap in rural-urban in the country are: Neglect of girl child resulting in their higher mortality rates at younger ages, high maternal mortality, sex selective abortions and female infanticide.

Causes

The causes for deficit of girl children in India context are many fold viz socio-economic, cultural, religious and political, which are complex in nature, most being are discussed here.

The son-preference trend in India

Apart from higher morbidity levels, which cause mortality of girl children, preference for son has been main causes for decline of girl children. Son-preference has being equally strong among different income groups and irrespective of caste and sex ratios where earlier period showed that sex ratios were better among lower castes and among the poor. The norms that have been part of India's socio-economic fabric for centuries are that Sons are considered pivotal to family welfare, as they are the ones who earn money, continue family lineage, and provide a form of old age security for parents. A daughter, meanwhile, is considered to be a "double loss" as she not only leaves her family when she marries, becoming an "asset" to her new family, but she is also a source of marriage expenses, including the payment of dowry to the groom's family.

Family planning-for sons

Some new trends, such as the two-child family norm encouraged by the Indian government, and an emphasis on education also influence decisions. However, it has been that although small families are accepted in Himachal Pradesh, Punjab, and Haryana, family planning effectively means, "Planning for sons." Generally, people want educated daughters-in law, because it "…is oriented towards the future family of the couple-children will get proper guidance and instructions from an educated mother…marriage prospects rather than employment appear to drive education." However, parents expressed the hope that more education for girls would result in them obtaining white-collar, regular, and secure work pre-marriage-and a better choice of prospective husbands. In rural areas of India, there may be a compromise in the duration of schooling. It observed that "… girls are encouraged to complete as much education as they can- but-

Table 1. Trends in Child sex ratio in India, 1951-2011.

Sex Ratios	Census Years						
	1951	1961	1971	1981	1991	2001	2011
Over all Sex Ratio	945	941	930	934	927	933	943
Child Sex Ratio	983	976	964	962	945	927	914

Source: Census of India, 2011.

Table 2. Child sex ratio of India

Child Sex ratio by Residence	Census Year					
	1961	1971	1981	1991	2001	2011
Total	976	964	962	945	927	914
Rural	957	968	963	948	934	919
Urban	951	948	959	935	906	902
Rural-Urban Gap	6	20	4	13	28	17

Source: Census of India, 2011.

if a 'good match' is found; the girl is married off before she completes her studies."

Sex-selection practices

In India, members of the older generation referred to children as natures or a divine gift, and of the sin of getting rid of a child. Women of reproductive age may agree with this view, and may protest, but decisions of family member's plays crucial role regarding gender of children. Since the 1980s, technology widely available in India, such as amniocentesis and ultrasound, has permitted parents to predetermine the size and gender composition of children for their families through abortion. Although sex-selective abortion is illegal and banned in India, it has been widely practicing even rural areas of India. Some people are did not stop at one abortion, but had more than two times-because a girl had been conceived each time. "Abortion," is the method of family planning par excellence-to limit family size, to enable spacing between children, and also to regulate the sex composition of the family. Sex Selective Abortion is referred as "High-Tech Sexism" by AmartyaSen[7] a renowned economist, who studied missing females in India.

Neglect of girls

Neglect of girls, whether planned or inadvertent, also contributes to the lower child sex ratio. The degree of discrimination varied by location, there nonetheless was widespread evidence of lower levels of nutrition, health care, schooling, and emotional care, and high levels of under immunization in general. "With nutrition and health, who may or may not take the decision is uncertain, but the discrimination is evident". A firstborn daughter was not typically subjected to inferior treatment; she was treated like her brothers. But with each additional girl, the pressure to have a son increased and starts discrimination against girl children.

Dissatisfaction of Daughters

When a daughter grows up and marries, she essentially becomes chattel in her husband's parents' home and has very limited contact with her natal family. Even if she earns a good living, it will be of no help to her own parents in their old age. So for parents, investing in a daughter is truly, in the Hindi expression, planting a seed in the neighbor's garden. Sons, by contrast, provide a kind of social security. Changes in work, education, marriage age, and marriage costs also seem to add up to disaffection for daughters, to a greater extent than before. The factors causing this include: increased investment that has to be made in daughters in terms of education and marriage; the loss of their material and labour support; fears for their sexual safety and security; and worries about their future happiness in an appropriate marriage.

Impending consequences: In India, the deficit of Girl Children leads to many severe upcoming consequences by way of socio-economic, cultural, religious, demographic, and political aspects, but many may be less gravity and some could be very serious, which are briefly discussed hereunder.

No relevance of institution of marriage: Continuous declining in Child Sex Ratio has many potentially serious consequences, although there are no historical model by which to learn about the implications of a lack of women relative to men, one fairly obvious social consequences is that there are not enough women for men to marry and the institution of marriage would lost its relevance.

Raise in Child marriages: The scarcity of brides might lead to the child betrothal and early marriage (child marriage) to cope with the problem. Increasing numbers of child brides will further contribute to the poor status of women, as will be less likely to finish the school or develop skills before

marriage.

Chances of Disease Burden: Young brides and their children are also more likely to suffer from the increased morbidity and mortality associated with early child birth Thus there are serious socio-economic and health implications of declining child sex ratio.

Increase in dowry Amount : Another consequence of scarcity of female is the increase in dowry i.e. payment of exorbitant dowry, daughters are often sold to higher castes and even poor man often paid a bride price to obtain a wife. Among the Jats in particular and various other in general, the scarcity of women led to wide spread system of polyandry.

Non available of suitable spouse by age and sect: Present trend of gender imbalance continues, one of the serious repercussions would be a rude shock to the institution of marriage in the decades to come. It has severe consequences especially in North Indian states of Punjab and Haryana which are characterized by in ability of men in marriageable age to find suitable partner by age as well as caste.

Increase in age gap: Scarcity of females may cause to increase in age gap between bide and bridegrooms. The brides will have much lower ages than bridegrooms, it causes to many problems like adjustment, family life, companionship etc.

Buying brides from other regions : The Hindustan Times, July 12, 2003read as "in Hathin (Haryana), because of shortage of women men buying brides from other states like Assam, West Bengal and from far away villages of Bihar. The price put on such a girl is much less than what people pay for cattle, after marriage they are condemned to a life of slavery.

Cultural Problems: Men from the shortage of female by caste, group, area and region causes to get marry of other castes, sects, areas and regions, it may causes to cultural problems, because brides have to adjust with bridegrooms family cultural, deviation may causes troubles in coping up of family life.

Abduction and trafficking of girls: Shortage of brides would be leads to abduction and trafficking of girls that resulted in expansion of the sex industry with the magnitude of spreading Sexually Transmitted Diseases and deadly disease like HIV/AIDS would increase manifold. The Hindustan Times recently reported that young girls from Assam and West Bengal are kidnapped and sold into marriage in neighbouring Haryana [8] .

Raise of anti-social behaviour: In this distorted social scenario marked by growing anti-social behaviour, crimes against women like rape, molestation,eve teasing, child marriages; forced polyandry etc. is also expected to rise.

Pressure on Women: Parents who have a fervent preference for male offspring will impose pressure on women. Thus, women who had given birth to only daughters were desperate for sons and would keep having children until they had one or two male children. In a study done by the Centre for Social Research in Haryana, fear of violence is a cause for female foeticide. Also the women who produce daughters face much more domestic violence which makes them complicit in getting rid of the girl child [9] .

Risk of ostracism: A family with only daughters will also likely lose its land when the father dies: although women can legally inherit property, in some areas of India, they risk ostracism or even murder if they claim what is theirs.

Some men may remain unmarried : Some states now experience a shortage of brides because of the adverse sex ratios. It was notes that 20% or more men in some states, including Haryana and Punjab, may remain unmarried. There are already examples of brides being "imported" from poorer eastern states. Further, unmarried men may faces Psycho-social problems like lack of sexual pleasure, family life, loneliness etc.

Delay in Marriages: Trends to higher age at marriage, more so in urban settings, were also observed, possibly as a function of the emphasis on education. In urban areas, it observed that the average age at marriage is now 20 for boys and 17 to 18 for girls, where earlier both were married at 14 years of age. Perhaps the rise in marriage age may be due to greater difficulty in finding an eligible spouse, with factors such as education, earning capacity, and dowries raising the stakes for the ideal match.

Choice of mate selection by girls may decline: Ensuring a girl's chastity is considered a great parental responsibility and is one of the arguments for promoting early marriage. For better or worse, some of the usual social, cultural, and economic norms in Indian society's choice of mates may be swayed. In some regions inter-caste marriage, marriage with girls of tribal communities, and polyandry are now becoming more common.

Social tensions arise: There are also reports of bride buying and forced remarriage of widows. In the near future social tension could rise because of the challenge of finding female partners, and may lead to crimes against women. Others wonder if a shortage of women will lead to less violence against them, or a decrease in dowries. Thus, the increasing imbalance in sex ratios is a sign of continued inequality between the sexes. The scarcity of females, they add, is symptomatic of their low value.

Disappear of mothering roles: In India, females are playing crucial role in household chores, childbearing as well as child rearing activities with more patience. Further, females role as mother cannot be ignored that strengthens family system;welfare of family members; however, in future, these can be slowly disappear if girl children decline rapidly.

Decline in Female labour: Apart from household works, females are engaging in outdoor employments, especially in agrarian sector of rural economy, the contribution of females by supporting men has been quite significant. However, their contribution is often unrecorded and unacknowledged. In

this context, decline in child sex ration leads squeezed female labour force. Further, the economic consequences are grave for deficit of females that a huge proportion of the productive population is missing and also the lack of women impairs the ability of men to work.

Decline Population Growth: In the entire world, for smooth growth of population of any county, both men and women are equally important. If females continuously declining, it causes to deficit of women population thereby it affects the growth of population by lack of females for men reproductive activity. Thus, scarcity of females brings down societies reproductive potential by lowering net reproductive rate. Moreover, events such as new household formation will decline.

Conclusion

Now a days, in a patriarchal society like India, a daughter is generally unwelcome due to "Guarding her chastity", as well as expenditures by way of Dowry are a heavy burden on parents apart from worry on uncertainty of her life after marriage. A son on the other hand continues the family line, provide the parents with emotional and financial security and perform the last rite i.e. male child is important for moksha. These are major cause apart from other reasons for rapid decline in child sex ratio in recent decades. Though, in India the acts are passed (such as The Prenatal DiagnosticTechniques Acts, 1994, The dowry prohibition Act), however these Acts are not properly implemented. It may be therefore, concluded that effective enforcement of laws along with softening a son-centered culture and bringing changes in cultures that are deeply rooted by way of socio-economic, and religious concerns which are causes for discrimination of girl children. Moreover, balanced child sex ratios are essential to avoid upcoming evil consequences of deficit of girl children in India.

Solutions and Advocacy

The long-term and short-term measures can stem to supersede from the deficit of girl children in India. In the long term, it is suggested that ensuring equal entitlements such as property rights, equal access to nutrition, health, education, affection, guarantee on safety and addressing the problem of dowry and life after marriage. While, in the short term, incentives to educate girls, financial support for girls, educating healthcare professionals and enhancing incentives for more number of female children born are recommended. "Another option is depositing some amount of cash to families where there are one or two female children in a household and no male children for future expenses such as education, marriage and life security. Such innovations are being started now in small settings in different places of India."

The development and focus aid on women are the two aspects that can tackle the declining girl population in India. The development can surely the wealthier the home, the more educated the parents, the more plugged in to the modern economy, the more a family will invest in its girls. But these efforts should be joined by an awareness of the unintended consequences of development and by efforts, aimed at parents; to weaken the cultural preference for sons. The other is focusing aid on women. The idea is that a mother who has more money, knowledge and authority in the family will direct her resources toward all her children's health and education. She will fight for her girls. While increasing women's decision-making power would reduce discrimination against girls, "When women's power is increased, prejudices and cultural practices opposite to girl children can decline".

In Indian context, it will not be enough to counter son-preference. But, dislike to daughters has to be evenly provoked through policy measures that increase the economic worth and support of daughters through improved employment opportunities, recognizing women's health and emphasizes on education levels than the mothering roles.

Finally, understand the formal and informal social, cultural, economic, and political processes that motivate the bias against having female children are needed to frame social policies to overcome a long-standing cultural preference for male children and to reverse a potentially disastrous future imbalance in the male/female child ratio of India's population.

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RESEARCH ARTICLE

Pattern of Housing Characteristics in India and its States : An Analysis

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Abstract

Housing plays a crucial role in the lives of individuals within any society. House ownership has traditionally been highly valued, seen as essential for family stability and wealth creation. The quality of housing, including access to basic amenities like water, sanitation, electricity, and more, is a significant indicator of a country's socio-economic development. Housing with basic necessities is a fundamental factor in economic, social, and civic progress, with various housing-related activities directly contributing to broader development objectives. When individuals and families do not have adequate housing with better characteristics, their well-being is severely affected. Inadequate housing can lead to poor health outcomes, placing a strain on the healthcare system. This study utilizes a descriptive research design, analyzing secondary data from the National Family Health Surveys (N.F.H.S) 1 to 5, to explore housing characteristics patterns in India and its states.

Keywords: Electricity; Drinking Water; Toilet; Fuel for Cooking; Pucca House and Persons Per Room

Introduction

India is home to a staggering 300 million individuals who endure extreme poverty and grapple with the lack of basic necessities such as food, clothing, and shelter. These individuals face the harsh reality of living in homes that lack essential services like water, sanitation, electricity, healthcare, and education **(Millennium Development Report, 2014)**. The provision of basic amenities in housing is crucial not only for improving the socio-economic status and standard of living of households, but also for fostering sustainable development. The absence of basic amenities within households, highlights the exclusion of a significant portion of the population from essential social infrastructures. In light of this, Rabiul Ansary and Bhaswati Das[(1)] argue that the denial of basic amenities like clean fuel and electricity will hinder India's efforts in controlling pollution and addressing issues such as climate change. The National Family Health Survey (N.F.H.S) offers insights into the demographic and socio-economic characteristics of households, shedding light on key housing aspects of the population. Understanding household characteristics and housing conditions provides valuable context for comprehending the socio-economic, demographic, and health situation of the population.

The study of housing and its characteristics serves as a reliable means of expressing human responses to the physical and cultural environment of a region. It represents the cultural achievements of the past and the preservation of traditions through simple architectural features. The housing conditions of families directly reflect their socio-economic and cultural status.

In typical human settlement patterns, there is a noticeable disparity in the types of houses occupied by different families. Affluent upper caste families reside in elaborate houses equipped with excellent all facilities, showcasing their social, cultural, and economic status. On the other hand, lower caste families find shelter in small houses or huts with inadequate basic facilities. Housing Characteristics like drinking water, bathroom and toilet facilities are essential to maintain one's good health and productivity. It is often argued that good housing conditions are essential elements for enhancing household health, and that poor housing and environmental conditions can lead to many health problems, including infectious diseases (such as tuberculosis and malaria), stress and depression (Udofia, Yawson, Aduful, & Bwambale, 2014). Zihan Kan et al[2] study results indicate that communities with relatively poor housing conditions have impact of housing on mental health may be more direct; while, for communities with relatively good housing conditions, the effect of housing characteristics on mental health may be indirect. The quality of life of any households in a region (state) is largely determined by availability of safe drinking water, sanitation, drainage facility for waste water, type of fuel used for cooking purposes and availability of separate kitchen, congestion of the households[3]. Availability of basic amenities within households is also another proxy indicator to study multi-dimensional deprivations and social inclusion or exclusion of a population. In many villages of India, the practice of untouchability still forces people belonging to a particular caste to fetch water from long distances[4].

Review

Bhagat et al. (2018)[4] conducted a study that focused on housing characteristics in nine villages located in the Melghat areas of Maharashtra and these areas are known for their high levels of poverty and malnutrition. In a study by Ibrahim Yakubu et al.[5], the link between housing conditions, resident health, and poverty levels was explored in the Metropolitan area. The findings revealed that a majority of houses in this area lack essential in-house facilities. Wei Guo[6] found that housing type and size have a significant impact on the health of migrants, while housing instability has a greater effect on the health of urban locals. Maria Löfstedt[7] conducted a new case study that reviewed the relationship between physical housing characteristics, housing accessibility, and various aspects of health among older people living in the community. Coley et al.[8] conducted research that demonstrated how poor housing conditions negatively affect the development of children and adolescents. Dekker et al.[9] concluded that individual characteristics such as age, presence of children, and length of stay are more influential in explaining residential satisfaction than specific estate characteristics. In a study by Daan Schipper[10], it was found that various socio-demographic variables have a significant impact on subjective well-being in relation to housing characteristics, as well as certain economic activities. Esraa A. Attia[11] aimed to reveal the relationship between rural housing characteristics and social-economic variables for the heads of families residing in these areas. Rabiul Ansary and Bhaswati Das[1] concluded that households lacking good housing conditions and basic amenities, which are essential for healthy and productive manpower, tend to have lower assets.

Objective

The paper aims at examine the pattern of housing characteristics in India and its 30 states based on secondary data during the period of 1992–93 of N.F.H.S-1 to 2019-21 of N.F.H.S-5.

Methodology

The research paper utilizes a descriptive research design and relies on secondary data obtained from the National Family Health Survey (N.F.H.S) conducted over a span of 38 years, from 1 to 5. The housing characteristics examined include electricity, drinking water, toilet/latrine facility, solid fuel used for cooking, pucca house, and the mean number of persons per room used for sleep. The N.F.H.S-1, conducted in 1992-93, encompassed 88,562 households. In 1998-99, the NFHS-2 survey included a representative sample of 91,196 households. NFHS-3 collected information from a nationally representative sample of 109,041 households in 2005-06, while N.F.H.S-4 in 2015-16 selected 628,900 households. Lastly, the NFHS-5 survey of 2019-21 covered a total of 636,699 sample households.

Results and Discussion

Housing characteristics data can be used as an indicator to address statistically how many people from various states have been excluded from an adequate standard/quality of living. The pattern of households' dwelling characteristics has been captured by seeing the condition of residential houses, types of house structures, the number of rooms a household possesses and other basic amenities such as electricity, drinking water, toilet/latrine facility, and percent of solid fuel used for cooking and these basic household amenities are discussed briefly hereunder.

Electricity

Electricity plays a crucial role in the daily lives of humans and is a significant factor in the modern economy. It is utilized for various purposes such as lighting, heating, cooling, refrigeration, operating appliances, computers/electronics, machinery, and transportation systems. Yunqing Lu et al.[12] conducted a study on energy consumption and household characteristics by implementing a dynamic pricing experiment in communal housing within a smart community in Japan. Table 1 illustrates the distribution of households with electricity in India and its states.

Table 1 reveals those substantial variations in households with access to electricity during the period of N.F.H.S-1 to N.F.H.S-3. However, access to electricity drastically improved in India and its states in the period of N.F.H.S-4 and N.F.H.S-5. In most states, over 95 percent of sampled households have electricity and almost all households in India (97%) have electricity in N.F.H.S- 5 of 2019-20. It clearly indicates that sampled households had electricity for many purposes in their homes to lead better life.

Drinking water

The provision and availability of safe drinking water and sanitation plays a crucial role in enhancing the quality of life and promoting good health. It helps in reducing illnesses, water-borne diseases, and fatalities, leading to lower health expenses, increased savings, and enhanced human efficiency. In rural areas, women or girls are typically tasked with fetching water from various sources for household purposes. The accessibility of water was a key aspect of the Minimum Need Programme initiated between 1974 and 1979 to cater to all segments of society. Ensuring access to clean and safe drinking water is essential for overall health and well-being. In certain states like Manipur, Odisha, Meghalaya, Tripura, Jharkhand, and Madhya Pradesh, around 33 percent of households, and in states like Nagaland, West Bengal, Chhattisgarh, and Rajasthan, approximately 25 percent of households, obtain water from sources located away from their homes[3] . Drinking water serves various vital functions in the body, such as regulating body temperature, maintaining healthy skin, and aiding in digestion (Duselis, Amanda R et al., 2007 and Amend, Sarah R et al., 2016). The National Family Health Survey (N.F.H.S) recognizes improved sources of drinking water, "including piped water, public taps, standpipes, tube wells, boreholes, protected dug wells and springs, rainwater, and community reverse osmosis (RO) plants". These sources help safeguard against external contamination, ensuring that the water is safe for consumption.

Table 2 reveals that significant percent of households had increaseaccess to improved source of drinking water in India and its states during the study period. In N.F.H.S-1, only over 40.0 percent access to improved source of drinking water in states like Assam, Manipur, Meghalaya, Mizoram, Tripura and Kerala being with least 21.0 percent) wherein most of the households get drinking water from open well with the premises of house in general., over 80.0 percent and 90.0 percent of household have access in most of the states and in India in N.F.H.S-3 and N.F.H.S-4 respectively. However, in most of the states and in India, over 95.0 percent of households have access to improved source of drinking water in N.F.H.S-5. This clearly indicates that most of people are protected from water born diseases with having access to improved source of drinking water.

Toilet facilities

According to the World Health Organization, open defecation is considered the most dangerous sanitation practice. Nearly 10 percent of all communicable diseases are associated with unsafe water and inadequate sanitation. In 1986, the Government of India initiated the Central Rural Sanitation Programme (CRSP) to enhance sanitation coverage in rural areas, aiming to improve the health and quality of life of rural residents, especially women, by providing privacy and dignity. The Total Sanitation Campaign (TSC), a variant of CRSP, was introduced in 1999 with a community-driven and people-centric approach. Despite efforts to achieve the MDG Goal of 'Sanitation for All' by 2012, the TSC programs fell short. The 2011 Census revealed that almost half of Indian households (49.8 percent) practices open defecation, with 53 percent lacking toilet facilities in their premises. A study by[3] based on the 2011 Census indicated that central Indian states have higher rates of open defecation compared to the rest of the country. While a significant portion of the population lacks household toilets, a majority own mobile phones. Cultural norms, traditional beliefs, lack of awareness, and low education levels are cited as the main reasons for this unhygienic practice[1]. The National Family Health Survey (N.F.H.S) defines toilet facilities as "any non-shared toilet types, including flush/pour flush toilets connected to piped sewer systems, septic tanks, and pit latrines; ventilated improved pit (VIP)/biogas latrines; pit latrines with slabs; and twin pit/composting toilets".

Table 3 depicts drastic improvement in households with any toilet facility in India and its states duringof N.F.H.S-1 of1992-93 and N.F.H.S-5 of 2019-20. In N.F.H.S-1, less than 25.0 percent of household have access to toilet in states like Himachal Pradesh, Jammu & Kashmir, Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Odisha and Andhra Pradesh. About 30.0 percent households have no toilet facility in state like Himachal Pradesh, Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Odisha and Andhra Pradesh in N.F.H.S-2, while significant percent of households had access to toilet facility in majority of the states and in India during the period of N.F.H.S-3 and N.F.H.S-4. However, less than 25.0

Table 1. Percent of households with electricity in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3(2005-06)	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	95.5	97.7	99.3	98.8	99.9
2.	Haryana	85.0	89.1	91.5	98.8	99.5
3.	Himachal Pradesh	90.2	97.2	98.4	99.5	99.4
4.	Jammu & Kashmir	86.7	90.1	93.2	97.4	99.3
5.	Punjab	92.0	95.5	96.3	99.6	99.6
6.	Rajasthan	51.9	64.4	66.1	91.0	97.9
7.	Uttarakhand	-	-	80.0	92.5	99.4
8.	Chhattisgarh	-	-	71.4	95.6	98.5
9.	Madhya Pradesh	62.4	68.1	71.4	89.9	98.1
10.	Uttar Pradesh	31.9	36.6	42.8	70.9	89.8
11.	Bihar	16.6	18.2	27.7	58.6	95.6
12.	Jharkhand	-	-	40.2	95.6	98.5
13.	Odisha	27.8	33.8	45.4	85.5	96.3
14.	West Bengal	32.9	36.7	52.5	93.7	97.0
15.	Arunachal Pradesh	63.1	68.9	76.9	88.7	94.7
16.	Assam	20.4	26.4	38.1	78.2	92.7
17.	Manipur	62.1	75.3	67.0	92.4	97.8
18.	Meghalaya	42.6	41.2	70.4	91.4	92.0
19.	Mizoram	76.0	64.1	92.3	95.9	98.0
20.	Nagaland	76.9	56.3	82.9	96.9	98.6
21.	Sikkim	-	80.7	92.1	99.4	99.3
22.	Tripura	45.1	-	68.8	92.7	97.9
23.	Goa	91.7	93.5	96.4	99.8	100.0
24.	Gujarat	76.6	84.3	89.3	96.0	97.2
25.	Maharashtra	73.6	82.1	83.5	92.5	97.4
26.	Andhra Pradesh	62.2	74.4	88.4	98.8	99.1
27.	Karnataka	64.0	80.9	89.3	97.8	98.8
28.	Kerala	60.3	71.8	91.0	99.2	99.5
29.	Tamil Nadu	63.8	78.8	88.6	98.8	99.0
30.	Telangana	-	-	-	98.3	99.3
India		**50.9**	**60.1**	**67.9**	**88.2**	**96.5**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health and Family Welfare, New Delhi, National Family Health Survey-1 to 5.

percent of household had not having toilet facility in states like Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Odisha, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu in the period of N.F.H.S-5, it causes to practice open defecation. No access to sanitary toilet provisions led to no ensure of hygiene conditions. It reveals the extreme conditions that exist in these states there by riskiest sanitation practice may causes to water and air born diseases that leads ill health of people.

Use of solid fuel for cooking

Exposure to indoor smoke, whether from cooking with solid fuels or smoking tobacco, can have adverse health effects. The risk of exposure to cooking smoke is higher when cooking is done indoors rather than in a separate structure or outdoors. India faces a significant challenge in providing safer cooking fuel options. The United Nations' efforts to combat extreme poverty may not reach their full potential unless countries prioritize bringing electricity and modern, safe cooking technologies to the billions of energy-poor individuals worldwide[13]. Majority (71.5 percent) of

Table 2. Percent of households with improved source of drinking water in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3 (2005- 06	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	99.5	98.7	92.1	80.0	99.5
2.	Haryana	73.0	88.0	95.6	91.6	98.6
3.	Himachal Pradesh	57.6	77.4	88.4	94.6	96.4
4.	Jammu & Kashmir	57.3	70.6	80.8	89.2	92.3
5.	Punjab	98.6	98.9	99.5	99.1	98.8
6.	Rajasthan	57.3	69.8	81.8	85.5	96.4
7.	Uttarakhand	-	-	87.4	92.9	95.5
8.	Chhattisgarh	-	-	77.9	91.1	95.6
9.	Madhya Pradesh	55.8	63.5	74.2	84.7	88.9
10.	Uttar Pradesh	74.3	85.6	93.7	96.4	99.2
11.	Bihar	63.6	75.4	96.1	98.2	99.1
12.	Jharkhand	-	-	57.0	77.7	86.8
13.	Odisha	50.9	65.3	78.4	88.8	90.8
14.	West Bengal	84.9	89.3	93.7	94.6	97.5
15.	Arunachal Pradesh	75.8	80.7	85.0	87.5	94.2
16.	Assam	43.2	60.1	72.4	83.8	86.4
17.	Manipur	47.0	48.9	52.1	41.6	77.0
18.	Meghalaya	47.6	42.1	63.1	67.9	79.2
19.	Mizoram	40.1	63.2	85.0	91.4	95.7
20.	Nagaland	72.1	40.5	62.8	80.6	91.0
21.	Sikkim	-	84.6	77.6	97.6	94.0
22.	Tripura	44.1	-	76.1	87.3	88.5
23.	Goa	56.5	61.8	80.1	96.3	98.2
24.	Gujarat	75.1	84.5	89.8	90.9	97.5
25.	Maharashtra	78.5	81.9	92.7	91.5	93.8
26.	Andhra Pradesh	63.4	78.5	94.0	72.7	96.7
27.	Karnataka	75.6	87.0	86.2	89.3	95.6
28.	Kerala	21.0	19.9	69.1	94.3	94.9
29.	Tamil Nadu	74.6	85.0	93.5	90.6	98.6
30.	Telangana	-	-	-	77.9	98.7
India		**68.2**	**77.9**	**87.9**	**89.9**	**95.9**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health and Family Welfare, New Delhi, National Family Health Survey-1 to 5.

Table 3. Percent of households with toilet facility in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3 (2005-06)	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	84.1	94.4	92.4	96.0	98.7
2.	Haryana	26.9	39.0	52.4	89.8	96.6
3.	Himachal Pradesh	12.6	26.7	46.4	85.7	93.5
4.	Jammu & Kashmir	19.1	51.0	61.7	79.3	94.3
5.	Punjab	36.7	51.4	70.8	92.9	97.2
6.	Rajasthan	19.8	27.8	30.8	54.0	77.5
7.	Uttarakhand	-	-	56.8	82.9	93.6
8.	Chhattisgarh	-	-	18.7	41.3	84.7
9.	Madhya Pradesh	21.3	22.2	27.0	42.8	73.8
10.	Uttar Pradesh	22.9	26.5	33.1	45.8	77.1
11.	Bihar	16.5	16.8	25.2	33.5	61.6
12.	Jharkhand	-	-	22.6	30.0	66.4
13.	Odisha	12.2	13.5	19.3	35.0	66.1
14.	West Bengal	40.4	44.8	59.6	74.9	88.0
15.	Arunachal Pradesh	73.6	73.0	80.6	90.8	98.5
16.	Assam	49.6	63.0	76.4	88.9	95.8
17.	Manipur	83.1	92.0	95.6	98.7	99.5
18.	Meghalaya	54.3	52.0	71.3	92.4	95.8
19.	Mizoram	98.3	97.7	98.0	99.1	99.9
20.	Nagaland	79.3	74.3	85.6	98.3	99.6
21.	Sikkim	-	72.7	89.0	99.7	99.6
22.	Tripura	79.4	-	96.7	97.9	98.9
23.	Goa	48.0	58.9	76.0	89.1	96.3
24.	Gujarat	35.0	44.9	54.6	71.0	80.7
25.	Maharashtra	40.8	45.9	52.9	71.2	82.7
26.	Andhra Pradesh	24.4	27.3	42.4	61.3	83.7
27.	Karnataka	31.2	38.6	46.5	65.8	82.3
28.	Kerala	70.9	85.2	96.1	99.2	99.7
29.	Tamil Nadu	29.4	34.0	42.9	61.7	77.5
30.	Telangana	-	-	-	69.0	87.3
India		**30.3**	**35.9**	**44.6**	**61.1**	**80.6**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health And Family Welfare, New Delhi, National Family Health Survey-1 to 5.

households in India still rely on firewood, crop residue, cow dung cakes, or coal for cooking, which are common traditional fuels in rural areas[1]. It is estimated that up to 70 percent of households in developing nations use wood, dung, and crop residues for cooking (International Energy Agency, 2002). The National Family Health Survey considers solid fuels for cooking to include "coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crop waste, and dung cakes".

Table 4 reveals the substantial variations across in India and states in households with usedsolid fuel for cooking. Significant percent of households had used solid fuel for cooking during the period of N.F.H.S-1 and N.F.H.S-4 in India and many states. Even in N.F.H.S-5 period also, over 50.0 percent of households used solid fuel for cooking in India and its many states. Hence, burn of solid fuel for cooking causes to harmful air pollution that leads health impact on lungs related diseases especially among women and children.

Type of House

Houses owned by the wealthy are considered 'pucca', indicating that they are constructed using durable materials such as stone, brick, and cement. On the other hand, the houses

Table 4. Percent of households with solid fuel for cooking in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3 (2005-06)	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	4.4	3.6	9.3	3.6	0.8
2.	Haryana	55.6	66.9	69.1	47.4	40.1
3.	Himachal Pradesh	84.8	64.0	68.9	62.5	47.7
4.	Jammu & Kashmir	64.9	65.8	59.5	41.5	30.2
5.	Punjab	44.9	60.6	54.9	33.5	22.1
6.	Rajasthan	81.0	81.0	77.2	67.8	58.5
7.	Uttarakhand	-	-	61.7	48.1	40.5
8.	Chhattisgarh	-	-	86.7	76.7	66.4
9.	Madhya Pradesh	68.2	79.3	80.3	69.7	59.3
10.	Uttar Pradesh	68.3	82.8	81.7	66.7	50.3
11.	Bihar	51.1	85.9	89.7	81.9	62.0
12.	Jharkhand	-	-	89.1	80.6	67.8
13.	Odisha	68.7	86.8	88.6	79.6	64.9
14.	West Bengal	31.6	65.7	79.2	69.6	59.1
15.	Arunachal Pradesh	87.7	80.8	67.7	54.2	46.6
16.	Assam	87.8	87.1	75.8	74.2	56.4
17.	Manipur	80.5	69.2	64.7	57.6	29.6
18.	Meghalaya	82.0	83.5	72.2	74.7	63.4
19.	Mizoram	66.2	57.4	34.1	31.2	16.0
20.	Nagaland	97.4	86.1	76.0	66.6	56.5
21.	Sikkim	-	63.2	52.4	39.1	20.7
22.	Tripura	91.1	-	80.4	62.1	53.0
23.	Goa	51.3	41.4	33.3	13.7	2.8
24.	Gujarat	55.9	54.5	52.3	44.2	32.2
25.	Maharashtra	55.2	51.9	48.1	36.0	18.2
26.	Andhra Pradesh	77.0	74.1	66.3	37.1	15.6
27.	Karnataka	75.4	67.8	63.8	43.4	19.4
28.	Kerala	87.4	81.7	71.4	42.3	27.4
29.	Tamil Nadu	77.7	66.5	60.5	24.3	15.4
30.	Telangana	-	-	-	30.8	7.7
India		63.9	71.7	70.8	54.7	40.6

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health And Family Welfare, New Delhi, National Family Health Survey-1to5.

of the poor are categorized as 'Semi katcha' or 'katcha', as they are built using less durable materials like country tiles, stone rubbles, mud, and thatch, which are readily available locally. In rural areas of India, the design of houses is influenced by the availability of local building materials. The construction of houses in rural settings aims to fulfill the functional needs of the families residing in them. Approximately 12 percent of residential structures in India are temporary in nature. The eastern and central regions (West Bengal, Odisha, Bihar, Jharkhand, and Chhattisgarh) have a higher percentage of dilapidated houses used for residential purposes, while the southern and western states report the lowest percentage [1]. According to the National Family Health Survey (N.F.H.S), "pucca houses are those constructed using high-quality materials for the floor, roof, and exterior walls".

Table 5 reveals the substantial variations in households living in a pucca house in India and its states during the period of N.F.H.S-1 to N.F.H.S-5 and majority of households were not lived in pucca houses in many states. However, an improvement was observed in percent of households living in a pucca house in India and its states during the period of N.F.H.S-1 to N.F.H.S-5 due to construction of pucca for socio-

Table 5. Percent of households living in a pucca house in India and its states

S. No	India/ State	NFHS-1 (1992‑93)	NFHS-2 (1998-99)	NFHS-3 (2005-06)	NFHS-4 (2015-16)	NFHS-5 (2019-21)
		Total	Total	Total	Total	Total
1.	Delhi	81.0	88.2	94.9	90.3	93.7
2.	Haryana	39.6	46.7	61.1	76.3	76.5
3.	Himachal Pradesh	22.7	28.7	52.7	70.2	76.1
4.	Jammu & Kashmir	32.5	36.1	50.3	70.9	75.2
5.	Punjab	52.6	52.1	68.9	80.8	78.3
6.	Rajasthan	38.1	41.4	50.1	64.2	54.4
7.	Uttarakhand	-	-	49.8	64.5	75.7
8.	Chhattisgarh	-	-	21.7	35.9	43.2
9.	Madhya Pradesh	13.8	19.2	26.2	35.7	45.2
10.	Uttar Pradesh	20.1	24.8	28.8	33.1	40.5
11.	Bihar	15.5	15.5	20.4	25.9	34.0
12.	Jharkhand	-	-	28.3	37.9	42.8
13.	Odisha	9.5	14.8	31.9	44.5	59.0
14.	West Bengal	22.5	32.8	39.5	46.5	52.5
15.	Arunachal Pradesh	2.2	14.2	20.8	23.9	24.5
16.	Assam	2.2	10.9	19.8	25.2	31.6
17.	Manipur	4.9	7.1	10.7	17.7	22.6
18.	Meghalaya	3.9	14.5	35.1	43.0	45.0
19.	Mizoram	6.0	16.2	22.9	54.7	50.5
20.	Nagaland	8.4	18.1	20.7	28.4	33.5
21.	Sikkim	-	50.6	51.0	71.6	75.7
22.	Tripura	3.1	-	12.1	26.6	33.0
23.	Goa	54.0	51.0	73.0	84.2	90.0
24.	Gujarat	33.2	45.2	67.3	77.1	77.2
25.	Maharashtra	30.6	28.3	59.0	72.9	76.8
26.	Andhra Pradesh	31.3	39.9	56.3	81.5	84.6
27.	Karnataka	16.5	41.2	55.1	62.9	63.7
28.	Kerala	19.9	79.8	85.1	89.0	83.4
29.	Tamil Nadu	22.7	27.6	69.9	78.9	87.9
30.	Telangana			-	75.0	79.2
India		**23.7**	**32.0**	**45.9**	**56.3**	**60.3**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health And Family Welfare, New Delhi, National Family Health Survey-1 to 5.

cultural and economically marginalized by the governments under housing schemes. But still in N.F.H.S-5 period, 30.0 percent in India and over half of sampled households were not living in a pucca house in the states like Madhya Pradesh, Uttar Pradesh, Bihar, Arunachal Pradesh, Assam, Manipur, Meghalaya and Tripura. This clearly indicates that significant percent of households not had living in a pucca house in India and its states due to poor socio-economic, cultural and geographical reasons though pucca house is being the one of basic need of human being to live comfortably.

Person per room

The measure of crowding known as ”persons per room” takes into account all the rooms in a private dwelling and the number of people living in the household. A higher value for ”persons per room” indicates a greater level of crowding. In India, approximately 3.9 percent of households do not have rooms specifically designated for residential purposes [1]. According to the Census 2011 data, there are 43,813 families living in shared rooms, with nearly 40,000 of them located in urban Delhi. This data clearly highlights a significant proportion of the lower middle class residing in shared rooms

Table 6. Percent of households with mean number of persons per room used for sleeping in India and its states

S. No	India/ State	NFHS-1 (1992‑93)2222	NFHS-2 (1998-99)	NFHS-3 (2005- 06)2222	NFHS-4 (2015-16)	NFHS-5 (2019-21)2222
		Total	Total	Total	Total	Total
1.	Delhi	2.6	2.2	3.1	2.9	2.8
2.	Haryana	2.9	2.4	3.3	2.7	2.7
3.	Himachal Pradesh	2.1	1.8	2.5	2.1	2.0
4.	Jammu & Kashmir	2.8	2.2	2.9	2.5	2.1
5.	Punjab	2.7	2.1	3.1	2.7	2.6
6.	Rajasthan	3.0	3.0	3.6	3.0	2.7
7.	Uttarakhand	-	-	3.0	2.7	2.5
8.	Chhattisgarh	-	-	3.0	2.8	2.4
9.	Madhya Pradesh	2.8	2.9	3.6	3.1	2.8
10.	Uttar Pradesh	3.0	3.1	3.8	3.4	3.0
11.	Bihar	2.8	2.9	3.3	3.3	3.0
12.	Jharkhand	-	-	3.2	2.7	2.4
13.	Odisha	2.4	2.4	3.1	2.8	2.5
14.	West Bengal	2.8	2.7	3.1	2.7	2.4
15.	Arunachal Pradesh	2.9	2.2	2.7	2.1	1.7
16.	Assam	2.4	2.1	2.7	2.3	2.1
17.	Manipur	2.1	2.1	2.6	2.4	2.3
18.	Meghalaya	2.1	2.0	2.9	2.3	2.3
19.	Mizoram	2.0	2.6	3.5	3.0	2.6
20.	Nagaland	1.9	1.6	2.6	2.1	1.6
21.	Sikkim	-	2.0	2.3	1.9	1.5
22.	Tripura	2.4	-	2.9	2.4	2.3
23.	Goa	1.8	1.6	2.7	2.4	2.2
24.	Gujarat	3.3	2.7	3.6	3.2	3.0
25.	Maharashtra	3.2	3.0	3.5	3.2	2.9
26.	Andhra Pradesh	2.8	2.9	3.2	2.9	2.7
27.	Karnataka	2.7	2.5	3.4	2.7	2.5
28.	Kerala	1.4	1.3	2.2	1.8	1.8
29.	Tamil Nadu	2.5	2.2	2.9	2.4	2.3
30.	Telangana	-	-	-	3.0	2.6
India		**2.8**	**2.7**	**3.3**	**2.9**	**2.7**

Source: International Institute for Population Sciences (IIPS) and Government of India; Ministry of Health And Family Welfare, New Delhi, National Family Health Survey-1 to 5.

within the city's population.

Table 6 reveals the significant variations across in India and its states in mean number of persons per room used for sleeping during N.F.H.S 1 of 1992-93 to N.F.H.S-5 of 2019-21. On an average 2.5 mean number of persons per room used for sleeping in India and in many states. However, over 2.5 mean number of persons per room used for sleeping in states like Delhi, Haryana, Himachal Pradesh, Punjab, Rajasthan, Madhya Pradesh, Mizoram, Maharashtra, AndhraPradesh, Kerala Andhra Pradesh, and highest being 3.0 mean number of persons in Uttar Pradesh, Bihar, Gujarat in N.F.H.S-5 period. In states with higher mean number of persons per room used for sleeping can be problems such as individual privacies, congested and health issues especially such as the period of Covid-19 etc.

Conclusion

Drastic improvement had observed in house hold electricity and improved source of drinking water during the period of N.F.H.S-1 to N.F.H.S-5. All most of sampled households' access to have electricity (97%) and over 95.0 percent of households have access to improved source of drinking water in India and its states in N.F.H.S-5. However, less than 25.0 percent of household had not having any toilet facility in states like Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Odisha, Gujarat, Maharashtra, Andhra Pradesh, Karnataka Tamil Nadu and Telangana in the period of N.F.H.S-5. Substantial variations have observed across in India and its states in households with use of solid fuel for cooking. Over 50.0 percent of households used solid fuel for cooking in India and its many states. This could lead to lungs and heart diseases. Over 2.5 mean number of persons per room used for sleeping in states like Delhi, Haryana, Himachal Pradesh, Punjab, Rajasthan, Madhya Pradesh, Mizoram, Maharashtra, Andhra Pradesh, Kerala, Andhra Pradesh, Telangana and highest being 3.0 mean persons per room used for sleeping observed in Uttar Pradesh, Bihar and Gujarat, can be cause to problems such as personal and health. Therefore, the N.G.Os and govern agencies should make better inclusive policies related sanitation/toilet, clean fuel for cooking and pucca house for poor/ marginalized sections that are the highest level of deprivation and contributing to poor health, high mortality and low quality of living.

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SRIVENKATESWARAUNIVERSITY

Tirupati – 517502
(AndhraPradesh)

PROF.M.BHUPATHI NAIDU
REGISTRAR

No.SVU/C&G/2024 Date : 16.08.2024

NOTE TO THE PRINICPALS OF THE CONSTITUENT COLLEGES

Sub: S.V. University – To conduct Clean & Green programme on 17.08.2024 – To observe office timings from 8.00 AM to 1.30 PM – Regarding.

* * * * *

It is to inform that, the University officials has decided to conduct "CLEAN & GREEN" programme in the campus on 17.08.2024 and you are requested to instruct all the Heads of the Departments, Office staff and students under your control to participate in the Clean and Green programme in order to make the University Campus Clean and Tidy.

In view of the above, the college office will work from 8.00 A.M. to 1.30 P.M on17.08.2024

16/8/24

REGISTRAR

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S.V. UNIVERSITY
TIRUPATI.

Copy to the University Engineer i/c, S.V. University, Tirupati, with a request to provide necessary support to the Principals.
Copy to the P.S. to the Vice-Chancellor, S.V. University, Tirupati.

DEPT. OF POPULATION STUDIES & SOCIAL WORK,

SRI VENKATESWARA UNIVERSITY

Tirupati, A.P - 517 502.

Certificate of Participation

Certify that Y.Sujatha

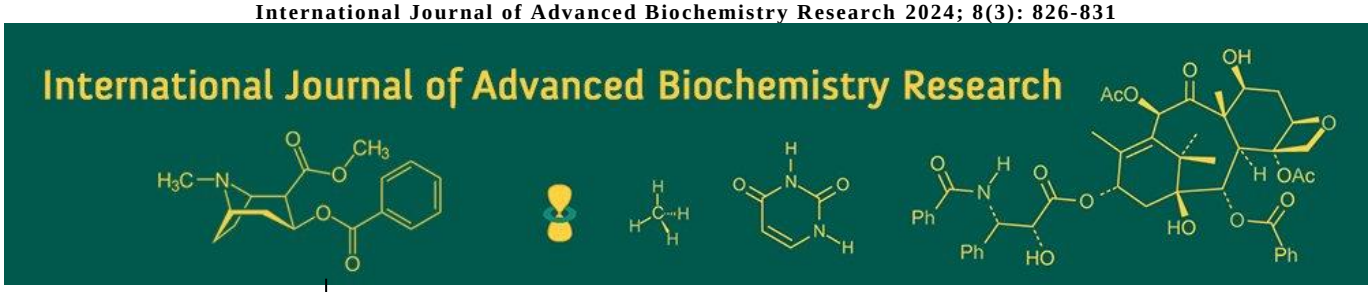
Designation Assistant Professor *Dept. of* Geography

has participated in one day online workshop on "Selection of UGC Care/ Web of Science/ Scopus Journals for publication of Research Papers" *Organized on 15 July, 2024.*

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Study on effect of millet milk on spleen iron concentration

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Abstract
Infant nutrition is the basis of the body's reservoir of nutrients including iron. Babies are born with a reserves of iron, which comes from their mother's blood, while they are in womb.
For the first 6 months of life, baby's get the nutrients from their mother's milk and is sufficient for the growth and development of infants. After 6 months of their life iron becomes a critical nutrient. The estimated daily iron requirement at the age of 6 to 12 months (0.9 to 1.3 mg per kg body weight) are higher than during any other period of life. During this period, they get the iron through infant milk formula and later from solid foods. From 6 months of age all infants should receive a sufficient intake of iron rich foods which may be meat products or iron fortified foods. Breast milk, infant formula, and water should be the only drinks offered after 6 months of age. A wide range of solid foods, including iron containing foods, should be introduced in an age appropriate form from around 6 months of age along with continued breastfeeding.
According to the American academy of pediatrics suggests that breast fed infants should be supplemented with 1mg/kg per day of oral iron. Standard infant formulae contain 12 mg per liter can full fill the needs of iron in infants until the age of 1year. Supplementation of iron through mediations may cause problems in health. Hence better to get iron through diet like iron fortified cereals.
The best food sources of iron are whole grain cereals, pulses, and legumes, liver, egg yolk and fish. And the best plant sources are green leafy vegetables such as radish greens, lotus stems, cauliflower greens, and turnip greens. Fruits such as watermelon, black currants, raisins and dried dates are rich sources of iron. Millets and soya based infant formula are best alternatives for milk because they are rich in iron along with other nutrients.
All the breast fed infants are not tolerated to breast milk because some infants are not able to digest lactose, the sugar present in milk. They do not produce enough enzyme known as Lactase which is used to digest lactose in the milk. This condition is called Lactose intolerance. Symptoms of lactose intolerance usually develop within a few hours of consuming food or drink that contains lactose. They may include bloating, diarrhoea, flatulence and abdominal cramps. The lactase enzyme is needed to break down lactose into glucose and galactose, which can then be absorbed into the bloodstream and used for energy.
An allergy to cow's milk and related dairy products affects one in 50 babies and is different to lactose intolerance. Peoples who are allergic to cow's milk can also be allergic to milk from other animals such as goats, sheep and buffalo. A cow's milk allergy can cause symptoms such as wheezing and asthma, diarrhoea, vomiting, and gastrointestinal distress. Other reactions include eczema, an itchy rash and rhinitis or inflammation in the nose. In several cases, it can lead to bleeding, pneumonia, and even anaphylaxis, a potentially fatal hypersensitivity reaction.
As concern about lactose intolerance and milk allergies widen, a range of substitute milks, such as millet and soya milk, have become available. Milk has long been seen as a healthy drink, because it is high in range of nutrients.
According to medical advice:
- Milk alternatives include soya milk and millet milk are the great sources of nutrients.
- Each type has a different nutritional profile, so it is important to check that all the nutrient requirements are meeting or not.
- Some plant based milk is not suitable for children, but it is possible to consume a balanced diet without dairy products.

Keywords: Lactose intolerance, breast feeding, infant milk formula, millet milk, soya milk, iron

Introduction
Millet is the main food source for people living in the drought and semi-arid tropics of Asia and Africa. Millet is an important source of carbohydrates, proteins and minerals. Due to its importance to national food security and potential health benefits, millet grains are currently receiving increased interest from scientists, engineers, and nutritionists. (Ahmed Sn Saleh *et al.*, 2013) [2].

According to IIMR (Indian Millet Research Institute), India was the largest millet producing country in 2000 and 2009, followed by Nigeria. The most common millet is pearl millet, which is an important crop in India. India is a major producer of small millets such as finger millet, porso millet, foxtail millet, kodo millet.

Importance

Millet contains health-promoting secondary plant substances such as polyphenols, lignin, phytosterols, phytoestrogens, and phytocyanins. These act as antioxidants, immune modulators, antidotes, etc.). Therefore, millet protects against age-related degenerative diseases such as cardiovascular disease, diabetes, and cancer. [Rao *et a1*. 2011] [6].

It is also rich in vitamins, minerals and essential fatty acids, which have health benefits in terms of preventing degenerative and malnutrition diseases. Millets are known to have high nutritional value comparable to major grains such as wheat and rice. [Saleh *et al*. 2013] [2]. Furthermore, it is rich in essential amino acids except lysine and threonine, but it also contains relatively high amounts of methionine. Millet grains exhibit prebiotic activity that helps increase the number of beneficial bacteria that play an important role in promoting digestion (Sarita *et al*. 2016) [1]. Millet is safe for people with gluten allergies and celiac disease. They do not produce acids and are not allergenic (Saleh *et al*. 2013) [2].

Millets are rich sources of insoluble fiber, binds with triglycerides in the body and remove out from the body to prevent coronary artery disorders. The ant diabetic effect of millet is mainly due to its rich fiber content. (Jayabhaye. *et al.* 2010) [4]. The high fiber content in millet and the presence of some anti-nutritional factors such as phytates and tannins affect the bioavailability of minerals. The phytonutrient lignin in millet is converted to mammalian lignin in the intestines, which protects against breast cancer. Mill*et al*so helps in losing weight as it is rich in fiber. It creates a feeling of fullness.

Nutrition in millets

Millet is a rich source of nutritional supplements and contains more fiber than wheat (or) rice. It also contains protein (9-14%). -80% carbohydrates. Millets such as sorghum and ragi are important sources of essential amino acids and micronutrients such as calcium, iron, and zinc in the Indian diet, especially for people living in poor socio-economic conditions. (Maha Lakshmi *et al*., 1997) [5]. A variety of traditional household food processing and preparation methods can also be used to improve the bioavailability of micronutrients in plant-based diets. These include heat treatment, mechanical treatment, steeping, fermentation and germination (or) malting. The purpose of these processing techniques is to increase the physicochemical accessibility of micronutrients and reduce the content of anti-nutrients such as phytates (or) increase the content of compounds that improve their bioavailability (Ahmed Sn Saleh 2013) [2].

Millet is an excellent source of magnesium and phosphorus. Magnesium can help reduce the effects of migraines and heart attacks, and phosphorus is an essential component of adenosine triphosphate (ATP), the body's energy precursor. Finger millet lowers plasma cholesterol, serum total cholesterol, and LDL cholesterol by 9% each, lowers triglycerides by 15%, and increases HDL cholesterol. This has a pronounced positive effect on the plasma profile. [Kajal Srivastava *et al*., 2012] [3]. Pearl millet has the highest protein content among all cereals which is helpful for tissue growth and muscle development, it has a property to convert acidic condition to alkaline to prevent stomach ulcers. The high fiber content in pearl millet is known to reduce gallstones occurrence. Ragi is a folk remedy for leprosy, liver disease, measles, pleurisy, pneumonia, and pneumonia. [Kajal Srivastava *et al*., 2012] [3].

Iron

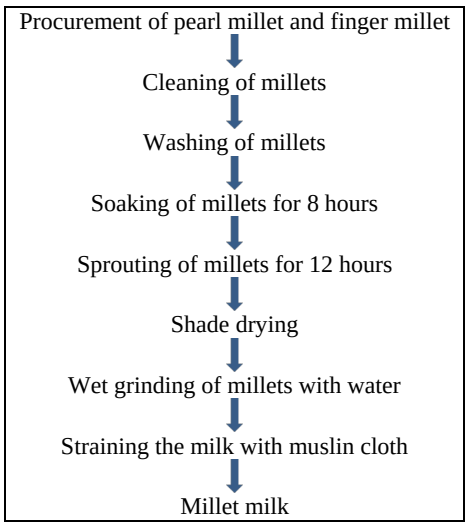
Iron is a micronutrient found in many foods, and daily intake of milligram amounts is sufficient for physical health and mental well-being. Iron deficiency is a major health problem worldwide. The average iron content in the body of an adult is about 4 g, about 50% of the iron is in the form of hemoglobin, and more than 25% of the iron is stored in the liver, spleen and bone marrow. The remaining small amount of iron forms myoglobin (which acts as an oxygen store) and other iron- containing proteins. Humans absorb approximately 12 to 18 mg of iron each day. Only 1-2 mg of iron is absorbed. (Journal of Medical Research (2008). Iron mainly exists in the human body in the form of complexes, which include heme compounds (Hemoglobin (or) myoglobin), heme enzymes (Or) proteins (Heme proteins) as the non-heme compound ferritin and transferrin (J Res Med sci. 2014). Primarily, iron is required for the production of heme enzymes, which are responsible for electron transport, oxidation, and reduction, and for the synthesis of heme proteins, which are responsible for gas transport in the body.

Materials and Methods

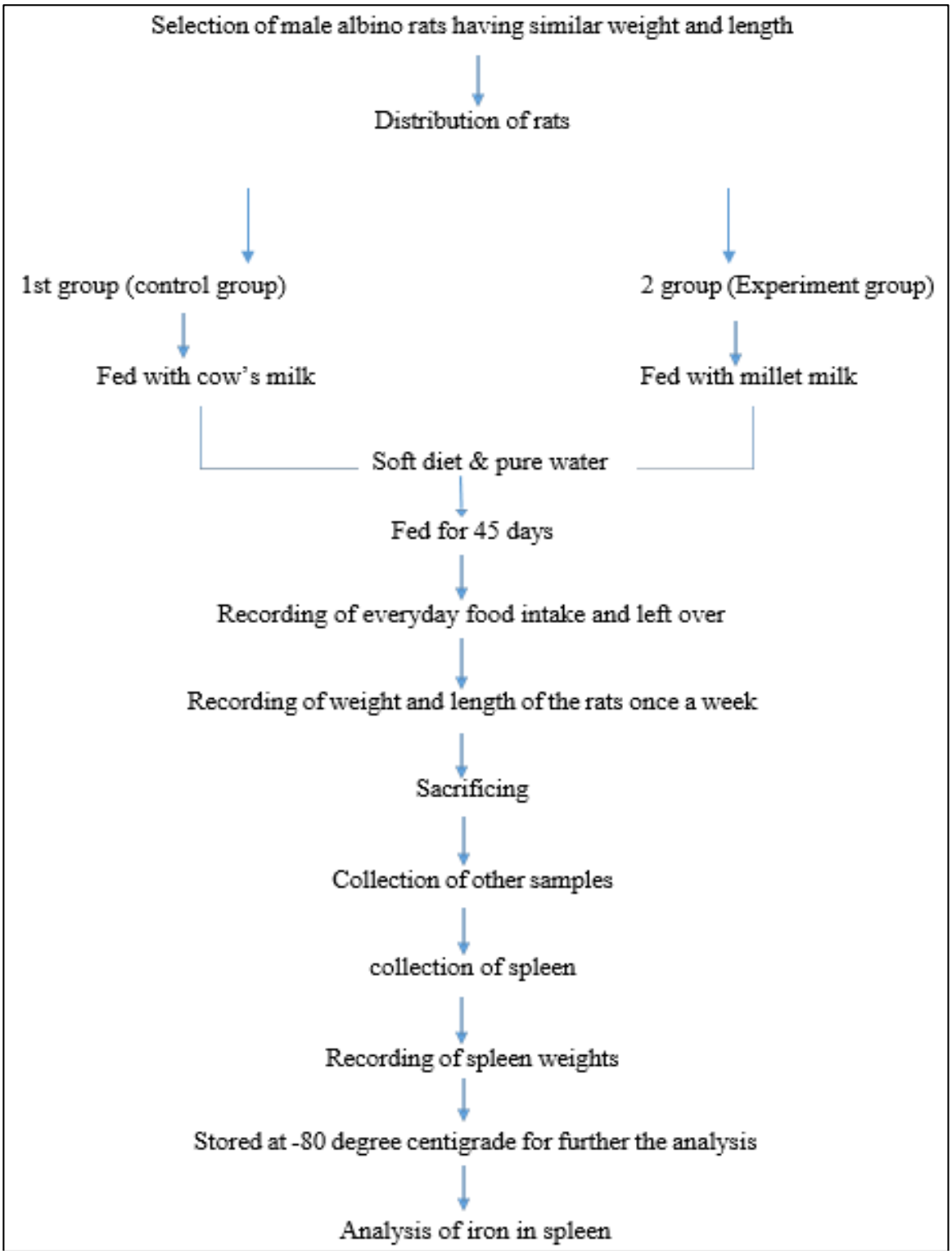
Selection and standardization of ingredients

For extracting milk two millets namely finger millet and pearl millet were selected. Finger millet is referred as the power house of proteins, minerals and amino acids. Among all cereals, finger millet has the highest calcium percentage and also rich in amino acids tryptophan, threonine, alanine, isoleucine and methionine. Pearl millet is also called as miracle millet as it contains iron which is eight times higher than in rice. Pearl millet is also a good source of protein, calcium, folic acid, fat, fiber, phosphorous and niacin. Millets used in study were procured from the local market in Tirupati.

Millet milk extraction process



Experimental Work



Feeding of rats

Each group of rats were fed with respective diets adlibitum. Everyday 7:00 a.m. in the morning and 5:00 p.m. in the evening, the leftover feed was weighed and recorded and then the rats were fed with the fresh stock diet and millet milk in the morning and only the stock diet during the evenings. The weekly consumption of feed was also increased from 5 ml to 15 ml by the end of the experiment based on their acceptance. The weekly consumption of feed was also increased after observing the zero percentage of leftover. During the first week the stork diet given was 10 grams which was gradually increased to 20 grams by the end of the experiment. Care was taken to clean and sterilize the Water bottles and food cups daily before administering the diet.

Growth-parameters

Sacrificing

The rats were not fed with any food before 24 hours of the sacrifice but the weight and length of the rats were measured. The rats were euthanized (Decapitated). Immediately after decapitation, the spleen was removed from the body. Spleen of the rats were collected individually, weighed, rinsed it with alcohol and further

analysis was carried out to estimate the iron content in the spleen.

Analysis

Spleens were weighed and stored at -80 degrees centigrade until prepared for the analysis. Spleen tissue iron concentrations were determined using a modification of the genome protocol.

Reagents required for estimation of spleen Ion concentration: Protein precipitant

100 grams of trichloro acetic acid dissolved in 700 ml of water and add 30 ml of thio glycolic acid and 86 ml of concentrated HCL, make up to 1 liter. It can be stored in 2 months.

Color reagent

Dissolve 204 gram of Sodium acetate tri hydrate dissolved in 800 ml of water add 250 milligrams of batho phenanthroline sulphate and make up to 1 liter, and stored in a dark bottle the reagent stables for 2 weeks at least.

Analysis

Spleens were weighed and stored at -80 degrees centigrade until prepared for the analysis. Spleen tissue iron concentrations were determined using a modification of the genome protocol.

Reagents required for estimation of spleen Ion concentration

Protein precipitant

100 grams of trichloro acetic acid dissolved in 700 ml of water and add 30 ml of thio glycolic acid and 86 ml of concentrated HCL, make up to 1 liter. It can be stored in 2 months.

Color reagent

Dissolve 204 gram of Sodium acetate tri hydrate dissolved in 800 ml of water add 250 milligrams of batho phenanthroline sulphate and make up to 1 liter, and stored in a dark bottle the reagent stables for 2 weeks at least.

Glassware's required

1. 100 ml standard flask
2. 10 ml measuring cylinder
3. Test tubes
4. Centrifuge tubes

Instruments required

1. Weighing balance
2. Centrifuge machine
3. Optical emissions spectrophotometer

Procedure for estimation of spleen iron



Table 1: Spleen iron levels of control and experiment group rats

Rats	Control group with cow milk (µg/g)	Experiment group with millet milk (µg/g)	T value
1	351.4	260.09	
2	305.3	399.29	
3	292.4	281.9	
4	272.2	242.7	
5	410.6	349.7	
6	329.5	212.5	
7	347.4	222.7	
8	429.1	308.7	
9	339.9	281.0	
10	348.4	304.4	
⁀	302.7	396.2	
12	344.0	361.8	
mean	339.3 ± 100	301.7 ± 100	0.112 NS

NS – Not significant

The data in the Table no.1 interprets the spleen iron levels of control and experimental group rats. The mean spleen iron levels of the control group were 339.3 µg/g and the experiment group was 301.7µg/g. There was no significant difference of spleen iron levels between both control and experiment groups. Hence the iron levels are almost equal between control and experiment rats and the millet milk is as good as cow's milk for feeding the infants. According to Jennifer Gibson et.al, (2011) the levels of iron concentration in male rats which were fed with adequate nutrition diet with adequate iron was 12.739 µg to 3869 µg. In the present study also the range was between in control rats 272.2 µg to 429.1 µg, and experiment rats between 212.5 µg to 399.29 µg.

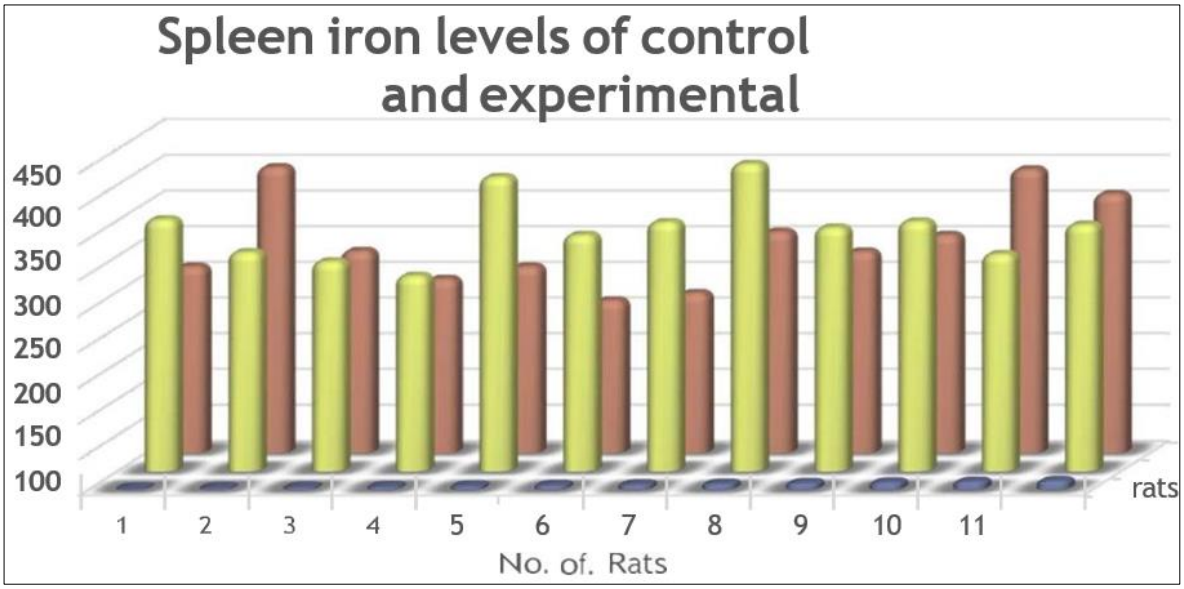


Fig 1: Graph showing the spleen iron levels of control and experimental group rats

The results of this study indicate that milk prepared from finger millet and pearl millet is also suitable as milk. Millet is an excellent source of nutrition. Additionally, millet is a rich source of essential amino acids and essential fatty acids that promote the physical and mental growth of infants. Results of a study on iron concentrations in the spleen showed no significant difference between rats weaned on millet milk and cow milk.

Summary and conclusion

Present research with animal models using albino rats was undertaken to study the effect of millet milk on spleen iron levels of albino rats. Speaking of millet, finger millet and pearl millet were selected for milk production. Finger millet is rich in protein, minerals, and amino acids. Finger millet has the highest calcium content of all grains and is also rich in the amino acids tryptophan, threonine, alanine, isoleucine, and methionine. It is also a good source of protein, calcium, folate, fat, fiber, phosphorus, and niacin. At the household level, we use traditional methods that result in less loss of nutrients.

Traditional methods such as soaking, germination, and wet grinding have been used to improve the nutritional content of milk. Product formulation is not indicated. This is because the formulation and technology are patented.

Male weanling albino rats (3 weeks old: n = 12) were purchased from Chennai and maintained in laboratory rat cages (Per cage). Rats were kept in cages for 2–5 days to get used to the new environment. Rats were fed food until the beginning of the experiment. Before the start of the experimental day, rats were weighed and body length measured.

The rats were divided into two groups based on body weight and body length. Each group of rats are fed with respective diets ad libitum. Every day, 7:00 a.m. in the morning Cow's

milk was fed to the control group rats and millet milk is fed to the experimental group rats ad libitum.

The experiment was carried out for 45 days. The rats were not fed with any food before 24 hours of the sacrifice. The weights and length of the rats were measured. The rats were euthanized or (Decapitated). Immediately after euthanization spleens were carefully dissected from the body and recorded the weights of the spleen. They were kept at -80 degrees centigrade for further analysis and performed iron analysis. Iron is the nutrient most commonly associated with red blood cell formation and metabolism. Large amounts of iron exist in the body as hemoglobin. The pigment contains iron and protein molecules and is responsible for transporting oxygen from the lungs to the tissues. Memories are stored in the liver, spleen, and bone marrow. Small amounts of iron are stored in muscle tissue as myoglobin. The mean spleen iron level of rats in the control group was 317.03±100 µg, and the mean spleen iron level of the experimental group was 311.84±100. There was no statistical difference between the control group fed cow's milk and the experimental group fed millet milk. Therefore, this study concludes that millet milk is as good as cow's milk. Further research is needed to confirm the study.

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Research Article

Optimization and Formulation of Lactose-Free Milk Using Finger and Pearl Millet

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ABSTRACT

Milk alternatives from non-dairy or plant-based sources help people with lactose intolerance and lactose indigestion. Formulations for alternate milk were optimized based on the sensory and nutritional properties. Optimized milk was proportioned by preparing different combinations of finger millet and pearl millet in ratios of T_1 (60:40), T_2 (70:30) and T_3 (80:20), while cow's milk was T_0 (control milk). The current investigation was carried out to optimize and develop a plant-based milk alternative using millets. The millet milk (Lactose-free milk) blends were analyzed for the organoleptic parameters, and further proximate analysis was done for the selected variation. Among the variations, the panellists most accepted T_2 (70% Finger millet + 30% Pearl millet). Nutrient analysis except for calcium, the other energy content, carbohydrate, fat, and mineral content all were higher in the lactose-free milk than in cow milk, and the protein content was the same. Based on the nutrient and sensory scores, millet milk is a non-dairy or Lactose-free milk alternative.

Keywords: *Finger millet, Pearl millet, Lactose-free milk, sensory score, blends.*

INTRODUCTION

Millets are commonly used for beverages that the population relishes for age-old decades, as they have a uniqueness for appetite, satiety and a healthy nutritional profile (Patil et al., 2010). In the present decade, the consumption of milk in day-to-day life has become a concern, as it is having many health issues like allergies to milk, lactose indigestion and lactose intolerance and also having effects on metabolic disorders due to high-fat content (Swagerty et al., 2002). Milk formulated from the plant-based is the best alternative for milk. Alternative milk formed from plant-based products is low in saturated fats, triglycerides, cholesterol and, importantly, the absence of Lactose. They contain essential fatty acids, proteins and minerals (Bode et al., 2008).

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Hence, plant-based products are taken as nutraceuticals and functional foods that contain antioxidants, fibre, vitamins and minerals. Millets, the minor cereals, are easy to acquire, and by using traditional methods, we can produce healthy, palatable, good flavour alternative milk (Kneepkens et al., 2009).

Finger millet has abundant stores of dietary fibre, phytates, and minerals. Also, the bran of the millet is a reservoir of numerous health benefits (Chandrasekara, 2010). They contain flavonoids with antioxidants and have the properties of anti-allergy, anti-inflammation, anti-cancer properties and gastro-protective properties (Sreeramulu, 2009). Finger millet consists of many phenolic compounds like vanillic acid and quercetin, which helps inhibit cataract in the eye lens. Clinical trials have shown that finger millet has good digestive attributes and has improved the bioavailability of minerals (Makokha et al., 2002).

Therefore, paediatricians in southern India mostly prefer and suggest finger millet products for infants above 6 months due to their good protein digestibility and micronutrient composition (Kannan, 2010). The functional grain is assimilated into different types of foods. The flour can be mixed with milk, boiling water and curds (Rai et al., 2008). Due to its high nutritional value, this is one of the ingredients used for product development.

Pearl millet was taken as the second millet to develop lactose-free milk. Malnutrition and, most commonly, protein-energy malnutrition is the dreadful cause of around 50% of childhood mortality in many developed countries (Grigsby, 2002). One of the growth defects, stunting was a major indication among 15% of infants below 12 months (SALDRU, 1994).

These malnutrition conditions result due to infections like diarrhoea, vomiting or insufficient dietary consumption due to intolerances (Pelletier, 1993). Thaoge et al. (2003) stated that the addition of small amounts of pearl millet could be a very good source of energy and has the good protein of 11.8%, fat of 4.8%, which are the essential nutrients during infancy and also gluten-free (FAO, 1995). The two millets were selected as the main ingredients for developing lactose-free milk (LFM), which were available locally and rich in energy, carbohydrates, calcium, protein and minerals like magnesium. The milk alternatives of millets are the liquids derived from the permeate of millets by soaking, sprouting and micronized to 5-20 µm by homogenization, which is similar in appearance and consistency (Das et al., 2012). The two millets have nutrients like carbohydrates, protein and calcium and give a creamy white liquid appearance and little similar consistency. Therefore, taking into the sensory attributes, both millets can be blended to develop milk. The current study optimized and formulated millet milk (Lactose-free).

MATERIALS AND METHODS

The current research was focused on the preparation and optimization of millet milk. The methodology adopted for the present study is illustrated below.

2.1. Locale of the study

The study was conducted at the food science laboratory in the Department of Home Science, Sri Venkateswara University, Tirupati of Andhra Pradesh.

2.2. Procurement of raw materials

Millets, finger millet and pearl millet were purchased from local markets in good quality conditions in Tirupati, Andhra Pradesh. Before the preparation of the millet milk, the purchased millets were cleaned thoroughly for any physical contaminants like dust particles, small stones and twigs.

2.3. Preparation of millet milk

Initially, to know the yield of milk, millets were processed separately. Finger millet milk was made by soaking finger millet for 12h in water overnight. The water is drained, and the finger millet is tied in a wet muslin cloth for sprouting for 24 hours. The sprouted finger millet was dry-roasted for 2-3 minutes and then pulverized in the blender with water for optimization at room temperature. The finger

millet mix was then filtered using the muslin cloth, and the milk was filtered. The same procedure was followed for the pearl millet milk preparation.

2.4. Optimization of millet milk

The amount of finger millet and water used for the extraction of finger millet milk was optimized based on the preliminary trials where finger millet and water were used in different ratios (1:1, 1:2, 1:3). The most suitable one, based on the sensory and nutritional profile was selected. The most acceptable ratio was 1:1, as it had the highest nutritional value among all three combinations. The millet flavour revealed in the sensory analysis was permissible, presuming that it would be later overcome by blending with pearl millet milk during optimization trials. The same procedure was followed for pearl millet milk.

Table-1: Finger millet and water combination in different treatments (100ml)

Trial	Finger millet	Water	Millet Milk
T1	100g	100ml	100ml
T2	100g	200ml	200ml
T3	100g	300ml	300ml

2.5. Finger – Pearl millet milk (Lactose-free milk)

Different finger millet and pearl millet blends were prepared by mixing finger millet and pearl millet in different proportions, as given in Table 1.

Table 1: Combination of finger millet and pearl millet in different proportions

Treatments	Finger millet	Pearl millet
V_0^*	-	-
V_1	60%	40%
V_2	70%	30%
V_3	80%	20%

*Cow's milk was taken as control (T_0)

2.6. Sensory Analysis of Millet Milk (Lactose-free)

The acceptability of the different millet milk (LF) formulations was evaluated through organoleptic evaluation using the nine-point hedonic scale. The sensory evaluation of millet milk was carried out in triplicates by a panel of 20 semi-trained judges. Prior instructions were given to the panel members, and they were requested to fill out the scorecard as per the guidelines instructed. The best accepted sample was selected for further proximate analysis.

2.7. Nutrient Analysis

The standardized sample was analyzed for proximate analysis as per the standard methods described in AOAC, 2000. Protein content was analyzed by the micro Kjeldahl method described in AOAC, 2005. Fat content was estimated by methods described in AOAC, 2005. AOAC, 1990 determined mineral content (calcium and iron).

2.8. Statistical analysis

The data from triplicate observations were analyzed statically, the mean and standard deviation were calculated in Microsoft Excel, ANOVA test, and t-test was done using SPSS version 26.

RESULTS

The minor millets, which are frequently used for their food security and abundant nutrients present, were taken to formulate millet milk. For optimization and formulation of millet milk, three ratios of finger millet: pearl millet were evaluated, that is, 60:40, 70:30 and 80:20. The different combinations obtained thereof were considered using the nutrient composition from the Nutritive value of Indian foods, C. Gopalan (1999).

Table 2: Nutrient composition of raw ingredients of finger millet:pearl millet (100g)

Finger millet: pearl millet (100g)			
Nutrients	**Variations**		
	V1 (60:40)	**V2 (70:30)**	**V3 (80:20)**
Energy (kcal)	331.65	328.92	326.2
Carbohydrate (g)	64.8	65.3	65.82
Protein (g)	8.68	8.3	7.92
Fat (g)	3.32	2.97	2.63
Iron (mg)	5.34	5.16	4.98
Calcium (mg)	229.34	263.01	296.67

The nutrient composition of ingredients was taken from the nutritive value of Indian foods, C. Gopalan

Protein, carbohydrate, fat content, energy, calcium and iron nutrient composition were calculated based on the (Gopalan, 1999). The protein content of the variations was 8.68g, 8.3g and 7.92g. carbohydrate content was 64.8g, 65.3g and 65.82g, and the fat content was 3.32g, 2.97g and 2.63g; the energy content of the combined millets was 331.65kcal, 328.92kcal and 326.2kcal respectively. The mineral content of iron was 5.34mg, 5.16mg and 4.98mg, whereas calcium was 229.34mg, 263.01mg and 296.67mg, respectively, for the variations of finger millet: pearl millet 60:40, 70:30 and 80:20 as shown in the below table-2. The optimization of millet milk was done by varying the ratio of finger millet to pearl millet (60:40, 70:30, 80:20), leading to different combinations. The evaluation of the adequacy of different formulations of millet milk was carried out on the basis of nutritional attributes and sensory profile.

2.4. Sensory evaluation for optimization of finger millet milk

Table 3 shows the sensory scores of finger millet milk, given by 20 panel members, who were given the optimized finger millet milk for evaluation of organoleptic characteristics, viz. aroma, colour, flavour, mouthfeel, taste and overall acceptability. The mean scores of sensory evaluations showed that in the three formulated optimizations with different water quantities. In that treatment, (T1) in which the water content was equal to the finger millet, i.e., finger millet: water was 100:100, had significantly better aroma (8.8), colour (8.1), flavour (8.2), mouthfeel (8.8), taste (8.7) and overall acceptability (8.7), when compared with other two treatments. It was revealed from the scores that the overall acceptability of the finger millet milk of 100:100 treatment was best acceptable among the panellists. The pearl millet milk was also optimized with 100:100 treatment.

Table 3: Optimization of finger millet with water (Finger millet: water)

Sensory Attributes	**T1 (100:100)**	**T2 (100:200)**	**T3 (100:100)**	**f-value**	**p-value**
Aroma	8.8±0.41	6.6±1.56	5.4±0.51	60.0393	0.00001*
Colour	8.1±0.81	6.4±1.19	5.4±0.51	47.7885	0.00001*
Flavor	8.2±0.85	6.3±1.30	5.3±0.73	45.1123	0.00001*
Mouthfeel	8.8±0.41	6.3±0.87	6.9±0.78	71.4105	0.00001*
Taste	8.7±0.44	6.5±1.46	5.3±0.47	71.7392	0.00001*
Overall acceptability	8.7±0.47	6.3±1.46	5.1±0.74	67.2215	0.00001*

*Statistically significant at 1% level

2.5. Sensory evaluation for Finger Pearl Millet milk (Lactose Free Milk)

The data in Table 4 and Figure 1 show the sensory score of millet milk developed, given by 20 panel members, who were given the formulated millet milk for evaluation of organoleptic characteristics, viz. aroma, colour, flavour, mouthfeel, taste and overall acceptability.

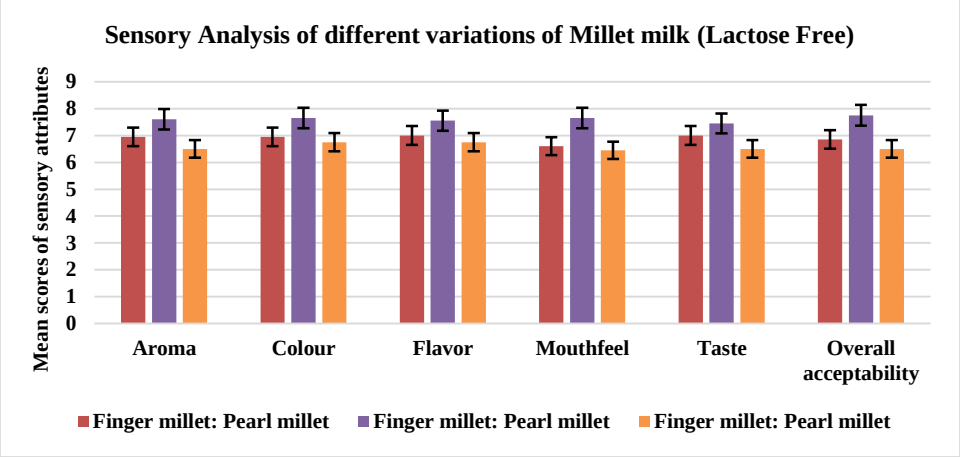


Fig 1: Graph representing the sensory analysis of millet milk

The mean scores of sensory evaluations showed that in the three formulated variations, variation V2 (70:30) had significantly better aroma (7.6), colour (7.6), flavour (7.5), mouthfeel (7.6), taste (6.4) and overall acceptability (7.7) when all the variations were compared with the cow's milk.

Table 4: Sensory Analysis by ANOVA of different variations of millet milk

Parameters	Finger millet: Pearl millet			f-value	p-value
	V1 (60:40)	V2 (70:30)	V3 (80:20)		
Aroma	6.95±0.615	7.6±0.812	6.5±0.688	14.1	0.00001*
Colour	6.95±0.510	7.65±0.745	6.75±0.443	13.22	0.00001*
Flavor	7±0.00	7.55±0.680	6.75±0.443	15.03	0.00001*
Mouthfeel	6.6±0.590	7.65±1.080	6.45±0.511	14.2	0.0001*
Taste	7±0.642	7.45±0.990	6.5±0.510	8.05	0.0008*
Overall acceptability	6.85±0.367	7.75±0.962	6.5±0.513	18.05	0.00001*

*Statistically significant at 1% level

It was revealed from the overall acceptability scores and, as shown in Figure 2 that the millet milk of V2 (70:30) is acceptable among the panellists. Hence, V2 was finalized and selected for further analysis.

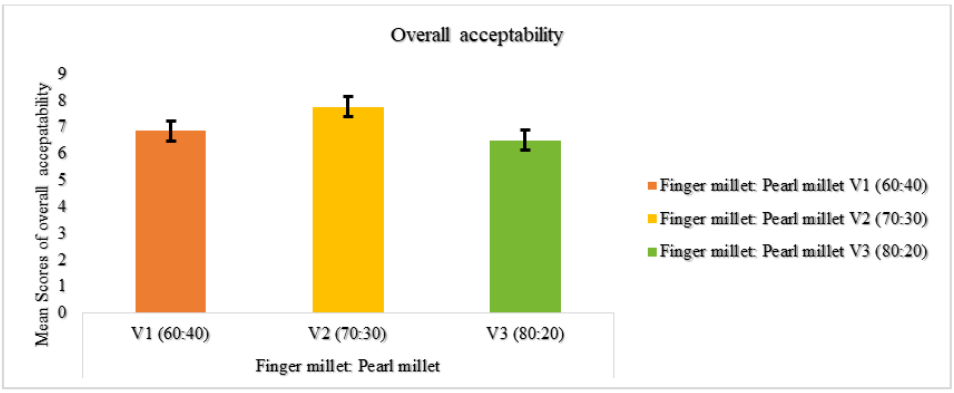


Fig 2: Graph representing the overall acceptability of millet milk by the panel members

2.6. Lactose determination

Lactose is a sugar molecule, a disaccharide found in the milk for about 4-5%. Lactase enzyme is required to properly digest Lactose, and the enzyme's insufficiency will lead to lactose intolerance. Benedict's test estimated the Lactose (Nande et al., 2008). No changes or precipitate formation was seen, confirming the absence of Lactose.

2.7. Nutrient Analysis

The energy value was the highest in the millet milk (87.12 kcal) compared to the cow's milk (67 kcal). Mbithi-Mwikya et al. 2000 stated that traditional technologies like soaking, sprouting, and shade drying processes help reduce the antinutritional factors and increase the millet's energy.

The protein content of the millet milk (3.2g) was similar to cow milk. Finger millet and pearl millet are relatively good in protein content when compared to the other millets. The high concentration of essential amino acids was threonine to the least valine. The finger millet contains 44% of the amino acids of total amino acids. Tryptophan is a deficient amino acid in many cereals, but it is present in the finger millet.

The fat content of millet milk (0.4g) when compared to cow's milk (4.1g). The fat content in the fermented and germinated/sprouted millets is relatively low when compared to the ungerminated millets and, therefore, helps in increasing the shelf life of any developed products from millets, as the risk of rancidity is very low.

The carbohydrate content of the millet milk (17.7g) when compared to the cow's milk (4.4g). The carbohydrate content in millets is around 63%- 70%, which the finger millet has good carbohydrate content due to the starches, pentosans, xylose, and simple sugars like fructose, glucose, maltose, raffinose, maltotriose and some higher oligosaccharides (Wankhede, 1979).

The iron content of millet milk (1mg) when compared to the cow's milk (0.2mg). The millets are rich in mineral content, and finger millet has a high content of iron. Except for calcium, all the other nutrients in the millet milk have high content compared to the cow's milk, and the protein content is the same as the cow's milk.

Table 4: Proximate analysis of Developed millet milk of variation 70:30 finger millet: pearl millet

Nutrients	Millet milk	Cow's milk	t-test	p-value
Carbohydrate (g)	17.7	4.4	210.29	0.0001*
Protein (g)	3.2	3.2	0.00	0.9^{ns}
Fat (g)	0.4	4.1	58.5	0.0001*
Energy (kcal)	87.12	67	318.12	0.0001*
Calcium (mg)	80	120	632.45	0.0001*
Iron (mg)	1	0.2	12.64	0.0001*
The nutrients were analyzed using the AOAC, 19th edition standards. **ns-Non significant** ***Extremely significant at 1% level**				

The graph below predicts that all the nutrients in millet milk have extremely significant levels at 1% level when compared to the cow's milk, and there was no significant difference between protein values in both millet milk and cow's milk.

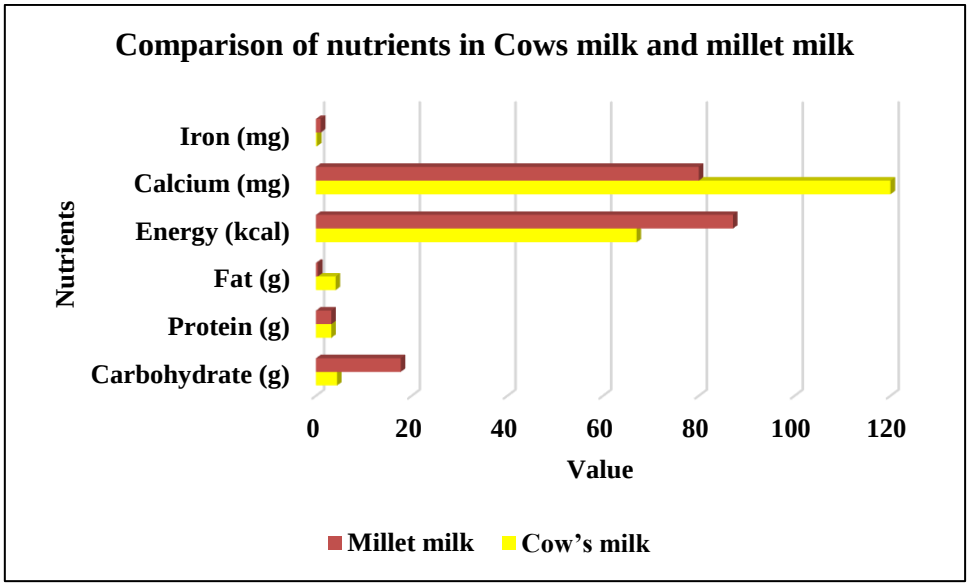


Fig 3: Graph representing the nutrients in both the cow's milk and the millet milk

CONCLUSION

Based on the analysis of cow's milk and millet milk used in this study, it can be concluded that millet-based milk prepared by the combination of finger millet and pearl millet can be a good alternative to cow milk due to the absence of Lactose and with good nutritional and sensory profile. Since it is a study based on lactose-free alternatives for milk, further alterations and modifications with respect to adding sweeteners, emulsifiers, or any other additives could be carried out to further commercialize the product.

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Author Contribution

All the authors made substantial contributions to the following: (1) Conception and Design of the study, (2) acquisition of the data, (3) interpretation of the data, (4) drafting the article or revising it critically for important content, and (5) final draft for the submission.

Author declaration: None

Conflicts of Interest: None

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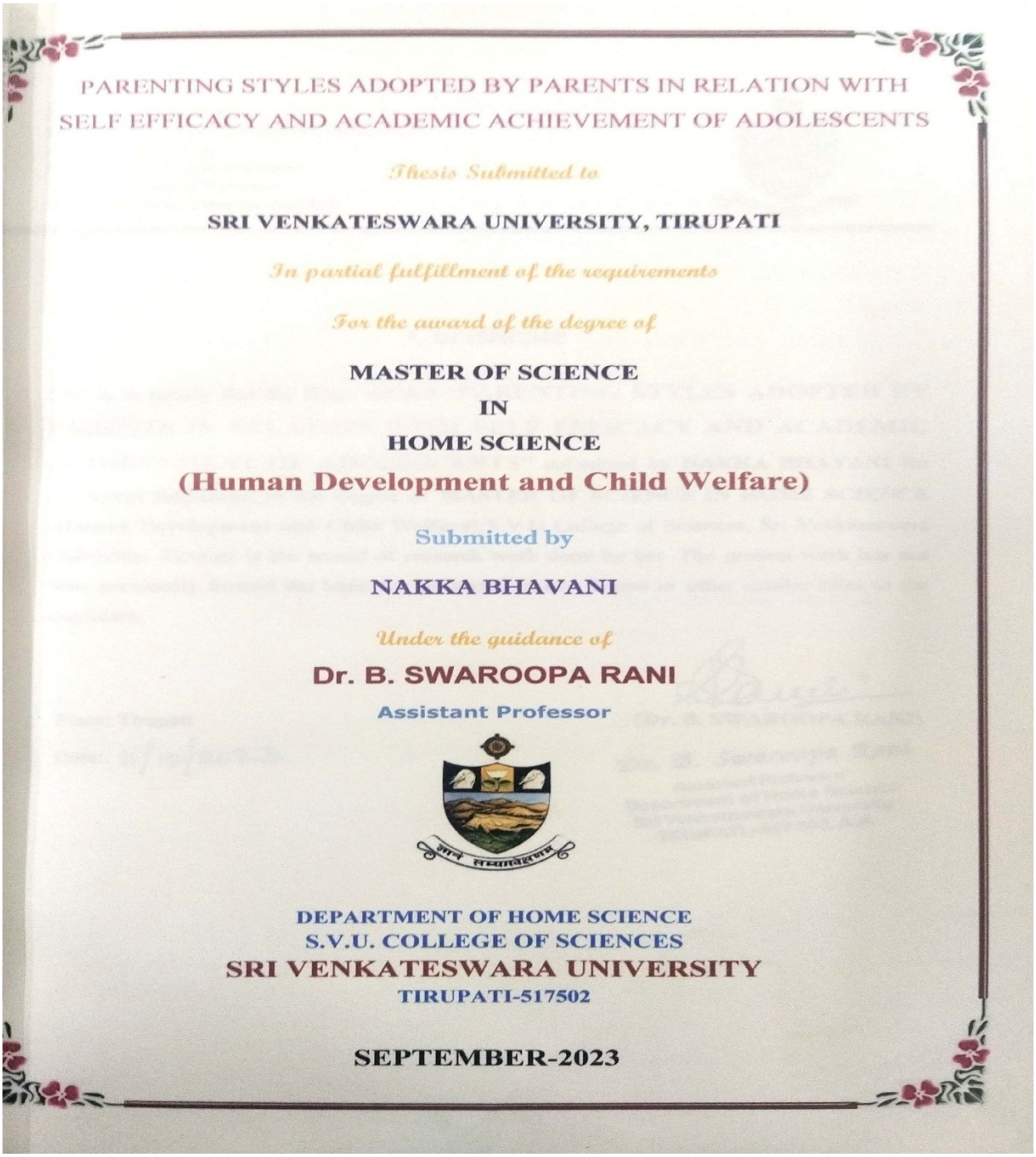
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SUPPORTING DOCUMENTS

1.3.4. Research projects & Internship

Research projects



PARENTING STYLES ADOPTED BY PARENTS IN RELATION WITH SELF EFFICACY AND ACADEMIC ACHIEVEMENT OF ADOLESCENTS

Thesis Submitted to

SRI VENKATESWARA UNIVERSITY, TIRUPATI

In partial fulfillment of the requirements

For the award of the degree of

MASTER OF SCIENCE

IN

HOME SCIENCE

(Human Development and Child Welfare)

Submitted by

NAKKA BHAVANI

Under the guidance of

Dr. B. SWAROOPA RANI

Assistant Professor

DEPARTMENT OF HOME SCIENCE
S.V.U. COLLEGE OF SCIENCES
SRI VENKATESWARA UNIVERSITY
TIRUPATI-517502

SEPTEMBER-2023

PARENTING STYLES ADOPTED BY PARENTS IN RELATION WITH EMOTIONAL MATURITY AND ACADEMIC ACHIEVEMENT OF ADOLESCENTS

Thesis Submitted to

SRI VENKATESWARA UNIVERSITY, TIRUPATI

In partial fulfillment of the requirements

For the award of the degree of

MASTER OF SCIENCE

IN

HOME SCIENCE

(Human Development and Child Welfare)

Submitted by

M.HANNA KUMARI

Under the guidance of

Dr. B. SWAROOPA RANI

Assistant Professor

DEPARTMENT OF HOME SCIENCE
S.V.U.COLLEGE OF SCIENCES
SRI VENKATESWARA UNIVERSITY
TIRUPATI-517502

SEPTEMBER-2023

Internship

INDLAS
Since 1983 HOSPITALS

Vijayawada

Date :
15th June 2024

Internship Certificate

This is to certify that **Mr. A. Rama Krishna,** a student of **Sri Venkateswara University** is presently pursuing 2nd year, M.Sc. Home Science (Human Development and Child Welfare) has successfully completed Internship at **INDLAS Hospitals** from 15th May 2024 to 15th June 2024.

During his internship, he was regular to the postings and exposed to patients with different kinds of psychiatric disorders.-

Director - INDLAS Hospitals
Dr. INDLA RAMASUBBA REDDY
MD. (Psych. Nimhans.,) D.Sc., D.P.M.
Regd. No. 9838
DIRECTOR-INDLAS HOSPITALS
since 1983

Address for Correspondence :
V.V. Rao Street, Suryaraopet, VIJAYAWADA - 520 002.
PH : 0866 - 2432040, 2442174
email : indlashelpdesk@gmail.com, website : www.indlashospitals.com

INDLAS HOSPITALS

Since 1983

Vijayawada

Date :
15th June 2024

Internship Certificate

This is to certify that **Ms. C. Jansi,** a student of **Sri Venkateswara University** is presently pursuing 2nd year, M.Sc. Home Science (Human Development and Child Welfare) has successfully completed Internship at **INDLAS Hospitals** from 15th May 2024 to 15th June 2024.

During her internship, she was regular to the postings and exposed to patients with different kinds of psychiatric disorders.

Director – INDLAS Hospitals

Dr. INDLA RAMASUBBA REDDY
MD. (Psych. Nimhans.,) D.Sc., D.P.M.
Regd. No. 9838
DIRECTOR-INDLAS HOSPITALS

Address for Correspondence :
V.V. Rao Street, Suryaraopet, VIJAYAWADA - 520 002.
PH : 0866 - 2432040, 2442174
email : indlashelpdesk@gmail.com, website : www.indlashospitals.com

INDLAS HOSPITALS

Since 1983

Vijayawada

Date :

15th June 2024

Internship Certificate

This is to certify that **Ms. N. Mowlika,** a student of **Sri Venkateswara University** is presently pursuing 2nd year, M.Sc. Home Science (Human Development and Child Welfare) has successfully completed Internship at **INDLAS Hospitals** from 15th May 2024 to 15th June 2024.

During her internship, she was regular to the postings and exposed to patients with different kinds of psychiatric disorders.

Director - INDLAS Hospitals

Since 1983
Dr. INDLA RAMASUBBA REDDY
MD. (Psych. Nimhans.,) D.Sc., D.P.M.
Regd. No. 9838
DIRECTOR-INDLAS HOSPITALS

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V.V. Rao Street, Suryaraopet, VIJAYAWADA - 520 002.
PH : 0866 - 2432040, 2442174
email : indlashelpdesk@gmail.com, website : www.indlashospitals.com

INDLAS HOSPITALS

Since 1983

Vijayawada

Date :
15th June 2024

Internship Certificate

This is to certify that **Ms. P.Radhamma** a student of **Sri Venkateswara University** is presently pursuing 2nd year, M.Sc. Home Science (Human Development and Child Welfare) has successfully completed Internship at **INDLAS Hospitals** from 15th May 2024 to 15th June 2024.

During his interriship, he was regular to the postings and exposed to patients with different kinds of psychiatric disorders.

Director - INDLAS Hospitals

Dr. INDLA RAMASUBBA REDDY
MD. (Psych. Nimhans.,) D.Sc., D.P.M.
Regd. No. 9838
DIRECTOR-INDLAS HOSPITALS

Address for Correspondence :
V.V. Rao Street, Suryaraopet, VIJAYAWADA - 520 002.
PH : 0866 - 2432040, 2442174
email : indlashelpdesk@gmail.com, website : www.indlashospitals.com

INDLAS HOSPITALS

Since 1983

Vijayawada

Date :

15th June 2024

Internship Certificate

This is to certify that **Ms. T. Lakshmi Sai,** a student of **Sri Venkateswara University** is presently pursuing 2nd year, M.Sc. Home Science (Human Development and Child Welfare) has successfully completed Internship at **INDLAS Hospitals** from 15th May 2024 to 15th June 2024.

During her internship, she was regular to the postings and exposed to patients with different kinds of psychiatric disorders.

Director - INDLAS Hospitals

Dr. INDLA RAMASUBBA REDDY
MD. (Psych. Nimhans.,) D.Sc., D.P.M.
Regd. No. 9838
DIRECTOR-INDLAS HOSPITALS

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PH : 0866 - 2432040, 2442174
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INDLAS HOSPITALS

Since 1983

Vijayawada

Date :
15th June 2024

Internship Certificate

This is to certify that **Ms. S. Nandini** a student of **Sri Venkateswara University** is presently pursuing 2nd year, M.Sc. Home Science (Human Development and Child Welfare) has successfully completed Internship at **INDLAS Hospitals** from 15th May 2024 to 15th June 2024.

During his internship, he was regular to the postings and exposed to patients with different kinds of psychiatric disorders.

Director - INDLAS Hospitals

Dr. INDLA RAMASUBBA REDDY
MD. (Psych. Nimhans.,) D.Sc., D.P.M.
Regd. No. 9838
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INDLAS HOSPITALS

Since 1983

Vijayawada

Date :
15th June 2024

Internship Certificate

This is to certify that **Ms. P. Sumathi,** a student of **Sri Venkateswara University** is presently pursuing 2nd year, M.Sc. Home Science (Human Development and Child Welfare) has successfully completed Internship at **INDLAS Hospitals** from 15th May 2024 to 15th June 2024.

During her internship, she was regular to the postings and exposed to patients with different kinds of psychiatric disorders.

Director – INDLAS Hospitals

Dr. INDLA RAMASUBBA REDDY
MD. (Psych. Nimhans.,) D.Sc., D.P.M.
Regd. No. 9838
DIRECTOR-INDLAS HOSPITALS

Address for Correspondence :
V.V. Rao Street, Suryaraopet, VIJAYAWADA - 520 002.
PH : 0866 - 2432040, 2442174
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2.4.4. Received awards



3.1.4. Research fellows enrolled (JRF)

NATIONAL TESTING AGENCY
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(An Autonomous Org. under the Deptartment of Higher Education, Ministry of Education, Govt. of India)
विश्वविद्यालय अनुदान आयोग

First Floor, NSIC-MDBP Building, Okhla Industrial Estate, New Delhi, Delhi 110020 (India), Phone 011-69227700, 011-40759000

JRF AWARD LETTER

Dated: 12-03-2022

NTA Ref. No.: **210510141690**

Roll No.: **KK04018225**

GOKAM SOWMYA
Son/Daughter of **GOKAM PADMA**
and **GOKAM SHEKAR**
Subject: **Home Science**



Dear Candidate,

I am pleased to inform you that you have qualified for Junior Research Fellowship (JRF) and eligibility for Assistant Professor in the National Eligibility Test (UGC-NET) conducted for December 2020 and June 2021 (merged session). The tenure of fellowship is five years and it commences from the date of declaration of NET result, i.e., **19-02-2022** *(or) from the date of admission under M.Phil./Ph.D. (or) from the date of joining M.Phil./Ph.D. programme, whichever is later. The summary of financial assistance offered under the scheme is mentioned at* ***Annexure I*** *available on www.ugc.ac.in/netjrf*

The Awardee is required to get admission and registration for regular and full time ***M.Phil./Ph.D.*** *course in a University/Institution/College recognized by UGC at the first available opportunity* ***but not later than three years*** *from the date of issue of this award letter. University/Institution/College is requested to process for award of JRF based on this letter, in accordance with the procedure available on www.ugc.ac.in/netjrf.*

It may be noted that the fellowship amount shall be disbursed through Canara Bank to bank account of the Awardee (any bank) directly. UGC has developed a dedicated web portal (https://scholarship.canarabank.in) for capturing data of the awardee. The Universities/Colleges/Institutions will link the data of the awardee with the master data on the UGC web portal with unique Maker/Checker Ids which have already been provided to them along with the passwords. The Universities/Colleges/Institutions shall update the information in the master data (regarding monthly payment confirmation, HRA, up-gradation, resignation etc.) of the beneficiaries on monthly basis. Based on the data updated on UGC web portal by the concerned Universities/Colleges/Institutions, the payment of the fellowship will be made to the beneficiaries (Detailed process available at https://www.ugc.ac.in/ugc_notices.aspx?id=2153).

It may also be noted that UGC has proposed to link ***"AADHAAR"*** *with bank account of students so that there can be direct cash transfer and effective disbursal of fellowship into bank account of the student. In this regard, Secretary, UGC has already requested the universities to help students in Aadhaar enrolment vide D.O. No. F.14-34/2011 (CPP-II) dated 11.01.2013.*

It may please be noted that the award is liable to be cancelled by Implementing/Awarding agency and it will also attract legal action against the Awardee in the following cases:

i. *If the awardee is found to be ineligible to receive the award at any point during the entire duration of fellowship.*
ii. *Misconduct of Awardee,*
iii. *Unsatisfactory progress of research work,*
iv. *Failure in any examination related to M.Phil./Ph.D.,*
v. *In case any other fellowship is drawn from other source(s),*
vi. *Concealment of facts.*

The e-Certificate of eligibility for Assistant Professor has been uploaded on https://ecertificate.nta.ac.in. The eligibility of the candidate is to be ensured by the institution/appointing authority. The category in which the candidate had appeared may be verified from NTA.

This electronic JRF award letter can also be verified by scanning the QR Code.

With best wishes,

Sadhana Parashar

(Dr Sadhana Parashar)
Senior Director

Note: NTA has issued the electronic JRF award letter on the basis of information provided by the candidate in his/her online application form. The appointing authority should verify the original records/certificates of the candidate while considering him/her for JRF award or appointment, as the NTA will not be liable for any false information provided by the candidate. The NTA is only responsible for the result which can be verified from the repository available in the website of NTA (ugcnet.nta.nic.in). The candidate must fulfil the minimum eligibility conditions as laid down in the notification for UGC-NET.

3.3.2 Workshops/Seminars Conducted

EMOTIONAL MANAGEMENT THROUGH BEHAVIOUR TECHNOLOGY: 25 JUL 2023

Organized One day National Workshop on "Emotional Management Through Behavior Technology" by HDCW, Department of Home Science in collaboration with Mind Craft, Kerala at S.V.U Senate hall, S.V. University, on 25-7-2023.

- **Chief Guest:** Prof. K. Raja Reddy (Vice-chancellor), S.V.U
- **Key note Speaker:** Dr. Rama Subba Reddy, Psychiatrist, Vijayawada
- **Resource Person:** Dr. Jayan Namboodiri, Kerala
- **Convener:** Dr. K. Anuradha
- **Organized Secretary:** Dr. B. Swaroopa Rani


Jointly Organizing
ONE DAY NATIONAL WORKSHOP
on
POSITIVE
MENTAL HEALTH CLUB

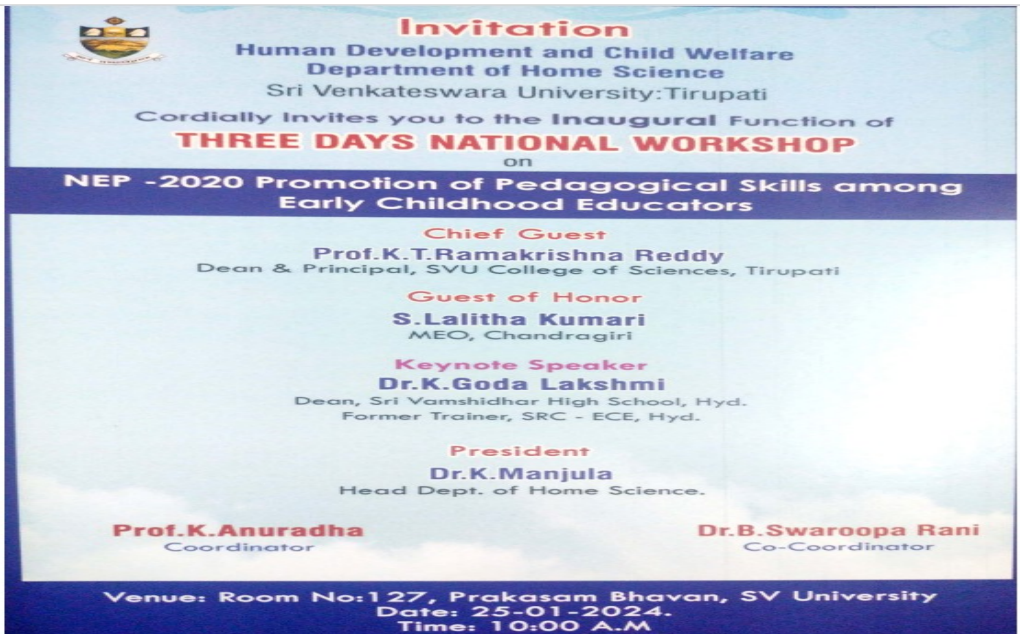

Human Development and Child Welfare
Department of Home Science
Sri Venkateswara University, Tirupati
In Collaboration with
Mindcraft, Thrissur, Kerala
Jointly Organizing
One Day National Workshop
On
"Emotional Management Through Behaviour Technology"
Chief Patron
Prof. K. Raja Reddy
Hon'ble Vice-Chancellor,
Sri Venkateswara University,
Tirupati.
Patron
Prof. O. Md. Hussain
Registrar
Sri Venkateswara University,
Tirupati.
Organizing Committee
Prof. K.T. Ramakrishna Reddy
Dean & Principal
SVU College of Sciences
Dr. K.V. Sucharitha
Head
Dept. of Home Science
Prof. K. Anuradha
Convener
HD & CW
Dept. of Home Science
Organizing Secretary
Assistant Professor
HD & CW
Dept. of Home Science
Venue: Senate Hall, S.V.U Administrative Bld., S.V.U., Tirupati Date: 25th July 2023

NEP-2020-PROMOTION OF PEDAGOGICAL SKILLS AMONG EARLY CHILDHOOD EDUCATORS: 25 JAN 2024 TO 27 JAN 2024

Organized Three days National Workshop on "NEP-2020-Promotion of Pedagogical Skills among Early Childhood Educators" by HDCW, Department of Home Science, S. V. University from 25th Jan 2024 to 27th Jan 2024.

- **Chief Guest:** Prof. K.T.Ramakrishna Reddy, Dean & Principal, SVU College of Sciences
- **Guest of Honor:** S. Lalitha Kumari, MEO, Chandragiri
- **Keynote Speaker:** Dr.K.Goda Lakshmi, Dean, Sri Vamshidar High School, Hyd. Former Trainer, SRC-ECE, Hyd.
- **President:** Dr. K. Manjula. Head – Dept. of Home Science
- **Coordinator:** Prof. K. Anuradha
- **Co-Coordinator:** Dr. B. Swaroopa Rani





UGC-MALAVIYA MISSION TEACHER TRAINING CENTRE
SRI VENKATESWARA UNIVERSITY
TIRUPATI - 517 502

R.O.C. No. MMTTC/Certificate/2023-24 Dt.25-11-2023

Prof. R.P. Vijayalakshmi
In-charge Director

CERTIFICATE

This is to certify that Dr. B. Swaroopa Rani, Assistant Profeessor, Dept. of Home Science, S V University has served as Coordinator for Refresher Course in Gender Studies from 14.10.2023 to 27.10.2023 organised by the UGC – MMTTC, S. V. University.

RP Vijayalakshmi

(Director I/c, HRDC)
I/C DIRECTOR
UGC-MMTTC, S.V. UNIVERSITY
TIRUPATI - 517 502, (A.P.)

Address: 2nd Floor, Andhra Bank Zonal Office Building, SVU Campus, Tirupati
Phone Nos. : Director's Chamber - 0877 – 2248620, 2289328, (Office) – 2289513
E-mail I.D. : hrdcsvutpt@gmail.com

3.4.5 Research Papers Published

ISSN: 2320-5407 Int. J. Adv. Res. 11(03), 606-610

Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/16470
DOI URL: http://dx.doi.org/10.21474/IJAR01/16470

ISSN NO. 2320-5407



RESEARCH ARTICLE

DETERMINANTS OF PARENTING STYLES ADOPTED BY MOTHERS OF PRE-SCHOOL CHILDREN ACCORDING TO CHILD AND MOTHERS VARIABLES

Dr. B. Swaroopa Rani
Assistant Professor, Department of Home Science, Sri Venkateswara University, Tirupati. Andhra Pradesh, India.

Manuscript Info

Manuscript History
Received: 19 January 2023
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Published: March 2023

Key words:-
Determinants Of Parenting Style, Parenting Styles,Determinants For Disciplinary Practices

Abstract

The parent- child relationship has a major influence on most aspects of child development. The present study is conducted to know the Determinants of Parenting Styles adopted by fathers according to Child variables. Sample consists of 220 mothers of pre-school age children selected from Thirupati and Hyderabad. Multi stage systematic random sampling technique was used to select sample. Sample mothers were administered with Parental Attitude towards their Own Upbringing Scale andParenting Styles Questionnaire.The results of linear regression analysis revealed that the major determinants of child variables for adoption of parenting styles adopted by mother, birth order of the child showed significant contribution towards adoption of authoritarian and authoritative parenting style. Only birth order showed significant contribution towards permissive parenting style. Age of the mother, education of the mother, occupation of the mother and attitude of the mother were contributing significantly towards authoritarian and permissive parenting styles adopted by mothers of pre-school children.

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Relation between level of internet addiction and aggression among adolescents

G Sowmya and Dr. B Swaroopa Rani

DOI: https://doi.org/10.22271/23957476.2024.v10.i2a.1596

Abstract
Due to the technological advancement and availability of smart phones, internet is easily accessible for every individual. Internet has been perceived as a best friend for everyone; hence, amount of time spent on the internet is rapidly increasing. Amongst any other age groups, adolescents are the most vulnerable group to use internet. The effects of excessive use of internet can lead to aggressiveness causing psychosocial behavioral problems. In the light of these perspectives, the present study was undertaken to find the relation between Internet Addiction and Aggression among adolescents. A sample of 200 adolescents between the age group of 13-15 years studying in 8th, 9th and 10th standard from different schools of Hyderabad, Telangana state were selected for the study. The Internet Addiction Test (IAT; Young, 1998) and Aggression Questionnaire (Buss & Perry, 1992) was used to elicit the data. The results revealed that there is a positive significant relation found between level of Internet addiction and dimensions of Physical aggression and Hostility among adolescents. Further, there is no significant relation found between level of Internet addiction and dimensions of Verbal aggression and Anger among adolescents.

Keywords: Internet addiction, aggression, adolescents

International Journal of Science and Research (IJSR)
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SJIF (2022): 7.942

Association between Internet Addiction and Aggression among Adolescents according to Their Gender

G. Sowmya[1], B. Swaroopa Rani[2]

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Abstract: ***Due to the technological advancement and availability of smart phones, internet is easily accessible for every individual. Internet has been perceived as a best friend for everyone; hence, amount of time spent on the internet is rapidly increasing. A future without internet is highly impossible as any information, entertainment, social networking, shopping, education etc. is available at spur-of-the-moment. Though, there are positive outcomes due to technological advancement, its negative consequences also need to be considered. Amongst any other age groups, adolescents are the most vulnerable group to use internet. The effects of excessive use of internet can lead to aggressiveness causing psychosocial behavioural problems. In the light of these perspectives, the present study was undertaken to find the association between Internet Addiction and Aggression among adolescents. A sample of 200 adolescents between the age group of 13-15 years studying in 8th, 9th and 10th standard from different schools of Hyderabad, Telangana state were selected for the study. The Internet Addiction Test (IAT; Young, 1998) and Aggression Questionnaire (Buss & Perry, 1992) was used to elicit the data. The results revealed that Internet Addiction have association with Aggressive behaviors of the respondents.***

Keywords: Internet Addiction, Aggression, Adolescents

1. Introduction

Adolescents begin spending more time with their peers and less time with their families. Their concept of friendship increasingly focuses on intimate exchanges of thoughts and feelings (lumen learning). They seem to communicate with their peers more electronically than face to face. They chat with their friends through instant messaging, texting, social network sites such as Facebook and email (Bob Livingstone). Internet use has become a vital part of one's life without internet many of them could not imagine their life. The Internet provides multifariousness of possibilities for communication, entertainment, and dealing with every day-life requirements (e.g., making restaurant reservations, searching for information, online gaming, online classes, etc.) (Shwetha, 2017)

The term internet is defined as, "an electronic communication network that connects computer networks and organizational computer facilities around the world" (Marriam-Webster). Internet Addiction has been called Internet dependency and Internet compulsivity. "Dr. Ivan Goldberg" suggested the term "internet addiction" in 1995 for pathological compulsive internet use. Internet addicts prioritize internet than family, friends and work. Along with all benefits the internet brings, problems due to excessive use are also becoming apparent (Khatoon, et.al, 2016).

According to Berkowitz (1968) people use this term "aggression" to explicate any behavior which objective is to damage other people or things. The term "aggression" may be defined as any act that can cause suffering or antipathy. Adolescents with problematic internet use were lonelier, hyperactive and aggressive (Lim et al., 2014). Mehroof and Griffiths (2010), and others' studies showed that internet addiction was significantly correlated with aggression.

Considering the above discussion, the researcher has made a sincere effort to study the "The Association between Internet Addiction and Aggression among Adolescents". The study provides an understanding of the adolescents' internet addiction and its effects on them.

The Objectives of the present study are –

1) To assess level of 'Internet addiction' among the adolescents
2) To assess level of 'Aggression' among the adolescents
3) To compare the levels of Internet addiction among adolescents according to their gender
4) To compare the levels of Aggression among adolescents according to their gender
5) To know the association between level of Internet addiction and level of aggression among the adolescents

2. Methodology

The present study was conducted in Hyderabad, Telangana state. The sample consist of 200 adolescents including both boys (100) and girls (100) between the age group of 13 to 15 years studying in VIII, IX and X. The random sampling technique was used to draw the sample. The Internet Addiction Test (IAT; Young, 1998) and Aggression Questionnaire (Buss & Perry, 1992) tools were used to collect the data. Due to the Covid -19 pandemic situation and lockdown in the Hyderabad, it was not possible to physically administer the tool. Hence, the researcher created a Google form of the questionnaire to administer it to the respondents. After the responses was sorted, the data was

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International Journal of Applied Home Science

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RESEARCH PAPER

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Parental attitudes Perceived by College going students – Correlation between Father and Mother

B. SWAROOPA RANI[1]* AND K. POORNIMA DURGA[2]

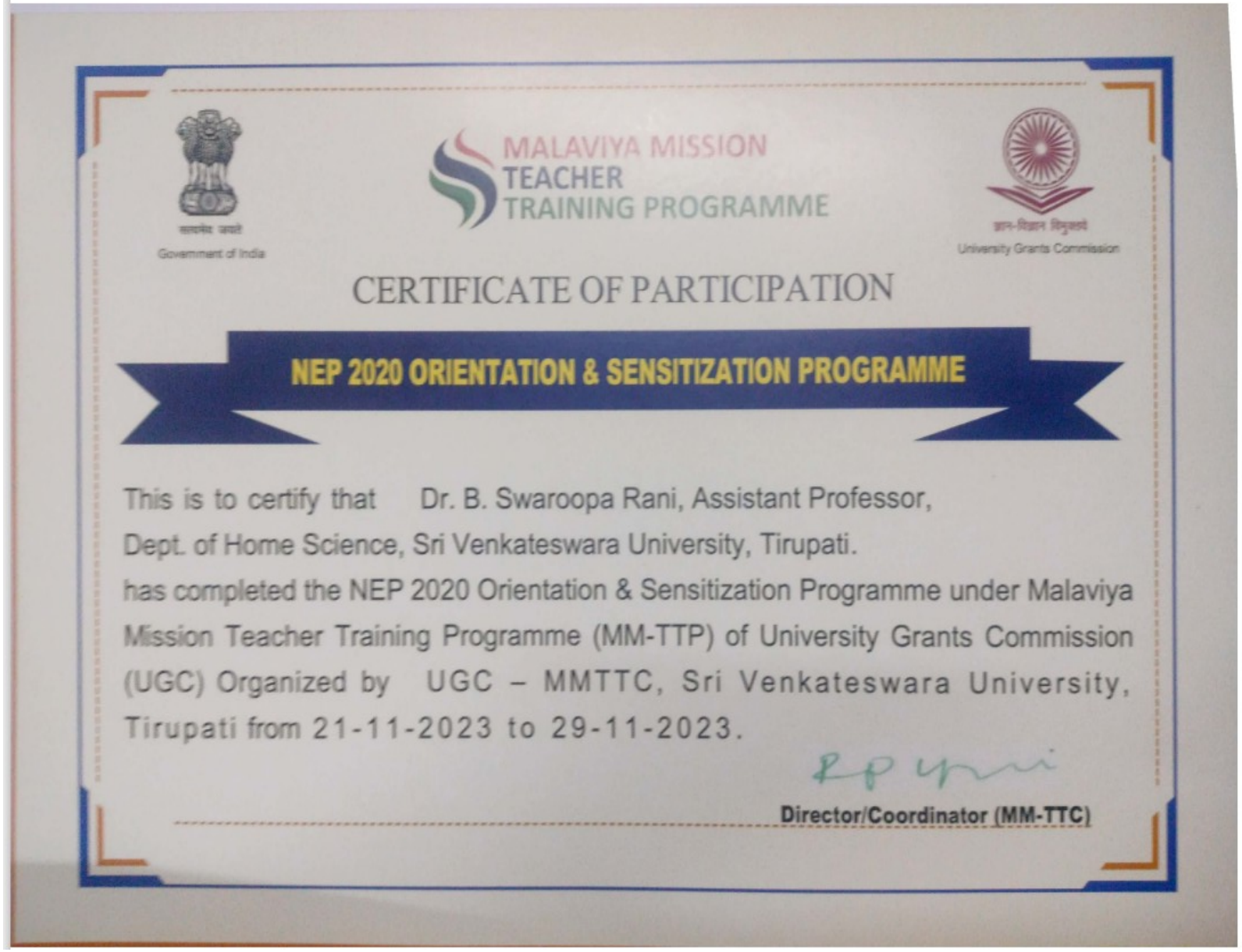
[1]Assistant Professor and [2]Research Scholar

Department of Home Science, S.V. University, Tirupati (A.P.) India

ABSTRACT

Family plays an important role in the all-round development of children. The three types of parental attitudes reported in literature are acceptance, concentration and avoidance (Roe, 1957). The formation of attitude plays a very significant role in the developmental process of individuals. The present study was conducted to know the "perceptions of adolescence about their parental attitudes". The samples were 50 Intermediate students (25 boys and 25 girls) who were selected randomly from two Inter colleges in Tirupathi town. Family Relation Inventory (Shersy and Sinha, 2011) was used to collect the data. Results revealed that family variables play a significant role in perceived parental attitude of adolescence. In areas of parental attitude majority of (58 %) girls perceived more parental acceptance. Whereas majority boys (52 %) scored more on avoidance which showed their negative perception of parental attitude. The results help to provide counseling to parents and students to improve parent child relationship.

Key Words : Family relation, Parental attitudes, Acceptance, Concentration, Avoidance, Perceptions of adolescents



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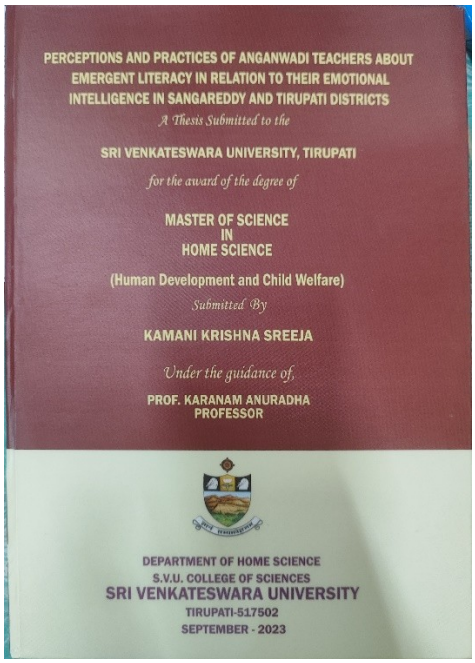
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PERCEPTIONS AND PRACTICES OF ANGANWADI TEACHERS ABOUT EMERGENT LITERACY IN RELATION TO THEIR EMOTIONAL INTELLIGENCE IN SANGAREDDY AND TIRUPATI DISTRICTS

A Thesis Submitted to the

SRI VENKATESWARA UNIVERSITY, TIRUPATI

for the award of the degree of

MASTER OF SCIENCE
IN
HOME SCIENCE

(Human Development and Child Welfare)

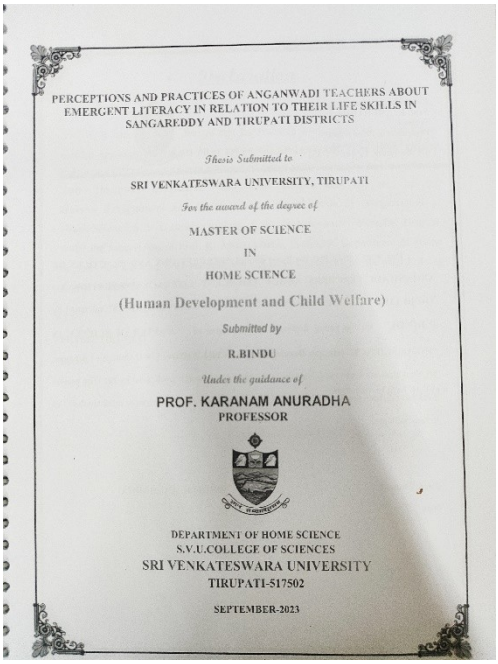
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KAMANI KRISHNA SREEJA

Under the guidance of,

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PROFESSOR

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SRI VENKATESWARA UNIVERSITY
TIRUPATI-517502
SEPTEMBER - 2023



PERCEPTIONS AND PRACTICES OF ANGANWADI TEACHERS ABOUT EMERGENT LITERACY IN RELATION TO THEIR LIFE SKILLS IN SANGAREDDY AND TIRUPATI DISTRICTS

Thesis Submitted to

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IN

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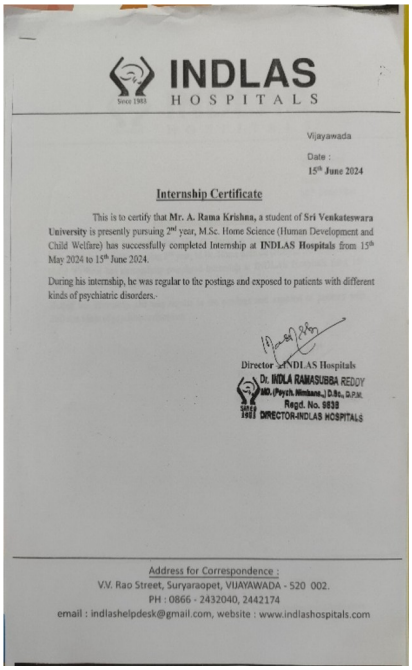
R.BINDU

Under the guidance of

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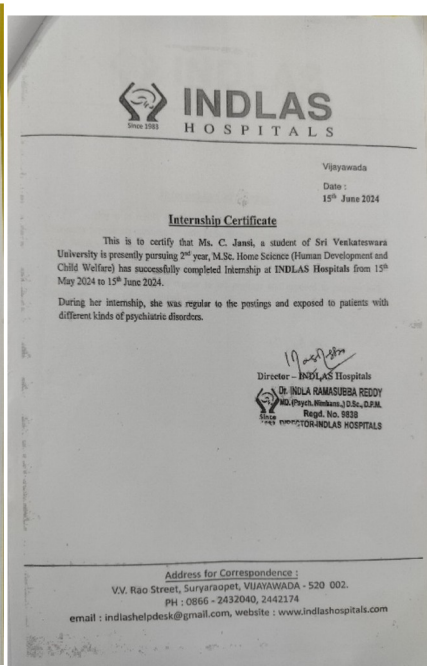
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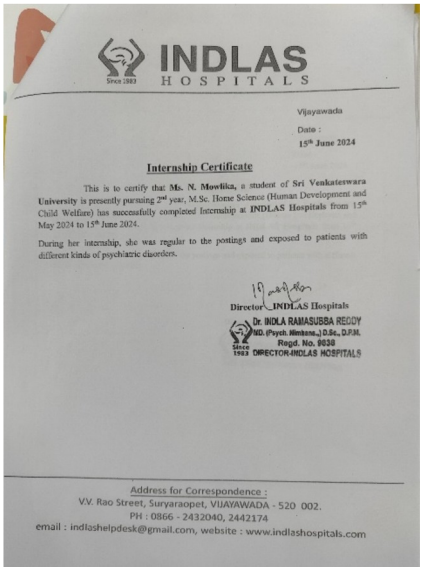
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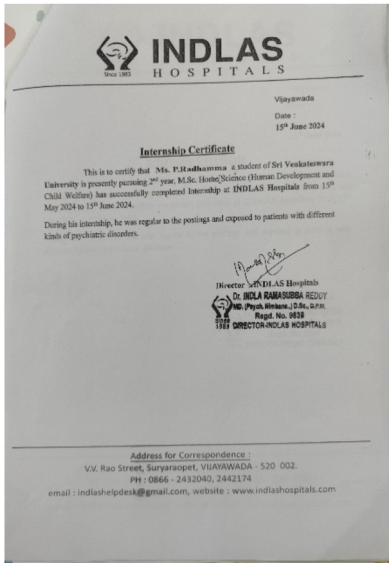
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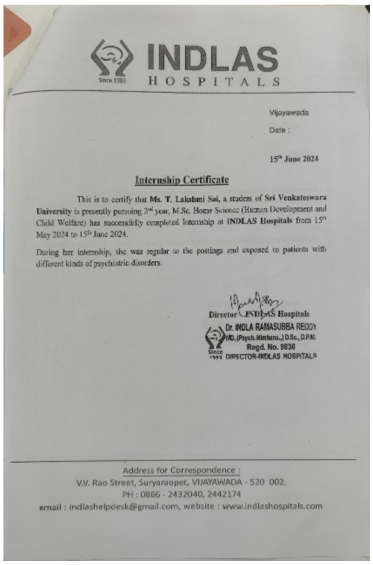
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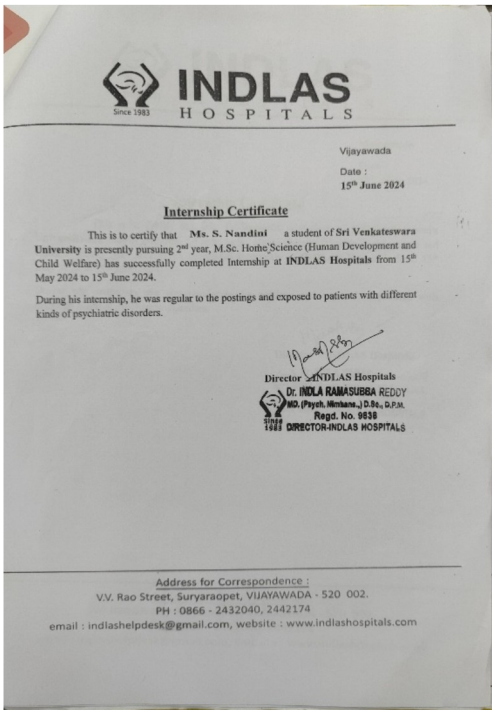
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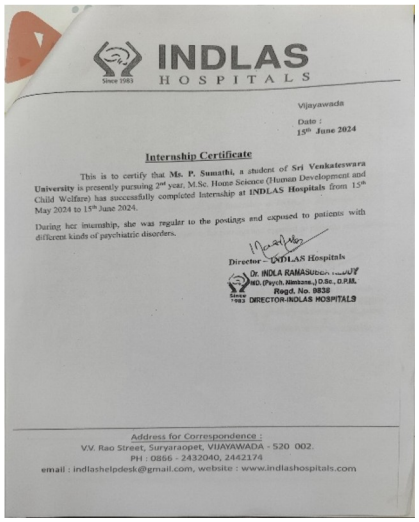
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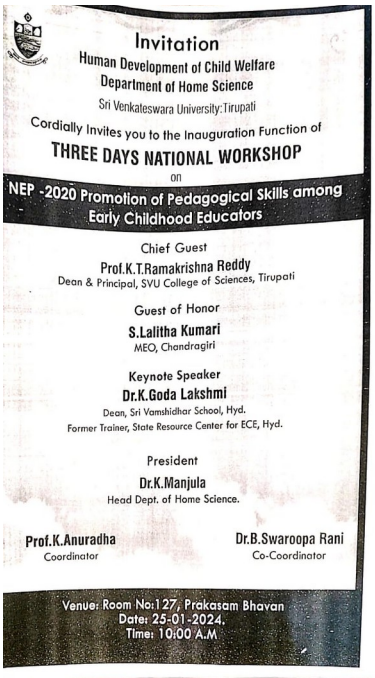
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3.3.2-



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on

NEP -2020 Promotion of Pedagogical Skills among Early Childhood Educators

Chief Guest
Prof.K.T.Ramakrishna Reddy
Dean & Principal, SVU College of Sciences, Tirupati

Guest of Honor
S.Lalitha Kumari
MEO, Chandragiri

Keynote Speaker
Dr.K.Goda Lakshmi
Dean, Sri Vamshidhar School, Hyd.
Former Trainer, State Resource Center for ECE, Hyd.

President
Dr.K.Manjula
Head Dept. of Home Science.

Prof.K.Anuradha
Coordinator

Dr.B.Swaroopa Rani
Co-Coordinator

Venue: Room No:127, Prakasam Bhavan
Date: 25-01-2024.
Time: 10:00 A.M



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Prof. K. Raja Reddy
Hon'ble Vice-Chancellor,
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Human Development and Child Welfare

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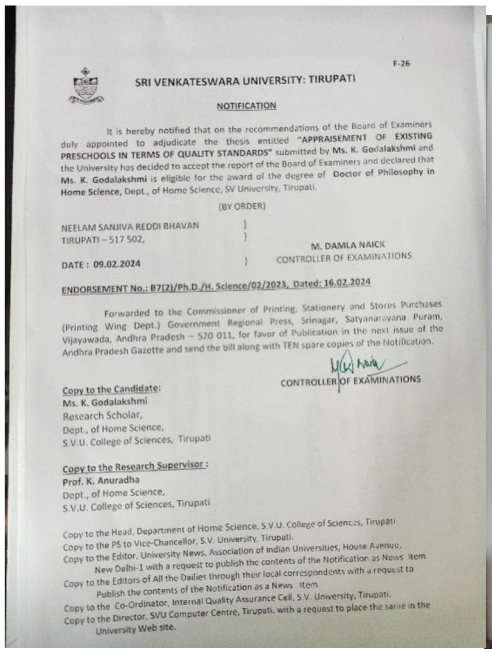
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Dr. B. Swaroopa Rani
Organizing Secretary
Assistant Professor
HD & CW
Dept. of Home Science

Date: 25th July 2023

3.4.4-



F-26

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NOTIFICATION

It is hereby notified that on the recommendations of the Board of Examiners duly appointed to adjudicate the thesis entitled "**APPRAISEMENT OF EXISTING PRESCHOOLS IN TERMS OF QUALITY STANDARDS**" submitted by **Ms. K. Godalakshmi** and the University has decided to accept the report of the Board of Examiners and declared that **Ms. K. Godalakshmi** is eligible for the award of the degree of **Doctor of Philosophy in Home Science**, Dept., of Home Science, SV University, Tirupati.

(BY ORDER)

NEELAM SANJIVA REDDI BHAVAN
TIRUPATI – 517 502,

M. DAMLA NAICK
CONTROLLER OF EXAMINATIONS

DATE : 09.02.2024

ENDORSEMENT No.: B7(2)/Ph.D./H. Science/02/2023, Dated: 16.02.2024

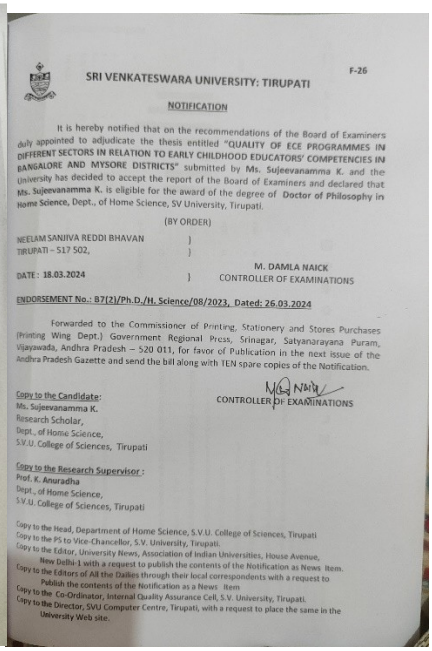
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It is hereby notified that on the recommendations of the Board of Examiners duly appointed to adjudicate the thesis entitled "**QUALITY OF ECE PROGRAMMES IN DIFFERENT SECTORS IN RELATION TO EARLY CHILDHOOD EDUCATORS' COMPETENCIES IN BANGALORE AND MYSORE DISTRICTS**" submitted by **Ms. Sujeevanamma K.** and the University has decided to accept the report of the Board of Examiners and declared that **Ms. Sujeevanamma K.** is eligible for the award of the degree of **Doctor of Philosophy in Home Science**, Dept., of Home Science, SV University, Tirupati.

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DATE : 18.03.2024

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3.4.5

Index Copernicus Value (2016): 79.57 | Impact Factor (2015): 6.391

Competencies of Early Childhood Educators in Bangalore According to their Professional Variables

K. Sujeevanamma[1], Dr. K. Anuradha[2]

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[2]Professor, Department of Homescience, S.V. University, Tirupati, Andhra Pradesh, India

Abstract: *The present study was conducted to assess the competencies of early childhood educators according to their professional variables. The study sample were 120 pre-school teachers (60 Government and 60 Private teachers), selected from six ICDS projects areas of Bangalore, Karnataka state using stratified random sampling technique. Self-Evaluation Checklist developed specially for ECE educators was used. Results revealed that the pre-school teachers differed significantly in their educational qualification, experience and training. The results can help to suggest that training for pre-school teachers will have more competencies which intern helps to improve the quality of preschool programme.*

Keywords: Competencies, Professional variables, Early Childhood Educators

1. Introduction

The early years of life are the most crucial periods in a child's life when the rate of development is very high and foundations are laid for cumulative lifelong learning. Over the past several decades, research has clearly demonstrated the importance of early care and education. This is the period during which there are specific sensitive periods for optimal learning in particular areas. During this period of 3 to 6 years a child starts attending the pre-school. Pre-school, Nursery school, ECE centre, ECCE centre, etc., are the different names for the school attended by young children. The enriched experiences can be provided in an ECE centre through the professionally competent Early Childhood Educator.

Early Childhood Educator

Early childhood educator or the pre-school teacher, who works directly with young children plays an important role in maintaining the quality of ECE programme. The vital relationships between early childhood educators and young children are formed in the daily routines and activities of infant/toddler and preschool settings.

It was reported that high quality early childhood education produces substantial long-term educational, social, and economic benefits with the largest benefits for children occurring when teachers are professionally prepared, implementing the practices and strategies they have learned, and adequately compensated (Whitebook, 2003). The Pre-school teacher or Early Childhood Educator plays a significant role in providing optimal learning to young children.The competencies needed to support, plan, and guide children's early learning and development are crucial.

The knowledge, skills, and practices of Early Childhood Educators are important factors in determining how much a young child learns and how prepared that child is for entry into school.

Competencies of ECCE Educators

Early Childhood Educators are expected to have a deeper understanding of child development and early education issues, so that they can provide richer educational experiences for all children, including those who are vulnerable and disadvantaged, engage children of varying abilities and backgrounds connect with a diverse array of families.

Sheridan (2009) and Samuelsson (2011) also reported that the main importance of staff lies in their effect on the process and content quality of ECCE. The training and education of ECCE staff affect the quality of services and outcomes primarily through the knowledge, skills and competencies that are transmitted and encouraged by practitioners. It is also considered important that staff believe in their ability to organize and execute the courses of action necessary to bring about desired results (Fives, 2003).

Review of research supported showed strong evidence that enriched stimulating environments and high-quality pedagogy are fostered by better qualified staff; and better quality pedagogy leads to better learning outcomes (Litjens and Taguma, 2010). But , in recent times pre schools are established like mush rooms in every nook and corner of towns and cities and teachers who are having less educational qualification without proper training are recruited with less wages. But there is a need to assess their competencies.

With this background the present study was conducted to understand the Early Childhood Educators' Competencies according to their professional variables in Bangalore of Karnataka state. The following are the objectives of the study.

2. Objectives

- To find out whether the early childhood educators'competencies differ according to their educational qualification.
- To find out whether the early childhood educators' competencies differ according to their training.

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Quality of ECE Programmes in Government and Private Sectors in Bangalore District of Karnataka State

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ABSTRACT

The present study was conducted to assess the quality of ECE programmes in different sectors of Bangalore District of Karnataka state. The study sample were 120 pre-schools (60 Government and 60 Private), selected from six ICDS projectsof Bangalore, Karnataka state using stratified random sampling technique. The ECE Quality Assessment checklist was developed based on Quality Standards Framework given by Ministry of Women and Child Development (MWCD,2013), and standardized was used to collect the data. Results revealed that according to quality indicators, 90 per cent of Anganwadicentres (AWCs)fell under average category and 10 percent under good category. With regard to private pre-schools 40% of sample schools fell under poor and an equal percent under average category. Around 20 per cent of pre-schools run by private management were graded as 'good'. Comparatively, schools run by Government scored more on aspects of Interaction, Health nutrition, personal care and routine, Organization and management and Children experiences and learning opportunities. Whereas, pre-schools run by private management scored more on Infrastructure/physical environment and Assessment and outcome measures.

Key Words : Quality of ECE Programmes, Anganwadis, Private pre-schools, Grading of pre-schools

INTRODUCTION

Early childhood period which extends from around two to six years of age is acknowledged as the most crucial period, when the rate of development is very high and foundations are laid for cognitive, physical, social, emotional, language and personality development. This period is crucial especially because a large proportion of human brain development takes place after birth as a result of interactions with the environment. Given the importance of the early years in shaping a child's brain development, every child has a right to an enriched and supportive environment in order to reach the full potential. Early childhood education is directly linked to the effectiveness and efficiency of success in later stages of education. Children who attend preschool are more likely to be ready for primary school and are more likely to persist and succeed in education. Quality preschool education plays an important compensatory role in reducing the developmental gap between children from resource backgrounds and their more privileged peers.

All children have the right to education resources and services that support their development in early childhood. In addition to young children's right to early childhood education, quality early childhood development interventions are proven to alleviate the effects of poverty on children, families, women, communities, and societies.

ECCE programs are typically rated on two dimensions of quality – process quality and structure quality. The interactions, activities, materials, learning opportunities, and health and safety routines are observed and rated as a measure of process quality. The second dimension, structural quality, includes the size of each group of children, the adult-child ratio, and the education and training of the teachers and staff.

Experimental research demonstrated sustained high-quality early care and education (ECE) can mitigate the consequences of poverty into adulthood (Andres *et al.*,

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Mini Review

Open Access

Undernutrition among Children in Andhra Pradesh and Strategies for Control

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Abstract

India continues to have serious levels of widespread hunger and under nutrition prevailing among under five children in India. India has performing very vulnerable on the global hunger index 2022; India ranked a very low 107th out of the 121 countries. The Indian Institute of Population Sciences (IIPS) published national family health survey NFHS 1-NFHS 5 fact sheets provides selected information on 3 indicators like underweight, stunting, wasting which are related under nutrition, health and nutrition for Andhra Pradesh's under five children. This paper explores to the major indicators related to nutritional status of under five children in last one decade is making a comparative analysis of all the NFHS 1-5 fact sheets data. This paper is divided in 3 sections and each of them focus on the important indicators of nutritional status of under five children such as underweight, stunting, wasting of urban and rural area's children. Identify the inconsistencies existing among the good and poor performing levels of urban and rural areas of Andhra Pradesh since 2005 to 2020.

Keywords: Under nutrition; Underweight; Stunting; Wasting; NFHS fact sheets

Introduction

Nutrition is the focal point for health and well-being. Nutrition is a basic right but it remains unmet for many young children below five years. Nutritional status is influenced by food, health, care, education, social, political factors and economic status [1]. Good nutritional status results when children have affordable, diverse, nutrition rich food, appropriate maternal and child care practices, adequate health services and a healthy environment including safe water, sanitation and good hygiene. Importance of these factors differ from country to country. Understanding the immediate and underlying causes of under nutrition in a given context is critical to deliver appropriate, effective and sustainable solutions and meeting the needs of the most vulnerable people [2].

Malnutrition is a common problem in children below 5 years of age, especially chronic malnutrition. Malnutrition can be described by variety of health problems, including stunted growth, weight loss and impairment of intellect and weakened infection [3]. Severe cases of malnutrition can lead to death. Malnutrition in India has been called as a "the silent emergency". Three types of malnutrition are Severe Acute Malnutrition (SAM), Moderate Acute Malnutrition (MAM) and chronic malnutrition. Protein energy malnutrition generally manifests early in children between age group 6 months and 2 years and associated with early weaning and delayed complementary foods, a low protein diet and severe infections.

Literature Review

Prompting concern that the COVID-19 pandemic could exacerbate the health and nutrition crisis among the poorest of the poor, the women and child development ministry estimates that there are 9,27,606 (17.76 lakh/1.7 million) Severely Acute Malnourished children (SAM) and 15,46,020 (15.46 lakh/1.5 million) Moderately Acute Malnourished (MAM) children as of October 14, 2021. The total 33,23,321 (33.23 lakh/3.3 million) is a computation of data from 34 States and union territories.

Prevalence of undernourishment in India for the triennium periods 2015-17, 2016-18, 2017-19 are 14.8%, 14.5% and 14.0% respectively. The global hunger index which is calculated on the basis of total undernourishment of the population, child stunting, wasting and child mortality places India at the 107 spot among 121 countries. Government conducts National Family Health Survey (NFHS) at regular intervals. As per recently released NFHS report, child stunting in the country has decreased from 38.4% (NFHS-4, 2015-16) to 35.5% (NFHS-5, 2019-21) and child wasting has decreased from 21.0% (NFHS-4, 2015-16) to 19.3% (NFHS-5, 2019-21). Further, percentage of underweight children has gone down from 35.8% (NFHS-4, 2015-16) to 32.1% (NFHS-5, 2019-21). Child wasting at 17.3% and child stunting at 34.7%, have remained unchanged in 2021 as compared to 2020.

As the district Andhra Pradesh indicated that there were 80,229 stunted children, 32,885 wasted children, 9,795 severely wasted children, 62,271 underweight children, 513 overweight/obesity children and 1,26,961 anaemia children.

Results and Discussion

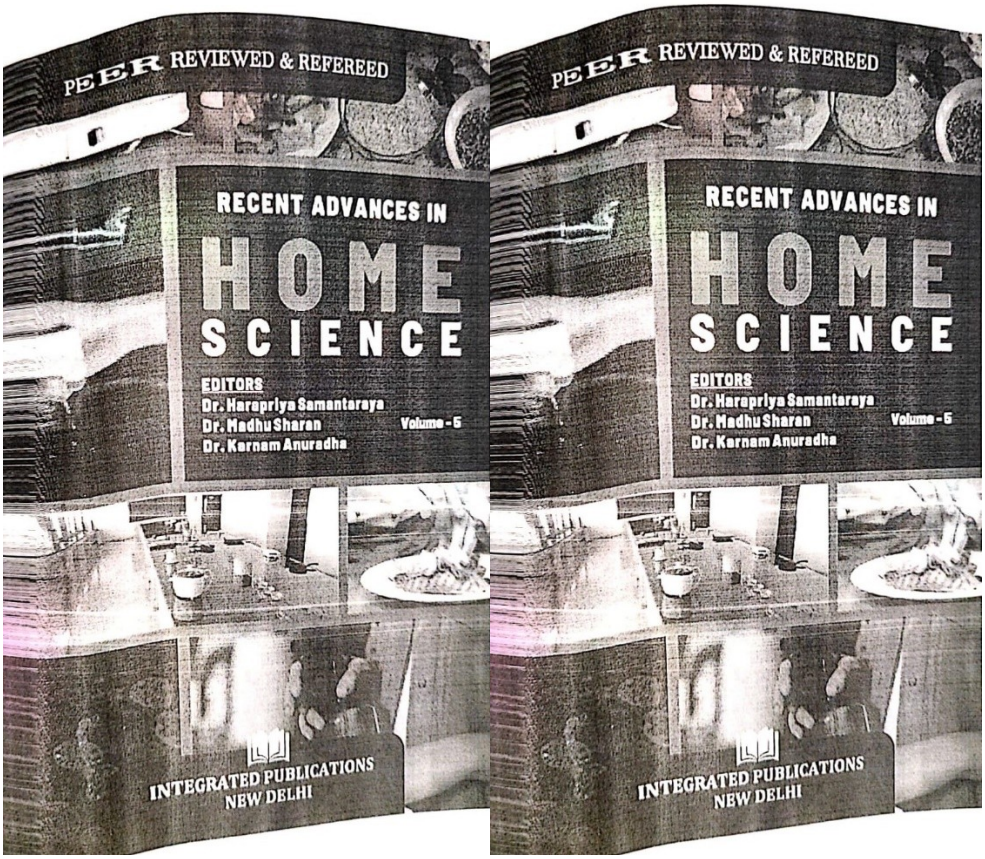
The NFHS fact sheets of 2005-2006, 2015-2016 and 2019-2020 were analysed. The data was segregated in the rural and urban categories across indicators of malnutrition like underweight, stunting and wasting. The observations are shown in Table 1 and Figure 1.

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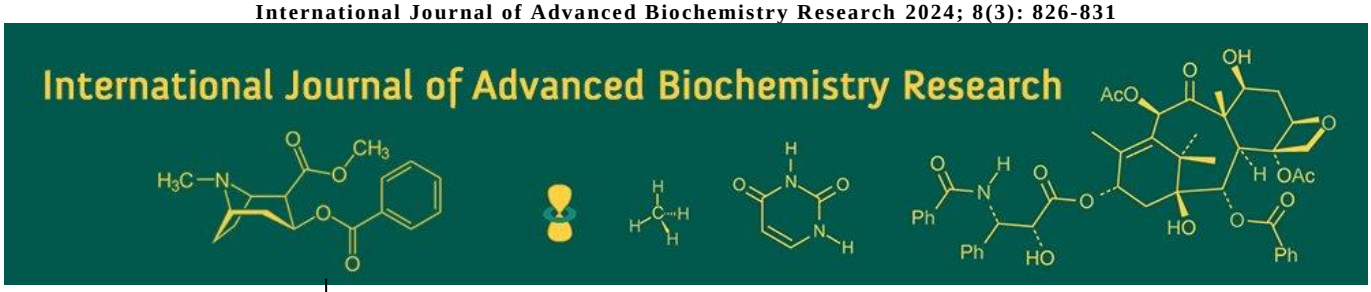
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This is to certify that Dr. K. Anuradha, Professor,
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has completed the NEP 2020 Orientation & Sensitization Programme under Malaviya Mission Teacher Training Programme (MM-TTP) of University Grants Commission (UGC) Organized by UGC – MMTTC, Sri Venkateswara University, Tirupati from 21-11-2023 to 29-11-2023.
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Dept of Home Science, Sri Venkateswara University, Tirupati participated in Three days National Workshop on "NEP-2020 Promotion of Pedagogical Skills Among Early Childhood Educators" organized by Human Development & Child Welfare, Department of Home Science, S. V. U College of Sciences, S.V.University, Tirupati during 25th - 27th January 2024.
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Study on effect of millet milk on spleen iron concentration

Vinod Kumar Ilapanda and Sucharitha KV

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Abstract
Infant nutrition is the basis of the body's reservoir of nutrients including iron. Babies are born with a reserves of iron, which comes from their mother's blood, while they are in womb.
For the first 6 months of life, baby's get the nutrients from their mother's milk and is sufficient for the growth and development of infants. After 6 months of their life iron becomes a critical nutrient. The estimated daily iron requirement at the age of 6 to 12 months (0.9 to 1.3 mg per kg body weight) are higher than during any other period of life. During this period, they get the iron through infant milk formula and later from solid foods. From 6 months of age all infants should receive a sufficient intake of iron rich foods which may be meat products or iron fortified foods. Breast milk, infant formula, and water should be the only drinks offered after 6 months of age. A wide range of solid foods, including iron containing foods, should be introduced in an age appropriate form from around 6 months of age along with continued breastfeeding.
According to the American academy of pediatrics suggests that breast fed infants should be supplemented with 1mg/kg per day of oral iron. Standard infant formulae contain 12 mg per liter can full fill the needs of iron in infants until the age of 1year. Supplementation of iron through mediations may cause problems in health. Hence better to get iron through diet like iron fortified cereals.
The best food sources of iron are whole grain cereals, pulses, and legumes, liver, egg yolk and fish. And the best plant sources are green leafy vegetables such as radish greens, lotus stems, cauliflower greens, and turnip greens. Fruits such as watermelon, black currants, raisins and dried dates are rich sources of iron. Millets and soya based infant formula are best alternatives for milk because they are rich in iron along with other nutrients.
All the breast fed infants are not tolerated to breast milk because some infants are not able to digest lactose, the sugar present in milk. They do not produce enough enzyme known as Lactase which is used to digest lactose in the milk. This condition is called Lactose intolerance. Symptoms of lactose intolerance usually develop within a few hours of consuming food or drink that contains lactose. They may include bloating, diarrhoea, flatulence and abdominal cramps. The lactase enzyme is needed to break down lactose into glucose and galactose, which can then be absorbed into the bloodstream and used for energy.
An allergy to cow's milk and related dairy products affects one in 50 babies and is different to lactose intolerance. Peoples who are allergic to cow's milk can also be allergic to milk from other animals such as goats, sheep and buffalo. A cow's milk allergy can cause symptoms such as wheezing and asthma, diarrhoea, vomiting, and gastrointestinal distress. Other reactions include eczema, an itchy rash and rhinitis or inflammation in the nose. In several cases, it can lead to bleeding, pneumonia, and even anaphylaxis, a potentially fatal hypersensitivity reaction.
As concern about lactose intolerance and milk allergies widen, a range of substitute milks, such as millet and soya milk, have become available. Milk has long been seen as a healthy drink, because it is high in range of nutrients.
According to medical advice:
- Milk alternatives include soya milk and millet milk are the great sources of nutrients.
- Each type has a different nutritional profile, so it is important to check that all the nutrient requirements are meeting or not.
- Some plant based milk is not suitable for children, but it is possible to consume a balanced diet without dairy products.

Keywords: Lactose intolerance, breast feeding, infant milk formula, millet milk, soya milk, iron

Introduction
Millet is the main food source for people living in the drought and semi-arid tropics of Asia and Africa. Millet is an important source of carbohydrates, proteins and minerals. Due to its importance to national food security and potential health benefits, millet grains are currently receiving increased interest from scientists, engineers, and nutritionists. (Ahmed Sn Saleh *et al.*, 2013) [2].

According to IIMR (Indian Millet Research Institute), India was the largest millet producing country in 2000 and 2009, followed by Nigeria. The most common millet is pearl millet, which is an important crop in India. India is a major producer of small millets such as finger millet, porso millet, foxtail millet, kodo millet.

Importance

Millet contains health-promoting secondary plant substances such as polyphenols, lignin, phytosterols, phytoestrogens, and phytocyanins. These act as antioxidants, immune modulators, antidotes, etc.). Therefore, millet protects against age-related degenerative diseases such as cardiovascular disease, diabetes, and cancer. [Rao *et a1*. 2011] [6].

It is also rich in vitamins, minerals and essential fatty acids, which have health benefits in terms of preventing degenerative and malnutrition diseases. Millets are known to have high nutritional value comparable to major grains such as wheat and rice. [Saleh *et al*. 2013] [2]. Furthermore, it is rich in essential amino acids except lysine and threonine, but it also contains relatively high amounts of methionine. Millet grains exhibit prebiotic activity that helps increase the number of beneficial bacteria that play an important role in promoting digestion (Sarita *et al*. 2016) [1]. Millet is safe for people with gluten allergies and celiac disease. They do not produce acids and are not allergenic (Saleh *et al*. 2013) [2].

Millets are rich sources of insoluble fiber, binds with triglycerides in the body and remove out from the body to prevent coronary artery disorders. The ant diabetic effect of millet is mainly due to its rich fiber content. (Jayabhaye. *et al.* 2010) [4]. The high fiber content in millet and the presence of some anti-nutritional factors such as phytates and tannins affect the bioavailability of minerals. The phytonutrient lignin in millet is converted to mammalian lignin in the intestines, which protects against breast cancer. Mill*et al*so helps in losing weight as it is rich in fiber. It creates a feeling of fullness.

Nutrition in millets

Millet is a rich source of nutritional supplements and contains more fiber than wheat (or) rice. It also contains protein (9-14%). -80% carbohydrates. Millets such as sorghum and ragi are important sources of essential amino acids and micronutrients such as calcium, iron, and zinc in the Indian diet, especially for people living in poor socio-economic conditions. (Maha Lakshmi *et al*., 1997) [5]. A variety of traditional household food processing and preparation methods can also be used to improve the bioavailability of micronutrients in plant-based diets. These include heat treatment, mechanical treatment, steeping, fermentation and germination (or) malting. The purpose of these processing techniques is to increase the physicochemical accessibility of micronutrients and reduce the content of anti-nutrients such as phytates (or) increase the content of compounds that improve their bioavailability (Ahmed Sn Saleh 2013) [2].

Millet is an excellent source of magnesium and phosphorus. Magnesium can help reduce the effects of migraines and heart attacks, and phosphorus is an essential component of adenosine triphosphate (ATP), the body's energy precursor. Finger millet lowers plasma cholesterol, serum total cholesterol, and LDL cholesterol by 9% each, lowers triglycerides by 15%, and increases HDL cholesterol. This has a pronounced positive effect on the plasma profile. [Kajal Srivastava *et al*., 2012] [3]. Pearl millet has the highest protein content among all cereals which is helpful for tissue growth and muscle development, it has a property to convert acidic condition to alkaline to prevent stomach ulcers. The high fiber content in pearl millet is known to reduce gallstones occurrence. Ragi is a folk remedy for leprosy, liver disease, measles, pleurisy, pneumonia, and pneumonia. [Kajal Srivastava *et al*., 2012] [3].

Iron

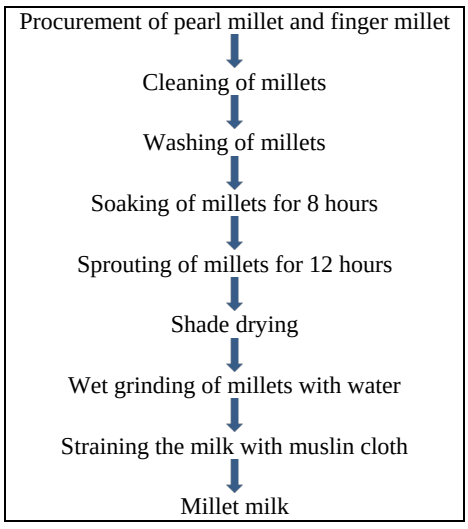
Iron is a micronutrient found in many foods, and daily intake of milligram amounts is sufficient for physical health and mental well-being. Iron deficiency is a major health problem worldwide. The average iron content in the body of an adult is about 4 g, about 50% of the iron is in the form of hemoglobin, and more than 25% of the iron is stored in the liver, spleen and bone marrow. The remaining small amount of iron forms myoglobin (which acts as an oxygen store) and other iron- containing proteins. Humans absorb approximately 12 to 18 mg of iron each day. Only 1-2 mg of iron is absorbed. (Journal of Medical Research (2008). Iron mainly exists in the human body in the form of complexes, which include heme compounds (Hemoglobin (or) myoglobin), heme enzymes (Or) proteins (Heme proteins) as the non-heme compound ferritin and transferrin (J Res Med sci. 2014). Primarily, iron is required for the production of heme enzymes, which are responsible for electron transport, oxidation, and reduction, and for the synthesis of heme proteins, which are responsible for gas transport in the body.

Materials and Methods

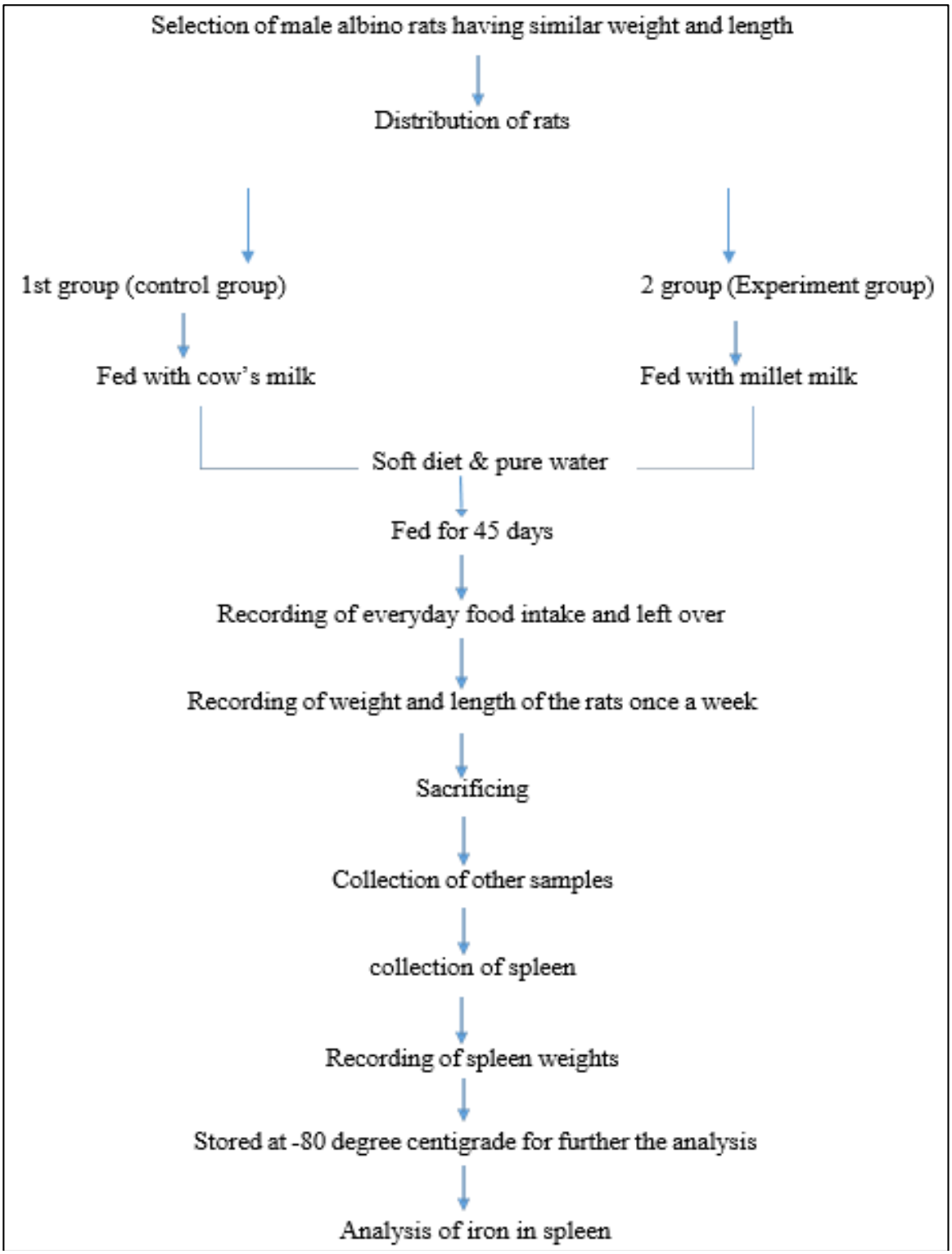
Selection and standardization of ingredients

For extracting milk two millets namely finger millet and pearl millet were selected. Finger millet is referred as the power house of proteins, minerals and amino acids. Among all cereals, finger millet has the highest calcium percentage and also rich in amino acids tryptophan, threonine, alanine, isoleucine and methionine. Pearl millet is also called as miracle millet as it contains iron which is eight times higher than in rice. Pearl millet is also a good source of protein, calcium, folic acid, fat, fiber, phosphorous and niacin. Millets used in study were procured from the local market in Tirupati.

Millet milk extraction process



Experimental Work



Feeding of rats

Each group of rats were fed with respective diets adlibitum. Everyday 7:00 a.m. in the morning and 5:00 p.m. in the evening, the leftover feed was weighed and recorded and then the rats were fed with the fresh stock diet and millet milk in the morning and only the stock diet during the evenings. The weekly consumption of feed was also increased from 5 ml to 15 ml by the end of the experiment based on their acceptance. The weekly consumption of feed was also increased after observing the zero percentage of leftover. During the first week the stork diet given was 10 grams which was gradually increased to 20 grams by the end of the experiment. Care was taken to clean and sterilize the Water bottles and food cups daily before administering the diet.

Growth-parameters

Sacrificing

The rats were not fed with any food before 24 hours of the sacrifice but the weight and length of the rats were measured. The rats were euthanized (Decapitated). Immediately after decapitation, the spleen was removed from the body. Spleen of the rats were collected individually, weighed, rinsed it with alcohol and further

analysis was carried out to estimate the iron content in the spleen.

Analysis

Spleens were weighed and stored at -80 degrees centigrade until prepared for the analysis. Spleen tissue iron concentrations were determined using a modification of the genome protocol.

Reagents required for estimation of spleen Ion concentration: Protein precipitant

100 grams of trichloro acetic acid dissolved in 700 ml of water and add 30 ml of thio glycolic acid and 86 ml of concentrated HCL, make up to 1 liter. It can be stored in 2 months.

Color reagent

Dissolve 204 gram of Sodium acetate tri hydrate dissolved in 800 ml of water add 250 milligrams of batho phenanthroline sulphate and make up to 1 liter, and stored in a dark bottle the reagent stables for 2 weeks at least.

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Glassware's required

1. 100 ml standard flask
2. 10 ml measuring cylinder
3. Test tubes
4. Centrifuge tubes

Instruments required

1. Weighing balance
2. Centrifuge machine
3. Optical emissions spectrophotometer

Procedure for estimation of spleen iron



Table 1: Spleen iron levels of control and experiment group rats

Rats	Control group with cow milk (µg/g)	Experiment group with millet milk (µg/g)	T value
1	351.4	260.09	
2	305.3	399.29	
3	292.4	281.9	
4	272.2	242.7	
5	410.6	349.7	
6	329.5	212.5	
7	347.4	222.7	
8	429.1	308.7	
9	339.9	281.0	
10	348.4	304.4	
⁀	302.7	396.2	
12	344.0	361.8	
mean	339.3 ± 100	301.7 ± 100	0.112 NS

NS – Not significant

The data in the Table no.1 interprets the spleen iron levels of control and experimental group rats. The mean spleen iron levels of the control group were 339.3 µg/g and the experiment group was 301.7µg/g. There was no significant difference of spleen iron levels between both control and experiment groups. Hence the iron levels are almost equal between control and experiment rats and the millet milk is as good as cow's milk for feeding the infants. According to Jennifer Gibson et.al, (2011) the levels of iron concentration in male rats which were fed with adequate nutrition diet with adequate iron was 12.739 µg to 3869 µg. In the present study also the range was between in control rats 272.2 µg to 429.1 µg, and experiment rats between 212.5 µg to 399.29 µg.

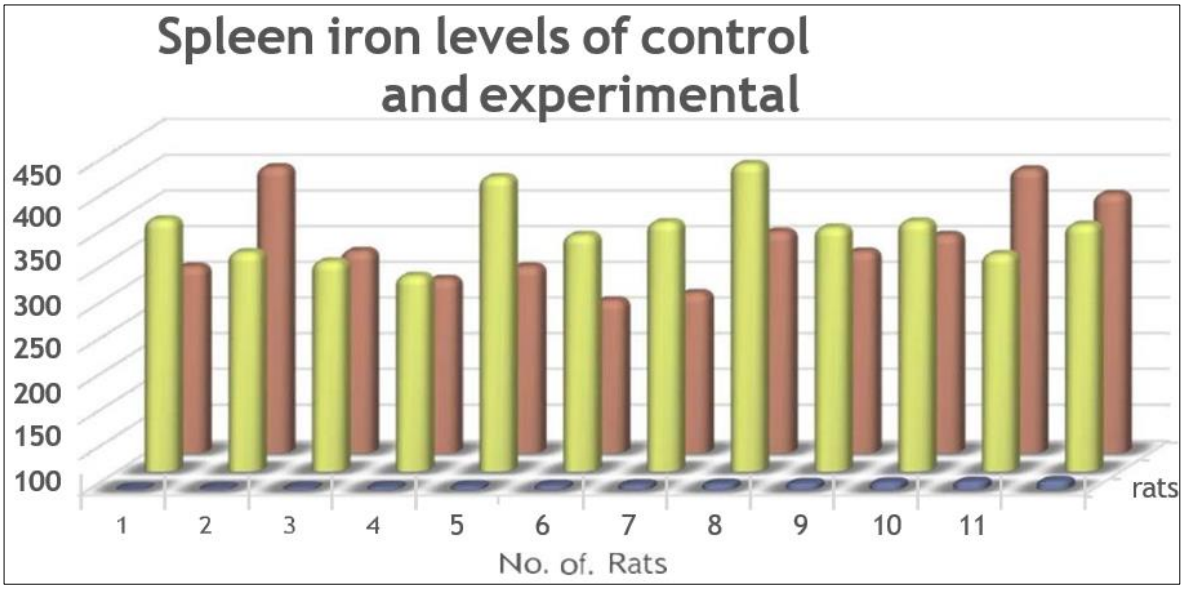


Fig 1: Graph showing the spleen iron levels of control and experimental group rats

The results of this study indicate that milk prepared from finger millet and pearl millet is also suitable as milk. Millet is an excellent source of nutrition. Additionally, millet is a rich source of essential amino acids and essential fatty acids that promote the physical and mental growth of infants. Results of a study on iron concentrations in the spleen showed no significant difference between rats weaned on millet milk and cow milk.

Summary and conclusion

Present research with animal models using albino rats was undertaken to study the effect of millet milk on spleen iron levels of albino rats. Speaking of millet, finger millet and pearl millet were selected for milk production. Finger millet is rich in protein, minerals, and amino acids. Finger millet has the highest calcium content of all grains and is also rich in the amino acids tryptophan, threonine, alanine, isoleucine, and methionine. It is also a good source of protein, calcium, folate, fat, fiber, phosphorus, and niacin. At the household level, we use traditional methods that result in less loss of nutrients.

Traditional methods such as soaking, germination, and wet grinding have been used to improve the nutritional content of milk. Product formulation is not indicated. This is because the formulation and technology are patented.

Male weanling albino rats (3 weeks old: n = 12) were purchased from Chennai and maintained in laboratory rat cages (Per cage). Rats were kept in cages for 2–5 days to get used to the new environment. Rats were fed food until the beginning of the experiment. Before the start of the experimental day, rats were weighed and body length measured.

The rats were divided into two groups based on body weight and body length. Each group of rats are fed with respective diets ad libitum. Every day, 7:00 a.m. in the morning Cow's

milk was fed to the control group rats and millet milk is fed to the experimental group rats ad libitum.

The experiment was carried out for 45 days. The rats were not fed with any food before 24 hours of the sacrifice. The weights and length of the rats were measured. The rats were euthanized or (Decapitated). Immediately after euthanization spleens were carefully dissected from the body and recorded the weights of the spleen. They were kept at -80 degrees centigrade for further analysis and performed iron analysis. Iron is the nutrient most commonly associated with red blood cell formation and metabolism. Large amounts of iron exist in the body as hemoglobin. The pigment contains iron and protein molecules and is responsible for transporting oxygen from the lungs to the tissues. Memories are stored in the liver, spleen, and bone marrow. Small amounts of iron are stored in muscle tissue as myoglobin. The mean spleen iron level of rats in the control group was 317.03±100 µg, and the mean spleen iron level of the experimental group was 311.84±100. There was no statistical difference between the control group fed cow's milk and the experimental group fed millet milk. Therefore, this study concludes that millet milk is as good as cow's milk. Further research is needed to confirm the study.

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Research Article

Optimization and Formulation of Lactose-Free Milk Using Finger and Pearl Millet

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ABSTRACT

Milk alternatives from non-dairy or plant-based sources help people with lactose intolerance and lactose indigestion. Formulations for alternate milk were optimized based on the sensory and nutritional properties. Optimized milk was proportioned by preparing different combinations of finger millet and pearl millet in ratios of T_1 (60:40), T_2 (70:30) and T_3 (80:20), while cow's milk was T_0 (control milk). The current investigation was carried out to optimize and develop a plant-based milk alternative using millets. The millet milk (Lactose-free milk) blends were analyzed for the organoleptic parameters, and further proximate analysis was done for the selected variation. Among the variations, the panellists most accepted T_2 (70% Finger millet + 30% Pearl millet). Nutrient analysis except for calcium, the other energy content, carbohydrate, fat, and mineral content all were higher in the lactose-free milk than in cow milk, and the protein content was the same. Based on the nutrient and sensory scores, millet milk is a non-dairy or Lactose-free milk alternative.

Keywords: *Finger millet, Pearl millet, Lactose-free milk, sensory score, blends.*

INTRODUCTION

Millets are commonly used for beverages that the population relishes for age-old decades, as they have a uniqueness for appetite, satiety and a healthy nutritional profile (Patil et al., 2010). In the present decade, the consumption of milk in day-to-day life has become a concern, as it is having many health issues like allergies to milk, lactose indigestion and lactose intolerance and also having effects on metabolic disorders due to high-fat content (Swagerty et al., 2002). Milk formulated from the plant-based is the best alternative for milk. Alternative milk formed from plant-based products is low in saturated fats, triglycerides, cholesterol and, importantly, the absence of Lactose. They contain essential fatty acids, proteins and minerals (Bode et al., 2008).

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Hence, plant-based products are taken as nutraceuticals and functional foods that contain antioxidants, fibre, vitamins and minerals. Millets, the minor cereals, are easy to acquire, and by using traditional methods, we can produce healthy, palatable, good flavour alternative milk (Kneepkens et al., 2009).

Finger millet has abundant stores of dietary fibre, phytates, and minerals. Also, the bran of the millet is a reservoir of numerous health benefits (Chandrasekara, 2010). They contain flavonoids with antioxidants and have the properties of anti-allergy, anti-inflammation, anti-cancer properties and gastro-protective properties (Sreeramulu, 2009). Finger millet consists of many phenolic compounds like vanillic acid and quercetin, which helps inhibit cataract in the eye lens. Clinical trials have shown that finger millet has good digestive attributes and has improved the bioavailability of minerals (Makokha et al., 2002).

Therefore, paediatricians in southern India mostly prefer and suggest finger millet products for infants above 6 months due to their good protein digestibility and micronutrient composition (Kannan, 2010). The functional grain is assimilated into different types of foods. The flour can be mixed with milk, boiling water and curds (Rai et al., 2008). Due to its high nutritional value, this is one of the ingredients used for product development.

Pearl millet was taken as the second millet to develop lactose-free milk. Malnutrition and, most commonly, protein-energy malnutrition is the dreadful cause of around 50% of childhood mortality in many developed countries (Grigsby, 2002). One of the growth defects, stunting was a major indication among 15% of infants below 12 months (SALDRU, 1994).

These malnutrition conditions result due to infections like diarrhoea, vomiting or insufficient dietary consumption due to intolerances (Pelletier, 1993). Thaoge et al. (2003) stated that the addition of small amounts of pearl millet could be a very good source of energy and has the good protein of 11.8%, fat of 4.8%, which are the essential nutrients during infancy and also gluten-free (FAO, 1995). The two millets were selected as the main ingredients for developing lactose-free milk (LFM), which were available locally and rich in energy, carbohydrates, calcium, protein and minerals like magnesium. The milk alternatives of millets are the liquids derived from the permeate of millets by soaking, sprouting and micronized to 5-20 µm by homogenization, which is similar in appearance and consistency (Das et al., 2012). The two millets have nutrients like carbohydrates, protein and calcium and give a creamy white liquid appearance and little similar consistency. Therefore, taking into the sensory attributes, both millets can be blended to develop milk. The current study optimized and formulated millet milk (Lactose-free).

MATERIALS AND METHODS

The current research was focused on the preparation and optimization of millet milk. The methodology adopted for the present study is illustrated below.

2.1. Locale of the study

The study was conducted at the food science laboratory in the Department of Home Science, Sri Venkateswara University, Tirupati of Andhra Pradesh.

2.2. Procurement of raw materials

Millets, finger millet and pearl millet were purchased from local markets in good quality conditions in Tirupati, Andhra Pradesh. Before the preparation of the millet milk, the purchased millets were cleaned thoroughly for any physical contaminants like dust particles, small stones and twigs.

2.3. Preparation of millet milk

Initially, to know the yield of milk, millets were processed separately. Finger millet milk was made by soaking finger millet for 12h in water overnight. The water is drained, and the finger millet is tied in a wet muslin cloth for sprouting for 24 hours. The sprouted finger millet was dry-roasted for 2-3 minutes and then pulverized in the blender with water for optimization at room temperature. The finger

millet mix was then filtered using the muslin cloth, and the milk was filtered. The same procedure was followed for the pearl millet milk preparation.

2.4. Optimization of millet milk

The amount of finger millet and water used for the extraction of finger millet milk was optimized based on the preliminary trials where finger millet and water were used in different ratios (1:1, 1:2, 1:3). The most suitable one, based on the sensory and nutritional profile was selected. The most acceptable ratio was 1:1, as it had the highest nutritional value among all three combinations. The millet flavour revealed in the sensory analysis was permissible, presuming that it would be later overcome by blending with pearl millet milk during optimization trials. The same procedure was followed for pearl millet milk.

Table-1: Finger millet and water combination in different treatments (100ml)

Trial	Finger millet	Water	Millet Milk
T1	100g	100ml	100ml
T2	100g	200ml	200ml
T3	100g	300ml	300ml

2.5. Finger – Pearl millet milk (Lactose-free milk)

Different finger millet and pearl millet blends were prepared by mixing finger millet and pearl millet in different proportions, as given in Table 1.

Table 1: Combination of finger millet and pearl millet in different proportions

Treatments	Finger millet	Pearl millet
V_0^*	-	-
V_1	60%	40%
V_2	70%	30%
V_3	80%	20%

*Cow's milk was taken as control (T_0)

2.6. Sensory Analysis of Millet Milk (Lactose-free)

The acceptability of the different millet milk (LF) formulations was evaluated through organoleptic evaluation using the nine-point hedonic scale. The sensory evaluation of millet milk was carried out in triplicates by a panel of 20 semi-trained judges. Prior instructions were given to the panel members, and they were requested to fill out the scorecard as per the guidelines instructed. The best accepted sample was selected for further proximate analysis.

2.7. Nutrient Analysis

The standardized sample was analyzed for proximate analysis as per the standard methods described in AOAC, 2000. Protein content was analyzed by the micro Kjeldahl method described in AOAC, 2005. Fat content was estimated by methods described in AOAC, 2005. AOAC, 1990 determined mineral content (calcium and iron).

2.8. Statistical analysis

The data from triplicate observations were analyzed statically, the mean and standard deviation were calculated in Microsoft Excel, ANOVA test, and t-test was done using SPSS version 26.

RESULTS

The minor millets, which are frequently used for their food security and abundant nutrients present, were taken to formulate millet milk. For optimization and formulation of millet milk, three ratios of finger millet: pearl millet were evaluated, that is, 60:40, 70:30 and 80:20. The different combinations obtained thereof were considered using the nutrient composition from the Nutritive value of Indian foods, C. Gopalan (1999).

Table 2: Nutrient composition of raw ingredients of finger millet:pearl millet (100g)

Finger millet: pearl millet (100g)			
Nutrients	**Variations**		
	V1 (60:40)	**V2 (70:30)**	**V3 (80:20)**
Energy (kcal)	331.65	328.92	326.2
Carbohydrate (g)	64.8	65.3	65.82
Protein (g)	8.68	8.3	7.92
Fat (g)	3.32	2.97	2.63
Iron (mg)	5.34	5.16	4.98
Calcium (mg)	229.34	263.01	296.67

The nutrient composition of ingredients was taken from the nutritive value of Indian foods, C. Gopalan

Protein, carbohydrate, fat content, energy, calcium and iron nutrient composition were calculated based on the (Gopalan, 1999). The protein content of the variations was 8.68g, 8.3g and 7.92g. carbohydrate content was 64.8g, 65.3g and 65.82g, and the fat content was 3.32g, 2.97g and 2.63g; the energy content of the combined millets was 331.65kcal, 328.92kcal and 326.2kcal respectively. The mineral content of iron was 5.34mg, 5.16mg and 4.98mg, whereas calcium was 229.34mg, 263.01mg and 296.67mg, respectively, for the variations of finger millet: pearl millet 60:40, 70:30 and 80:20 as shown in the below table-2. The optimization of millet milk was done by varying the ratio of finger millet to pearl millet (60:40, 70:30, 80:20), leading to different combinations. The evaluation of the adequacy of different formulations of millet milk was carried out on the basis of nutritional attributes and sensory profile.

2.4. Sensory evaluation for optimization of finger millet milk

Table 3 shows the sensory scores of finger millet milk, given by 20 panel members, who were given the optimized finger millet milk for evaluation of organoleptic characteristics, viz. aroma, colour, flavour, mouthfeel, taste and overall acceptability. The mean scores of sensory evaluations showed that in the three formulated optimizations with different water quantities. In that treatment, (T1) in which the water content was equal to the finger millet, i.e., finger millet: water was 100:100, had significantly better aroma (8.8), colour (8.1), flavour (8.2), mouthfeel (8.8), taste (8.7) and overall acceptability (8.7), when compared with other two treatments. It was revealed from the scores that the overall acceptability of the finger millet milk of 100:100 treatment was best acceptable among the panellists. The pearl millet milk was also optimized with 100:100 treatment.

Table 3: Optimization of finger millet with water (Finger millet: water)

Sensory Attributes	**T1 (100:100)**	**T2 (100:200)**	**T3 (100:100)**	**f-value**	**p-value**
Aroma	8.8±0.41	6.6±1.56	5.4±0.51	60.0393	0.00001*
Colour	8.1±0.81	6.4±1.19	5.4±0.51	47.7885	0.00001*
Flavor	8.2±0.85	6.3±1.30	5.3±0.73	45.1123	0.00001*
Mouthfeel	8.8±0.41	6.3±0.87	6.9±0.78	71.4105	0.00001*
Taste	8.7±0.44	6.5±1.46	5.3±0.47	71.7392	0.00001*
Overall acceptability	8.7±0.47	6.3±1.46	5.1±0.74	67.2215	0.00001*

*Statistically significant at 1% level

2.5. Sensory evaluation for Finger Pearl Millet milk (Lactose Free Milk)

The data in Table 4 and Figure 1 show the sensory score of millet milk developed, given by 20 panel members, who were given the formulated millet milk for evaluation of organoleptic characteristics, viz. aroma, colour, flavour, mouthfeel, taste and overall acceptability.

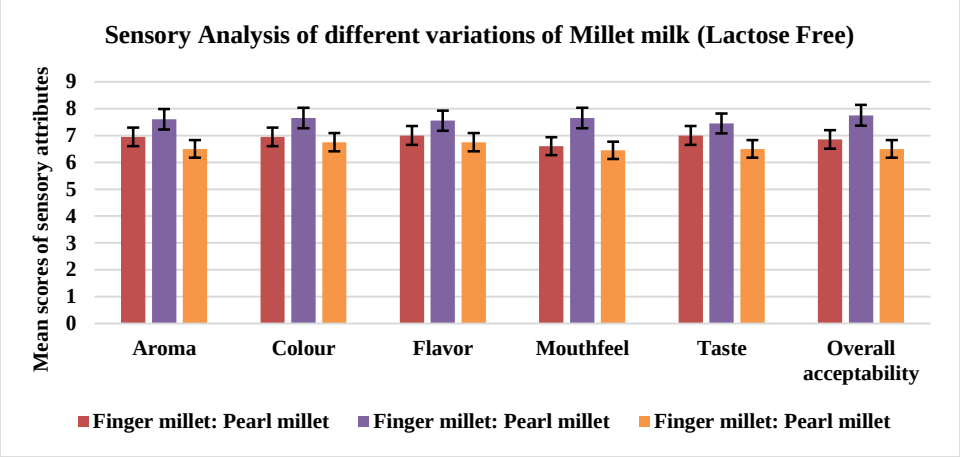


Fig 1: Graph representing the sensory analysis of millet milk

The mean scores of sensory evaluations showed that in the three formulated variations, variation V2 (70:30) had significantly better aroma (7.6), colour (7.6), flavour (7.5), mouthfeel (7.6), taste (6.4) and overall acceptability (7.7) when all the variations were compared with the cow's milk.

Table 4: Sensory Analysis by ANOVA of different variations of millet milk

Parameters	Finger millet: Pearl millet			f-value	p-value
	V1 (60:40)	V2 (70:30)	V3 (80:20)		
Aroma	6.95±0.615	7.6±0.812	6.5±0.688	14.1	0.00001*
Colour	6.95±0.510	7.65±0.745	6.75±0.443	13.22	0.00001*
Flavor	7±0.00	7.55±0.680	6.75±0.443	15.03	0.00001*
Mouthfeel	6.6±0.590	7.65±1.080	6.45±0.511	14.2	0.0001*
Taste	7±0.642	7.45±0.990	6.5±0.510	8.05	0.0008*
Overall acceptability	6.85±0.367	7.75±0.962	6.5±0.513	18.05	0.00001*

*Statistically significant at 1% level

It was revealed from the overall acceptability scores and, as shown in Figure 2 that the millet milk of V2 (70:30) is acceptable among the panellists. Hence, V2 was finalized and selected for further analysis.

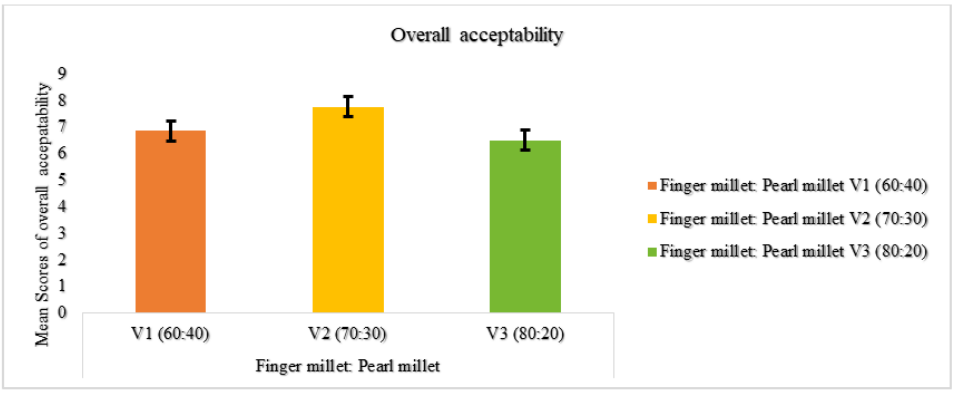


Fig 2: Graph representing the overall acceptability of millet milk by the panel members

2.6. Lactose determination

Lactose is a sugar molecule, a disaccharide found in the milk for about 4-5%. Lactase enzyme is required to properly digest Lactose, and the enzyme's insufficiency will lead to lactose intolerance. Benedict's test estimated the Lactose (Nande et al., 2008). No changes or precipitate formation was seen, confirming the absence of Lactose.

2.7. Nutrient Analysis

The energy value was the highest in the millet milk (87.12 kcal) compared to the cow's milk (67 kcal). Mbithi-Mwikya et al. 2000 stated that traditional technologies like soaking, sprouting, and shade drying processes help reduce the antinutritional factors and increase the millet's energy.

The protein content of the millet milk (3.2g) was similar to cow milk. Finger millet and pearl millet are relatively good in protein content when compared to the other millets. The high concentration of essential amino acids was threonine to the least valine. The finger millet contains 44% of the amino acids of total amino acids. Tryptophan is a deficient amino acid in many cereals, but it is present in the finger millet.

The fat content of millet milk (0.4g) when compared to cow's milk (4.1g). The fat content in the fermented and germinated/sprouted millets is relatively low when compared to the ungerminated millets and, therefore, helps in increasing the shelf life of any developed products from millets, as the risk of rancidity is very low.

The carbohydrate content of the millet milk (17.7g) when compared to the cow's milk (4.4g). The carbohydrate content in millets is around 63%- 70%, which the finger millet has good carbohydrate content due to the starches, pentosans, xylose, and simple sugars like fructose, glucose, maltose, raffinose, maltotriose and some higher oligosaccharides (Wankhede, 1979).

The iron content of millet milk (1mg) when compared to the cow's milk (0.2mg). The millets are rich in mineral content, and finger millet has a high content of iron. Except for calcium, all the other nutrients in the millet milk have high content compared to the cow's milk, and the protein content is the same as the cow's milk.

Table 4: Proximate analysis of Developed millet milk of variation 70:30 finger millet: pearl millet

Nutrients	Millet milk	Cow's milk	t-test	p-value
Carbohydrate (g)	17.7	4.4	210.29	0.0001*
Protein (g)	3.2	3.2	0.00	0.9^{ns}
Fat (g)	0.4	4.1	58.5	0.0001*
Energy (kcal)	87.12	67	318.12	0.0001*
Calcium (mg)	80	120	632.45	0.0001*
Iron (mg)	1	0.2	12.64	0.0001*
The nutrients were analyzed using the AOAC, 19th edition standards. **ns-Non significant** ***Extremely significant at 1% level**				

The graph below predicts that all the nutrients in millet milk have extremely significant levels at 1% level when compared to the cow's milk, and there was no significant difference between protein values in both millet milk and cow's milk.

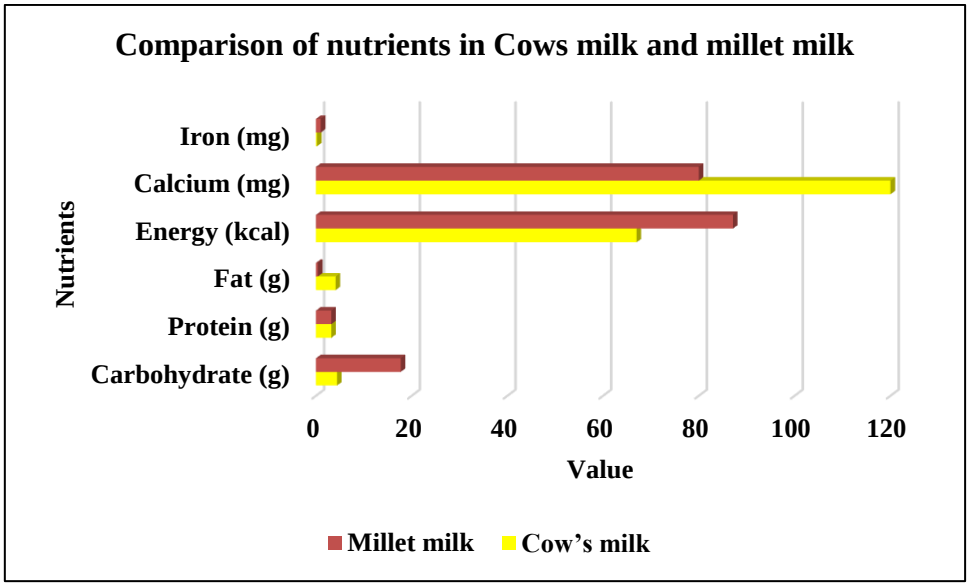


Fig 3: Graph representing the nutrients in both the cow's milk and the millet milk

CONCLUSION

Based on the analysis of cow's milk and millet milk used in this study, it can be concluded that millet-based milk prepared by the combination of finger millet and pearl millet can be a good alternative to cow milk due to the absence of Lactose and with good nutritional and sensory profile. Since it is a study based on lactose-free alternatives for milk, further alterations and modifications with respect to adding sweeteners, emulsifiers, or any other additives could be carried out to further commercialize the product.

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Author Contribution

All the authors made substantial contributions to the following: (1) Conception and Design of the study, (2) acquisition of the data, (3) interpretation of the data, (4) drafting the article or revising it critically for important content, and (5) final draft for the submission.

Author declaration: None

Conflicts of Interest: None

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Original article

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Feasibility of integrated numerical and Adaptive Neuro-Fuzzy Inference System models in predicting the thermophysical properties of unsteady coupled micropolar–Casson hybrid nanofluids

Abbai Reddy Divya[1], Thandra Jithendra[1] and Esambattu Hemalatha[2]

Abstract

This article aims to probe postulated phenomena using a paired micropolar and Casson hybrid fluid over a rotating disk. The intension to design a numerical technique (Runge–Kutta fourth-order along with shooting technique) integrated Adaptive Neuro-Fuzzy Inference System (ANFIS) envisioned with a thermal and exponentially space-dependent heat source, nonlinear thermal radiation and entropy production is developed in this phase of work. To ensure that, a nonlinear partial differential equation set of equations has been transformed into an ordinary differential equation by using the proper self-similarity variables. The model's research results, with a few notable outliers, are mostly consistent with those from prior research that was merged into the dataset used to train the ANFIS model. With the impact of active factors, the results are esthetically exhibited for numerous profiles. This displays that with the rise in magnetic field and radiation, the velocity and temperature profiles increase sharply, resulting in a contradiction phenomenon with the decreasing electric field inputs. Also, tilting of vortex viscosity, spin gradient viscosity and microinertia density on the various microrotation components displays inclination. Moreover, ANFIS training was exploited to analyze the approximate solutions for specific scenarios, and the developed ANFIS was evaluated against a testing dataset to emphasize its performance. Due to their longer render, the nanoparticles exploited here are deemed suitable for use in bone implants, iodinated agents for blood imaging and red blood cell stimulation. Thus, the results of this study may be applied to therapeutic anemia therapies.

Keywords

EMHD, thermal and exponential space dependent heat source, ANFIS, micropolar and Casson hybrid fluids, entropy generation

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Introduction

In the core, nanofluid is superior to normal fluid for increased heat transfer. Initiation of that hybrid nanofluid makes it even better. Only a fluid with two different nanoparticles may be deemed as hybrid nanofluid. As of today, it has been discovered that hybrid nanofluids have more heat transfer capabilities than regular nanofluids or any other usable fluids.[1] Hybrid nanofluids are implemented in a variety of industries for greater performance in terms of heat conductivity than regular nanofluids, including electronic cooling types of equipment, vehicle heat management, welding, power frameworks, grease, hydroelectric creation, papers and biomedicine creation, in the atomic segment, rocket gadget making and a host of others. Theoretically growing the thermophysical characteristics of hybrid nanofluids to mathematically build a boundary layer stream of 3D-turning hybrid nanofluid across an expanding sheet with radiation, heat production and chemical reaction effects, is established by avant-grade Hayat and Nadeem.[2] Basit et al.[3] tackled the exploration of a mixture nanoliquid spilling through the focal point of two equal disks by considering viscous dissipation and heat radiation. Li et al.[4] examined the peculiarity of hybrid nanofluid by using the effect of viscous dissipation and buoyancy. Sharma et al.[5] concentrated on the upgrade of nuclear power move in hybrid nanofluid stream prompted by a rotating Riga disk within the

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sight of warm radiation and chemical reaction. Moreover, several notable studies on the use of nanofluids in various geometries for flow analysis are included in Refs.[6–11]

While aimed at microscale devices, the classical Newtonian fluids model's mass, heat and momentum transfer methods can be recognizably not quite the same as those used to larger-scale machinery. Since, the three primary fields of microscale research are atherogenesis, molecular mechanisms and microfluidics. Also, material traits of such a model evolve constantly and exhibit translational velocity. The Navier–Stokes model aides the flow of fluid at length scales larger than a micrometer. So, the Navier–Stokes model is inadequate to fully convey the microlevel rotating impact of fluid particles.[12] Micropolar fluid, which is a dispersion of haphazardly oriented particles in a viscous medium and has a microstructure model, is one of aforementioned microlevel fluids. As per this liquid, the particles in little volume components can pivot about the centroid of the volume component. The law of conservation of mass, momentum and constitutive relationships, which demonstrate spin inertia, micromotion and couple stress, effectively depicts the motion of the micropolar fluid. This model portrays the flow of liquid crystals, dumb-bell molecules or short rigid cylindrical elements, flow in microchannels and capillaries, shear turbulent flows, porous media, polymer fluids, Ferrofluid, lubricants, fluid suspensions and animal blood.[13] Micropolar liquid elements may likewise be utilized to mimic the presence of residue or smoke in a particular gas.[14] The idea of micropolar fluid has drawn in a ton of interest in the engineering community over the past few decades due to its wide range of applications. The hypothesis of micropolar fluids, which tends with the effects of microrotation on microstructures, actually originated by Eringen.[15] Raja et al.[16] explored the flow of a spinning disk model by employing a magneto hydro dynamics micropolar nanofluid flow and the partial slip condition. Rauf et al.[17] delved at the steady-state flow of a micropolar nanofluid between two porous disks. Hussain and Xu[18] exhibited the electrically conducting squeezing flow of micropolar fluid that is obliged across two disks.

Machine learning techniques have been pivotal in resolving real-world problems and challenges that are nonlinear or complex for decades. These techniques possess an extensive array of applications, which include medical diagnosis,[19,20] manufacturing[21] and environmental modeling.[22] In recent years, numerous machine learning and deep learning techniques, including artificial neural networks (ANNs), fuzzy logic, Adaptive Neuro-Fuzzy Inference System (ANFIS) and many, have been implemented to model nonlinear problems in fluid mechanics and thermodynamics. For instance, Ullah et al.[23] analyzed the application of ANNs to simulate the impact of electric and magnetic fields involving a pair of parallel plates through the motion of a micropolar fluid. In a similar vein, Shoaib et al.[24] investigated the movement of an MHD micropolar nanofluid model by simulating the discrepancies of velocity slip variables, magnetic field variables, material factors, Brownian motion variables, thermophoresis variables and Lewis number. Rashidi et al.[25] optimized entropy generation in unsteady MHD flow over a rotating disk by integrating ANN with particle swarm optimization (PSO). Alzahrani et al.[26] utilized ANN to forecast the generation of entropy and the Bejan number in the context of Darcy–Forchheimer flow of Ree–Eyring nanofluid caused by double-rotating disks.

According to the aforementioned studies, thinking that there is scope to investigate the behavior of coupled micropolar and Casson fluid flows with the assist of entropy generation has taken account. Since, no studies have been addressed and which is acknowledged as one of the most effective fluid models for correctly predicting blood events. This is how the draft is set up:

- The inaugural section includes a compilation of literature.
- The mathematical modeling and dimensionless analysis are summarized underneath in the next section;
  - An innovative mathematical model emerges using a hybrid nanofluid constituted by tantalum and cobalt nanoparticles with blood serving as the core fluid.
  - Combined effects of porous medium, thermal and exponential space dependent heat source, joule heating, viscous dissipation, electromagnetohydrodynamic (EMHD) and nonlinear thermal radiation are examined.
  - Primarily an ordinary differential system is constructed from the nonlinear PDE system of equations by employing the proper self-similarity variables.
  - Entropy generation and the Bejan algorithm are also executed concurrently.
- In the third section, methodology is dealt with and a solution is delivered.
  - The Runge–Kutta fourth order with shooting tackle is implemented to figure out the governing flow outputs, regarding this mathematical model.
  - Then an ANFIS technique is laid out with the intent of comparison and prediction.
- The justification of the results is covered in the fourth section, where the relevant graphs and tables are originated for various factors.
- The final assessments are laid out in the last section.

Formulation of the problem

Time-dependent incompressible EMHD conducting flow across a rotating disk is explored. The rotation and stretching of the disk causes non-Newtonian fluids like Casson and micropolar hybrid nanofluid to move about in porous media. The microrotation components is designated as N_1,N_2 and N_3, respectively, since the velocity components is symbolized as u, v and w in the cylindrical coordinate system (r, φ, z). Also, the disk is placed at

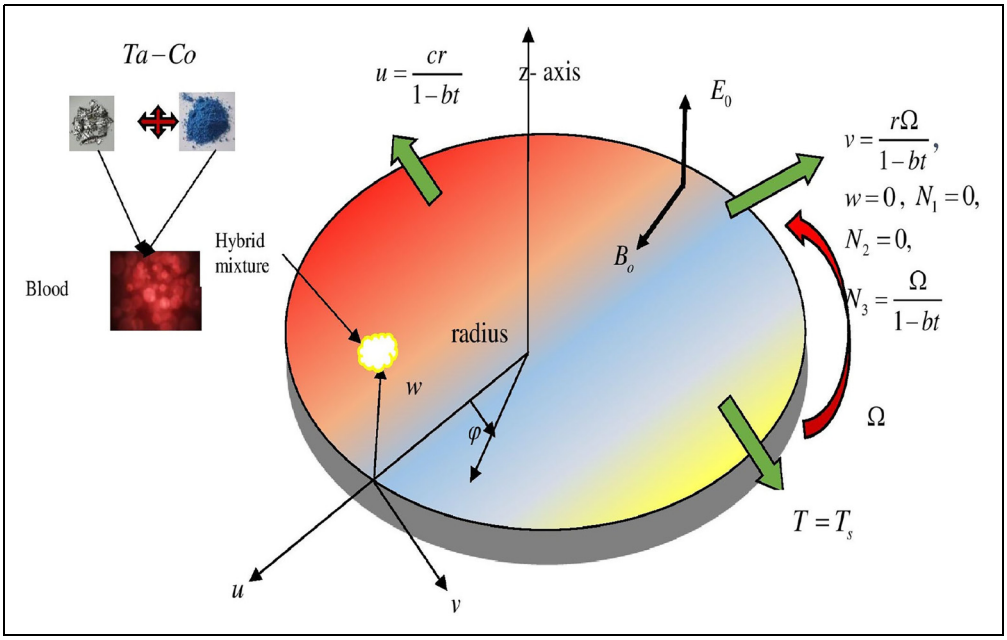


Figure 1. The model's schematic design.

$z = 0$, and rotates with angular velocity Ω which is represented in Figure 1. A time dependent magnetic field $B(t) = \frac{B_0}{(1-bt)^{\frac{1}{2}}}$ is applied in the z-direction where B_0 is termed as uniform magnetic field. The stretching velocity u, of disk which is taken to be $u = \frac{cr}{(1-bt)}$, where c is the stretching rate and b *is* a constant. The disk rotating velocity v is assumed to be $v = \frac{r\Omega}{(1-bt)}$, where Ω is the disk rotating rate. The temperature of the stretchable rotating disk surface T_s is defined by $T_s = T_0 - T_{ref}\frac{r^2\Omega}{\upsilon(1-bt)^{\frac{3}{2}}}$, where T_0 is the temperature at the origin and T_{ref} is the constant reference temperature.

For an incompressible Casson fluid model, the rheological equation is as follows:[27]

$$\tau_{ij} = \begin{cases} 2\left(\mu_B + \frac{p_y}{\sqrt{2\pi}}\right)e_{ij}, & \pi > \pi_c \\ 2\left(\mu_B + \frac{p_y}{\sqrt{2\pi_c}}\right)e_{ij}, & \pi < \pi_c \end{cases} \quad (1)$$

where these ideograms like μ_B, P_y, τ_{ij}, π_c, e_{ij}, $\pi = e_{ij}e_{ij}$ are tagged as termed as plastic dynamic viscosity, yield stress tensor, stress tensor of particularly non-Newtonian fluid, critical value, rate of the strain tensor and signifies product of the component of deformation rate with itself respectively. Mainly, for one of the non-Newtonian models, considered $\alpha = \mu_B\sqrt{2\pi_c}\,/\,P_y$ as Casson parameter.

The generic forms of the conservation law for mass, momentum, micropolar and energy equations by utilizing the above pre-assumptions are sketched below:[14,28]

$$\frac{\partial w}{\partial z} + \frac{1}{r}\frac{\partial}{\partial r}(ur) = 0 \quad (2)$$

$$\left(\frac{\partial u}{\partial t} - \frac{v^2}{r} + w\frac{\partial u}{\partial z} + u\frac{\partial u}{\partial r}\right) = \left(\frac{\mu_{hnf}\left(1+\frac{1}{\alpha}\right)+k}{\rho_{hnf}}\right)\left(\frac{\partial^2 u}{\partial z^2}\right) + \frac{\sigma_{hnf}B_0}{\rho_{hnf}(1-bt)}(E_0 - B_0 u) - \left(\frac{k}{\rho_{hnf}}\right)\frac{\partial N_2}{\partial z} - \frac{\upsilon_{hnf}}{k^*}u \quad (3)$$

$$\left(\frac{\partial v}{\partial t} + \frac{uv}{r} + w\frac{\partial v}{\partial z} + u\frac{\partial v}{\partial r}\right) = \left(\frac{\mu_{hnf}\left(1+\frac{1}{\alpha}\right)+k}{\rho_{hnf}}\right)\left(\frac{\partial^2 v}{\partial z^2}\right) + \frac{\sigma_{hnf}B_0}{\rho_{hnf}(1-bt)}(E_0 - B_0 v) + \left(\frac{k}{\rho_{hnf}}\right)\left(\frac{\partial N_1}{\partial z} - \frac{\partial N_3}{\partial r}\right) - \frac{\upsilon_{hnf}}{k^*}v \quad (4)$$

$$\left(\frac{\partial w}{\partial t} + w\frac{\partial w}{\partial z} + u\frac{\partial w}{\partial r}\right) = \left(\frac{\mu_{hnf}\left(1+\frac{1}{\alpha}\right)+k}{\rho_{hnf}}\right)\left(\frac{\partial^2 w}{\partial z^2}\right) + \left(\frac{k}{\rho_{hnf}}\right)\frac{\partial}{r\,\partial r}\left(\frac{\partial N_2}{\partial r}\right) \quad (5)$$

$$\left(\frac{\partial N_1}{\partial t}-\frac{v}{r}N_2+w\frac{\partial N_1}{\partial z}+u\frac{\partial N_1}{\partial r}\right)=\left(\frac{\gamma_1}{\rho_{hnf}\,j}\right)\left(\frac{\partial^2 N_1}{\partial z^2}\right)-\left(\frac{k}{\rho_{hnf}\,j}\right)\left(\frac{\partial v}{\partial z}\right)-2\left(\frac{k}{\rho_{hnf}\,j}\right)N_1 \tag{6}$$

$$\left(\frac{\partial N_2}{\partial t}+\frac{v}{r}N_1+w\frac{\partial N_2}{\partial z}+u\frac{\partial N_2}{\partial r}\right)=\left(\frac{\gamma_1}{\rho_{hnf}\,j}\right)\left(\frac{\partial^2 N_2}{\partial z^2}\right)+\left(\frac{k}{\rho_{hnf}\,j}\right)\left(\frac{\partial u}{\partial z}\right)-2\left(\frac{k}{\rho_{hnf}\,j}\right)N_2-\left(\frac{k}{\rho_{hnf}\,j}\right)\frac{\partial w}{\partial r} \tag{7}$$

$$\left(\frac{\partial N_3}{\partial t}+w\frac{\partial N_3}{\partial z}+u\frac{\partial N_3}{\partial r}\right)=\left(\frac{\gamma_1}{\rho_{hnf}\,j}\right)\left(\frac{\partial^2 N_3}{\partial z^2}\right)-\left(\frac{k}{\rho_{hnf}\,j}\right)\left(\frac{\partial v}{\partial r}+\frac{v}{r}+2N_3\right) \tag{8}$$

$$\begin{aligned}\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial r}+w\frac{\partial T}{\partial z}=\alpha_{hnf}\left(\frac{\partial^2 T}{\partial z^2}\right)&+\frac{\mu_{hnf}}{(\rho c_p)_{hnf}}\left(1+\frac{1}{\alpha}\right)\left[\left(\frac{\partial u}{\partial z}\right)^2+\left(\frac{\partial v}{\partial z}\right)^2\right]\\&-\frac{16}{3}\frac{\sigma^*}{k^*(\rho c_p)_{hnf}}\frac{\partial}{\partial z}(T^3\frac{\partial T}{\partial z})\\&+\frac{Q_T^*}{(\rho c_p)_{hnf}}(T-T_0)\\&+\frac{Q_E^*(T_s-T_0)}{(\rho c_p)_{hnf}}\exp(-n\sqrt{\frac{\Omega}{\upsilon}}z)+\\&\frac{\sigma_{hnf}}{(\rho c_p)_{hnf}(1-bt)}[E_0-B_0(u+v)]^2\end{aligned} \tag{9}$$

Generally, the radiative heat flux can be expressed by using Rosseland approximation as:

$$q_r=-\frac{4\sigma^*}{3k^*}\nabla T^4=-\frac{16\sigma^* T_0^3}{3k^*}\frac{\partial T}{\partial z} \tag{10}$$

where σ^* and k^* are the Stefan Boltzmann and mean absorption coefficients, respectively.

Followed with the boundary conditions as:

$$\begin{aligned}&u=\frac{cr}{1-bt},\ v=\frac{r\Omega}{1-bt},\ w=0,\ N_1=0,\ N_3\\&=\frac{\Omega}{1-bt},\ T=T_s \text{ at } z=0\\&u\to 0,\ v\to 0,\ N_1\to 0,\ N_2\to 0,\ N_3\to 0,\ T\\&\to T_\infty \text{ as } z\to\infty\end{aligned} \tag{11}$$

Table 1 gives some of the instances in which mixture theory and phenomenological criteria can potentially be employed in producing hybrid nanoliquid assets. Basically, that theories contains k_{hnf} as thermal conductivity, ρ_{hnf} termed as density, $(\rho c_p)_{hnf}$ stands for specific heat, σ_{hnf} is electrical conduction and ν_{hnf} is the kinematic viscosity

The following are the similarity transformations:

$$\begin{aligned}u=\frac{r\Omega}{(1-bt)}f'(\eta),\quad v=\frac{r\Omega}{(1-bt)}g(\eta),\\ w=-2\left(\frac{\upsilon\Omega}{(1-bt)}\right)^{\frac{1}{2}}f(\eta),\quad \eta=\sqrt{\frac{\Omega}{\upsilon(1-bt)}}\ z,\end{aligned}$$

$$\begin{aligned}T=T_0-T_{ref}\frac{r^2\Omega}{\upsilon(1-bt)^{\frac{3}{2}}}\theta(\eta),\\ N_1=\frac{r\Omega}{(1-bt)}\sqrt{\frac{\Omega}{\upsilon(1-bt)}}M_1(\eta),\\ N_2=\frac{r\Omega}{(1-bt)}\sqrt{\frac{\Omega}{\upsilon(1-bt)}}M_2(\eta),\\ N_3=\frac{\Omega}{(1-bt)}M_3(\eta).\end{aligned} \tag{12}$$

By employing the self-similarity transformation mentioned in equation (12), the highly coupled nonlinear partial differential equations are reduced into ordinary differential equations which are illustrated as follows:

$$\begin{aligned}&\left(A_1(1+\frac{1}{\alpha})+a_1\right)f'''-SA_3(\frac{\eta}{2}f''\\&+f')+A_3(g^2+2f\,f''-f'^2)\\&+A_2M\,[E_1-f']-a_1M_2'\\&-A_1\beta\,f'=0\end{aligned} \tag{13}$$

$$\begin{aligned}&\left(A_1(1+\frac{1}{\alpha})+a_1\right)g''+2A_3(g'f\\&-f'g)-SA_3(\frac{\eta}{2}g'+g)+A_2M\,[E_1-g]\\&-a_1M_1'\\&-A_1\,\beta\,g=0\end{aligned} \tag{14}$$

$$\begin{aligned}&a_2M_1''-a_3(g'+2M_1)-SA_3(\frac{\eta}{2}M_1'+\frac{3}{2}M_1)\\&-A_3M_1\,f'+A_3gM_2+2A_3fM_1'\\&=0\end{aligned} \tag{15}$$

$$\begin{aligned}&a_2M_2''+a_3(f''-2M_2)-SA_3(\frac{\eta}{2}M_2'+\frac{3}{2}M_2)\\&-A_3M_2\,f'-A_3gM_1+2A_3fM_2'\\&=0\end{aligned} \tag{16}$$

Table 1. Thermophysical properties of hybrid nanofluids.[31]

Properties	Hybrid nanofluid
Mixture Theory	$\rho_{hnf} = \rho_f(1-\phi_2)[(1-\phi_1)+\phi_1(\frac{\rho_1}{\rho_f})]+\phi_2(\rho_2)$
	$(\rho c_p)_{hnf} = (\rho c_p)_f(1-\phi_2)(1-\phi_1)+\phi_1(\rho c_p)_1+\phi_2(\rho c_p)_2$
Phenomenological Laws	$\frac{\sigma_{hnf}}{\sigma_{bf}} = \left(\frac{(1+2\phi_2)\sigma_2+2(1-\phi_2)\sigma_{bf}}{(1-\phi_2)\sigma_2+(2+\phi_2)\sigma_{bf}}\right)$ where, $\frac{\sigma_{bf}}{\sigma_f} = \left(\frac{(1+2\phi_1)\sigma_1+2(1-\phi_1)\sigma_f}{(1-\phi_1)\sigma_1+(2+\phi_1)\sigma_f}\right)$
	$\mu_{hnf} = \frac{\mu_f}{(1-\phi_1)^{2.5}(1-\phi_2)^{2.5}}$
	$\frac{k_{hnf}}{k_{bf}} = \left(\frac{(1+2\phi_2)k_2+2(1-\phi_2)k_{bf}}{(1-\phi_2)k_2+(2+\phi_2)k_{bf}}\right)$ where $\frac{k_{bf}}{k_f} = \left(\frac{(1+2\phi_1)k_1+2(1-\phi_1)k_f}{(1-\phi_1)k_1+(2+\phi_1)k_f}\right)$

$$a_3M_3'' - SA_3\left(\frac{\eta}{2}M_3' + M_3\right) - 2a_3M_3 - 2a_3g + 2A_3fM_3' = 0 \tag{17}$$

$$A_4\theta'' + Rd\left(\frac{4}{3}\right)\left\{\begin{array}{l}\theta'' + (\theta_w-1)^3(3\theta^2\theta'^2+\theta^3\theta'') \\ +3(\theta_w-1)^2(2\theta\theta'^2+\theta^2\theta'') \\ +3(\theta_w-1)(\theta'^2+\theta\theta'')\end{array}\right\} + A_1\,\mathrm{Pr}\,Ec\left(1+\frac{1}{\alpha}\right)(f''^2+g'^2) + A_2\,M\,Ec\,\mathrm{Pr}\,[E_1-(f'+g)]^2 + 2\,\mathrm{Pr}\,A_5(f\theta'-\theta f') - A_5S\,\mathrm{Pr}\left(\frac{3}{2}\theta+\frac{\eta}{2}\theta'\right) + \mathrm{Pr}\,Q_t\theta + \mathrm{Pr}\,Q\,Exp(-n\xi) = 0 \tag{18}$$

With the boundary conditions as:

$$\begin{aligned} &f' = \omega, \quad g = 1, \quad f = 0, \quad M_1 = 0, \quad M_2 = 0, \\ &M_3 = 1, \quad \theta = 1 \quad \text{at} \quad \eta = 0 \\ &f' \to 0, \quad g \to 0, \quad M_1 \to 0, \quad M_2 \to 0, \quad M_3 \to 0, \\ &\theta \to 0 \quad \text{as} \quad \eta \to \infty \end{aligned} \tag{19}$$

The dimensionless parameters are as:

$$S = \frac{b}{\Omega},\ \omega = \frac{c}{\Omega},\ \beta = \frac{v(1-bt)}{k^*\Omega},\ \mathrm{Pr} = \frac{\mu_f(C_p)_f}{k_f},\ Rd = \frac{4\sigma^*T_0^3}{k^*k_f},\ Ec = \frac{r^2\Omega^2}{(1-bt)^2(\Delta T)(C_p)_f},$$

$$a_1 = \frac{k}{\mu_f},\ a_2 = \frac{\gamma_1}{\mu_f j},\ a_3 = \frac{k(1-bt)}{\rho_f j\Omega},\ \theta_w = \frac{T_s}{T_0},\ Q = \frac{Q_E^*(1-bt)}{(\rho c_p)\Omega},\ \xi = z\sqrt{\frac{\Omega}{v}},\ M = \left(\frac{\sigma_f B_0^2}{\rho_f\Omega}\right),$$

$$Q_t = \frac{Q_T^*(1-bt)}{(\rho c_p)\Omega},\ A_1 = \frac{\mu_{hnf}}{\mu_f},\ A_2 = \frac{\sigma_{hnf}}{\sigma_f},\ A_3 = \frac{\rho_{hnf}}{\rho_f},\ A_4 = \frac{k_{hnf}}{k_f},\ A_5 = \frac{(\rho C_p)_{hnf}}{(\rho C_p)_f},$$

$$E_1 = \left(\frac{E_0(1-bt)}{r\Omega B_0}\right).$$

Factors of engineering curiosity

For engineering interest, the significant physical quantities, such as skin friction coefficients C_f and C_g are defined as follows:

$$C_f = \frac{\tau_{w1}(1-bt)^2}{\rho_f(r\Omega)^2} \tag{20}$$

$$C_g = \frac{\tau_{w2}(1-bt)^2}{\rho_f(r\Omega)^2} \tag{21}$$

Here, τ_{w1} denotes the radial stress and it is defined as,

$$\tau_{w1} = \mu_{hnf}\left(1+\frac{1}{\alpha}\right) \times \left(\frac{\partial u}{\partial z}\right)_{z=0} + \left[\mu_{hnf}\left(\frac{\partial u}{\partial z}+\frac{\partial w}{\partial r}\right) + k\left(\frac{\partial u}{\partial z}+N_2\right)\right]_{z=0},$$

Also, the azimuthal shear–stress component is represented as:

$$\tau_{w2} = \mu_{hnf}\left(1+\frac{1}{\alpha}\right) \times \left(\frac{\partial v}{\partial z}\right)_{z=0} + \left[\mu_{hnf}\left(\frac{\partial v}{\partial z}+\frac{1}{r}\frac{\partial w}{\partial r}\right) + k\left(\frac{\partial v}{\partial z}+N_1\right)\right]_{z=0}$$

Invoking the above transformation, dimensionless form of equations assumes the following form:

$$\mathrm{Re}_x^{\frac{1}{2}} C_f = \left[A_1\left(1+\frac{1}{\alpha}\right)+(A_1+a_1)\right] f''(0) + a_1 M_2(0) \tag{22}$$

$$\mathrm{Re}_x^{\frac{1}{2}} C_g = \left[A_1\left(1+\frac{1}{\alpha}\right)+(A_1+a_1)\right] g'(0) + a_1 M_1(0) \tag{23}$$

The physical quantity under discussion is the heat transfer rate, frequently referred to as the Nusselt number.

$$Nu_r = \frac{r q_w}{k_f (T_s - T_0)} \tag{24}$$

where $q_w = (-k_{hnf}(\frac{\partial T}{\partial z})_{z=0}) + (\frac{16\sigma^* T_\infty^3}{3k^* k_f})_{z=0}$, defines the heat flux and the reduced model is as,

$$Nu_x \mathrm{Re}_x^{\frac{-1}{2}} = -\left\{A_4 + \frac{4}{3} Rd[1+(\theta_w-1)\theta(0)]^3\right\}\theta'(0) \tag{25}$$

In these equations $\mathrm{Re}_x = \left(\frac{r^2\Omega}{\upsilon(1-bt)}\right)$, named as local Reynolds number.

The thermophysical characteristics which is considered for this investigation are listed in Table 2.

Exploration of entropy generation

The entropy production rate for a viscoelastic incompressible in the presence of an electric and magnetic field is indicated as follows[32,33]:

$$S'''_{gen} = \frac{k_{hnf}}{T_0^2}\left[\left(\frac{\partial T}{\partial z}\right)^2 + \frac{16\sigma^* T_0^3}{3k^* k_{hnf}}\left(\frac{\partial T}{\partial z}\right)^2\right] + \frac{\mu_{hnf}}{T_0}\left[\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2\right] + \frac{\sigma_{hnf}}{T_0(1-bt)}[E_0 - B_0(u+v)]^2 \tag{26}$$

Generally, this entropy generation consist of three irreversible processes. Namely, thermal, fluid friction and electromagnetic irreversible processes. By using the suitable transformations, the PDEs equations are reduced to ODEs are as follows:

$$N_G = \alpha_1\left\{A_4 + \frac{4}{3} Rd(1+\theta(\theta_w-1))^3\right\}\theta'^2 + A_1 Br\,(f''^2 + g'^2) + A_2 M\, Br\,\{E_1 - (f'+g)\}^2 \tag{27}$$

Here, the dimensionless parameters are given below:

$$N_G = \frac{T_0 S'''_{gen}\,\upsilon(1-bt)}{k_f\,\Omega\,\Delta T}, \quad \Delta T = (T_s - T_0), \quad \alpha_1 = \frac{\Delta T}{T_0}, \quad Br = \frac{\mu_f r^2 \Omega^2}{k_f (T_s - T_0)(1-bt)^2}.$$

In general, the Bejan number can be stated as follows:

$$Be = \frac{\text{Entropy generation due to heat transfer}}{\text{Total entropy generation}}$$

Now,

$$Be = \frac{\alpha_1\left\{A_4 + \frac{4}{3} Rd(1+\theta(\theta_w-1))^3\right\}\theta'^2}{\alpha_1\left\{A_4 + \frac{4}{3} Rd(1+\theta(\theta_w-1))^3\right\}\theta'^2 + A_1 Br\,(f''^2 + g'^2) + A_2 M\, Br\,\{E_1 - (f'+g)\}^2} \tag{28}$$

Table 2. Thermophysical properties of hybrid nanofluid.

Physical properties	Blood	Cobalt (Co)	Tantalum (Ta)
$\rho(kg\,m^{-3})$	3617	8900	16,650
$C_p(J(kg)^{-1}K^{-1})$	1050	445	140
$k(W(m^{-1}K^{-1}))$	0.52	100	57
$\sigma(\Omega m)^{-1}$	1.33	1.7×10^7	7.7×10^6
Pr	21		

Methodology

R–K fourth order method

The dimensionless equations (13)–(18) and equation (19) generate a boundary value issue. As a result, Bejan number equation (28) and entropy generation equation (27) are likewise transformed. The shooting technique is used to solve these equations by converting them into initial value problems. For this, the aforementioned nonlinear ordinary differential equations are changed into

the following set of first-order differential equations:

$$f = \wp_1,\ f' = \wp_2,\ f'' = \wp_3,\ f''' = \wp_3',\ g = \wp_4,\ g' = \wp_5,\ g'' = \wp'_5,\ M_1 = \wp_6,\ M_1' = \wp_7,\ M_1'' = \wp'_7,\ M_2 = \wp_8,\ M_2' = \wp_9,\ M_2'' = \wp'_9,\ M_3 = \wp_{10},\ M_3' = \wp_{11},\ M_3'' = \wp'_{11}, \theta = \wp_{12},\ \theta' = \wp_{13},\ \theta'' = \wp'_{13}.$$

$$\wp_3' = -\frac{\begin{bmatrix} -S(\wp_2 + (\eta/2)\wp_3) + A_3(\wp_4^2 + 2\wp_1\wp_3 - \wp_2^2) \\ -a_1\wp_9 + A_2M(E_1 - \wp_2) - A_1\beta\wp_2 \end{bmatrix}}{(A_1(1+\frac{1}{\alpha}) + a_1)} \tag{29}$$

$$\wp_5' = -\frac{\begin{bmatrix} a_1\wp_7 + A_2M(E_1 - \wp_4) - A_1\beta\wp_6 \\ -A_3S[(\eta/2)\wp_5 + \wp_4] + 2A_3(\wp_1\wp_5 - \wp_2\wp_4) \end{bmatrix}}{(A_1(1+\frac{1}{\alpha}) + a_1)} \tag{30}$$

$$\wp_7' = -\frac{\begin{bmatrix} -a_3(\wp_5 + 2\wp_6) + A_3(\wp_4\wp_8) - A_3S[(\eta/2)\wp_7 \\ +(3/2)\wp_6] - A_3(\wp_2\wp_6) + 2A_3(\wp_1\wp_7) \end{bmatrix}}{a_2} \tag{31}$$

$$\wp_9' = -\frac{\begin{bmatrix} a_3(\wp_3 - 2\wp_8) + 2A_3(\wp_1\wp_9) - A_3S[(\eta/2)\wp_9 \\ +(3/2)\wp_8] - A_3(\wp_4\wp_6) - A_3(\wp_2\wp_8) \end{bmatrix}}{a_2} \tag{32}$$

$$\wp_{11}' = -\frac{\begin{bmatrix} -2a_3(\wp_4) + 2A_3(\wp_1\wp_{11}) \\ -A_3S[(\eta/2)\wp_{11} + \wp_{10}] - 2a_3(\wp_{10}) \end{bmatrix}}{a_3} \tag{33}$$

$$\wp_2(\infty) \to 0,\ \wp_4(\infty) \to 0,\ \wp_6(\infty) \to 0,\ \wp_8(\infty) \to 0,\ \wp_{10}(\infty) \to 0,\ \wp_{12}(\infty) \to 0 \quad \text{as } \eta \to \infty$$

Entropy generation and Bejan number is as follows:

$$N_G = \alpha_1\{A_4 + (4/3)(Rd)[1 + \wp_{12}(Tw-1)]^3\}\wp_{13}^2 + A_1Br(\wp_3^2 + \wp_5^2) + A_2MBr(E_1 - \wp_2 - \wp_4)^2 \tag{35}$$

$$Be = \frac{\alpha_1\{A_4 + (4/3)(Rd)[1 + \wp_{12}(Tw-1)]^3\}\wp_{13}^2}{\alpha_1\{A_4 + (4/3)(Rd)[1 + \wp_{12}(Tw-1)]^3\}\wp_{13}^2 + A_1Br(\wp_3^2 + \wp_5^2) + A_2MBr(E_1 - \wp_2 - \wp_4)^2} \tag{36}$$

With a step size of h = 0.01, we employ the fourth-order R–K method. Until the outcomes are precise, the previous method is applied 10^{-8} repeatedly.

This technique involves dragging the skin friction coefficients and Nusselt number for various parameters, subsequently involving application of ANFIS for comparison and for plotting the results. The comparison of skin friction in the radial and azimuthal paths for M values with the earlier works in the R–K fourth order approach, carried out in MATLAB, is shown in Table 3.

Adaptive neuro-fuzzy inference system

The architecture of ANFIS indicates that it involves neural networks and fuzzy logic at five distinct levels. Fuzzy inference system and fuzzy logic, two concepts that were conceptualized by Zadeh[37] in 1965, aim to address concerns associated with decision-making when erratic, vague or unreliable data is involved. The concept of neural networks, originally designed by Warren McCulloch and Walter Pitts in 1943, was inspired by the functioning of brain neurons.

$$\wp_{13}' = -\frac{\begin{bmatrix} (4/3)(Rd)[(Tw-1)^3(3\wp_{12}^2\wp_{13}^2) + 3(Tw-1)^2(2\wp_{12}\wp_{13}^2) \\ +3(Tw-1)(\wp_{13}^2)] + A_1Ec\,\mathrm{Pr}\,(\wp_3^2 + \wp_5^2)(1+\frac{1}{\alpha}) \\ +2\,\mathrm{Pr}\,A_5(\wp_1\wp_{13} - \wp_{12}\wp_2) - A_5S\,\mathrm{Pr}\,[(3/2)\wp_{12} + (\eta/2)\wp_{13}] \\ +(\mathrm{Pr})Qe\,Exp(-n\xi) + (\mathrm{Pr})Qt\,\wp_{12} + A_2MEc\,\mathrm{Pr}\,(-\wp_2 - \wp_4 + E_1)^2 \end{bmatrix}}{\begin{matrix} A_4 + (Rd)(4/3) \\ [1 + (Tw-1)^3\wp_{12}^3 + \\ 3(Tw-1)^2\wp_{12}^2 + \\ 3(Tw-1)\wp_{12}] \end{matrix}} \tag{34}$$

Also, the boundary conditions as,

$$\wp_1(0) = 0,\quad \wp_2(0) = \omega,\quad \wp_4(0) = 1,\quad \wp_6(0) = 0,\ \wp_8(0) = 0,\ \wp_{10}(0) = 1,\ \wp_{12}(0) = 1, \quad \text{at } \eta = 0$$

This idea is commonly referred to as "connectionism" and involves the use of neurons that are interlinked to simulate intellectual ability.[38] In the past decade, the neuro-fuzzy system, which combines neural networks and fuzzy logic, has been widely applied to model unpredictable or complicated real-world situations. Jang[39] devised the ANFIS in

Table 3. Comparision of skin friction values for various values of M.

	$C_f \mathrm{Re}_x^{\frac{1}{2}}$				$C_g \mathrm{Re}_x^{\frac{1}{2}}$			
M	Ali et al.[34]	Shahzad et al.[35]	Siddiq and Ashraf [36]	Present	Ali et al.	Shahzad et al.[35]	Siddiq and Ashraf [36]	Present
0	10.5522	10.5522	10.5522	10.5699	1.2595	1.2595	1.2595	1.2678
0.5	11.4483	11.4483	11.4482	11.4533	1.2816	1.2816	1.2817	1.2246
1.0	13.7080	13.7082	13.7081	13.7193	1.3347	1.3348	1.3346	1.3564
1.5	16.6320	16.6319	16.6320	16.6456	1.3970	1.3969	1.3971	1.3357
2.0	19.8207	19.8208	19.8208	19.8365	1.4560	1.4560	1.4560	1.4786

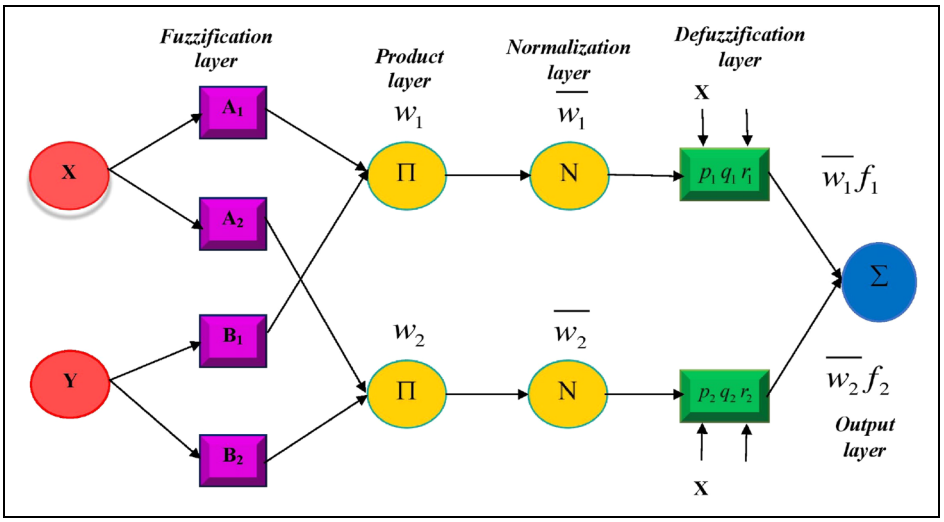


Figure 2. Architecture of ANFIS.

1993. It is a neuro-fuzzy system that effectively combines fuzzy logic and neural network simulation capabilities to mimic an expert decision-making system. The ANFIS simulation process is predicated on the Takagi–Sugeno fuzzy system, which comprises a preceding and consequent step. To optimize the premise and subsequent factors, a method of learning combining gradient descent and least squares methods was implemented.[40] The ANFIS model comprises five distinct layers, as illustrated in Figure 2: fuzzification, product, normalization, defuzzification and output layer.

Layer 1

Within layer 1, every node possesses the ability to adapt, and membership functions are utilized to convert input values from precise to fuzzy. Using a variety of membership functions with an interval of [0, 1], the input values are converted to fuzzy values, such as the generalized bell function, trapezium, triangle, Gaussian and sigmoid. In the current study, the input layer incorporates the triangular membership function, which can be expressed in equation (37).

$$\mu_A(x) = \begin{cases} 0 & if\ x \le a \\ \dfrac{x-a}{b-a} & if\ \ a \le x \le b \\ \dfrac{c-x}{c-b} & if\ b \le x \le c \\ 0 & if\ x \ge c \end{cases} \tag{37}$$

$$O_{l_1,j} = \mu_{A_j}(x) \tag{38}$$

Layer 2

Within layer 2, the outcome of each node is determined through the imprecise AND operation, which involves multiplying its input connections. During this level, the output of the nodes is determined using equation (39), which labels them as w_j.

$$O_{l_2,j} = w_j = \mu_{A_j}(x) \times \mu_{B_j}(y), \quad j = 1,\ 2 \tag{39}$$

Layer 3

Within layer 3, the normalization mechanism estimates the ratio of the present firing strength to the sum of all firing strengths from all rules. At this level, nodes are not adaptive. The outcome for this layer can be derived using equation (40).

$$O_{l_3,j} = \overline{w_j} = \frac{w_j}{w_1 + w_2}, \quad j = 1,\ 2 \tag{40}$$

Layer 4

Within layer 4, defuzzification methods are implemented to transform fuzzy outcomes into precise ones. Therefore, in accordance with equation (41), the outcome is determined by multiplying the previous output by the linear equation.

$$O_{l_4,j} = \overline{w_j} f_j = \overline{w_j} * (p_j x + q_j y + r_j) \tag{41}$$

where $\{p_j,\ q_j,\ r_j\}$ denotes the consequent parameters.

Layer 5

Within layer 5, it is proven that the nodes lack adaptability and that the outcome is produced through an accumulation of the outputs from the prior layers.

$$O_{l_5,j} = \sum_j \overline{w_j} f_j = \frac{\sum_j w_j f_j}{\sum_j w_j} \tag{42}$$

Developed ANFIS model for analyzing skin friction co-efficients and nusselt number.

The objective of the proposed model is to provide a more efficient method for determining the optimal Nusselt number and skin friction co-efficients for fluid flow analysis. The current study devises an adaptive neuro-fuzzy inference system-based prediction model. The sigmoidal membership function is exploited to fuzzify the input values to improve the model's precision because the input dataset is normalized and the resultant dataset falls within the range [0, 1]. Overall, the effectiveness of ANFIS is significantly dependent on its fundamental premise and consequent parameters. The study adopted the gradient descent method due to its robustness and fast convergence while minimizing the objective function for identifying the optimal parameters of ANFIS to improve the predictive capability of the ANFIS model. Further, ANFIS, a robust predictor for modeling fluid flow parameters that examines input parameters including unsteady parameter, magnetic field, electric field, radiation, Casson parameter, vortex viscosity parameter, spin gradient viscosity parameter, microinertia density parameter, rotation parameter, Eckert number, porous and exponential based heat source parameters are usually implemented as the initial

Table 4. Estimated skin friction co-efficient (radial velocity) using the input parameters by NM and ANFIS techniques.

												$C_f \mathrm{Re}_x^{1/2}$	
S	M	E_1	Rd	α	a_1	a_2	a_3	ω	Ec	β	Q	NM	ANFIS
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.37511	3.37418
0.2	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.58568	3.58869
0.3	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.58611	3.58776
0.4	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	2.84404	2.94536
0.1	0.3	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	2.81027	2.95634
0.1	0.4	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.20982	3.20935
0.1	0.5	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.13992	3.14188
0.1	0.1	0.7	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.15037	3.15142
0.1	0.1	0.9	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.16117	3.16118
0.1	0.1	1.1	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.13786	3.15272
0.1	0.1	0.5	1.2	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.29503	3.29577
0.1	0.1	0.5	1.4	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.36503	3.35776
0.1	0.1	0.5	1.6	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.46503	3.41886
0.1	0.1	0.5	1	2	0.5	1	0.2	1.1	0.01	0.01	0.5	3.16639	3.20927
0.1	0.1	0.5	1	2.5	0.5	1	0.2	1.1	0.01	0.01	0.5	3.13919	3.10292
0.1	0.1	0.5	1	3	0.5	1	0.2	1.1	0.01	0.01	0.5	3.12134	3.11625
0.1	0.1	0.5	1	1	1	1	0.2	1.1	0.01	0.01	0.5	3.49201	3.45724
0.1	0.1	0.5	1	1	1.5	1	0.2	1.1	0.01	0.01	0.5	3.57433	3.57182
0.1	0.1	0.5	1	1	1.7	1	0.2	1.1	0.01	0.01	0.5	3.65125	3.60152
0.1	0.1	0.5	1	1	0.5	1.1	0.2	1.1	0.01	0.01	0.5	3.38027	3.41263
0.1	0.1	0.5	1	1	0.5	1.2	0.2	1.1	0.01	0.01	0.5	3.39073	3.41902
0.1	0.1	0.5	1	1	0.5	1.3	0.2	1.1	0.01	0.01	0.5	3.30634	3.34615
0.1	0.1	0.5	1	1	0.5	1	0.4	1.1	0.01	0.01	0.5	3.33351	3.30009
0.1	0.1	0.5	1	1	0.5	1	0.5	1.1	0.01	0.01	0.5	3.31523	3.30228
0.1	0.1	0.5	1	1	0.5	1	0.7	1.1	0.01	0.01	0.5	3.28939	3.29000
0.1	0.1	0.5	1	1	0.5	1	0.2	1.2	0.01	0.01	0.5	3.86044	3.82530
0.1	0.1	0.5	1	1	0.5	1	0.2	2.2	0.01	0.01	0.5	3.48291	3.58884
0.1	0.1	0.5	1	1	0.5	1	0.2	3.2	0.01	0.01	0.5	3.14186	3.10200
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.02	0.01	0.5	3.26503	3.26502
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.03	0.01	0.5	3.26503	3.26502
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.04	0.01	0.5	3.26503	3.26503
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.05	0.5	3.37893	3.35065
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.1	0.5	3.56915	3.50967
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	1.5	0.5	3.85023	3.85022
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	1.5	3.26503	3.26502
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2	3.39503	3.39503
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2.5	3.49603	3.49602

network structure consisting of five distinct layers. Often, the dataset is partitioned into two subsets, the first of which entails 70% of the dataset and is utilized to train the network in determining the optimal settings. The optimal network constructed utilizing ANFIS is assessed using the second set, which accounts for 30% of the total dataset. Following this, the framework involves training by exploring the training input data and is assessed using the root mean square error (RMSE), which is frequently employed and expressed by equation (43).

$$RMSE = \sqrt{\frac{\sum_{j=1}^{N} (y_j - \widehat{y_j})^2}{N}} \tag{43}$$

where y_j represents the observed values and $\widehat{y_j}$ referred to as predicted values.

In this study, the numerical values obtained for skin friction co-efficients and Nusselt number, of all of the parameters in the R–K fourth order technique as given in Tables 4–6, were used to train the ANFIS model.

Results and discussion

For this phase of the exploration, employed the R–K fourth order along with shooting procedure and ANFIS model to outline the way of behavior of micropolar and Casson hybrid nanofluids. Numerous flow characteristics such as magnetic field, electric field, micropolar fluid parameters, temperature ratio difference parameters are portrayed on radial and azimuthal velocities, temperature, local entropy generation and Bejan profiles. They are contrasted in both Newtonian and non-Newtonian scenarios. However, the temperature in both linear and nonlinear instances is analyzed. All of the physical parameter's

Table 5. Estimated skin friction co-efficient (azimuthal velocity) using the input parameters by NM and ANFIS techniques.

												$C_g Re_x^{1/2}$	
S	M	E_1	Rd	α	a_1	a_2	a_3	ω	Ec	β	Q	NM	ANFIS
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.40014	4.25646
0.2	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.51343	4.50124
0.3	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.56919	4.56467
0.4	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.85962	4.12595
0.1	0.3	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.92319	3.87279
0.1	0.4	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.98746	4.00256
0.1	0.5	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.16469	4.14252
0.1	0.1	0.7	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.15207	4.15626
0.1	0.1	0.9	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.14368	4.14263
0.1	0.1	1.1	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.12298	4.12377
0.1	0.1	0.5	1.2	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.23465	4.25646
0.1	0.1	0.5	1.4	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.33465	4.35646
0.1	0.1	0.5	1.6	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.43465	4.49726
0.1	0.1	0.5	1	2	0.5	1	0.2	1.1	0.01	0.01	0.5	4.06167	4.10072
0.1	0.1	0.5	1	2.5	0.5	1	0.2	1.1	0.01	0.01	0.5	4.03161	4.05273
0.1	0.1	0.5	1	3	0.5	1	0.2	1.1	0.01	0.01	0.5	4.01293	4.01572
0.1	0.1	0.5	1	1	1	1	0.2	1.1	0.01	0.01	0.5	4.55262	4.50420
0.1	0.1	0.5	1	1	1.5	1	0.2	1.1	0.01	0.01	0.5	4.66814	4.62435
0.1	0.1	0.5	1	1	1.7	1	0.2	1.1	0.01	0.01	0.5	4.77124	4.79726
0.1	0.1	0.5	1	1	0.5	1.1	0.2	1.1	0.01	0.01	0.5	4.24852	4.26012
0.1	0.1	0.5	1	1	0.5	1.2	0.2	1.1	0.01	0.01	0.5	4.24969	4.25152
0.1	0.1	0.5	1	1	0.5	1.3	0.2	1.1	0.01	0.01	0.5	4.25141	4.25646
0.1	0.1	0.5	1	1	0.5	1	0.4	1.1	0.01	0.01	0.5	4.24382	4.24112
0.1	0.1	0.5	1	1	0.5	1	0.5	1.1	0.01	0.01	0.5	4.24153	4.24000
0.1	0.1	0.5	1	1	0.5	1	0.7	1.1	0.01	0.01	0.5	4.23811	4.24100
0.1	0.1	0.5	1	1	0.5	1	0.2	1.2	0.01	0.01	0.5	5.38073	5.38071
0.1	0.1	0.5	1	1	0.5	1	0.2	2.2	0.01	0.01	0.5	5.49004	5.40039
0.1	0.1	0.5	1	1	0.5	1	0.2	3.2	0.01	0.01	0.5	5.59098	5.58097
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.02	0.01	0.5	4.23465	4.34652
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.03	0.01	0.5	4.23465	4.33464
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.04	0.01	0.5	4.23465	4.31234
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.05	0.5	4.29084	4.29088
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.1	0.5	4.40148	4.39014
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	1.5	0.5	4.66841	4.66840
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	1.5	4.23465	4.34646
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2	4.33465	4.33465
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2.5	4.43465	4.43464

Table 6. Estimated Nusselt number using the input parameters by NM and ANFIS techniques.

												$Nu_x Re_x^{-1/2}$	
S	M	E_1	Rd	α	a_1	a_2	a_3	ω	Ec	β	Q	NM	ANFIS
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.56585	0.56894
0.2	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.26128	0.29315
0.3	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.11023	0.15894
0.4	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.97524	0.88664
0.1	0.3	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.18577	0.18555
0.1	0.4	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.50381	0.58858
0.1	0.5	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.97567	0.97560
0.1	0.1	0.7	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.14172	0.20816
0.1	0.1	0.9	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.35131	0.30182
0.1	0.1	1.1	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.55249	0.55244
0.1	0.1	0.5	1.2	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.21253	0.27816
0.1	0.1	0.5	1.4	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.21808	0.25162
0.1	0.1	0.5	1.6	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.57982	0.51826
0.1	0.1	0.5	1	2	0.5	1	0.2	1.1	0.01	0.01	0.5	0.30263	0.31589
0.1	0.1	0.5	1	2.5	0.5	1	0.2	1.1	0.01	0.01	0.5	0.35861	0.32735
0.1	0.1	0.5	1	3	0.5	1	0.2	1.1	0.01	0.01	0.5	0.38713	0.38713
0.1	0.1	0.5	1	1	1	1	0.2	1.1	0.01	0.01	0.5	0.11268	0.27354
0.1	0.1	0.5	1	1	1.5	1	0.2	1.1	0.01	0.01	0.5	0.16047	0.19826
0.1	0.1	0.5	1	1	1.7	1	0.2	1.1	0.01	0.01	0.5	0.19061	0.19192
0.1	0.1	0.5	1	1	0.5	1.1	0.2	1.1	0.01	0.01	0.5	0.11437	0.12863
0.1	0.1	0.5	1	1	0.5	1.2	0.2	1.1	0.01	0.01	0.5	0.11995	0.11999
0.1	0.1	0.5	1	1	0.5	1.3	0.2	1.1	0.01	0.01	0.5	0.11121	0.11902
0.1	0.1	0.5	1	1	0.5	1	0.4	1.1	0.01	0.01	0.5	0.11964	0.11809
0.1	0.1	0.5	1	1	0.5	1	0.5	1.1	0.01	0.01	0.5	0.11618	0.12010
0.1	0.1	0.5	1	1	0.5	1	0.7	1.1	0.01	0.01	0.5	0.17006	0.16297
0.1	0.1	0.5	1	1	0.5	1	0.2	1.2	0.01	0.01	0.5	0.57341	0.57338
0.1	0.1	0.5	1	1	0.5	1	0.2	2.2	0.01	0.01	0.5	0.03008	0.30080
0.1	0.1	0.5	1	1	0.5	1	0.2	3.2	0.01	0.01	0.5	0.49339	0.42991
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.02	0.01	0.5	0.14925	0.19249
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.03	0.01	0.5	0.13226	0.15180
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.04	0.01	0.5	0.18594	0.18594
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.05	0.5	0.13285	0.14037
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.1	0.5	0.17876	0.17881
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	1.5	0.5	0.27807	0.27069
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	1.5	0.50484	0.48392
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2	0.29009	0.31290
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2.5	0.84022	0.77956

numerical values, with the notable exception of those used for table comparison, are fixed and their actual values are modeled as follows: $M = 0.1, \omega = 0.1, \quad S = 0.3, \beta = 0.5, E_1 = 1.0, \mathrm{Pr} = 21, Ec = 0.05, \quad Q = 0.1, Q_t = 0.2, \quad Rd = 1.0, \alpha = 0.2, Br = 0.2, \alpha_1 = 0.1, \lambda = 1.0, \theta_w = 1.5, a_1 = 0.1, a_2 = 0.2$ and $a_3 = 1.0$.

The ANFIS simulation was executed for a total of 200 runs, during which the convergence speed of the proposed model was assessed and is illustrated in Figure 3. Furthermore, Tables 4–6 detail the estimated results and input parameters utilized for skin friction co-efficients and Nusselt number using ANFIS. Figures 4 and 5 show a comparison between experimental data and the estimated Nusselt number produced by the ANFIS model for training and testing datasets. The ANFIS model provides more precise outcomes, as illustrated through the visualizations of the observed and predicted Nusselt numbers. Also, to facilitate a more comprehensive examination of the predicted values of the Nusselt number in comparison to the observed values, regression plots of training and testing are illustrated in Supplemental Figures 10 and 11. In a similar vein, the estimated skin friction co-efficient on radial velocity of the training set obtained from ANFIS, as shown in Figure 6, and the testing dataset is depicted in Supplemental Figure 7. Also, so as to analyze the accuracy, a regression analysis is conducted between the observed and predicted values for training and testing; this process is illustrated in Supplemental Figures 12 and 13. Moreover, the outcomes of simulating the training dataset of skin friction co-efficient of azimuthal velocity with ANFIS are illustrated in Supplemental Figure 8. Supplemental Figure 9 further illustrates the estimated skin friction of the testing dataset in comparison to the observed values. Supplemental Figures 14 and 15 depict the regression plots of the skin friction training and testing sets,

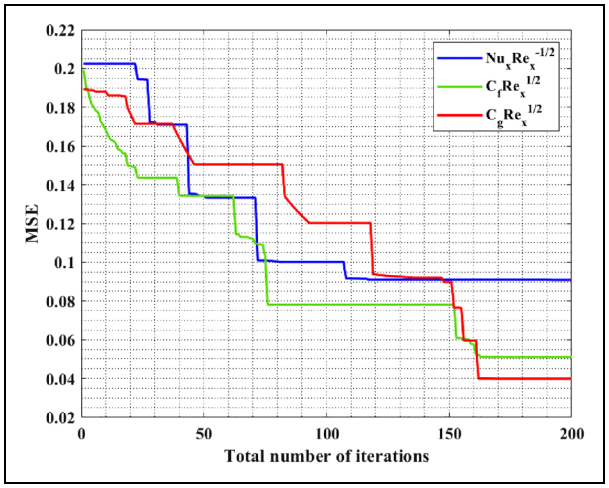


Figure 3. Convergence speed of ANFIS for predicting NNusselt and skin friction co-efficients.

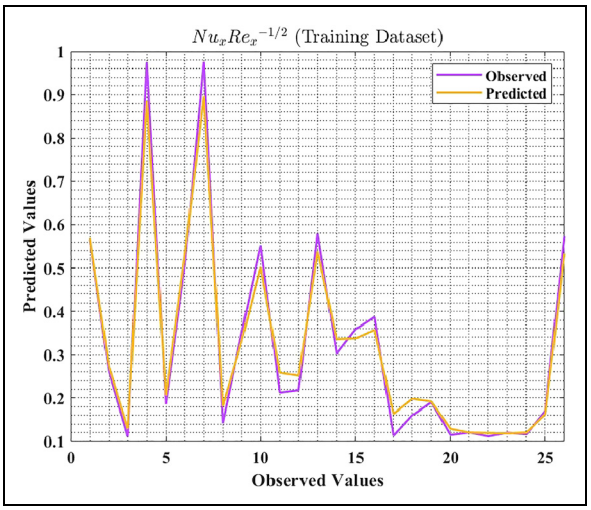


Figure 4. Nusselt number predictions using ANFIS for training dataset.

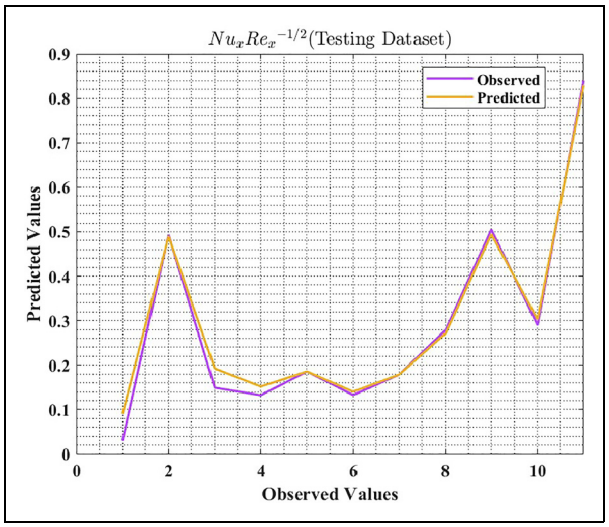


Figure 5. Nusselt number predictions using ANFIS for testing dataset.

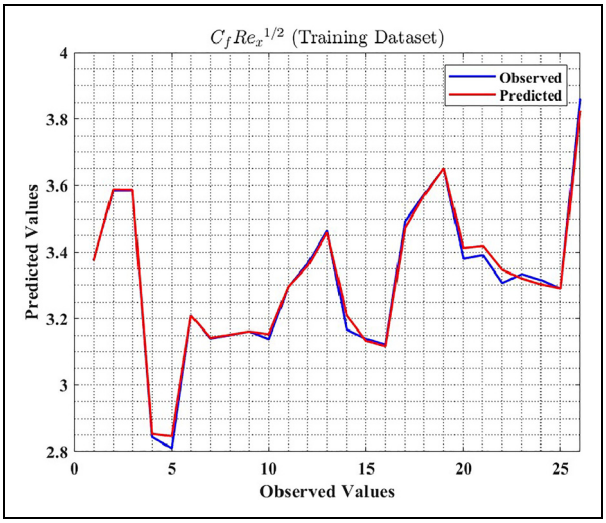


Figure 6. Skin friction on radial velocity predictions using ANFIS for training dataset.

respectively. In addition, Supplemental Figures 16 and 17 illustrate the training and testing accuracy of ANFIS with respect to the Nusselt number and skin friction coefficients, respectively. The corresponding mean squared errors of testing datasets for calculating the Nusselt number and skin friction coefficients for f and g are 0.0064, 0.0152 and 0.0178.

The fluid velocity dispersion in Newtonian and non-Newtonian scenarios is illustrated graphically in Supplemental Figures 18 and 19, which might additionally be utilized to generate new numerical conclusions. Supplemental Figure 18 exhibits how the radial velocity profile $f'(\eta)$ decreases as the values of the magnetic field parameter M boost up. From an actual stance, bigger values of M lead to more grounded Lorentz powers, which eventually cause velocities to drop. Additionally, by raising magnetic field parameter M, the viscosity of the porous medium also rises, improving the viscosity of the hybrid nanofluid. Recognizing that viscosity is inversely related to fluid velocity through a porous medium, so that the hybrid nanofluid's velocities drop. In Supplemental Figure 19, the effect of the electric field E_1 on azimuthal velocity $g(\eta)$ is depicted. Automatically, the flow rate significantly increased throughout the disk as the electric field values rose. Since the electric field amplifies the Lorentz force, which has the effect of speeding motion, azimuthal velocity $g(\eta)$ rises in both Newtonian and non-Newtonian scenarios.

Supplemental Figure 20 illustrates the vital effects of thermal radiation Rd on the temperature profile $\theta(\eta)$ of the hybrid nanofluid. It is implied that an increasing amount of radiation from the border gained temperature for the hybrid nanofluid, causing an enhancement in the temperature profile. Actually, the addition of radiation to the temperature field led to an upward trend in subatomic Brownian growth. Additionally, regular interactions between tiny nanoparticles will often generate

heat, which will raise the fluid's temperature $\theta(\eta)$ in both linear and nonlinear comparison cases. The effects of the vortex viscosity parameter a_1, spin gradient viscosity parameter a_2 and microinertia density parameter a_3 on the various microrotation components M_1, M_2, M_3 are depicted in Supplemental Figures 21–23, respectively. Supplemental Figure 21 demonstrates that the microrotation component M_1 rises and eventually declines when varied values of the material constants are taken into account. The setup for M_2 rises for both decreasing and rising values of a_1, a_2 and a_3 in both comparison phases as shown in Supplemental Figure 22. Supplemental Figure 23 demonstrates that when a_3 advances, the microrotation component M_3 climbs in Newtonian and non-Newtonian cases comparison.

Supplemental Figures 24 and 25 demonstrate, respectively, how the temperature ratio parameter α_1 and magnetic field affect the rate of local entropy generation N_G and the Bejan number *Be*. Supplemental Figure 24 provides evidence that the temperature ratio parameter values considerably accelerate the production of entropy. The primary contributory factor to this rise in the ratio parameter's detrimental impact on the rate of heat transfer and friction at the surface, which ultimately increases entropy production N_G, which is the stimulation in the entropy generation rate. According to Supplemental Figure 25 analysis, the Bejan number *Be* degrades when magnetic parameter values rise across both Newtonian and non-Newtonian phases.

Conclusion

In order to solve the fluidic system based on coupled micropolar and Casson hybrid nanofluid, a stochastic numerical computation using the proposed solver, ANFIS is used. The PDEs pertaining to the mathematical system are converted into equivalent ODEs that depict the problem's dynamics. Many vital parameters are taken into consideration when generating the data set for the ANFIS technique. Below is a thorough account of this most recent round of experiments and its excellent conclusion.

- As the magnetic field parameter increases, the radial velocity decreases; however, an opposite trend is seen when the electrical field parameter increases in terms of azimuthal velocity.
- The temperature profile also naturally rises as thermal radiation rises.
- The inclination factor may be seen in the rising impacts of the spin gradient viscosity, vortex viscosity and microinertia density factors on multiple microrotation components.
- For both Newtonian and non-Newtonian phases of the magnetic field, the Bejan number shows the opposite pattern; shortly, entropy generation increases as the ratio parameter is increased.
- To simulate the ANFIS model, the reference data is partitioned in to training (70%) and testing (30%). The ANFIS framework accuracy is certified by both suggested and reference results with level matching.
- Furthermore, the accuracy is also explained via predicted results against reference data through the graphical representations of RMSE, observed versus predicted values and regression analysis of observed against predicted values.

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List of symbols

r, φ, z	are the cylindrical coordinates
u, v, w	are the velocity components
f	is the axial velocity field
f'	is the radial velocity field

g	is the azimuthal velocity field
T	is the temperature of the fluid
S	is the measure of unsteadiness
M	is referred as Magnetic field parameter
B_0	is referred as uniform magnetic field
T_s	is called surface temperature
T_0	is origin temperature
T_{ref}	is constant reference temperature
Re_x	is referred as Local Reynolds number
Ec	is Eckert number
Pr	is Prandtl number
Rd	is thermal radiation
N_G	is the Local entropy generation
C_f	is the skin friction co-efficient of f velocity
C_g	is the skin friction co-efficient of g velocity
Nu_x	is the Local Nusselt number
Be	is the Bejan number
A_1, A_2, A_3, A_4, A_5	are the hybrid nanofluid constants
N_1, N_2, N_3	are the microrotation components
a_1	is the vortex viscosity parameter
a_2	is the spin gradient viscosity parameter
a_3	is the micro inertia density parameter
Q_T^*	is the thermal-dependent heat source coefficient
Q_E^*	is the exponential space-dependent heat source coefficient
n	is the exponential index
c	is the stretching rate
Q	is the exponential based heat source parameter
Q_t	is the thermal space dependent heat source parameter

Greek symbols

ρ	is the fluid density
υ	is the kinematic viscosity
μ	is the dynamic viscosity
σ	is the electric conductivity
η	is the dimensionless variable
k^*	is the mean absorption co-efficient
σ^*	is the Stefan Boltzmann constant
θ	is the dimensionless temperature
α	is the Casson parameter
Ω	is the angular velocity
β	is the Porosity parameter
θ_w	is the temperature ratio parameter
α_1	is the temperature difference parameter
ω	is the rotation parameter

Subscripts

f	represents the fluid
nf	represents the nanofluid
hnf	represents the hybrid nanofluid

Radiation and Chemical Reaction Effects on Mhd Mixed Convection Flow Past an Inclined Porous Plate Embedded in A Porous Medium with Heat Source and Thermodiffusion

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Abstract – This paper focuses on the radiation and chemical reaction effects on MHD mixed convective flow along inclined porous plate embedded in a porous medium with thermo diffusion in the presence of heat generation. The governing boundary layer equations are reduced to a system of ordinary differential equations using similarity transformations and the resulting equations are then solved numerically using Runge - Kutta fourth order method along with shooting technique. A parametric study is conducted to illustrate the influence of various governing parameters on the velocity, temperature, concentration, skin-friction coefficient, Nusselt number and Sherwood number and discussed in detail.

Key Words – Chemical Reaction, Mixed Convection, Porous Plate, Radiation, Thermo diffusion.

I. INTRODUCTION

In free convection fluid, motion is due to buoyancy effects within the fluid resulting from density variation caused by temperature differences in the fluid, while in forced convection it is externally imposed. The combination of free and forced convection is known as mixed convection. Mixed convection flow has important applications in electronic equipment cooled by a fan and flows in the ocean and in the atmosphere. In mixed convection flows, the forced and free convection effects are of comparable magnitude. Thus, mixed convection occurs if the effect of buoyancy forces on a forced flow or vice versa is significant. The mixed convection on laminar flow takes place in various applications in science and thermal engineering and has drawn attention of researchers in the past decades. Examples of these applications include solar energy systems, atmospheric boundary layer flows, compact heat exchangers, boilers and cooling of electronic devices. Sengupta *et al*. [1] studied the mixed convection boundary layer of linear spatial stability analysis along a heated plate. Ali *et al*. [2] considered the free-forced convective hydro magnetic boundary layer flow towards a stagnation point on a vertical surface in presence of induced magnetic field. Subhashini *et al.* [3] analyzed mixed convection boundary layer flow with buoyancy assisting and opposing effects past a permeable vertical surface. Many researchers investigated the effects of mixed convection viscous boundary layer flow past vertical/ inclined/ horizontal plate and wedge surfaces. Lloyd and Sparrow [4] studied the effects of mixed convective boundary layer flow on vertical surfaces. Schneider [5] analyzed similarity solution for mixed convection boundary layer flow along a horizontal plate. Wilks [6] presented the mixed convection flow along vertical surfaces. Yao [7] studied the mixed convection two-dimensional flow past a flat plate. Ramachandran *et al.* [8] presented the mixed convection in stagnation flows adjacent to vertical surfaces.

From the literature survey it has been observed that the combined heat and mass transfer on mixed convection have been extensively studied on horizontal and vertical configurations and paid little attention on inclined geometries. Laaroussi *et al.* [9] presented numerically the effect of variable density on laminar forced and free convection flow with thin liquid film evaporation in a vertical channel. Ait Hammou *et al.*

[10] studied the numerical solution of evaporation or condensation on laminar mixed convection flow of humid air in a vertical channel. Said *et al.* [11] carried out a numerical study on turbulent free convection boundary layer flow between inclined isothermal plates.

Magnetohydrodynamics has attracted the interest of many researchers because of its wide range of applications in engineering such as astrophysics, purification of crude oil, geothermal reservoirs, ship propulsion, magnetic material processing, cooling of nuclear reactors, MHD generators, Jet printers, petroleum industries, crystal growth, boundary layer control in aerodynamics and so on. Moreover the study of MHD is largely concerned with the flow, heat and mass transfer characteristics in various physical situations. Sri Hari Babu and Ramana Reddy [12] presented the effects of mixed convective mass transfer on hydro magnetic flow past a vertical surface with viscous dissipation in presence of Ohmic heating. Chen *et al*. [13] studied the effects on natural convection heat and mass transfer MHD flow from a permeable, inclined surface with concentration in the presence of variable wall temperature.

Simultaneous heat and mass transfer in porous media with different geometries has attracted many researchers due to its numerous engineering and geophysical applications such as geothermal reservoirs, thermal insulation, packed-bed catalytic reactors, underground energy transport, cooling of nuclear reactors, enhanced oil recovery, drying of porous solids, etc. Lai and Kulacki [14] discussed heat and mass transfer effects on non-Darcy mixed convection boundary layer past vertical plate through a saturated porous medium. Nasir Uddin *et al.* [15] investigated the conjugate heat and mass transfer effects on magneto hydrodynamic mixed convective flow along inclined plate embedded in a porous medium. Sattar and Hossain [16] analyzed the effects of mass transfer with Hall currents on an unsteady free convective boundary layer flow past an accelerated vertical porous plate as time depending temperature and concentration. Vajravelu [17] examined the heat transfer effects on steady flow past a stretching surface through a saturated porous medium. Hong *et al*. [18], Chen and Lin [19] and Jaiswal and Soundalgekar [20] investigated the free convection flows embedded in a porous medium with high porosity.

In many situations there may be an appreciable temperature difference between the surface and ambient fluid. These necessities the consideration of temperature dependent heat sources or sinks which may exert strong influence on the heat transfer characteristics. The study of heat generation or absorption in moving fluids is important in view of several physical problems, such as fluids undergoing exothermic or endothermic chemical reactions. Sparrow and Cess [21] provided similarity solution for stagnation point flow in presence of heat source/sink varying with time. Pop and Soundalgekar [22] presented an unsteady free convection flow past an infinite plate with constant suction in presence of heat source. Reddy *et al.* [23] studied the mass transfer effects on two-dimensional natural convection boundary layer flow along an inclined semi-infinite vertical surface in the presence of heat generation embedded in a porous medium.

Radiation becomes the only significant mode of heat transfer when no medium is present. At high absolute temperature levels such as those prevailing in furnaces, combustion chambers, nuclear explosions and in space applications, the contribution of radiation to heat transfer is very significant. Recent advancement in hypersonic flights, gas cooled nuclear reactors, rocket combustion chambers and missile reentry, have perhaps shifted researchers' attention to thermal radiation as a mode of energy transfer, and emphasize the need for improved understanding of radiative transfer in these processes. Ramachandra Prasad *et al.* [24] studied effects of convective heat and mass transfer on an unsteady MHD radiating flow along a semi-infinite vertical permeable moving plate through a porous medium. Ramana Reddy *et al*. [25] have studied an unsteady free convective MHD viscous incompressible and radiating fluid flow embedded in porous medium with heat generation/absorption. MHD mixed convective heat transfer about a semi-infinite inclined plate in the presence of magnetic field and thermal radiation has been examined by Aydin *et al*. [26]. Recently, Samad and Rahman [27] presented the interaction of the thermal radiation on MHD unsteady boundary layer flow along vertical porous plate immersed in a porous medium. Uddin and Kumar [28] studied the effects of free convection MHD radiating flow of an isothermal cylinder embedded in a porous medium.

It is essential to study the heat and mass transfer problems with chemical reaction because of its growing need in chemical and hydrometallurgical industries. The study of such process takes place in number of chemical technologies such as food processing, polymer production, the manufacturing of ceramics or glassware and so on. Singh *et al.* [29] presented absorption of chemical reaction and radiation effects on magnetohydrodynamic natural convective heat and mass transfer flow along a semi-infinite vertical moving plate in the presence of suction depending on time. Ibrahim *et al*. [30] presented an unsteady magneto hydrodynamic natural convection chemical reacting and radiation absorbing fluid flow along a continuously moving permeable surface with heat source and time dependent suction. Rajeswari *et al*. [31] investigated the effect of chemical reaction on unsteady MHD natural convection boundary layer of radiation absorption fluid flow along a semi-infinite vertical permeable moving plate in the presence of heat source with suction. Recently, Kandasamy et al. [32, 33] presented chemical reaction effects on heat and mass transfer boundary layer flows with heat source. Gangadhar and Bhaskar reddy [34] analyzed the chemically reaction, heat and mass transfer effects on MHD flows along a moving vertical plate embedded in a porous medium with suction. Patil and Kulkarni [35] investigated the effects of chemically reacting natural convective polar fluid flow in a porous medium with internal heat generation.

Thermophoresis is a phenomenon which causes small particles to be driven away from a hot surface and towards a cold one. Small particles, such as dust, when suspended in a gas with a temperature gradient, experience a force in the direction opposite to the temperature gradient. This phenomenon has many practical applications in removing small particles from gas streams, in determining exhaust gas particle trajectories from combustion devices, and in studying the particulate material deposition on turbine blades. Recently, Chamkha *et al*. [36] studied the effect of thermophoretic particle deposition in free convection boundary layer from a vertical flat plate embedded in a porous medium. Bakier *et al*. [37] dealt with the effects of thermophoresis particle deposistion on MHD boundary layer flow past a vertical flat plate through a fluid-saturated porous medium. Lin *et al* [38] investigated the suppression of particle deposition from flow through a tube with circular cross-section when the wall temperature exceeds that of the gas. Seddek [39] presented the effects of thermophoresis of chemically reacting MHD flow over a heat surface in the presence of variable viscosity and heat source/absorption. Alam *et al*. [40] considered the effects heat thermophoresis on magneto hydrodynamic boundary flow with heat and mass transfer past a semi-infinite permeable inclined flat surface. Loganathan and Arasu [41] presented the effect of thermophoresis on non-Darcy free-forced convective heat and mass transfer along a porous wedge with suction or injection.

II. MATHEMATICAL ANALYSIS

A steady two-dimensional MHD laminar mixed convective flow of a viscous incompressible, electrically conducting, radiating and chemically reacting fluid past a semi-infinite inclined porous plate embedded in porous mdium with an acute angle α to the vertical is considered. The flow is assumed to be in the x - direction, which is taken along the semi-infinite inclined porous plate and y - axis normal to it. The velocity components in the directions of flow and normal to the flow are u and v respectively. A uniform magnetic field strength B_0 is applied normal to the direction of y-axis.

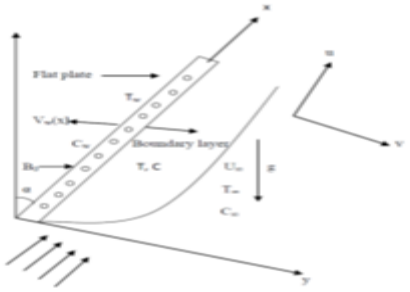


Fig. 1 Schematic diagram of the physical model

The fluid is assumed to be slightly conducting, so that the magnetic Reynolds number is much less than unity, and hence the induced magnetic field is negligible in comparison with applied magnetic field. The external flow with a uniform velocity U_∞ takes place in the direction parallel to the inclined plate. It is assumed that T and C are the temperature and concentration of the fluid which are the same, everywhere in the fluid. The surface is maintained at a constant temperature T_w, which is higher than the constant temperature T_∞ and the concentration C_w is

greater than the constant concentration C_∞ of the surrounding fluid. It is assumed that there is no applied voltage which implies the absence of electrical field. The fluid is considered to be a gray, absorbing emitting radiation but non-scattering medium and the Rosseland approximation is used to describe the heat flux in the energy equation.

Under the above assumptions and usual Boussinesq's approximation, the governing boundary layer equations describing the flow can be written as

Continuity equation

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{2.1}$$

Momentum equation

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\upsilon\frac{\partial^2 u}{\partial y^2}+g\beta\left(T-T_\infty\right)\cos\alpha+g\beta^*\left(C-C_\infty\right)\cos\alpha-\left(\frac{\sigma B_0^2}{\rho}+\frac{\upsilon}{K^*}\right)u \tag{2.2}$$

Energy equation

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{k}{\rho C_p}\frac{\partial^2 T}{\partial y^2}+\frac{Q_0}{\rho C_p}\left(T-T_\infty\right)-\frac{1}{\rho C_p}\frac{\partial q_r}{\partial y} \tag{2.3}$$

Species equation

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D\frac{\partial^2 C}{\partial y^2}-\frac{\partial}{\partial y}\left\{V_T\left(C-C_\infty\right)\right\}-Kr'C \tag{2.4}$$

where υ is the kinematics viscosity, g is the acceleration due to gravity, β, β^* are the volumetric coefficients of thermal and concentration expansions, respectively, T, C are the temperature and concentration of the fluid, respectively, T_∞, C_∞ are the free stream temperature and concentrations respectively, σ is the electrical conductivity, B_0 - the magnetic induction, ρ is the fluid density of the fluid, K^* is permeability of the porous medium, k is the thermal conductivity of the fluid, C_p is the specific heat at constant pressure, Q_0 is the heat generation constant, q_r is the radiative heat flux, D is the mass diffusivity, V_T is the thermophoretic velocity and Kr' is the chemical reaction rate of the species concentration.

The third and fourth terms on the RHS of the momentum equation (2.2) denote the thermal and concentration buoyancy effects, and last two terms of the momentum equation represent magnetic field and porous effects, respectively. Also the last two terms of on the RHS of the energy equation (2.3) represent the heat absorption and thermal radiation effects, respectively. The last two terms on the RHS of the species equation (2.4) represents the thermophoretic and chemical reaction effects, respectively. It is assumed that the physical properties, that is, viscosity, heat capacity, thermal diffusivity and the mass diffusivity of the fluid remain invariant throughout the fluid.

The boundary conditions for the velocity, temperature and concentration fields are

$u=0$, $v=\pm v_w(x)$, $T=T_w$, $C=C_w$ *at* $y=0$

$u=U_\infty$, $T=T_\infty$, $C=C_\infty$, *as* $y\to\infty$ (2.5)

In addition, U_∞ is the free stream velocity and $v_w(x)$ represent the permeability of the porous plate where its sign indicates suction (< 0) or blowing (> 0), subscripts w and ∞ refer to the wall and boundary layer edge, respectively.

The effects of thermophoresis are being taken into account to help in the understanding of the mass deposition variation on the surface. The effect of thermophoresis is usually prescribed by means of an average velocity that a particle will acquire when exposed to a temperature gradient. For boundary layer analysis it is found that the temperature gradient along the plate is much lower than the temperature gradient normal to the surface, *i.e.*, $\frac{\partial T}{\partial y}>>\frac{\partial T}{\partial x}$. So the component of thermophoretic velocity along the plate is negligible compared to the component of its normal to the surface. As a result, the thermophoretic velocity V_T which appears in the equation (2.4) can be written as

$$V_T=-k\upsilon\frac{\Delta T}{T_{ref}}=-\frac{k\upsilon}{T_{ref}}\frac{\partial T}{\partial y} \tag{2.6}$$

where T_{ref} is some reference temperature and k is the thermophoretic coefficient which is defined by[42].

By using the Rosseland approximation (Brewster [43]), the heat flux q_r is given by

$$q_r=\frac{4\sigma^*}{3k^*}\frac{\partial T^4}{\partial y} \tag{2.7}$$

Where σ^* is the Stephen-Boltzmann constant and k^* is the mean absorption. It should be noted that by using the Rosseland approximation, the present analysis is limited to optically thick fluids. If the temperature differences within the flow are sufficiently small, then equation (2.3) can be linearized by expanding T^4 into the Taylor series about T_∞, which after neglecting higher order terms takes the form

$$T^4 = 4T_\infty^3 T - 3T_\infty^4 \tag{2.8}$$

In view of the equations (2.7) and (2.8), the equation (2.3) reduces to

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 T}{\partial y^2} + \frac{Q_0}{\rho C_p}(T - T_\infty) + \frac{16\sigma^* T_\infty^3}{3k^*\rho c_p}\frac{\partial^2 T}{\partial y^2} \tag{2.9}$$

The continuity equation (2.1) is satisfied by the Cauchy Riemann equations

$$u = \frac{\partial \psi}{\partial y} \text{ and } v = -\frac{\partial \psi}{\partial x} \tag{2.10}$$

where $\psi(x,y)$ is the stream function.

In order to write the governing equations and the boundary conditions in dimensionless form, the following dimensionless quantities are introduced.

$$\eta = y\sqrt{\frac{U_\infty}{\upsilon x}}, \qquad \psi = \sqrt{\upsilon x U_\infty}\, f(\eta),$$

$$u = U_\infty f'(\eta), \quad v = \frac{1}{2}\sqrt{\frac{\upsilon U_\infty}{x}}\left(\eta f' - f\right),$$

$$\theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty}, \qquad \phi(\eta) = \frac{C - C_\infty}{C_w - C_\infty},$$

$$M_x = \frac{\sigma B_0^2 x}{\rho U_0},\ Gr_x = \frac{g\beta(T_w - T_\infty)x}{U_\infty^2}, \tag{2.11}$$

$$Gc_x = \frac{g\beta^*(C_w - C_\infty)x}{U_\infty^2}, \qquad K_x = \frac{\upsilon x}{K^* U_\infty},$$

$$\Pr = \frac{\upsilon\rho C_p}{k}, \quad Sc = \frac{\upsilon}{D},$$

$$Q_x = \frac{Q_0 x}{U_\infty \rho C_p},\ Kr_x = \frac{Kr' x}{U_\infty},\ R = \frac{4\sigma^* T_\infty^3}{3k^* k},$$

$$\tau = \frac{k\left(T_w - T_\infty\right)}{T_{ref}},$$

where prime denotes differentiation with respect to η, η - the similarity variable, $f(\eta)$ - the dimensionless stream function, $f'(\eta)$ - the dimensionless velocity, $\theta(\eta)$- the dimensionless temperature, $\varphi(\eta)$ - the dimensionless concentration M_x - the local magnetic field parameter, Gr_x - the local thermal Grashof number, Gc_x - the modified Grashof number, K_x – the permeability parameter, Pr - the Prandtl number, Sc - the Schmidt number, Q_x - the heat generation parameter, Kr_x - the chemical reaction parameter, R - the radiation parameter and τ - thermophoretic parameter.

In the view of the above similarity transformations, the equations (2.2), (2.9) and (2.4) reduce to

$$f''' + \frac{1}{2}ff'' + Gr_x\theta\cos\alpha + Gc_x\varphi\cos\alpha - \left(M_x + K_x\right)f' = 0 \tag{2.12}$$

$$\left(4R+1\right)\theta'' + \frac{1}{2}\Pr\, f\theta' + \Pr Q_x\theta = 0 \tag{2.13}$$

$$\varphi'' + Sc\left(\frac{1}{2}f - \tau\theta'\right)\varphi' - Sc\varphi\left(\tau\theta'' - Kr_x\right) = 0 \tag{2.14}$$

The corresponding boundary conditions are

$f = f_w$, $f' = 0$, $\theta = 1$, $\varphi = 1$ at $\eta = 0$ (2.15)

$f' \to 1$, $\theta \to 0$, $\varphi \to 0$ as $\eta \to \infty$ (2.16)

$f_w = -v_w(x)\sqrt{x/\upsilon U_\infty}$ is the non dimensional wall mass transfer coefficient such that $f_w > 0$ indicates wall suction and $f_w < 0$ indicates wall injection or blowing.

For the type of boundary layer flow under consideration the skin-friction coefficient, Nusselt number and Sherwood number are important parameters. They are described as follows.

By employing definition of wall shear stress $\tau_w = \mu(\partial u/\partial y)_{y=0}$ along with Fourier's law $q_w = -k(\partial T/\partial y)_{y=0}$ and Fick's law $J_s = -D(\partial c/\partial y)_{y=0}$ the non-dimensional forms of local skin-friction coefficient is $C_f = 2\,\mathrm{Re}^{-1/2} f''(0)$, local Nusselt number is $N_u = -2\,\mathrm{Re}^{1/2}\theta'(0)$ and local Sherwood number is $S_h = -2\,\mathrm{Re}^{1/2}\phi'(0)$, where $\mathrm{Re}_x = xU_\infty/\upsilon$ is the local Reynolds number.

It can be noted that the local parameters Ha_x, Gr_x, Gc_x, K_x, Q_x and Kr_x in the equations (2.12) - (2.14) are functions of x and generate local similarity solution. In order to have a true similarity solution all the parameters Ha_x, Gr_x, Gc_x, K_x, Q_x and Kr_x must be constant and we therefore assume

$$\sigma = \frac{b}{x}, \quad \beta = \frac{c}{x}, \ \beta^* = \frac{d}{x},$$

$$K^* = \frac{a}{x}, \ Q_0 = \frac{e}{x}, \quad Kr' = \frac{m}{x}$$

where *a, b, c, d, e* and *m* are the constants with appropriate dimensions.

III. SOLUTION OF THE PROBLEM

The non-linear boundary value problem given by equations (2.12) - (2.14) and boundary conditions (2.15) does not possess a closed form analytical solution. Therefore it has been solved numerically by using fourth order Runge-Kutta scheme together with Newton Raphson shooting method. First of all, writing higher order non-linear differential equations (2.12), (2.13) and (2.14) into simultaneous first order differential equations as follows.

Let $f = y_1$, $f' = y_2$, $f'' = y_3$, $\theta = y_4$, $\theta' = y_5$, $\varphi = y_6$, $\varphi' = y_7$.

Thus, the corresponding first order differential equations are

$$\frac{dy_1}{d\eta} = y_2,$$

$$\frac{dy_2}{d\eta} = y_3,$$

$$\frac{dy_3}{d\eta} = -\{\frac{1}{2} y_1 y_3 + Gr_x y_4 \cos\alpha + Gc_x y_6 Cos\alpha - (M_x + K_x) y_2\},$$

$$\frac{dy_4}{d\eta} = y_5,$$

$$\frac{dy_5}{d\eta} = \frac{-1}{(4R+1)}\{\frac{1}{2}\Pr y_1 y_5 + \Pr Q y_4\},$$

$$\frac{dy_6}{d\eta} = y_7,$$

$$\frac{dy_7}{d\eta} = -\{Sc(\frac{1}{2} y_1 - \tau y_5) y_7 - Scy_6(\tau \frac{dy_5}{d\eta} + Kr_x\},$$

subject to following initial conditions

$$y_1(0) = f_w, \ \ y_2(0) = 0, \quad y_4(0) = 1, \ y_6(0) = 1,$$

$$y_2(\infty) = 1, \ y_4(\infty) = 0, \ \ y_6(\infty) = 0$$

Then the set of above equations are transformed into initial value problem by applying the shooting technique (Jain *et al*. [44]). We have chosen a step size of $\Delta\eta$ = 0.01 to satisfy the convergence criterion of 10^{-6} in all cases. From the process of numerical computation, the skin-friction coefficient, Nusselt number and Sherwood number which are respectively proportional to $f''(0)$, $-\theta'(0)$, and $-\varphi'(0)$ are also sorted out and their numerical values are presented in a tabular form.

IV. RESULTS AND DISCUSSION

In order to get a physical insight into the problem, a parametric study is conducted to illustrate the effects of different governing parameters viz local magnetic field parameter *M*, the thermal Grashof number Gr_x, the modified Grashof number Gc_x, internal heat generation parameter *Q*, permeability of the porous medium *K*, the Prandtl number *Pr*, the Schmidt number *Sc*, the chemical reaction parameter *Kr*, the thermophoretic parameter τ and the non-dimensional wall mass transfer coefficient f_w and radiation parameter *R* upon the nature of flow and transport, the numerical results are depicted graphically in Figs. 2-26. Throughout the calculations, the parametric values are chosen as for *Gr* =*Gc*=0.87, *M*= 0. 1, *K*=0.01, α=30^0, *Pr*= 0.71, *Q* =0.5, *R*=1.0, f_w = 0.5, *Kr*=0.1, *Sc* = 0.6 τ = 0.1. All the graphs therefore correspond to these values unless specifically indicated on the appropriate graph. In order to ascertain the accuracy of the numerical results, the present study is compared with the previous study. The velocity profiles for *Gr* = 2.0, *Gc* = 2.0, *K*=0.5, *M*= 0.01, *Q* =0.5, α=30^0, *Pr*= 0.71, f_w = 0.5, *Sc* = 0.22. τ = 0.1, *R*=0, *K*r=0 are compared with the available solution of Nasir Uddin *et al.* [45] in Fig. 2. It is observed that the present results are in good agreement with that of Nasir Uddin *et al.* Numerical results for the skin-friction coefficient, the Nusselt number, the Sherwood number and the plate surface temperature for various values of physical parameters are reported in Tables.

The effect of magnetic parameter (*M*) on the velocity field is shown in Fig. 3. It illustrates that the velocity decreases with an increase in the magnetic parameter, because the magnetic parameter is found to retard the velocity at all points of the flow field. It is because that the application of transverse magnetic field will result in a resistive type force (Lorentz force) similar to drag force which tends to resist the fluid flow and thus reducing its velocity. Also, the boundary layer thickness decreases with an increase in the

magnetic parameter. Fig. 4 represents the effect of the magnetic parameter on the temperature. It is noticed that the temperature of the fluid increases as the magnetic parameter increases. This is due to the fact that the applied magnetic field tends to heat the fluid, and thus reduces the heat transfer from the wall.

Fig. 5 and Fig. 6 illustrate the effect of the thermal Grashof number (*Gr*) and mass (solutal) Grashof number (*Gc*) on the velocity field. The thermal Grashof number signifies the relative effect of the thermal buoyancy force to the viscous hydrodynamic force and the mass (solutal) Grashof number defines the ratio of species buoyancy force to the viscous hydrodynamic force in the boundary layer. It is observed that with an increase in *Gr* or *Gc*, there is an increase in the velocity. It is due to the fact that an increase in the values of *Gr* or *Gc* has the tendency to increase the thermal and mass buoyancy effects. Further, the velocity increases rapidly and suddenly falls near the boundary and then approaches the far field boundary condition due to favorable buoyancy force with an increase in *Gc*. Fig. 7 and Fig. 8 represents the temperature for different values of the Grashof number and modified Grashof number respectively. It is observed that the thermal boundary layer decreases with an increasing thermal Grashof number or modified Grashof number. The effect of buoyancy parameters (*Gr*, *Gc*) on the concentration field is illustrated in Fig. 9 and Fig. 10. It is noticed that concentration boundary layer thickness decreases with an increase in the thermal or solutal Grashof numbers. It is due to the fact that an increase in the values of Grashof number or modified Grashof number has the tendency to increase the mass buoyancy effect.

Fig. 11 illustrates the effect of permeability parameter (*K*) on the velocity. It is noticed that as the permeability parameter increases, the velocity decreases. The parameter *K* as defined in (2.11) is inversely proportional to the actual permeability K^* of the porous medium. An increase in *K* will therefore decrease the resistance of the porous medium (as the permeability physically becomes less with increasing K^*) which will tend to decelerate the flow and reduce the velocity. Fig. 12, display the effect of temperature across the boundary layer for different values of the permeability parameter. It is noticed that an increase in the permeability parameter leads to an increase in the fluid temperature.

Fig. 14 shows the effect of the Prandtl number (*Pr*) on the temperature. It is observed that, an increase in the Prandtl number results in decrease of the thermal boundary layer, and hence temperature decreases. Prandtl number signifies the ratio of momentum diffusivity to thermal diffusivity. In heat transfer problems, the Prandtl number controls the relative thickening of the momentum and thermal boundary layers. The reason is that, smaller values of *Pr* are equivalent to increase the thermal conductivities, when Prandtl number is small, heat is able to diffuse away from the heated surface more rapidly than for higher values of *Pr*. As *Pr* enhances, it can be seen from Fig. 13 that the velocity reduces. This is due to the fact that with an increase in *Pr*, rate of viscous diffusion exceeds the rate of thermal diffusion and hence it is seen that velocity decreases throughout the regime.

The positive value of (*Q*) represents heat source *i.e*. heat generation in the fluid. From Fig. 15, it is observed that due to increase in heat generation parameter enhances the thermal buoyancy force of driving force due to mass density variations which are coupled to the temperature distribution which in turn gives rises the velocity in the boundary layer. The effect of the heat generation parameter on the temperature is shown in Fig. 16. It is seen that with an increase in the heat generation parameter, the temperature increases. This is due to the fact that the presence of a heat source on the flow field, the thermal state of the fluid increases causing the thermal boundary layer to increase. The influence of heat generation parameter on concentration is shown in Fig. 17. It is seen that the concentration decreases as *Q* increase.

The influence of thermal radiation parameter *R* on the velocity and temperature is shown in Fig. 18 and Fig. 19. The radiation parameter defines the relative contribution of conduction heat transfer to thermal radiation transfer. It is obvious that, with an increase in the radiation parameter results an increase in both the velocity and temperature within the boundary layer.

The effect of chemical reaction parameter (*Kr*) on the concentration is presented in Fig. 20. It is observed that the species concentration decreases with an increase in the chemical reaction parameter. Physically this shows that an increase in chemical reaction parameter breaks up the bonds between the

atoms and thus the density of the species dilutes and thereby decreases the concentration of the fluid.

The effect of the Schmidt number (*Sc*) on the velocity, temperature and concentration are shown in Figs. 21-23, respectively. Moreover, the Schmidt number is an important parameter in heat and mass transfer processes as the Schmidt number embodies the ratio of momentum to mass diffusivity. The Schmidt number quantifies the relative effectiveness of momentum and mass transport by diffusion in the hydrodynamic (velocity) and concentration (species) boundary layers. Its effect on the species concentration has similarities to the Prandtl number effect on the temperature. As the Schmidt number increases the concentration decreases. This causes the concentration buoyancy effects to decreases yielding reduction in the fluid velocity resulting in less induced flow and higher fluid temperatures.

The influence of thermophoretic parameter (τ) on the concentration is shown in Fig. 24. It is seen that the concentration decreases with an increase of the thermophoretic parameter due to the small temperature difference between the hot fluid and the free stream.

Figs. 25-27 illustrate the effect of suction parameter (f_w>0) on the velocity, temperature and concentration. It is observed that with an increase in the suction parameter velocity, temperature and concentration decreases. This is due to the fact that with an increase in suction rate, more warm fluid is pushed towards the wall where the buoyancy forces acts to reduce the fluid velocity due to influence of high viscosity. This effect also reduces the wall sear stress. An increase in the suction parameter destroys the momentum transfer and stabilizes the boundary layer flow on the surface.

From Table 1, it is observed that the local skin-friction, Nusselt number and Sherwood number coefficient increase with an increase in the buoyancy forces (*Gc* or *Gr*). As the magnetic parameter (*M*) increases, the skin-friction, Nusselt number and Sherwood number decrease. It can be seen that the local skin-friction coefficient, Nusselt number and Sherwood number decrease with an increase in the porous medium parameter (*K*).It is noted that an increase in suction parameter (f_w>0) increase the skin friction coefficient, Nusselt number Sherwood number.

From Table 2, it is found that the local skin-friction coefficient, Nusselt number and Sherwood number decrease with an increase in the Prandtl number (*Pr*). It is noticed that the skin-friction and Sherwood number increase, where as Nusselt number decreases with an increase in the internal heat generation parameter (*Q*). It is observed that the skin-friction coefficient and Sherwood number increase, whereas Nusselt number decreases with an increase in the radiation parameter(*R*).

From Table 3, it is clear that both the skin friction coefficient and Nusselt number decrease while Sherwood number increases as the Schmidt number (*Sc*) or chemical reaction parameter (*Kr*) or thermophoretic parameter (τ) increases.

V. CONCLUSION

The present model helps us to understand numerically as well as physically the effect of the radiation and chemical reaction on a steady magneto hydrodynamic heat and mass transfer flow of laminar mixed convective boundary layer flow of viscous incompressible, electrically conducting fluid past an inclined porous plate with thermo diffusion. The set of governing equations and the boundary condition are reduced to ordinary differential equations with appropriate boundary conditions using similarity transformations. The resultant dimensionless equations are then solved numerically by shooting technique with Runge-Kutta scheme. A comparison with previously published work is performed and the results are found to be in good agreement. Based on the obtained results, the following conclusions may be drawn.

- The velocity, skin friction coefficient, rate of heat transfer as well as the rate of mass transfer decreases whereas the temperature increases with an increase in the magnetic parameter.
- As mass (solutal) Grashof number increases the velocity increases near the plate and then it decreases smoothly away from the plate, while velocity increases throughout the boundary layer with an increase in the thermal Grashof number.
- An increase in the mass (solutal) Grashof number or thermal Grashof number causes a fall in the temperature and concentration, whereas a rise in

the skin friction coefficient, rate of heat transfer, as well as rate of mass transfer.

- An increase in the permeability parameter reduces the velocity, skin friction coefficient, heat transfer coefficient and the mass transfer coefficient but enhances the temperature.
- An increase in the Prandtl number decreases all the physical quantities.
- The velocity, temperature as well as the skin friction coefficient and the mass transfer rate increases whereas the concentration and local heat transfer rate decreases with an increase in the heat generation or radiation parameter.
- With an increase in the heat generation parameter the concentration decreases.
- The velocity as well as concentration decreases while the temperature increase with an increase in the Schmidt number.
- There is a decrease in the concentration with an increase in the chemical reaction parameter or thermophoretic parameter
- With an increase in the local chemical reaction parameter or Schmidt number or thermophoretic parameter there is a decrease in the skin friction coefficient, Nusselt number and an increase in the Sherwood number.
- As the suction parameter increases, skin friction coefficient, Nusselt number and Sherwood number increase while the velocity, temperature and concentration decrease.

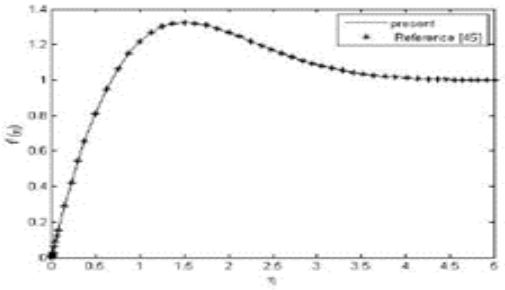


Fig. 2 Comparison of velocity distribution

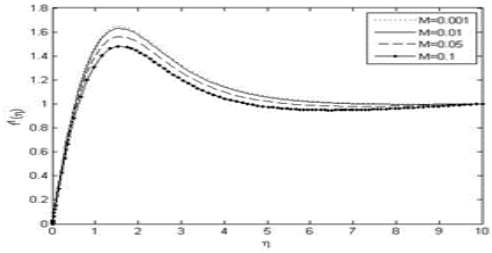


Fig. 3 Velocity profiles for different values of *M*

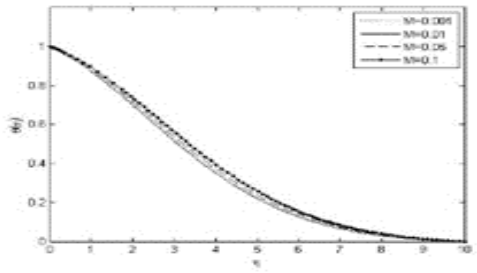


Fig. 4 Temperature profiles for different values of *M*

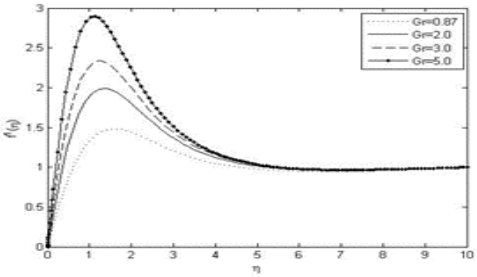


Fig. 5 Velocity profiles for different values of *Gr*

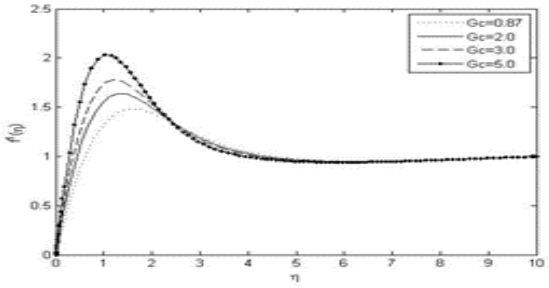


Fig. 6 Velocity profiles for different values of *Gc*

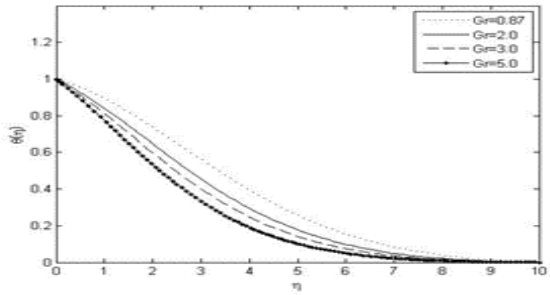


Fig.7 Temperature profiles for different values of *Gr*

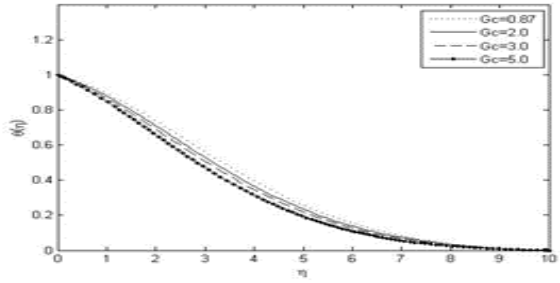


Fig. 8 Temperature profiles for different values *Gc*

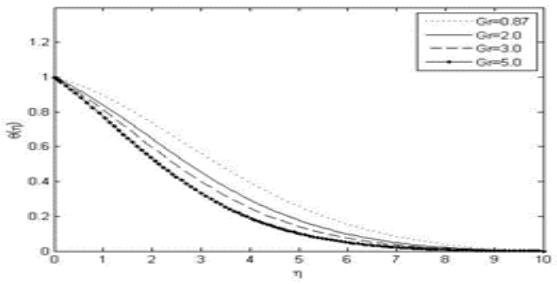


Fig. 9 Concentration profiles for different values of *Gr*

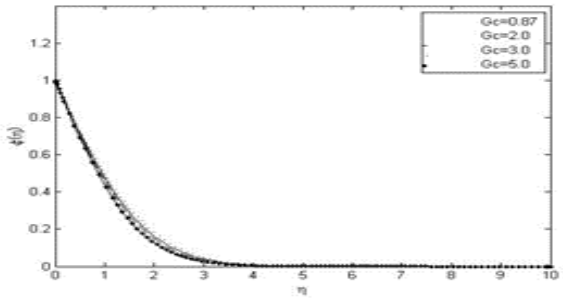


Fig. 10 Concentration profiles for different values of *Gc*

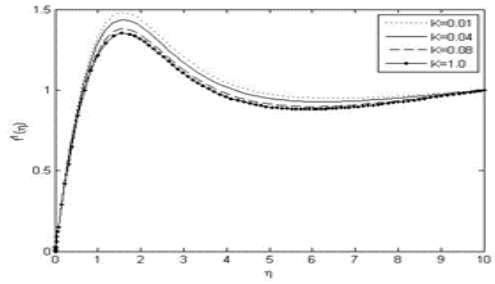


Fig. 11 Velocity profiles for different values of *K*

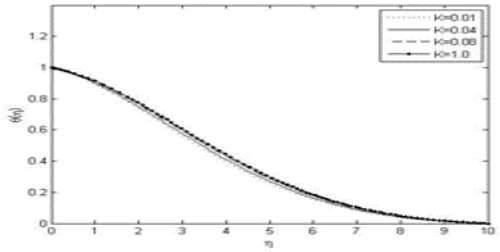


Fig. 12 Temperature profiles for different values of *K*

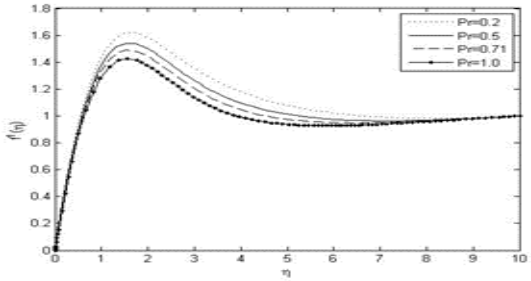


Fig. 13 Velocity profiles for different values of *Pr*

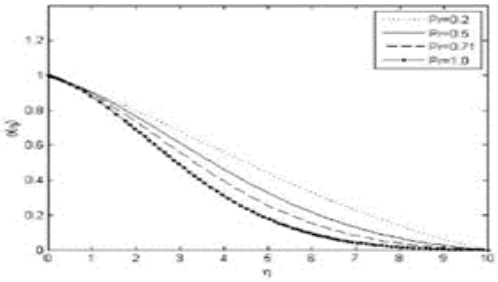


Fig.14 Temperature profiles for different values of *Pr*

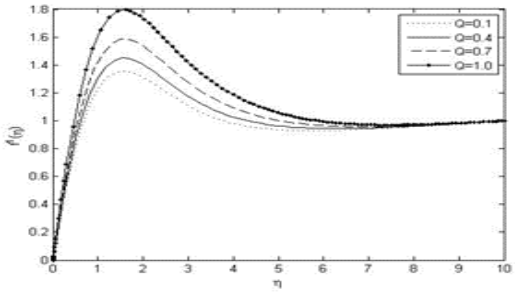


Fig. 15 Velocity profiles for different values of *Q*

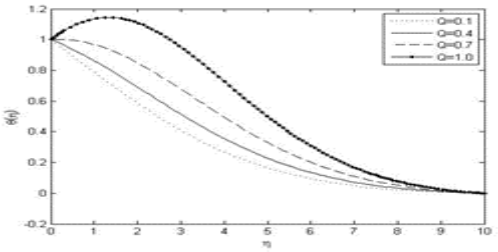


Fig. 16 Temperature profiles for different values of *Q*

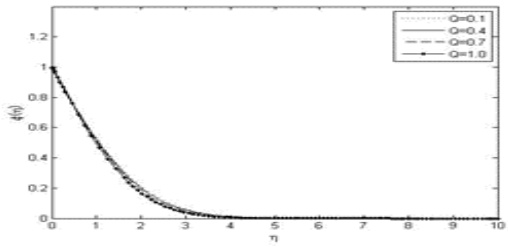


Fig. 17 Concentration profiles for different values of *Q*

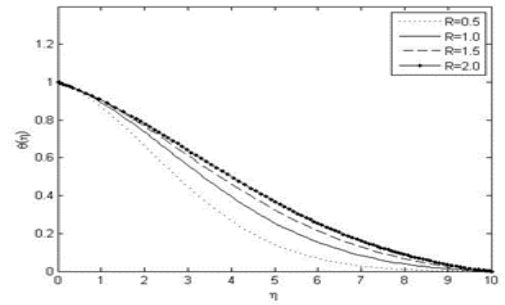


Fig. 18 Velocity profiles for different values of *R*

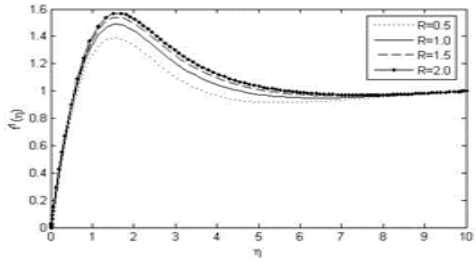


Fig. 19 Temperature profiles for different values of *R*

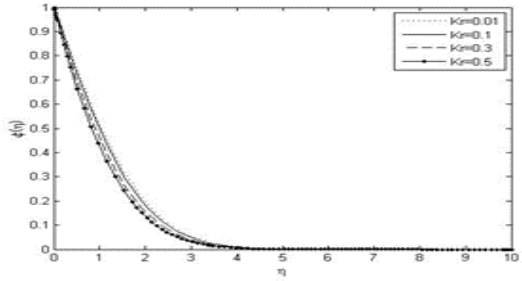


Fig. 20 Concentration profiles for different values of *Kr*

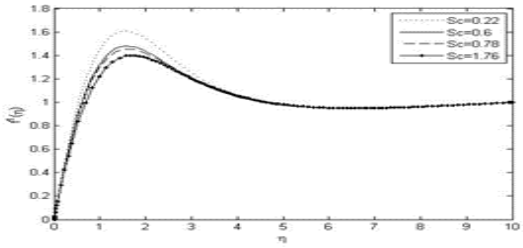


Fig. 21 Velocity profiles for different values of *Sc*

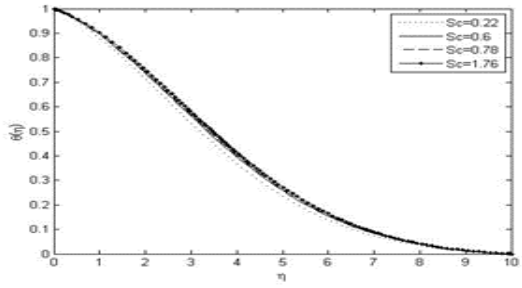


Fig. 22 Temperature profiles for different values of *Sc*

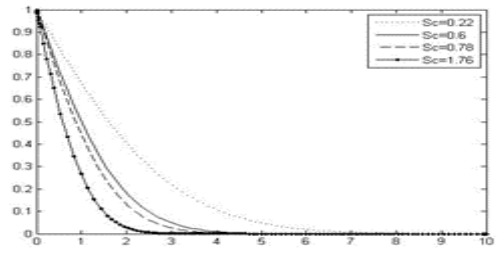


Fig. 23 Concentration profiles for different values of *Sc*

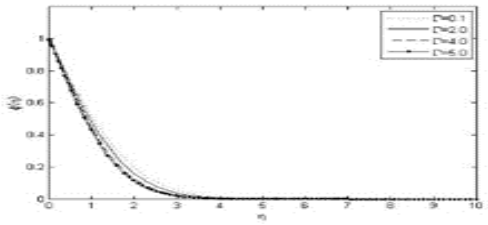


Fig. 24 Concentration profiles for different values of τ

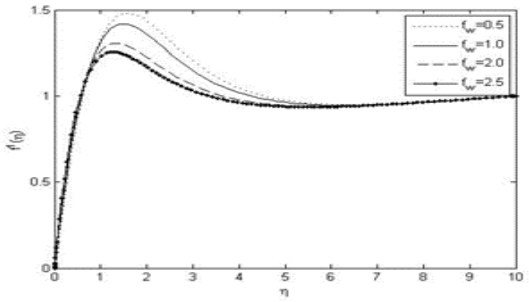


Fig. 25 Velocity profiles for different values of f_w

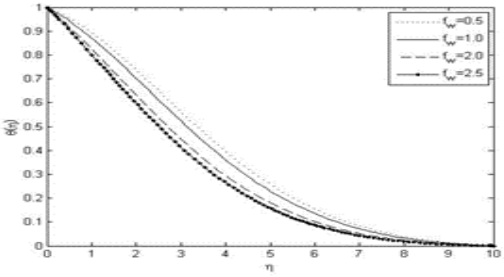


Fig. 26 Temperature profiles for different values of f_w

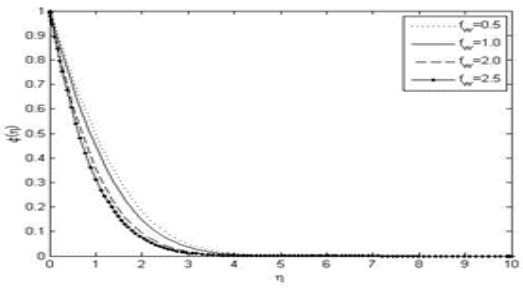


Fig. 27 Concentrations profiles for different values of f_w

Table 1: Numerical values of $f''(0)$, $-\theta'(0)$ and $-\varphi'(0)$ for Pr= 0.71, α=30^0, Q =0.5, R=1.0, f_w = 0.5, Kr=0.1, Sc = 0.6 τ = 0.1

Gc	*Gr*	*M*	*K*	f_w	$f''(0)$	$-\theta'(0)$	$-\varphi'(0)$
0.87	0.87	0.1	0.01	0.5	2.221793	0.074524	0.578133
2.0	0.87	0.1	0.01	0.5	2.899177	0.091296	0.605090
3.0	0.87	0.1	0.01	0.5	3.460697	0.103610	0.625349
5.0	0.87	0.1	0.01	0.5	4.508549	0.123744	0.659311
0.87	0.87	0.1	0.01	0.5	2.221793	0.074524	0.578133
0.87	2.0	0.1	0.01	0.5	3.356764	0.128842	0.639806
0.87	3.0	0.1	0.01	0.5	4.234310	0.159216	0.678375
0.87	5.0	0.1	0.01	0.5	5.801055	0.200977	0.735831
0.87	0.87	0.001	0.01	0.5	2.427690	0.097084	0.595850
0.87	0.87	0.01	0.01	0.5	2.407343	0.095025	0.594164

0.87	0.87	0.05	0.01	0.5	2.320923	0.085889	0.586849
0.87	0.87	0.1	0.01	0.5	2.221793	0.074524	0.578133
0.87	0.87	0.1	0.04	0.5	2.166794	0.067758	0.573137
0.87	0.87	0.1	0.08	0.5	2.098349	0.058820	0.566752
0.87	0.87	0.1	0.01	0.5	2.221793	0.074524	0.578133
0.87	0.87	0.1	0.01	1.0	2.402005	0.099446	0.678866
0.87	0.87	0.1	0.01	2.0	2.742168	0.153422	0.900122
0.87	0.87	0.1	0.01	2.5	2.903299	0.182384	1.019239

Table 2: Numerical values of $f''(0)$, $-\theta'(0)$ and $-\varphi'(0)$ for for $Gr = Gc = 0.87$, $M = 0.1$, $K = 0.01$, $\alpha = 30^0$, $f_w = 0.5$, $Kr = 0.1$, $Sc = 0.6$ $\tau = 0.1$.

Pr	*Q*	*R*	$f''(0)$	$-\theta'(0)$	$-\varphi'(0)$
0.2	0.5	1.0	2.347548	0.084355	0.546870
0.5	0.5	1.0	2.283498	0.075632	0.538743
0.71	0.5	1.0	2.236659	0.075288	0.533045
1.0	0.5	1.0	2.179124	0.077419	0.526031
0.71	0.1	1.0	2.088310	0.208997	0.524009
0.71	0.4	1.0	2.192459	0.113759	0.530353
0.71	0.7	1.0	2.345613	0.016754	0.539547
0.71	1.0	1.0	2.585153	0.214642	0.552725
0.71	0.5	0.5	2.147838	0.079146	0.522170
0.71	0.5	1.0	2.236659	0.075288	0.533045
0.71	0.5	1.5	2.281870	0.075569	0.538544
0.71	0.5	2.0	2.307403	0.077189	0.541692

Table 3: Numerical values of $f''(0)$, $\theta'(0)$ and $-\varphi'(0)$ for $Gr = Gc = 0.87$, $M = 0.1$, $K = 0.01$, $\alpha = 30^0$, $Pr = 0.71$, $Q = 0.5$, $R = 1.0$, $f_w = 0.5$

Kr	*Sc*	τ	$f''(0)$	$-\theta'(0)$	$-\varphi'(0)$
0.01	0.6	0.1	2.236659	0.075288	0.533045
0.1	0.6	0.1	2.221793	0.074524	0.578133
0.3	0.6	0.1	2.193005	0.073073	0.670121
0.5	0.6	0.1	2.168782	0.071884	0.753061
0.1	0.22	0.1	2.391037	0.088190	0.349239
0.1	0.6	0.1	2.221793	0.074524	0.578133
0.1	0.78	0.1	2.179728	0.071962	0.661986
0.1	1.76	0.1	2.056207	0.066037	1.030045
0.1	0.6	0.1	2.236659	0.075288	0.533045
0.1	0.6	2.0	2.208092	0.073471	0.572966
0.1	0.6	4.0	2.180499	0.071851	0.618500
0.1	0.6	5.0	2.167510	0.071144	0.642471

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THE MANGOLDT GRAPHS AND ITS PERFECT CODES

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Abstract: The mangolgt Graph M_n is defined as the graph whose vertices are the elements of the set, two vertices x ,y are adjacent if and only if $\Lambda(x,y) \neq 0$. Where $\Lambda(n) = \begin{cases} \log p & , if\ n = p^m, for\ some\ prime\ p\ and\ some\ m \geq 1 \\ 0 & otherwise \end{cases}$ next part of this is focused on the perfect codes of Mangoldt graph. To obtain the perfect codes the distance between the vertices of the mangoldt graph is determined. Perfect codes are found by its definition.

Keywords: Mangoldt Function, Mangoldt Graph, Perfect codes and e-Perfect codes.

I. INTRODUCTION

In a graph G the entire vertex set V trivially covers every edge of G in the sense that every edge of G is incident with some vertex of V [Ref.1]. In practical problems one may be interested in a subset of V with minimum cordinality which covers every edge of G. In the same way a subset of the edge E of G with minimum cordinality which covers every vertex of G plays a crucial roll. These considerations lead to the concepts of vertex cover, vertex covering number, edge cover, edge covering number and other domination parameters of a graph[Ref..3], which constitute the domination theory of graphs[Ref.4]. Domination theory of graphs has many applications in Engineering and Communication Networks[Ref.2]. For these applications, the arithmetic graphs associated with certain number theoretic arithmetic functions like the Euler totient function Φ(n), the divison function d(n), the quadratic residue function and the Mangoldt function Λ(n), n ≥ 1, an integer come handy. These arithmetic graphs have been studied in detail by Madhavi (2003). © CNCS, Mekelle University ISSN:2220-184X ,Madhavi, L and Maheswari,B(MEJS) Volume 3 (1):37-51, 2011 Maheswari and Madhavi (2008) have studied the basic properties and vertex cover of the Mangoldt graph associated with Mangoldt function Λ(n)[Ref.5,6]. This paper is devoted for the study of edge domination of a Mangoldt graph.

Originally, perfect code was always associated with coding theory, specifically in error correcting codes [Ref.8]. This topic is then extended in other fields, including graph theory. In 1973, Biggs [Ref.9] started the idea by studying the perfect codes of distance-transitive graphs. Later in 1986, Kratochvil [Ref.10] introduced a variant of perfect codes in graphs, which is the t-perfect code[Ref.11]. The study was done on complete bipartite graph and products of graphs, where the independent sets of the graphs are considered to determine the t-perfect codes.

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Perfect Codes In Quadratic Residue Cayley Graphs G(Zn,Q)

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ABSTRACT
In this paper the concept of perfect codes to Quadratic Residue Cayley graph modulo an odd prime p. is introduced. Let p be an odd prime & let S be the set of quadratic residue modulo p. Consider the set S^* ={ s, p-s/s ∈ S}. Then S^* is a symmetric subset of an additive abelian group of $(Z_P,\oplus)$, of integers 0,1,2,..., P-1. The cayley graph of the group $(Z_P,\oplus)$ is associated with the symmetric subset S^* of Z_P is called quadratic residue Cayley graph. Associated with odd prime P and it is denoted by G(Zp,Q), where the vertex set $V=Z_p$={ 0,1,2,....p-1} and edge set $E = \{(x,y)/x,y \in V, x-y \in S^* \text{ or } y-x \in S^*\}$. To obtain perfect codes the between the vertices of the cayley residue of the graph $G(Z_p,Q)$ is determined, then the perfect codes are found by using quadratic residue Cayley Graph, Also we show that these perfect codes are not unique for this graph.
Keywords: - *Cayley Graph, Quadratic residue Cayley Graph, Symmetric set, Perfect code.*

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I. Introduction

Unitary Cayley graphs, generator Cayley graphs and their cycle structure were studied by Dejter [3], Berrizbeite, Giudici [1,2]. Significant contributions are made to this class of graphs in recent times. For complete graphs also this problem has been studied. In this paper we have made an attempt to study this aspect for the Cayley graphs associated with quadratic residue modulo an odd prime p. Domination theory of graphs is an important branch of Graph Theory and has many applications in Engineering, Communication Networks and many others. Allan and Laskar (1978); Allan et al. (1984); Cockayne and Hedetniemi (1977); Haynes et al. (1998) have studied various domination parameters of graphs. Graphs associated with certain arithmetical functions which are usually called arithmetical graphs have been studied extensively by many researchers. Here we consider quadratic residue Cayley graph G(Zp, Q).

Originally, perfect code was always associated with coding theory, specifically in error correcting codes [6]. This topic is then extended in other fields, including graph theory. In 1973, Biggs [7] started the idea by studying the perfect codes of distance-transitive graphs. Later in 1986, Kratochvil [8] introduced a variant of perfect codes in graphs, which is the t-perfect code. The study was done on complete bipartite graph and products of graphs, where the independent sets of the graphs are considered to determine the t-perfect codes.

II.Preliminaries

Definition 1.1

Let p be an odd prime and n a positive integer such that $n \equiv 0 \pmod p$. If the quadratic congruence, $x^2 \equiv n \pmod p$ has a solution, then n is called a quadratic residue mod p and it is written as nRp.

Let p be an odd prime and let S be the set of quadratic residues modulo p. Consider the set $S^* = \{s, p - s/s \in S\}$. Then S^* is a symmetric subset of the additive abelian group (Zp, ⊕) of integers 0, 1, 2, . . . , p − 1 modulo p.

Definition 1.2.

The Cayley graph of the group (Zp,(+)) associated with the symmetric subset S^* of Zp is called the quadratic residue Cayley graph associated with odd prime P and it is denoted by G (Z_p,Q). Where the vertex set $V=Z_p$={ 0,1,2,....p-1} and edge set $E = \{(x,y)/x,y \in V, x-y \in S^* \text{ or } y-x \in S^*\}$.

Definition 1.3

Let p be an odd prime, S, the set of quadratic residues modulo p and let $S^* = \{s, p - s / s \in S, s \neq p\}$. The quadratic residue Cayley graph G(Zp, Q) is defined as the graph whose vertex set is Zp = {0, 1, 2,..., (p − 1)} and the edge set E = {(x, y) / x − y or y − x is in S^*}.

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Binary Cyclic Codes in Circular Cliques

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Abstract: ***In this paper, we study the relationship between circular cliques and binary cyclic codes. We introduced the concept of binary cyclic codes in circular cliques. Every circular clique $K_{k/d}$ clearly admits a (k,d)- vertices. We observed that a circular clique $K_{k/d}$ with gcd(k, d) = 1 if $d \leq |i-j| \leq k-d$ are Prime circular cliques.***

Keywords: ***Clique number, Circular clique, adjacency matrix, cyclic codes, generator polynomial, generator matrix.***

I. INTRODUCTION

Circular Cliques form a natural superclass of perfect graphs, introduced by Zhu[4] almost 20 years ago. Various papers have been written on the theory of circular cliques. Also graphs with circular adjacency matrices is discussed .

Graph coloring theory has a central position in discrete mathematics - for its own interest as well as for the large variety of applications, dating back to the famous four-color problem stated by Guthrie in 1852 Zhu[4] .

Circular cliques have important applications to the theory of designs and error correcting codes.

As generalization of circular cliques, Zhu [4] introduced the class of circular cliques based on a more general coloring concept introduced by Vince [10]. This variation of colorings is based on the observation that odd holes C_{2k+}satisfy $\omega(C_{2k+1}) = 2$ and $\chi(C_{2k+1}) = 3$, whereas their chromatic number should be intuitively about 2, as only one vertex needs to receive the third color. Vince aimed at refining the usual coloring concept taking this intuition into account. He defined the star chromatic number $\chi*(G)$ of a graph in such a way that indeed $\chi*(C_{2k+}) = 2+\frac{1}{k}$ is satisfied for each odd hole, whereas $\chi*(K_k) = k$ still holds for every complete graph on k vertices.

The combinatorial concept being dual to colorings corresponds to cliques in a graph[8]. In a set of k pairwise adjacent vertices, called clique K_k, all k vertices have to be colored differently. Thus the size of a largest clique in G, the **clique number** $\omega(G)$, is a trivial lower bound on $\chi(G)$. This bound can be arbitrarily bad and is in general hard to evaluate as well. From the definition, we immediately obtain $\chi c(G) \leq \chi(G)$ because a usual k-coloring of G is (k,1)-circular coloring.

Numerous works have been devoted to the circular-chromatic number and we refer to the two surveys by X. Zhu for a detailed overview [2].

In view of the max-min relation between clique and chromatic number and to obtain a lower bound on $\chi c(G)$, Bondy and Hell [1] generalized cliques as follows. Let $K_{k/d}$ with $k \geq 2d$ denote the graph with the k vertices 0, . . . , k−1 and edges i j if and only if $d \leq |i-j| \leq k-d$. Such graphs $K_{k/d}$ are called circular cliques (note that they are also known as antiwebs in the literature, see [1]). A circular clique $K_{k/d}$ with gcd(k, d) = 1 is said to be prime. Prime circular cliques include all cliques $K_k = K_{k/1}$ as well as all odd antiholes $C_{2k+1} = K_{2k+1/2}$ and all odd holes $C_{2k+1} = K_{2k+1/k}$, see Figure 1.1.

II. PRELIMINARIES

Definition 2.1: A graph G is a pair G = (V,E) consisting of a finite set V and a set E of 2-element subsets of V. The elements of V are called vertices and the elements of E are called edges. Two vertices u and v of G are said to E.∈be adjacent if there is an edge e = (u,v) Two edges are said to be adjacent if they have a common vertex.

Definition 2.2: An undirected graphs do not show the direction which must be taken between nodes. Instead, travel between nodes is allowed along an edge in either direction. There are no loops or multiple edges in undirected graphs.

Definition 2.3: Circular clique is the graph with vertex set and edges between elements at distance. It is denoted by $K_{k/d}$,

Definition 2.4: Adjacency Matrix: The adjacency matrix of a directed graph X is the matrix (X) with rows and columns indexed by vertices of X. Each entry ij is equal to the number of times the arc (i, j) appears in X.

The adjacency matrix of a circulant graph has a pleasing nature : each row is the cyclic shift of the preceding row. If (a_1, a_2, ... a_n) is the first row, then (a_n, a_1, ... a_{n-1}) is the second row (a_{n-1}, a_n, ... a_{n-2}) is the third row and finally (a_2, a_3 , ..., a_1) is the nth row.

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PAIRS (54963, 52974), (6543, 2187) & (3285, 5274) WITH ALS' ROUTINE

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***Abstract*:** This paper introduces ALS Routine, a mathematical procedure inspired by Kaprekar's constant 6174. Kaprekar's routine, named after Indian Mathematician D. R. Kaprekar, involves iteratively applying a set of rules to any four-digit number, ultimately converging to 6174. ALS' Routine extends this concept to five-digit numbers, employing a unique approach of rearranging digits in descending and ascending order and swapping specific positions. Through this process, distinct pairs of numbers are identified, including the A-pair (54963, 52974) for five-digit numbers and the L-pair (6543, 2187) and S-pair (3285, 5274) for four-digit numbers, which repeat consistently in subsequent iterations.

Keywords: Kaprekar's constant, Kaprekar's Routine, Madhan's Routine, ALS' Routine, Happy number, digit sum.

I. INTRODUCTION:

The quest for repetitive patterns within seemingly random sequences has long captivated mathematicians. One such example is Kaprekar's constant (6174). This number holds a remarkable property: when a specific procedure is applied to any four-digit number (excluding all digits being the same), the process inevitably converges to 6174 within a limited number of steps. This procedure, known as Kaprekar's routine, involves rearranging digits and performing a specific subtraction.Another example is Madhan's Routine, introduced by A. Sudhakaraiah and A. Madhankumar in 2022 [3]. When a specific procedure is applied to any positive multi-digit number, the process inevitably converges to 2 within a limited number of steps. This simple yet captivating procedure involves any multi-digit number. Repeatedly, you subtract the sum of its digits, reverse the result, add it back, and then divide by 9.

This paper builds upon this intriguing concept by introducing ALS' Routine. Taking inspiration from Kaprekar's constant, ALS' Routine ventures beyond four digits, delving into the behavior of five-digit numbers. It employs a novel approach that involves manipulating digits through a unique combination of rearrangement and strategic swapping. Unlike Kaprekar's singular fixed point, ALS' Routine identifies distinct pairs of numbers for both five-digit (A-pair) and specific four-digit scenarios (L-pair and S-pair). These pairs exhibit a fascinating characteristic: they consistently reappear within subsequent iterations of the ALS Routine.

This exploration aims to unlock the secrets behind these newly identified number pairs. By analyzing the behavior of these pairs and the underlying mechanisms of ALS' Routine, the paper seeks to contribute to the understanding of iterative processes and potentially uncover hidden mathematical relationships that govern these fascinating number sequences.

II. PRELIMINARIES:

Iterative processes reveal surprising regularities, like Kaprekar's constant (6174). This four-digit number, when manipulated by rearranging digits and subtracting, converges to 6174.Another captivating iterative process is Madhan's Routine, introduced in 2022. This routine delves into the world of multi-digit numbers (excluding single digits). Madhan's Routine exhibits a remarkable property as well: when a specific procedure is applied to any positive multi-digit number, the process inevitably converges to 2 within a limited number of steps. This simple yet captivating procedure involves repeatedly subtracting the sum of its digits, reversing the result, adding it back, and then dividing by 9. Inspired by this, ALS' Routine explores five-digit numbers. It reveals distinct number pairs (A-pairs, L & S-pairs) that resurface repeatedly within the routine. Our goal is to understand these pairs and the underlying mechanisms of the ALS Routine, seeking hidden mathematical relationships in these fascinating sequences.

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Feasibility of integrated numerical and Adaptive Neuro-Fuzzy Inference System models in predicting the thermophysical properties of unsteady coupled micropolar–Casson hybrid nanofluids

Abbai Reddy Divya[1], Thandra Jithendra[1] and Esambattu Hemalatha[2]

Abstract

This article aims to probe postulated phenomena using a paired micropolar and Casson hybrid fluid over a rotating disk. The intension to design a numerical technique (Runge–Kutta fourth-order along with shooting technique) integrated Adaptive Neuro-Fuzzy Inference System (ANFIS) envisioned with a thermal and exponentially space-dependent heat source, nonlinear thermal radiation and entropy production is developed in this phase of work. To ensure that, a nonlinear partial differential equation set of equations has been transformed into an ordinary differential equation by using the proper self-similarity variables. The model's research results, with a few notable outliers, are mostly consistent with those from prior research that was merged into the dataset used to train the ANFIS model. With the impact of active factors, the results are esthetically exhibited for numerous profiles. This displays that with the rise in magnetic field and radiation, the velocity and temperature profiles increase sharply, resulting in a contradiction phenomenon with the decreasing electric field inputs. Also, tilting of vortex viscosity, spin gradient viscosity and microinertia density on the various microrotation components displays inclination. Moreover, ANFIS training was exploited to analyze the approximate solutions for specific scenarios, and the developed ANFIS was evaluated against a testing dataset to emphasize its performance. Due to their longer render, the nanoparticles exploited here are deemed suitable for use in bone implants, iodinated agents for blood imaging and red blood cell stimulation. Thus, the results of this study may be applied to therapeutic anemia therapies.

Keywords

EMHD, thermal and exponential space dependent heat source, ANFIS, micropolar and Casson hybrid fluids, entropy generation

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Introduction

In the core, nanofluid is superior to normal fluid for increased heat transfer. Initiation of that hybrid nanofluid makes it even better. Only a fluid with two different nanoparticles may be deemed as hybrid nanofluid. As of today, it has been discovered that hybrid nanofluids have more heat transfer capabilities than regular nanofluids or any other usable fluids.[1] Hybrid nanofluids are implemented in a variety of industries for greater performance in terms of heat conductivity than regular nanofluids, including electronic cooling types of equipment, vehicle heat management, welding, power frameworks, grease, hydroelectric creation, papers and biomedicine creation, in the atomic segment, rocket gadget making and a host of others. Theoretically growing the thermophysical characteristics of hybrid nanofluids to mathematically build a boundary layer stream of 3D-turning hybrid nanofluid across an expanding sheet with radiation, heat production and chemical reaction effects, is established by avant-grade Hayat and Nadeem.[2] Basit et al.[3] tackled the exploration of a mixture nanoliquid spilling through the focal point of two equal disks by considering viscous dissipation and heat radiation. Li et al.[4] examined the peculiarity of hybrid nanofluid by using the effect of viscous dissipation and buoyancy. Sharma et al.[5] concentrated on the upgrade of nuclear power move in hybrid nanofluid stream prompted by a rotating Riga disk within the

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sight of warm radiation and chemical reaction. Moreover, several notable studies on the use of nanofluids in various geometries for flow analysis are included in Refs.[6–11]

While aimed at microscale devices, the classical Newtonian fluids model's mass, heat and momentum transfer methods can be recognizably not quite the same as those used to larger-scale machinery. Since, the three primary fields of microscale research are atherogenesis, molecular mechanisms and microfluidics. Also, material traits of such a model evolve constantly and exhibit translational velocity. The Navier–Stokes model aides the flow of fluid at length scales larger than a micrometer. So, the Navier–Stokes model is inadequate to fully convey the microlevel rotating impact of fluid particles.[12] Micropolar fluid, which is a dispersion of haphazardly oriented particles in a viscous medium and has a microstructure model, is one of aforementioned microlevel fluids. As per this liquid, the particles in little volume components can pivot about the centroid of the volume component. The law of conservation of mass, momentum and constitutive relationships, which demonstrate spin inertia, micromotion and couple stress, effectively depicts the motion of the micropolar fluid. This model portrays the flow of liquid crystals, dumb-bell molecules or short rigid cylindrical elements, flow in microchannels and capillaries, shear turbulent flows, porous media, polymer fluids, Ferrofluid, lubricants, fluid suspensions and animal blood.[13] Micropolar liquid elements may likewise be utilized to mimic the presence of residue or smoke in a particular gas.[14] The idea of micropolar fluid has drawn in a ton of interest in the engineering community over the past few decades due to its wide range of applications. The hypothesis of micropolar fluids, which tends with the effects of microrotation on microstructures, actually originated by Eringen.[15] Raja et al.[16] explored the flow of a spinning disk model by employing a magneto hydro dynamics micropolar nanofluid flow and the partial slip condition. Rauf et al.[17] delved at the steady-state flow of a micropolar nanofluid between two porous disks. Hussain and Xu[18] exhibited the electrically conducting squeezing flow of micropolar fluid that is obliged across two disks.

Machine learning techniques have been pivotal in resolving real-world problems and challenges that are nonlinear or complex for decades. These techniques possess an extensive array of applications, which include medical diagnosis,[19,20] manufacturing[21] and environmental modeling.[22] In recent years, numerous machine learning and deep learning techniques, including artificial neural networks (ANNs), fuzzy logic, Adaptive Neuro-Fuzzy Inference System (ANFIS) and many, have been implemented to model nonlinear problems in fluid mechanics and thermodynamics. For instance, Ullah et al.[23] analyzed the application of ANNs to simulate the impact of electric and magnetic fields involving a pair of parallel plates through the motion of a micropolar fluid. In a similar vein, Shoaib et al.[24] investigated the movement of an MHD micropolar nanofluid model by simulating the discrepancies of velocity slip variables, magnetic field variables, material factors, Brownian motion variables, thermophoresis variables and Lewis number. Rashidi et al.[25] optimized entropy generation in unsteady MHD flow over a rotating disk by integrating ANN with particle swarm optimization (PSO). Alzahrani et al.[26] utilized ANN to forecast the generation of entropy and the Bejan number in the context of Darcy–Forchheimer flow of Ree–Eyring nanofluid caused by double-rotating disks.

According to the aforementioned studies, thinking that there is scope to investigate the behavior of coupled micropolar and Casson fluid flows with the assist of entropy generation has taken account. Since, no studies have been addressed and which is acknowledged as one of the most effective fluid models for correctly predicting blood events. This is how the draft is set up:

- The inaugural section includes a compilation of literature.
- The mathematical modeling and dimensionless analysis are summarized underneath in the next section;
  - An innovative mathematical model emerges using a hybrid nanofluid constituted by tantalum and cobalt nanoparticles with blood serving as the core fluid.
  - Combined effects of porous medium, thermal and exponential space dependent heat source, joule heating, viscous dissipation, electromagnetohydrodynamic (EMHD) and nonlinear thermal radiation are examined.
  - Primarily an ordinary differential system is constructed from the nonlinear PDE system of equations by employing the proper self-similarity variables.
  - Entropy generation and the Bejan algorithm are also executed concurrently.
- In the third section, methodology is dealt with and a solution is delivered.
  - The Runge–Kutta fourth order with shooting tackle is implemented to figure out the governing flow outputs, regarding this mathematical model.
  - Then an ANFIS technique is laid out with the intent of comparison and prediction.
- The justification of the results is covered in the fourth section, where the relevant graphs and tables are originated for various factors.
- The final assessments are laid out in the last section.

Formulation of the problem

Time-dependent incompressible EMHD conducting flow across a rotating disk is explored. The rotation and stretching of the disk causes non-Newtonian fluids like Casson and micropolar hybrid nanofluid to move about in porous media. The microrotation components is designated as N_1,N_2 and N_3, respectively, since the velocity components is symbolized as u, v and w in the cylindrical coordinate system (r, φ, z). Also, the disk is placed at

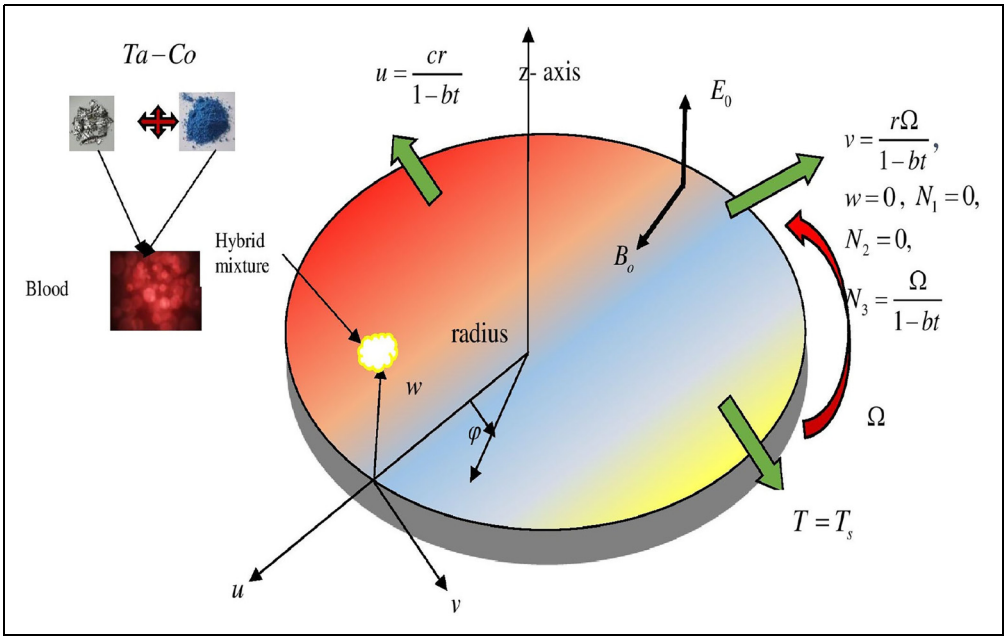


Figure 1. The model's schematic design.

$z = 0$, and rotates with angular velocity Ω which is represented in Figure 1. A time dependent magnetic field $B(t) = \frac{B_0}{(1-bt)^{\frac{1}{2}}}$ is applied in the z-direction where B_0 is termed as uniform magnetic field. The stretching velocity u, of disk which is taken to be $u = \frac{cr}{(1-bt)}$, where c is the stretching rate and b *is* a constant. The disk rotating velocity v is assumed to be $v = \frac{r\Omega}{(1-bt)}$, where Ω is the disk rotating rate. The temperature of the stretchable rotating disk surface T_s is defined by $T_s = T_0 - T_{ref}\frac{r^2\Omega}{\upsilon(1-bt)^{\frac{3}{2}}}$, where T_0 is the temperature at the origin and T_{ref} is the constant reference temperature.

For an incompressible Casson fluid model, the rheological equation is as follows:[27]

$$\tau_{ij} = \begin{cases} 2\left(\mu_B + \frac{p_y}{\sqrt{2\pi}}\right)e_{ij}, & \pi > \pi_c \\ 2\left(\mu_B + \frac{p_y}{\sqrt{2\pi_c}}\right)e_{ij}, & \pi < \pi_c \end{cases} \quad (1)$$

where these ideograms like μ_B, P_y, τ_{ij}, π_c, e_{ij}, $\pi = e_{ij}e_{ij}$ are tagged as termed as plastic dynamic viscosity, yield stress tensor, stress tensor of particularly non-Newtonian fluid, critical value, rate of the strain tensor and signifies product of the component of deformation rate with itself respectively. Mainly, for one of the non-Newtonian models, considered $\alpha = \mu_B\sqrt{2\pi_c}\,/\,P_y$ as Casson parameter.

The generic forms of the conservation law for mass, momentum, micropolar and energy equations by utilizing the above pre-assumptions are sketched below:[14,28]

$$\frac{\partial w}{\partial z} + \frac{1}{r}\frac{\partial}{\partial r}(ur) = 0 \quad (2)$$

$$\left(\frac{\partial u}{\partial t} - \frac{v^2}{r} + w\frac{\partial u}{\partial z} + u\frac{\partial u}{\partial r}\right) = \left(\frac{\mu_{hnf}\left(1+\frac{1}{\alpha}\right)+k}{\rho_{hnf}}\right)\left(\frac{\partial^2 u}{\partial z^2}\right) + \frac{\sigma_{hnf}B_0}{\rho_{hnf}(1-bt)}(E_0 - B_0 u) - \left(\frac{k}{\rho_{hnf}}\right)\frac{\partial N_2}{\partial z} - \frac{\upsilon_{hnf}}{k^*}u \quad (3)$$

$$\left(\frac{\partial v}{\partial t} + \frac{uv}{r} + w\frac{\partial v}{\partial z} + u\frac{\partial v}{\partial r}\right) = \left(\frac{\mu_{hnf}\left(1+\frac{1}{\alpha}\right)+k}{\rho_{hnf}}\right)\left(\frac{\partial^2 v}{\partial z^2}\right) + \frac{\sigma_{hnf}B_0}{\rho_{hnf}(1-bt)}(E_0 - B_0 v) + \left(\frac{k}{\rho_{hnf}}\right)\left(\frac{\partial N_1}{\partial z} - \frac{\partial N_3}{\partial r}\right) - \frac{\upsilon_{hnf}}{k^*}v \quad (4)$$

$$\left(\frac{\partial w}{\partial t} + w\frac{\partial w}{\partial z} + u\frac{\partial w}{\partial r}\right) = \left(\frac{\mu_{hnf}\left(1+\frac{1}{\alpha}\right)+k}{\rho_{hnf}}\right)\left(\frac{\partial^2 w}{\partial z^2}\right) + \left(\frac{k}{\rho_{hnf}}\right)\frac{\partial}{r\,\partial r}\left(\frac{\partial N_2}{\partial r}\right) \quad (5)$$

$$\left(\frac{\partial N_1}{\partial t}-\frac{v}{r}N_2+w\frac{\partial N_1}{\partial z}+u\frac{\partial N_1}{\partial r}\right)=\left(\frac{\gamma_1}{\rho_{hnf}\,j}\right)\left(\frac{\partial^2 N_1}{\partial z^2}\right)-\left(\frac{k}{\rho_{hnf}\,j}\right)\left(\frac{\partial v}{\partial z}\right)-2\left(\frac{k}{\rho_{hnf}\,j}\right)N_1 \tag{6}$$

$$\left(\frac{\partial N_2}{\partial t}+\frac{v}{r}N_1+w\frac{\partial N_2}{\partial z}+u\frac{\partial N_2}{\partial r}\right)=\left(\frac{\gamma_1}{\rho_{hnf}\,j}\right)\left(\frac{\partial^2 N_2}{\partial z^2}\right)+\left(\frac{k}{\rho_{hnf}\,j}\right)\left(\frac{\partial u}{\partial z}\right)-2\left(\frac{k}{\rho_{hnf}\,j}\right)N_2-\left(\frac{k}{\rho_{hnf}\,j}\right)\frac{\partial w}{\partial r} \tag{7}$$

$$\left(\frac{\partial N_3}{\partial t}+w\frac{\partial N_3}{\partial z}+u\frac{\partial N_3}{\partial r}\right)=\left(\frac{\gamma_1}{\rho_{hnf}\,j}\right)\left(\frac{\partial^2 N_3}{\partial z^2}\right)-\left(\frac{k}{\rho_{hnf}\,j}\right)\left(\frac{\partial v}{\partial r}+\frac{v}{r}+2N_3\right) \tag{8}$$

$$\begin{aligned}\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial r}+w\frac{\partial T}{\partial z}=\alpha_{hnf}\left(\frac{\partial^2 T}{\partial z^2}\right)&+\frac{\mu_{hnf}}{(\rho c_p)_{hnf}}\left(1+\frac{1}{\alpha}\right)\left[\left(\frac{\partial u}{\partial z}\right)^2+\left(\frac{\partial v}{\partial z}\right)^2\right]\\&-\frac{16}{3}\frac{\sigma^*}{k^*(\rho c_p)_{hnf}}\frac{\partial}{\partial z}(T^3\frac{\partial T}{\partial z})\\&+\frac{Q_T^*}{(\rho c_p)_{hnf}}(T-T_0)\\&+\frac{Q_E^*(T_s-T_0)}{(\rho c_p)_{hnf}}\exp(-n\sqrt{\frac{\Omega}{\upsilon}}z)+\\&\frac{\sigma_{hnf}}{(\rho c_p)_{hnf}(1-bt)}[E_0-B_0(u+v)]^2\end{aligned} \tag{9}$$

Generally, the radiative heat flux can be expressed by using Rosseland approximation as:

$$q_r=-\frac{4\sigma^*}{3k^*}\nabla T^4=-\frac{16\sigma^* T_0^3}{3k^*}\frac{\partial T}{\partial z} \tag{10}$$

where σ^* and k^* are the Stefan Boltzmann and mean absorption coefficients, respectively.

Followed with the boundary conditions as:

$$\begin{aligned}&u=\frac{cr}{1-bt},\ v=\frac{r\Omega}{1-bt},\ w=0,\ N_1=0,\ N_3\\&=\frac{\Omega}{1-bt},\ T=T_s \text{ at } z=0\\&u\to 0,\ v\to 0,\ N_1\to 0,\ N_2\to 0,\ N_3\to 0,\ T\\&\to T_\infty \text{ as } z\to\infty\end{aligned} \tag{11}$$

Table 1 gives some of the instances in which mixture theory and phenomenological criteria can potentially be employed in producing hybrid nanoliquid assets. Basically, that theories contains k_{hnf} as thermal conductivity, ρ_{hnf} termed as density, $(\rho c_p)_{hnf}$ stands for specific heat, σ_{hnf} is electrical conduction and ν_{hnf} is the kinematic viscosity

The following are the similarity transformations:

$$\begin{aligned}u=\frac{r\Omega}{(1-bt)}f'(\eta),\quad v=\frac{r\Omega}{(1-bt)}g(\eta),\\ w=-2\left(\frac{\upsilon\Omega}{(1-bt)}\right)^{\frac{1}{2}}f(\eta),\quad \eta=\sqrt{\frac{\Omega}{\upsilon(1-bt)}}\ z,\end{aligned}$$

$$\begin{aligned}T=T_0-T_{ref}\frac{r^2\Omega}{\upsilon(1-bt)^{\frac{3}{2}}}\theta(\eta),\\ N_1=\frac{r\Omega}{(1-bt)}\sqrt{\frac{\Omega}{\upsilon(1-bt)}}M_1(\eta),\\ N_2=\frac{r\Omega}{(1-bt)}\sqrt{\frac{\Omega}{\upsilon(1-bt)}}M_2(\eta),\\ N_3=\frac{\Omega}{(1-bt)}M_3(\eta).\end{aligned} \tag{12}$$

By employing the self-similarity transformation mentioned in equation (12), the highly coupled nonlinear partial differential equations are reduced into ordinary differential equations which are illustrated as follows:

$$\begin{aligned}&\left(A_1(1+\frac{1}{\alpha})+a_1\right)f'''-SA_3(\frac{\eta}{2}f''\\&+f')+A_3(g^2+2f\,f''-f'^2)\\&+A_2M\,[E_1-f']-a_1M_2'\\&-A_1\beta\,f'=0\end{aligned} \tag{13}$$

$$\begin{aligned}&\left(A_1(1+\frac{1}{\alpha})+a_1\right)g''+2A_3(g'f\\&-f'g)-SA_3(\frac{\eta}{2}g'+g)+A_2M\,[E_1-g]\\&-a_1M_1'\\&-A_1\,\beta\,g=0\end{aligned} \tag{14}$$

$$\begin{aligned}&a_2M_1''-a_3(g'+2M_1)-SA_3(\frac{\eta}{2}M_1'+\frac{3}{2}M_1)\\&-A_3M_1\,f'+A_3gM_2+2A_3fM_1'\\&=0\end{aligned} \tag{15}$$

$$\begin{aligned}&a_2M_2''+a_3(f''-2M_2)-SA_3(\frac{\eta}{2}M_2'+\frac{3}{2}M_2)\\&-A_3M_2\,f'-A_3gM_1+2A_3fM_2'\\&=0\end{aligned} \tag{16}$$

Table 1. Thermophysical properties of hybrid nanofluids.[31]

Properties	Hybrid nanofluid
Mixture Theory	$\rho_{hnf} = \rho_f(1-\phi_2)[(1-\phi_1)+\phi_1(\frac{\rho_1}{\rho_f})]+\phi_2(\rho_2)$
	$(\rho c_p)_{hnf} = (\rho c_p)_f(1-\phi_2)(1-\phi_1)+\phi_1(\rho c_p)_1+\phi_2(\rho c_p)_2$
Phenomenological Laws	$\frac{\sigma_{hnf}}{\sigma_{bf}} = \left(\frac{(1+2\phi_2)\sigma_2+2(1-\phi_2)\sigma_{bf}}{(1-\phi_2)\sigma_2+(2+\phi_2)\sigma_{bf}}\right)$ where, $\frac{\sigma_{bf}}{\sigma_f} = \left(\frac{(1+2\phi_1)\sigma_1+2(1-\phi_1)\sigma_f}{(1-\phi_1)\sigma_1+(2+\phi_1)\sigma_f}\right)$
	$\mu_{hnf} = \frac{\mu_f}{(1-\phi_1)^{2.5}(1-\phi_2)^{2.5}}$
	$\frac{k_{hnf}}{k_{bf}} = \left(\frac{(1+2\phi_2)k_2+2(1-\phi_2)k_{bf}}{(1-\phi_2)k_2+(2+\phi_2)k_{bf}}\right)$ where $\frac{k_{bf}}{k_f} = \left(\frac{(1+2\phi_1)k_1+2(1-\phi_1)k_f}{(1-\phi_1)k_1+(2+\phi_1)k_f}\right)$

$$a_3M_3'' - SA_3\left(\frac{\eta}{2}M_3' + M_3\right) - 2a_3M_3 - 2a_3g + 2A_3fM_3' = 0 \tag{17}$$

$$A_4\theta'' + Rd\left(\frac{4}{3}\right)\left\{\begin{array}{l}\theta'' + (\theta_w-1)^3(3\theta^2\theta'^2+\theta^3\theta'') \\ +3(\theta_w-1)^2(2\theta\theta'^2+\theta^2\theta'') \\ +3(\theta_w-1)(\theta'^2+\theta\theta'')\end{array}\right\} + A_1\,\mathrm{Pr}\,Ec\left(1+\frac{1}{\alpha}\right)(f''^2+g'^2) + A_2\,M\,Ec\,\mathrm{Pr}\,[E_1-(f'+g)]^2 + 2\,\mathrm{Pr}\,A_5(f\theta'-\theta f') - A_5S\,\mathrm{Pr}\left(\frac{3}{2}\theta+\frac{\eta}{2}\theta'\right) + \mathrm{Pr}\,Q_t\theta + \mathrm{Pr}\,Q\,Exp(-n\xi) = 0 \tag{18}$$

With the boundary conditions as:

$$\begin{aligned} &f' = \omega, \quad g = 1, \quad f = 0, \quad M_1 = 0, \quad M_2 = 0, \\ &M_3 = 1, \quad \theta = 1 \quad \text{at} \quad \eta = 0 \\ &f' \to 0, \quad g \to 0, \quad M_1 \to 0, \quad M_2 \to 0, \quad M_3 \to 0, \\ &\theta \to 0 \quad \text{as} \quad \eta \to \infty \end{aligned} \tag{19}$$

The dimensionless parameters are as:

$$S = \frac{b}{\Omega},\ \omega = \frac{c}{\Omega},\ \beta = \frac{v(1-bt)}{k^*\Omega},\ \mathrm{Pr} = \frac{\mu_f(C_p)_f}{k_f},\ Rd = \frac{4\sigma^*T_0^3}{k^*k_f},\ Ec = \frac{r^2\Omega^2}{(1-bt)^2(\Delta T)(C_p)_f},$$

$$a_1 = \frac{k}{\mu_f},\ a_2 = \frac{\gamma_1}{\mu_f j},\ a_3 = \frac{k(1-bt)}{\rho_f j\Omega},\ \theta_w = \frac{T_s}{T_0},\ Q = \frac{Q_E^*(1-bt)}{(\rho c_p)\Omega},\ \xi = z\sqrt{\frac{\Omega}{v}},\ M = \left(\frac{\sigma_f B_0^2}{\rho_f\Omega}\right),$$

$$Q_t = \frac{Q_T^*(1-bt)}{(\rho c_p)\Omega},\ A_1 = \frac{\mu_{hnf}}{\mu_f},\ A_2 = \frac{\sigma_{hnf}}{\sigma_f},\ A_3 = \frac{\rho_{hnf}}{\rho_f},\ A_4 = \frac{k_{hnf}}{k_f},\ A_5 = \frac{(\rho C_p)_{hnf}}{(\rho C_p)_f},$$

$$E_1 = \left(\frac{E_0(1-bt)}{r\Omega B_0}\right).$$

Factors of engineering curiosity

For engineering interest, the significant physical quantities, such as skin friction coefficients C_f and C_g are defined as follows:

$$C_f = \frac{\tau_{w1}(1-bt)^2}{\rho_f(r\Omega)^2} \tag{20}$$

$$C_g = \frac{\tau_{w2}(1-bt)^2}{\rho_f(r\Omega)^2} \tag{21}$$

Here, τ_{w1} denotes the radial stress and it is defined as,

$$\tau_{w1} = \mu_{hnf}\left(1+\frac{1}{\alpha}\right) \times \left(\frac{\partial u}{\partial z}\right)_{z=0} + \left[\mu_{hnf}\left(\frac{\partial u}{\partial z}+\frac{\partial w}{\partial r}\right) + k\left(\frac{\partial u}{\partial z}+N_2\right)\right]_{z=0},$$

Also, the azimuthal shear–stress component is represented as:

$$\tau_{w2} = \mu_{hnf}\left(1+\frac{1}{\alpha}\right) \times \left(\frac{\partial v}{\partial z}\right)_{z=0} + \left[\mu_{hnf}\left(\frac{\partial v}{\partial z}+\frac{1}{r}\frac{\partial w}{\partial r}\right) + k\left(\frac{\partial v}{\partial z}+N_1\right)\right]_{z=0}$$

Invoking the above transformation, dimensionless form of equations assumes the following form:

$$\mathrm{Re}_x^{\frac{1}{2}} C_f = \left[A_1\left(1+\frac{1}{\alpha}\right)+(A_1+a_1)\right] f''(0) + a_1 M_2(0) \tag{22}$$

$$\mathrm{Re}_x^{\frac{1}{2}} C_g = \left[A_1\left(1+\frac{1}{\alpha}\right)+(A_1+a_1)\right] g'(0) + a_1 M_1(0) \tag{23}$$

The physical quantity under discussion is the heat transfer rate, frequently referred to as the Nusselt number.

$$Nu_r = \frac{r q_w}{k_f (T_s - T_0)} \tag{24}$$

where $q_w = (-k_{hnf}(\frac{\partial T}{\partial z})_{z=0}) + (\frac{16\sigma^* T_\infty^3}{3k^* k_f})_{z=0}$, defines the heat flux and the reduced model is as,

$$Nu_x \mathrm{Re}_x^{\frac{-1}{2}} = -\left\{A_4 + \frac{4}{3} Rd[1+(\theta_w-1)\theta(0)]^3\right\}\theta'(0) \tag{25}$$

In these equations $\mathrm{Re}_x = \left(\frac{r^2\Omega}{\upsilon(1-bt)}\right)$, named as local Reynolds number.

The thermophysical characteristics which is considered for this investigation are listed in Table 2.

Exploration of entropy generation

The entropy production rate for a viscoelastic incompressible in the presence of an electric and magnetic field is indicated as follows[32,33]:

$$S'''_{gen} = \frac{k_{hnf}}{T_0^2}\left[\left(\frac{\partial T}{\partial z}\right)^2 + \frac{16\sigma^* T_0^3}{3k^* k_{hnf}}\left(\frac{\partial T}{\partial z}\right)^2\right] + \frac{\mu_{hnf}}{T_0}\left[\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2\right] + \frac{\sigma_{hnf}}{T_0(1-bt)}[E_0 - B_0(u+v)]^2 \tag{26}$$

Generally, this entropy generation consist of three irreversible processes. Namely, thermal, fluid friction and electromagnetic irreversible processes. By using the suitable transformations, the PDEs equations are reduced to ODEs are as follows:

$$N_G = \alpha_1\left\{A_4 + \frac{4}{3} Rd(1+\theta(\theta_w-1))^3\right\}\theta'^2 + A_1 Br\,(f''^2 + g'^2) + A_2 M\, Br\,\{E_1 - (f'+g)\}^2 \tag{27}$$

Here, the dimensionless parameters are given below:

$$N_G = \frac{T_0 S'''_{gen}\,\upsilon(1-bt)}{k_f\,\Omega\,\Delta T}, \quad \Delta T = (T_s - T_0), \quad \alpha_1 = \frac{\Delta T}{T_0}, \quad Br = \frac{\mu_f r^2 \Omega^2}{k_f (T_s - T_0)(1-bt)^2}.$$

In general, the Bejan number can be stated as follows:

$$Be = \frac{\text{Entropy generation due to heat transfer}}{\text{Total entropy generation}}$$

Now,

$$Be = \frac{\alpha_1\left\{A_4 + \frac{4}{3} Rd(1+\theta(\theta_w-1))^3\right\}\theta'^2}{\alpha_1\left\{A_4 + \frac{4}{3} Rd(1+\theta(\theta_w-1))^3\right\}\theta'^2 + A_1 Br\,(f''^2 + g'^2) + A_2 M\, Br\,\{E_1 - (f'+g)\}^2} \tag{28}$$

Table 2. Thermophysical properties of hybrid nanofluid.

Physical properties	Blood	Cobalt (Co)	Tantalum (Ta)
$\rho(kg\,m^{-3})$	3617	8900	16,650
$C_p(J(kg)^{-1}K^{-1})$	1050	445	140
$k(W(m^{-1}K^{-1}))$	0.52	100	57
$\sigma(\Omega m)^{-1}$	1.33	1.7×10^7	7.7×10^6
Pr	21		

Methodology

R–K fourth order method

The dimensionless equations (13)–(18) and equation (19) generate a boundary value issue. As a result, Bejan number equation (28) and entropy generation equation (27) are likewise transformed. The shooting technique is used to solve these equations by converting them into initial value problems. For this, the aforementioned nonlinear ordinary differential equations are changed into

the following set of first-order differential equations:

$$f = \wp_1,\ f' = \wp_2,\ f'' = \wp_3,\ f''' = \wp_3',\ g = \wp_4,\ g' = \wp_5,\ g'' = \wp'_5,\ M_1 = \wp_6,\ M_1' = \wp_7,\ M_1'' = \wp'_7,\ M_2 = \wp_8,\ M_2' = \wp_9,\ M_2'' = \wp'_9,\ M_3 = \wp_{10},\ M_3' = \wp_{11},\ M_3'' = \wp'_{11}, \theta = \wp_{12},\ \theta' = \wp_{13},\ \theta'' = \wp'_{13}.$$

$$\wp_3' = -\frac{\begin{bmatrix} -S(\wp_2 + (\eta/2)\wp_3) + A_3(\wp_4^2 + 2\wp_1\wp_3 - \wp_2^2) \\ -a_1\wp_9 + A_2M(E_1 - \wp_2) - A_1\beta\wp_2 \end{bmatrix}}{(A_1(1+\frac{1}{\alpha}) + a_1)} \tag{29}$$

$$\wp_5' = -\frac{\begin{bmatrix} a_1\wp_7 + A_2M(E_1 - \wp_4) - A_1\beta\wp_6 \\ -A_3S[(\eta/2)\wp_5 + \wp_4] + 2A_3(\wp_1\wp_5 - \wp_2\wp_4) \end{bmatrix}}{(A_1(1+\frac{1}{\alpha}) + a_1)} \tag{30}$$

$$\wp_7' = -\frac{\begin{bmatrix} -a_3(\wp_5 + 2\wp_6) + A_3(\wp_4\wp_8) - A_3S[(\eta/2)\wp_7 \\ +(3/2)\wp_6] - A_3(\wp_2\wp_6) + 2A_3(\wp_1\wp_7) \end{bmatrix}}{a_2} \tag{31}$$

$$\wp_9' = -\frac{\begin{bmatrix} a_3(\wp_3 - 2\wp_8) + 2A_3(\wp_1\wp_9) - A_3S[(\eta/2)\wp_9 \\ +(3/2)\wp_8] - A_3(\wp_4\wp_6) - A_3(\wp_2\wp_8) \end{bmatrix}}{a_2} \tag{32}$$

$$\wp_{11}' = -\frac{\begin{bmatrix} -2a_3(\wp_4) + 2A_3(\wp_1\wp_{11}) \\ -A_3S[(\eta/2)\wp_{11} + \wp_{10}] - 2a_3(\wp_{10}) \end{bmatrix}}{a_3} \tag{33}$$

$$\wp_2(\infty) \to 0,\ \wp_4(\infty) \to 0,\ \wp_6(\infty) \to 0,\ \wp_8(\infty) \to 0,\ \wp_{10}(\infty) \to 0,\ \wp_{12}(\infty) \to 0 \quad \text{as } \eta \to \infty$$

Entropy generation and Bejan number is as follows:

$$N_G = \alpha_1\{A_4 + (4/3)(Rd)[1 + \wp_{12}(Tw-1)]^3\}\wp_{13}^2 + A_1Br(\wp_3^2 + \wp_5^2) + A_2MBr(E_1 - \wp_2 - \wp_4)^2 \tag{35}$$

$$Be = \frac{\alpha_1\{A_4 + (4/3)(Rd)[1 + \wp_{12}(Tw-1)]^3\}\wp_{13}^2}{\alpha_1\{A_4 + (4/3)(Rd)[1 + \wp_{12}(Tw-1)]^3\}\wp_{13}^2 + A_1Br(\wp_3^2 + \wp_5^2) + A_2MBr(E_1 - \wp_2 - \wp_4)^2} \tag{36}$$

With a step size of h = 0.01, we employ the fourth-order R–K method. Until the outcomes are precise, the previous method is applied 10^{-8} repeatedly.

This technique involves dragging the skin friction coefficients and Nusselt number for various parameters, subsequently involving application of ANFIS for comparison and for plotting the results. The comparison of skin friction in the radial and azimuthal paths for M values with the earlier works in the R–K fourth order approach, carried out in MATLAB, is shown in Table 3.

Adaptive neuro-fuzzy inference system

The architecture of ANFIS indicates that it involves neural networks and fuzzy logic at five distinct levels. Fuzzy inference system and fuzzy logic, two concepts that were conceptualized by Zadeh[37] in 1965, aim to address concerns associated with decision-making when erratic, vague or unreliable data is involved. The concept of neural networks, originally designed by Warren McCulloch and Walter Pitts in 1943, was inspired by the functioning of brain neurons.

$$\wp_{13}' = -\frac{\begin{bmatrix} (4/3)(Rd)[(Tw-1)^3(3\wp_{12}^2\wp_{13}^2) + 3(Tw-1)^2(2\wp_{12}\wp_{13}^2) \\ +3(Tw-1)(\wp_{13}^2)] + A_1Ec\,\mathrm{Pr}\,(\wp_3^2 + \wp_5^2)(1+\frac{1}{\alpha}) \\ +2\,\mathrm{Pr}\,A_5(\wp_1\wp_{13} - \wp_{12}\wp_2) - A_5S\,\mathrm{Pr}\,[(3/2)\wp_{12} + (\eta/2)\wp_{13}] \\ +(\mathrm{Pr})Qe\,Exp(-n\xi) + (\mathrm{Pr})Qt\,\wp_{12} + A_2MEc\,\mathrm{Pr}\,(-\wp_2 - \wp_4 + E_1)^2 \end{bmatrix}}{\begin{matrix} A_4 + (Rd)(4/3) \\ [1 + (Tw-1)^3\wp_{12}^3 + \\ 3(Tw-1)^2\wp_{12}^2 + \\ 3(Tw-1)\wp_{12}] \end{matrix}} \tag{34}$$

Also, the boundary conditions as,

$$\wp_1(0) = 0,\quad \wp_2(0) = \omega,\quad \wp_4(0) = 1,\quad \wp_6(0) = 0,\ \wp_8(0) = 0,\ \wp_{10}(0) = 1,\ \wp_{12}(0) = 1, \quad \text{at } \eta = 0$$

This idea is commonly referred to as "connectionism" and involves the use of neurons that are interlinked to simulate intellectual ability.[38] In the past decade, the neuro-fuzzy system, which combines neural networks and fuzzy logic, has been widely applied to model unpredictable or complicated real-world situations. Jang[39] devised the ANFIS in

Table 3. Comparision of skin friction values for various values of M.

	$C_f \mathrm{Re}_x^{\frac{1}{2}}$				$C_g \mathrm{Re}_x^{\frac{1}{2}}$			
M	Ali et al.[34]	Shahzad et al.[35]	Siddiq and Ashraf [36]	Present	Ali et al.	Shahzad et al.[35]	Siddiq and Ashraf [36]	Present
0	10.5522	10.5522	10.5522	10.5699	1.2595	1.2595	1.2595	1.2678
0.5	11.4483	11.4483	11.4482	11.4533	1.2816	1.2816	1.2817	1.2246
1.0	13.7080	13.7082	13.7081	13.7193	1.3347	1.3348	1.3346	1.3564
1.5	16.6320	16.6319	16.6320	16.6456	1.3970	1.3969	1.3971	1.3357
2.0	19.8207	19.8208	19.8208	19.8365	1.4560	1.4560	1.4560	1.4786

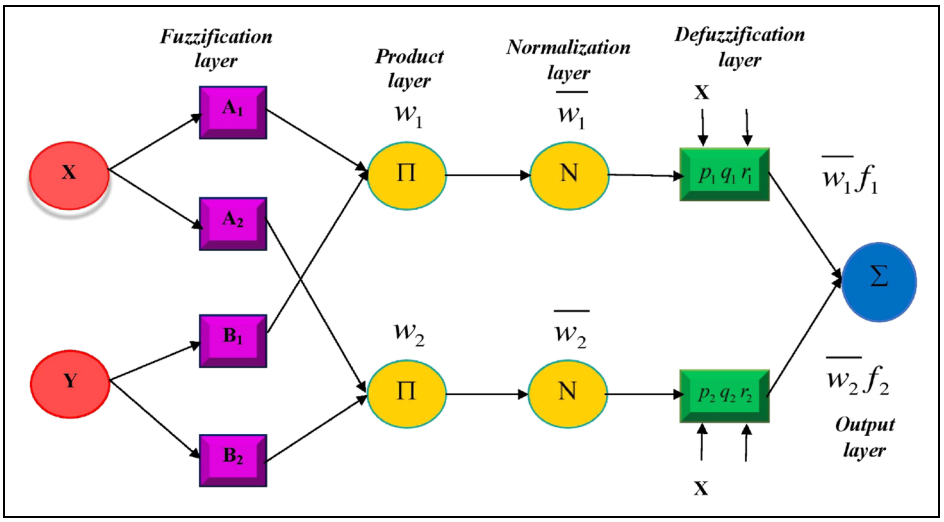


Figure 2. Architecture of ANFIS.

1993. It is a neuro-fuzzy system that effectively combines fuzzy logic and neural network simulation capabilities to mimic an expert decision-making system. The ANFIS simulation process is predicated on the Takagi–Sugeno fuzzy system, which comprises a preceding and consequent step. To optimize the premise and subsequent factors, a method of learning combining gradient descent and least squares methods was implemented.[40] The ANFIS model comprises five distinct layers, as illustrated in Figure 2: fuzzification, product, normalization, defuzzification and output layer.

Layer 1

Within layer 1, every node possesses the ability to adapt, and membership functions are utilized to convert input values from precise to fuzzy. Using a variety of membership functions with an interval of [0, 1], the input values are converted to fuzzy values, such as the generalized bell function, trapezium, triangle, Gaussian and sigmoid. In the current study, the input layer incorporates the triangular membership function, which can be expressed in equation (37).

$$\mu_A(x) = \begin{cases} 0 & if\ x \le a \\ \dfrac{x-a}{b-a} & if\ \ a \le x \le b \\ \dfrac{c-x}{c-b} & if\ b \le x \le c \\ 0 & if\ x \ge c \end{cases} \tag{37}$$

$$O_{l_1,j} = \mu_{A_j}(x) \tag{38}$$

Layer 2

Within layer 2, the outcome of each node is determined through the imprecise AND operation, which involves multiplying its input connections. During this level, the output of the nodes is determined using equation (39), which labels them as w_j.

$$O_{l_2,j} = w_j = \mu_{A_j}(x) \times \mu_{B_j}(y), \quad j = 1,\ 2 \tag{39}$$

Layer 3

Within layer 3, the normalization mechanism estimates the ratio of the present firing strength to the sum of all firing strengths from all rules. At this level, nodes are not adaptive. The outcome for this layer can be derived using equation (40).

$$O_{l_3,j} = \overline{w_j} = \frac{w_j}{w_1 + w_2}, \quad j = 1,\ 2 \tag{40}$$

Layer 4

Within layer 4, defuzzification methods are implemented to transform fuzzy outcomes into precise ones. Therefore, in accordance with equation (41), the outcome is determined by multiplying the previous output by the linear equation.

$$O_{l_4,j} = \overline{w_j} f_j = \overline{w_j} * (p_j x + q_j y + r_j) \tag{41}$$

where $\{p_j,\ q_j,\ r_j\}$ denotes the consequent parameters.

Layer 5

Within layer 5, it is proven that the nodes lack adaptability and that the outcome is produced through an accumulation of the outputs from the prior layers.

$$O_{l_5,j} = \sum_j \overline{w_j} f_j = \frac{\sum_j w_j f_j}{\sum_j w_j} \tag{42}$$

Developed ANFIS model for analyzing skin friction co-efficients and nusselt number.

The objective of the proposed model is to provide a more efficient method for determining the optimal Nusselt number and skin friction co-efficients for fluid flow analysis. The current study devises an adaptive neuro-fuzzy inference system-based prediction model. The sigmoidal membership function is exploited to fuzzify the input values to improve the model's precision because the input dataset is normalized and the resultant dataset falls within the range [0, 1]. Overall, the effectiveness of ANFIS is significantly dependent on its fundamental premise and consequent parameters. The study adopted the gradient descent method due to its robustness and fast convergence while minimizing the objective function for identifying the optimal parameters of ANFIS to improve the predictive capability of the ANFIS model. Further, ANFIS, a robust predictor for modeling fluid flow parameters that examines input parameters including unsteady parameter, magnetic field, electric field, radiation, Casson parameter, vortex viscosity parameter, spin gradient viscosity parameter, microinertia density parameter, rotation parameter, Eckert number, porous and exponential based heat source parameters are usually implemented as the initial

Table 4. Estimated skin friction co-efficient (radial velocity) using the input parameters by NM and ANFIS techniques.

												$C_f \mathrm{Re}_x^{1/2}$	
S	M	E_1	Rd	α	a_1	a_2	a_3	ω	Ec	β	Q	NM	ANFIS
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.37511	3.37418
0.2	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.58568	3.58869
0.3	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.58611	3.58776
0.4	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	2.84404	2.94536
0.1	0.3	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	2.81027	2.95634
0.1	0.4	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.20982	3.20935
0.1	0.5	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.13992	3.14188
0.1	0.1	0.7	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.15037	3.15142
0.1	0.1	0.9	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.16117	3.16118
0.1	0.1	1.1	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.13786	3.15272
0.1	0.1	0.5	1.2	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.29503	3.29577
0.1	0.1	0.5	1.4	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.36503	3.35776
0.1	0.1	0.5	1.6	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.46503	3.41886
0.1	0.1	0.5	1	2	0.5	1	0.2	1.1	0.01	0.01	0.5	3.16639	3.20927
0.1	0.1	0.5	1	2.5	0.5	1	0.2	1.1	0.01	0.01	0.5	3.13919	3.10292
0.1	0.1	0.5	1	3	0.5	1	0.2	1.1	0.01	0.01	0.5	3.12134	3.11625
0.1	0.1	0.5	1	1	1	1	0.2	1.1	0.01	0.01	0.5	3.49201	3.45724
0.1	0.1	0.5	1	1	1.5	1	0.2	1.1	0.01	0.01	0.5	3.57433	3.57182
0.1	0.1	0.5	1	1	1.7	1	0.2	1.1	0.01	0.01	0.5	3.65125	3.60152
0.1	0.1	0.5	1	1	0.5	1.1	0.2	1.1	0.01	0.01	0.5	3.38027	3.41263
0.1	0.1	0.5	1	1	0.5	1.2	0.2	1.1	0.01	0.01	0.5	3.39073	3.41902
0.1	0.1	0.5	1	1	0.5	1.3	0.2	1.1	0.01	0.01	0.5	3.30634	3.34615
0.1	0.1	0.5	1	1	0.5	1	0.4	1.1	0.01	0.01	0.5	3.33351	3.30009
0.1	0.1	0.5	1	1	0.5	1	0.5	1.1	0.01	0.01	0.5	3.31523	3.30228
0.1	0.1	0.5	1	1	0.5	1	0.7	1.1	0.01	0.01	0.5	3.28939	3.29000
0.1	0.1	0.5	1	1	0.5	1	0.2	1.2	0.01	0.01	0.5	3.86044	3.82530
0.1	0.1	0.5	1	1	0.5	1	0.2	2.2	0.01	0.01	0.5	3.48291	3.58884
0.1	0.1	0.5	1	1	0.5	1	0.2	3.2	0.01	0.01	0.5	3.14186	3.10200
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.02	0.01	0.5	3.26503	3.26502
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.03	0.01	0.5	3.26503	3.26502
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.04	0.01	0.5	3.26503	3.26503
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.05	0.5	3.37893	3.35065
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.1	0.5	3.56915	3.50967
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	1.5	0.5	3.85023	3.85022
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	1.5	3.26503	3.26502
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2	3.39503	3.39503
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2.5	3.49603	3.49602

network structure consisting of five distinct layers. Often, the dataset is partitioned into two subsets, the first of which entails 70% of the dataset and is utilized to train the network in determining the optimal settings. The optimal network constructed utilizing ANFIS is assessed using the second set, which accounts for 30% of the total dataset. Following this, the framework involves training by exploring the training input data and is assessed using the root mean square error (RMSE), which is frequently employed and expressed by equation (43).

$$RMSE = \sqrt{\frac{\sum_{j=1}^{N} (y_j - \widehat{y_j})^2}{N}} \tag{43}$$

where y_j represents the observed values and $\widehat{y_j}$ referred to as predicted values.

In this study, the numerical values obtained for skin friction co-efficients and Nusselt number, of all of the parameters in the R–K fourth order technique as given in Tables 4–6, were used to train the ANFIS model.

Results and discussion

For this phase of the exploration, employed the R–K fourth order along with shooting procedure and ANFIS model to outline the way of behavior of micropolar and Casson hybrid nanofluids. Numerous flow characteristics such as magnetic field, electric field, micropolar fluid parameters, temperature ratio difference parameters are portrayed on radial and azimuthal velocities, temperature, local entropy generation and Bejan profiles. They are contrasted in both Newtonian and non-Newtonian scenarios. However, the temperature in both linear and nonlinear instances is analyzed. All of the physical parameter's

Table 5. Estimated skin friction co-efficient (azimuthal velocity) using the input parameters by NM and ANFIS techniques.

												$C_g Re_x^{1/2}$	
S	M	E_1	Rd	α	a_1	a_2	a_3	ω	Ec	β	Q	NM	ANFIS
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.40014	4.25646
0.2	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.51343	4.50124
0.3	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.56919	4.56467
0.4	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.85962	4.12595
0.1	0.3	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.92319	3.87279
0.1	0.4	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	3.98746	4.00256
0.1	0.5	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.16469	4.14252
0.1	0.1	0.7	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.15207	4.15626
0.1	0.1	0.9	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.14368	4.14263
0.1	0.1	1.1	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.12298	4.12377
0.1	0.1	0.5	1.2	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.23465	4.25646
0.1	0.1	0.5	1.4	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.33465	4.35646
0.1	0.1	0.5	1.6	1	0.5	1	0.2	1.1	0.01	0.01	0.5	4.43465	4.49726
0.1	0.1	0.5	1	2	0.5	1	0.2	1.1	0.01	0.01	0.5	4.06167	4.10072
0.1	0.1	0.5	1	2.5	0.5	1	0.2	1.1	0.01	0.01	0.5	4.03161	4.05273
0.1	0.1	0.5	1	3	0.5	1	0.2	1.1	0.01	0.01	0.5	4.01293	4.01572
0.1	0.1	0.5	1	1	1	1	0.2	1.1	0.01	0.01	0.5	4.55262	4.50420
0.1	0.1	0.5	1	1	1.5	1	0.2	1.1	0.01	0.01	0.5	4.66814	4.62435
0.1	0.1	0.5	1	1	1.7	1	0.2	1.1	0.01	0.01	0.5	4.77124	4.79726
0.1	0.1	0.5	1	1	0.5	1.1	0.2	1.1	0.01	0.01	0.5	4.24852	4.26012
0.1	0.1	0.5	1	1	0.5	1.2	0.2	1.1	0.01	0.01	0.5	4.24969	4.25152
0.1	0.1	0.5	1	1	0.5	1.3	0.2	1.1	0.01	0.01	0.5	4.25141	4.25646
0.1	0.1	0.5	1	1	0.5	1	0.4	1.1	0.01	0.01	0.5	4.24382	4.24112
0.1	0.1	0.5	1	1	0.5	1	0.5	1.1	0.01	0.01	0.5	4.24153	4.24000
0.1	0.1	0.5	1	1	0.5	1	0.7	1.1	0.01	0.01	0.5	4.23811	4.24100
0.1	0.1	0.5	1	1	0.5	1	0.2	1.2	0.01	0.01	0.5	5.38073	5.38071
0.1	0.1	0.5	1	1	0.5	1	0.2	2.2	0.01	0.01	0.5	5.49004	5.40039
0.1	0.1	0.5	1	1	0.5	1	0.2	3.2	0.01	0.01	0.5	5.59098	5.58097
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.02	0.01	0.5	4.23465	4.34652
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.03	0.01	0.5	4.23465	4.33464
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.04	0.01	0.5	4.23465	4.31234
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.05	0.5	4.29084	4.29088
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.1	0.5	4.40148	4.39014
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	1.5	0.5	4.66841	4.66840
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	1.5	4.23465	4.34646
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2	4.33465	4.33465
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2.5	4.43465	4.43464

Table 6. Estimated Nusselt number using the input parameters by NM and ANFIS techniques.

												$Nu_x Re_x^{-1/2}$	
S	M	E_1	Rd	α	a_1	a_2	a_3	ω	Ec	β	Q	NM	ANFIS
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.56585	0.56894
0.2	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.26128	0.29315
0.3	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.11023	0.15894
0.4	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.97524	0.88664
0.1	0.3	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.18577	0.18555
0.1	0.4	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.50381	0.58858
0.1	0.5	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.97567	0.97560
0.1	0.1	0.7	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.14172	0.20816
0.1	0.1	0.9	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.35131	0.30182
0.1	0.1	1.1	1	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.55249	0.55244
0.1	0.1	0.5	1.2	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.21253	0.27816
0.1	0.1	0.5	1.4	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.21808	0.25162
0.1	0.1	0.5	1.6	1	0.5	1	0.2	1.1	0.01	0.01	0.5	0.57982	0.51826
0.1	0.1	0.5	1	2	0.5	1	0.2	1.1	0.01	0.01	0.5	0.30263	0.31589
0.1	0.1	0.5	1	2.5	0.5	1	0.2	1.1	0.01	0.01	0.5	0.35861	0.32735
0.1	0.1	0.5	1	3	0.5	1	0.2	1.1	0.01	0.01	0.5	0.38713	0.38713
0.1	0.1	0.5	1	1	1	1	0.2	1.1	0.01	0.01	0.5	0.11268	0.27354
0.1	0.1	0.5	1	1	1.5	1	0.2	1.1	0.01	0.01	0.5	0.16047	0.19826
0.1	0.1	0.5	1	1	1.7	1	0.2	1.1	0.01	0.01	0.5	0.19061	0.19192
0.1	0.1	0.5	1	1	0.5	1.1	0.2	1.1	0.01	0.01	0.5	0.11437	0.12863
0.1	0.1	0.5	1	1	0.5	1.2	0.2	1.1	0.01	0.01	0.5	0.11995	0.11999
0.1	0.1	0.5	1	1	0.5	1.3	0.2	1.1	0.01	0.01	0.5	0.11121	0.11902
0.1	0.1	0.5	1	1	0.5	1	0.4	1.1	0.01	0.01	0.5	0.11964	0.11809
0.1	0.1	0.5	1	1	0.5	1	0.5	1.1	0.01	0.01	0.5	0.11618	0.12010
0.1	0.1	0.5	1	1	0.5	1	0.7	1.1	0.01	0.01	0.5	0.17006	0.16297
0.1	0.1	0.5	1	1	0.5	1	0.2	1.2	0.01	0.01	0.5	0.57341	0.57338
0.1	0.1	0.5	1	1	0.5	1	0.2	2.2	0.01	0.01	0.5	0.03008	0.30080
0.1	0.1	0.5	1	1	0.5	1	0.2	3.2	0.01	0.01	0.5	0.49339	0.42991
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.02	0.01	0.5	0.14925	0.19249
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.03	0.01	0.5	0.13226	0.15180
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.04	0.01	0.5	0.18594	0.18594
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.05	0.5	0.13285	0.14037
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.1	0.5	0.17876	0.17881
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	1.5	0.5	0.27807	0.27069
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	1.5	0.50484	0.48392
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2	0.29009	0.31290
0.1	0.1	0.5	1	1	0.5	1	0.2	1.1	0.01	0.01	2.5	0.84022	0.77956

numerical values, with the notable exception of those used for table comparison, are fixed and their actual values are modeled as follows: $M = 0.1, \omega = 0.1, \quad S = 0.3, \beta = 0.5, E_1 = 1.0, \mathrm{Pr} = 21, Ec = 0.05, \quad Q = 0.1, Q_t = 0.2, \quad Rd = 1.0, \alpha = 0.2, Br = 0.2, \alpha_1 = 0.1, \lambda = 1.0, \theta_w = 1.5, a_1 = 0.1, a_2 = 0.2$ and $a_3 = 1.0$.

The ANFIS simulation was executed for a total of 200 runs, during which the convergence speed of the proposed model was assessed and is illustrated in Figure 3. Furthermore, Tables 4–6 detail the estimated results and input parameters utilized for skin friction co-efficients and Nusselt number using ANFIS. Figures 4 and 5 show a comparison between experimental data and the estimated Nusselt number produced by the ANFIS model for training and testing datasets. The ANFIS model provides more precise outcomes, as illustrated through the visualizations of the observed and predicted Nusselt numbers. Also, to facilitate a more comprehensive examination of the predicted values of the Nusselt number in comparison to the observed values, regression plots of training and testing are illustrated in Supplemental Figures 10 and 11. In a similar vein, the estimated skin friction co-efficient on radial velocity of the training set obtained from ANFIS, as shown in Figure 6, and the testing dataset is depicted in Supplemental Figure 7. Also, so as to analyze the accuracy, a regression analysis is conducted between the observed and predicted values for training and testing; this process is illustrated in Supplemental Figures 12 and 13. Moreover, the outcomes of simulating the training dataset of skin friction co-efficient of azimuthal velocity with ANFIS are illustrated in Supplemental Figure 8. Supplemental Figure 9 further illustrates the estimated skin friction of the testing dataset in comparison to the observed values. Supplemental Figures 14 and 15 depict the regression plots of the skin friction training and testing sets,

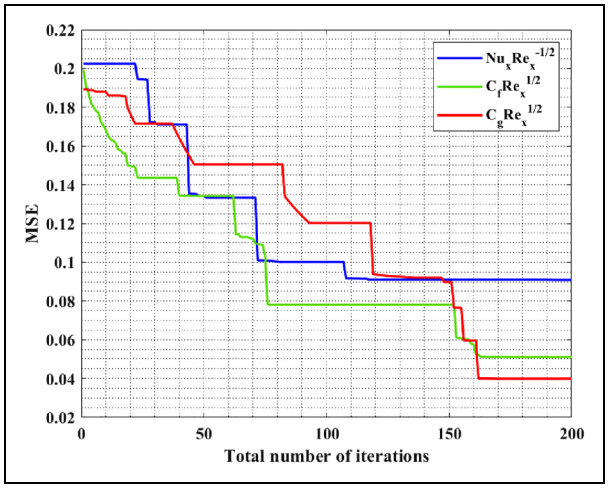


Figure 3. Convergence speed of ANFIS for predicting NNusselt and skin friction co-efficients.

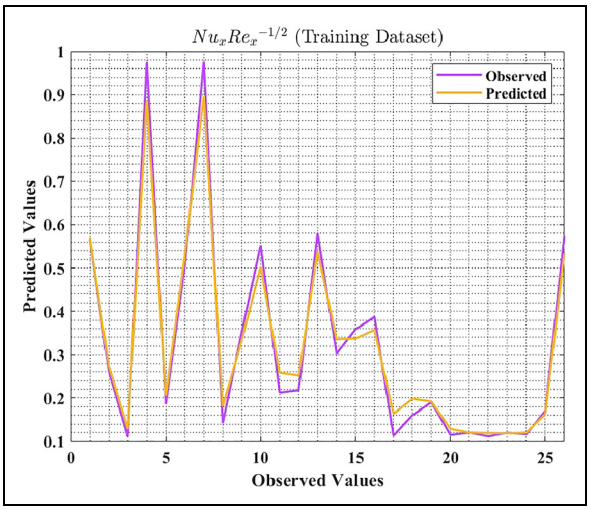


Figure 4. Nusselt number predictions using ANFIS for training dataset.

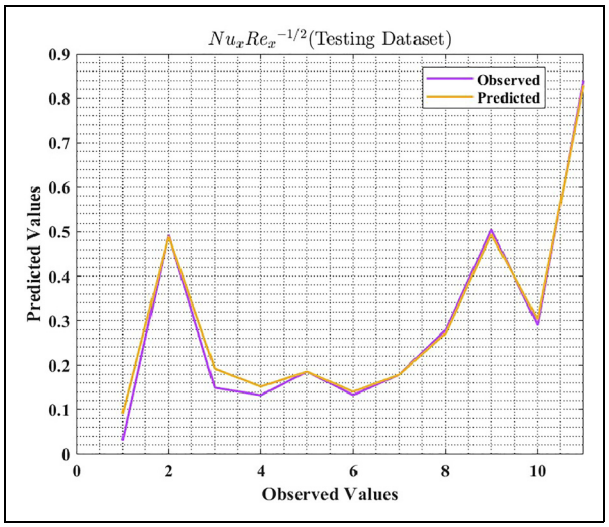


Figure 5. Nusselt number predictions using ANFIS for testing dataset.

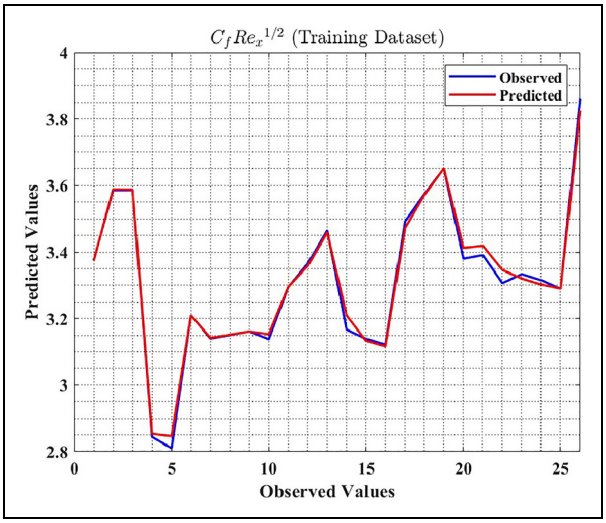


Figure 6. Skin friction on radial velocity predictions using ANFIS for training dataset.

respectively. In addition, Supplemental Figures 16 and 17 illustrate the training and testing accuracy of ANFIS with respect to the Nusselt number and skin friction coefficients, respectively. The corresponding mean squared errors of testing datasets for calculating the Nusselt number and skin friction coefficients for f and g are 0.0064, 0.0152 and 0.0178.

The fluid velocity dispersion in Newtonian and non-Newtonian scenarios is illustrated graphically in Supplemental Figures 18 and 19, which might additionally be utilized to generate new numerical conclusions. Supplemental Figure 18 exhibits how the radial velocity profile $f'(\eta)$ decreases as the values of the magnetic field parameter M boost up. From an actual stance, bigger values of M lead to more grounded Lorentz powers, which eventually cause velocities to drop. Additionally, by raising magnetic field parameter M, the viscosity of the porous medium also rises, improving the viscosity of the hybrid nanofluid. Recognizing that viscosity is inversely related to fluid velocity through a porous medium, so that the hybrid nanofluid's velocities drop. In Supplemental Figure 19, the effect of the electric field E_1 on azimuthal velocity $g(\eta)$ is depicted. Automatically, the flow rate significantly increased throughout the disk as the electric field values rose. Since the electric field amplifies the Lorentz force, which has the effect of speeding motion, azimuthal velocity $g(\eta)$ rises in both Newtonian and non-Newtonian scenarios.

Supplemental Figure 20 illustrates the vital effects of thermal radiation Rd on the temperature profile $\theta(\eta)$ of the hybrid nanofluid. It is implied that an increasing amount of radiation from the border gained temperature for the hybrid nanofluid, causing an enhancement in the temperature profile. Actually, the addition of radiation to the temperature field led to an upward trend in subatomic Brownian growth. Additionally, regular interactions between tiny nanoparticles will often generate

heat, which will raise the fluid's temperature $\theta(\eta)$ in both linear and nonlinear comparison cases. The effects of the vortex viscosity parameter a_1, spin gradient viscosity parameter a_2 and microinertia density parameter a_3 on the various microrotation components M_1, M_2, M_3 are depicted in Supplemental Figures 21–23, respectively. Supplemental Figure 21 demonstrates that the microrotation component M_1 rises and eventually declines when varied values of the material constants are taken into account. The setup for M_2 rises for both decreasing and rising values of a_1, a_2 and a_3 in both comparison phases as shown in Supplemental Figure 22. Supplemental Figure 23 demonstrates that when a_3 advances, the microrotation component M_3 climbs in Newtonian and non-Newtonian cases comparison.

Supplemental Figures 24 and 25 demonstrate, respectively, how the temperature ratio parameter α_1 and magnetic field affect the rate of local entropy generation N_G and the Bejan number *Be*. Supplemental Figure 24 provides evidence that the temperature ratio parameter values considerably accelerate the production of entropy. The primary contributory factor to this rise in the ratio parameter's detrimental impact on the rate of heat transfer and friction at the surface, which ultimately increases entropy production N_G, which is the stimulation in the entropy generation rate. According to Supplemental Figure 25 analysis, the Bejan number *Be* degrades when magnetic parameter values rise across both Newtonian and non-Newtonian phases.

Conclusion

In order to solve the fluidic system based on coupled micropolar and Casson hybrid nanofluid, a stochastic numerical computation using the proposed solver, ANFIS is used. The PDEs pertaining to the mathematical system are converted into equivalent ODEs that depict the problem's dynamics. Many vital parameters are taken into consideration when generating the data set for the ANFIS technique. Below is a thorough account of this most recent round of experiments and its excellent conclusion.

- As the magnetic field parameter increases, the radial velocity decreases; however, an opposite trend is seen when the electrical field parameter increases in terms of azimuthal velocity.
- The temperature profile also naturally rises as thermal radiation rises.
- The inclination factor may be seen in the rising impacts of the spin gradient viscosity, vortex viscosity and microinertia density factors on multiple microrotation components.
- For both Newtonian and non-Newtonian phases of the magnetic field, the Bejan number shows the opposite pattern; shortly, entropy generation increases as the ratio parameter is increased.
- To simulate the ANFIS model, the reference data is partitioned in to training (70%) and testing (30%). The ANFIS framework accuracy is certified by both suggested and reference results with level matching.
- Furthermore, the accuracy is also explained via predicted results against reference data through the graphical representations of RMSE, observed versus predicted values and regression analysis of observed against predicted values.

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Supplemental material

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List of symbols

r, φ, z	are the cylindrical coordinates
u, v, w	are the velocity components
f	is the axial velocity field
f'	is the radial velocity field

g	is the azimuthal velocity field
T	is the temperature of the fluid
S	is the measure of unsteadiness
M	is referred as Magnetic field parameter
B_0	is referred as uniform magnetic field
T_s	is called surface temperature
T_0	is origin temperature
T_{ref}	is constant reference temperature
Re_x	is referred as Local Reynolds number
Ec	is Eckert number
Pr	is Prandtl number
Rd	is thermal radiation
N_G	is the Local entropy generation
C_f	is the skin friction co-efficient of f velocity
C_g	is the skin friction co-efficient of g velocity
Nu_x	is the Local Nusselt number
Be	is the Bejan number
A_1, A_2, A_3, A_4, A_5	are the hybrid nanofluid constants
N_1, N_2, N_3	are the microrotation components
a_1	is the vortex viscosity parameter
a_2	is the spin gradient viscosity parameter
a_3	is the micro inertia density parameter
Q_T^*	is the thermal-dependent heat source coefficient
Q_E^*	is the exponential space-dependent heat source coefficient
n	is the exponential index
c	is the stretching rate
Q	is the exponential based heat source parameter
Q_t	is the thermal space dependent heat source parameter

Greek symbols

ρ	is the fluid density
υ	is the kinematic viscosity
μ	is the dynamic viscosity
σ	is the electric conductivity
η	is the dimensionless variable
k^*	is the mean absorption co-efficient
σ^*	is the Stefan Boltzmann constant
θ	is the dimensionless temperature
α	is the Casson parameter
Ω	is the angular velocity
β	is the Porosity parameter
θ_w	is the temperature ratio parameter
α_1	is the temperature difference parameter
ω	is the rotation parameter

Subscripts

f	represents the fluid
nf	represents the nanofluid
hnf	represents the hybrid nanofluid

Radiation and Chemical Reaction Effects on Mhd Mixed Convection Flow Past an Inclined Porous Plate Embedded in A Porous Medium with Heat Source and Thermodiffusion

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Abstract – This paper focuses on the radiation and chemical reaction effects on MHD mixed convective flow along inclined porous plate embedded in a porous medium with thermo diffusion in the presence of heat generation. The governing boundary layer equations are reduced to a system of ordinary differential equations using similarity transformations and the resulting equations are then solved numerically using Runge - Kutta fourth order method along with shooting technique. A parametric study is conducted to illustrate the influence of various governing parameters on the velocity, temperature, concentration, skin-friction coefficient, Nusselt number and Sherwood number and discussed in detail.

Key Words – Chemical Reaction, Mixed Convection, Porous Plate, Radiation, Thermo diffusion.

I. INTRODUCTION

In free convection fluid, motion is due to buoyancy effects within the fluid resulting from density variation caused by temperature differences in the fluid, while in forced convection it is externally imposed. The combination of free and forced convection is known as mixed convection. Mixed convection flow has important applications in electronic equipment cooled by a fan and flows in the ocean and in the atmosphere. In mixed convection flows, the forced and free convection effects are of comparable magnitude. Thus, mixed convection occurs if the effect of buoyancy forces on a forced flow or vice versa is significant. The mixed convection on laminar flow takes place in various applications in science and thermal engineering and has drawn attention of researchers in the past decades. Examples of these applications include solar energy systems, atmospheric boundary layer flows, compact heat exchangers, boilers and cooling of electronic devices. Sengupta *et al*. [1] studied the mixed convection boundary layer of linear spatial stability analysis along a heated plate. Ali *et al*. [2] considered the free-forced convective hydro magnetic boundary layer flow towards a stagnation point on a vertical surface in presence of induced magnetic field. Subhashini *et al.* [3] analyzed mixed convection boundary layer flow with buoyancy assisting and opposing effects past a permeable vertical surface. Many researchers investigated the effects of mixed convection viscous boundary layer flow past vertical/ inclined/ horizontal plate and wedge surfaces. Lloyd and Sparrow [4] studied the effects of mixed convective boundary layer flow on vertical surfaces. Schneider [5] analyzed similarity solution for mixed convection boundary layer flow along a horizontal plate. Wilks [6] presented the mixed convection flow along vertical surfaces. Yao [7] studied the mixed convection two-dimensional flow past a flat plate. Ramachandran *et al.* [8] presented the mixed convection in stagnation flows adjacent to vertical surfaces.

From the literature survey it has been observed that the combined heat and mass transfer on mixed convection have been extensively studied on horizontal and vertical configurations and paid little attention on inclined geometries. Laaroussi *et al.* [9] presented numerically the effect of variable density on laminar forced and free convection flow with thin liquid film evaporation in a vertical channel. Ait Hammou *et al.*

[10] studied the numerical solution of evaporation or condensation on laminar mixed convection flow of humid air in a vertical channel. Said *et al.* [11] carried out a numerical study on turbulent free convection boundary layer flow between inclined isothermal plates.

Magnetohydrodynamics has attracted the interest of many researchers because of its wide range of applications in engineering such as astrophysics, purification of crude oil, geothermal reservoirs, ship propulsion, magnetic material processing, cooling of nuclear reactors, MHD generators, Jet printers, petroleum industries, crystal growth, boundary layer control in aerodynamics and so on. Moreover the study of MHD is largely concerned with the flow, heat and mass transfer characteristics in various physical situations. Sri Hari Babu and Ramana Reddy [12] presented the effects of mixed convective mass transfer on hydro magnetic flow past a vertical surface with viscous dissipation in presence of Ohmic heating. Chen *et al*. [13] studied the effects on natural convection heat and mass transfer MHD flow from a permeable, inclined surface with concentration in the presence of variable wall temperature.

Simultaneous heat and mass transfer in porous media with different geometries has attracted many researchers due to its numerous engineering and geophysical applications such as geothermal reservoirs, thermal insulation, packed-bed catalytic reactors, underground energy transport, cooling of nuclear reactors, enhanced oil recovery, drying of porous solids, etc. Lai and Kulacki [14] discussed heat and mass transfer effects on non-Darcy mixed convection boundary layer past vertical plate through a saturated porous medium. Nasir Uddin *et al.* [15] investigated the conjugate heat and mass transfer effects on magneto hydrodynamic mixed convective flow along inclined plate embedded in a porous medium. Sattar and Hossain [16] analyzed the effects of mass transfer with Hall currents on an unsteady free convective boundary layer flow past an accelerated vertical porous plate as time depending temperature and concentration. Vajravelu [17] examined the heat transfer effects on steady flow past a stretching surface through a saturated porous medium. Hong *et al*. [18], Chen and Lin [19] and Jaiswal and Soundalgekar [20] investigated the free convection flows embedded in a porous medium with high porosity.

In many situations there may be an appreciable temperature difference between the surface and ambient fluid. These necessities the consideration of temperature dependent heat sources or sinks which may exert strong influence on the heat transfer characteristics. The study of heat generation or absorption in moving fluids is important in view of several physical problems, such as fluids undergoing exothermic or endothermic chemical reactions. Sparrow and Cess [21] provided similarity solution for stagnation point flow in presence of heat source/sink varying with time. Pop and Soundalgekar [22] presented an unsteady free convection flow past an infinite plate with constant suction in presence of heat source. Reddy *et al.* [23] studied the mass transfer effects on two-dimensional natural convection boundary layer flow along an inclined semi-infinite vertical surface in the presence of heat generation embedded in a porous medium.

Radiation becomes the only significant mode of heat transfer when no medium is present. At high absolute temperature levels such as those prevailing in furnaces, combustion chambers, nuclear explosions and in space applications, the contribution of radiation to heat transfer is very significant. Recent advancement in hypersonic flights, gas cooled nuclear reactors, rocket combustion chambers and missile reentry, have perhaps shifted researchers' attention to thermal radiation as a mode of energy transfer, and emphasize the need for improved understanding of radiative transfer in these processes. Ramachandra Prasad *et al.* [24] studied effects of convective heat and mass transfer on an unsteady MHD radiating flow along a semi-infinite vertical permeable moving plate through a porous medium. Ramana Reddy *et al*. [25] have studied an unsteady free convective MHD viscous incompressible and radiating fluid flow embedded in porous medium with heat generation/absorption. MHD mixed convective heat transfer about a semi-infinite inclined plate in the presence of magnetic field and thermal radiation has been examined by Aydin *et al*. [26]. Recently, Samad and Rahman [27] presented the interaction of the thermal radiation on MHD unsteady boundary layer flow along vertical porous plate immersed in a porous medium. Uddin and Kumar [28] studied the effects of free convection MHD radiating flow of an isothermal cylinder embedded in a porous medium.

It is essential to study the heat and mass transfer problems with chemical reaction because of its growing need in chemical and hydrometallurgical industries. The study of such process takes place in number of chemical technologies such as food processing, polymer production, the manufacturing of ceramics or glassware and so on. Singh *et al.* [29] presented absorption of chemical reaction and radiation effects on magnetohydrodynamic natural convective heat and mass transfer flow along a semi-infinite vertical moving plate in the presence of suction depending on time. Ibrahim *et al*. [30] presented an unsteady magneto hydrodynamic natural convection chemical reacting and radiation absorbing fluid flow along a continuously moving permeable surface with heat source and time dependent suction. Rajeswari *et al*. [31] investigated the effect of chemical reaction on unsteady MHD natural convection boundary layer of radiation absorption fluid flow along a semi-infinite vertical permeable moving plate in the presence of heat source with suction. Recently, Kandasamy et al. [32, 33] presented chemical reaction effects on heat and mass transfer boundary layer flows with heat source. Gangadhar and Bhaskar reddy [34] analyzed the chemically reaction, heat and mass transfer effects on MHD flows along a moving vertical plate embedded in a porous medium with suction. Patil and Kulkarni [35] investigated the effects of chemically reacting natural convective polar fluid flow in a porous medium with internal heat generation.

Thermophoresis is a phenomenon which causes small particles to be driven away from a hot surface and towards a cold one. Small particles, such as dust, when suspended in a gas with a temperature gradient, experience a force in the direction opposite to the temperature gradient. This phenomenon has many practical applications in removing small particles from gas streams, in determining exhaust gas particle trajectories from combustion devices, and in studying the particulate material deposition on turbine blades. Recently, Chamkha *et al*. [36] studied the effect of thermophoretic particle deposition in free convection boundary layer from a vertical flat plate embedded in a porous medium. Bakier *et al*. [37] dealt with the effects of thermophoresis particle deposistion on MHD boundary layer flow past a vertical flat plate through a fluid-saturated porous medium. Lin *et al* [38] investigated the suppression of particle deposition from flow through a tube with circular cross-section when the wall temperature exceeds that of the gas. Seddek [39] presented the effects of thermophoresis of chemically reacting MHD flow over a heat surface in the presence of variable viscosity and heat source/absorption. Alam *et al*. [40] considered the effects heat thermophoresis on magneto hydrodynamic boundary flow with heat and mass transfer past a semi-infinite permeable inclined flat surface. Loganathan and Arasu [41] presented the effect of thermophoresis on non-Darcy free-forced convective heat and mass transfer along a porous wedge with suction or injection.

II. MATHEMATICAL ANALYSIS

A steady two-dimensional MHD laminar mixed convective flow of a viscous incompressible, electrically conducting, radiating and chemically reacting fluid past a semi-infinite inclined porous plate embedded in porous mdium with an acute angle α to the vertical is considered. The flow is assumed to be in the x - direction, which is taken along the semi-infinite inclined porous plate and y - axis normal to it. The velocity components in the directions of flow and normal to the flow are u and v respectively. A uniform magnetic field strength B_0 is applied normal to the direction of y-axis.

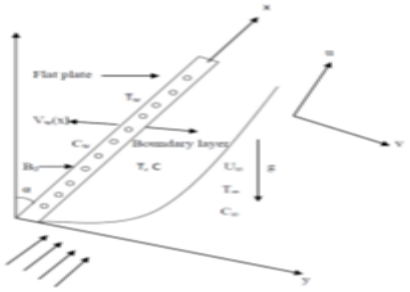


Fig. 1 Schematic diagram of the physical model

The fluid is assumed to be slightly conducting, so that the magnetic Reynolds number is much less than unity, and hence the induced magnetic field is negligible in comparison with applied magnetic field. The external flow with a uniform velocity U_∞ takes place in the direction parallel to the inclined plate. It is assumed that T and C are the temperature and concentration of the fluid which are the same, everywhere in the fluid. The surface is maintained at a constant temperature T_w, which is higher than the constant temperature T_∞ and the concentration C_w is

greater than the constant concentration C_∞ of the surrounding fluid. It is assumed that there is no applied voltage which implies the absence of electrical field. The fluid is considered to be a gray, absorbing emitting radiation but non-scattering medium and the Rosseland approximation is used to describe the heat flux in the energy equation.

Under the above assumptions and usual Boussinesq's approximation, the governing boundary layer equations describing the flow can be written as

Continuity equation

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{2.1}$$

Momentum equation

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\upsilon\frac{\partial^2 u}{\partial y^2}+g\beta\left(T-T_\infty\right)\cos\alpha+g\beta^*\left(C-C_\infty\right)\cos\alpha-\left(\frac{\sigma B_0^2}{\rho}+\frac{\upsilon}{K^*}\right)u \tag{2.2}$$

Energy equation

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{k}{\rho C_p}\frac{\partial^2 T}{\partial y^2}+\frac{Q_0}{\rho C_p}\left(T-T_\infty\right)-\frac{1}{\rho C_p}\frac{\partial q_r}{\partial y} \tag{2.3}$$

Species equation

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D\frac{\partial^2 C}{\partial y^2}-\frac{\partial}{\partial y}\left\{V_T\left(C-C_\infty\right)\right\}-Kr'C \tag{2.4}$$

where υ is the kinematics viscosity, g is the acceleration due to gravity, β, β^* are the volumetric coefficients of thermal and concentration expansions, respectively, T, C are the temperature and concentration of the fluid, respectively, T_∞, C_∞ are the free stream temperature and concentrations respectively, σ is the electrical conductivity, B_0 - the magnetic induction, ρ is the fluid density of the fluid, K^* is permeability of the porous medium, k is the thermal conductivity of the fluid, C_p is the specific heat at constant pressure, Q_0 is the heat generation constant, q_r is the radiative heat flux, D is the mass diffusivity, V_T is the thermophoretic velocity and Kr' is the chemical reaction rate of the species concentration.

The third and fourth terms on the RHS of the momentum equation (2.2) denote the thermal and concentration buoyancy effects, and last two terms of the momentum equation represent magnetic field and porous effects, respectively. Also the last two terms of on the RHS of the energy equation (2.3) represent the heat absorption and thermal radiation effects, respectively. The last two terms on the RHS of the species equation (2.4) represents the thermophoretic and chemical reaction effects, respectively. It is assumed that the physical properties, that is, viscosity, heat capacity, thermal diffusivity and the mass diffusivity of the fluid remain invariant throughout the fluid.

The boundary conditions for the velocity, temperature and concentration fields are

$u=0$, $v=\pm v_w(x)$, $T=T_w$, $C=C_w$ *at* $y=0$

$u=U_\infty$, $T=T_\infty$, $C=C_\infty$, *as* $y\to\infty$ (2.5)

In addition, U_∞ is the free stream velocity and $v_w(x)$ represent the permeability of the porous plate where its sign indicates suction (< 0) or blowing (> 0), subscripts w and ∞ refer to the wall and boundary layer edge, respectively.

The effects of thermophoresis are being taken into account to help in the understanding of the mass deposition variation on the surface. The effect of thermophoresis is usually prescribed by means of an average velocity that a particle will acquire when exposed to a temperature gradient. For boundary layer analysis it is found that the temperature gradient along the plate is much lower than the temperature gradient normal to the surface, *i.e.*, $\frac{\partial T}{\partial y}>>\frac{\partial T}{\partial x}$. So the component of thermophoretic velocity along the plate is negligible compared to the component of its normal to the surface. As a result, the thermophoretic velocity V_T which appears in the equation (2.4) can be written as

$$V_T=-k\upsilon\frac{\Delta T}{T_{ref}}=-\frac{k\upsilon}{T_{ref}}\frac{\partial T}{\partial y} \tag{2.6}$$

where T_{ref} is some reference temperature and k is the thermophoretic coefficient which is defined by[42].

By using the Rosseland approximation (Brewster [43]), the heat flux q_r is given by

$$q_r=\frac{4\sigma^*}{3k^*}\frac{\partial T^4}{\partial y} \tag{2.7}$$

Where σ^* is the Stephen-Boltzmann constant and k^* is the mean absorption. It should be noted that by using the Rosseland approximation, the present analysis is limited to optically thick fluids. If the temperature differences within the flow are sufficiently small, then equation (2.3) can be linearized by expanding T^4 into the Taylor series about T_∞, which after neglecting higher order terms takes the form

$$T^4 = 4T_\infty^3 T - 3T_\infty^4 \tag{2.8}$$

In view of the equations (2.7) and (2.8), the equation (2.3) reduces to

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 T}{\partial y^2} + \frac{Q_0}{\rho C_p}(T - T_\infty) + \frac{16\sigma^* T_\infty^3}{3k^*\rho c_p}\frac{\partial^2 T}{\partial y^2} \tag{2.9}$$

The continuity equation (2.1) is satisfied by the Cauchy Riemann equations

$$u = \frac{\partial \psi}{\partial y} \text{ and } v = -\frac{\partial \psi}{\partial x} \tag{2.10}$$

where $\psi(x,y)$ is the stream function.

In order to write the governing equations and the boundary conditions in dimensionless form, the following dimensionless quantities are introduced.

$$\eta = y\sqrt{\frac{U_\infty}{\upsilon x}}, \qquad \psi = \sqrt{\upsilon x U_\infty}\, f(\eta),$$

$$u = U_\infty f'(\eta), \quad v = \frac{1}{2}\sqrt{\frac{\upsilon U_\infty}{x}}\left(\eta f' - f\right),$$

$$\theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty}, \qquad \phi(\eta) = \frac{C - C_\infty}{C_w - C_\infty},$$

$$M_x = \frac{\sigma B_0^2 x}{\rho U_0},\ Gr_x = \frac{g\beta(T_w - T_\infty)x}{U_\infty^2}, \tag{2.11}$$

$$Gc_x = \frac{g\beta^*(C_w - C_\infty)x}{U_\infty^2}, \qquad K_x = \frac{\upsilon x}{K^* U_\infty},$$

$$\Pr = \frac{\upsilon\rho C_p}{k}, \quad Sc = \frac{\upsilon}{D},$$

$$Q_x = \frac{Q_0 x}{U_\infty \rho C_p},\ Kr_x = \frac{Kr' x}{U_\infty},\ R = \frac{4\sigma^* T_\infty^3}{3k^* k},$$

$$\tau = \frac{k\left(T_w - T_\infty\right)}{T_{ref}},$$

where prime denotes differentiation with respect to η, η - the similarity variable, $f(\eta)$ - the dimensionless stream function, $f'(\eta)$ - the dimensionless velocity, $\theta(\eta)$- the dimensionless temperature, $\varphi(\eta)$ - the dimensionless concentration M_x - the local magnetic field parameter, Gr_x - the local thermal Grashof number, Gc_x - the modified Grashof number, K_x – the permeability parameter, Pr - the Prandtl number, Sc - the Schmidt number, Q_x - the heat generation parameter, Kr_x - the chemical reaction parameter, R - the radiation parameter and τ - thermophoretic parameter.

In the view of the above similarity transformations, the equations (2.2), (2.9) and (2.4) reduce to

$$f''' + \frac{1}{2}ff'' + Gr_x\theta\cos\alpha + Gc_x\varphi\cos\alpha - \left(M_x + K_x\right)f' = 0 \tag{2.12}$$

$$\left(4R+1\right)\theta'' + \frac{1}{2}\Pr\, f\theta' + \Pr Q_x\theta = 0 \tag{2.13}$$

$$\varphi'' + Sc\left(\frac{1}{2}f - \tau\theta'\right)\varphi' - Sc\varphi\left(\tau\theta'' - Kr_x\right) = 0 \tag{2.14}$$

The corresponding boundary conditions are

$f = f_w$, $f' = 0$, $\theta = 1$, $\varphi = 1$ at $\eta = 0$ (2.15)

$f' \to 1$, $\theta \to 0$, $\varphi \to 0$ as $\eta \to \infty$ (2.16)

$f_w = -v_w(x)\sqrt{x/\upsilon U_\infty}$ is the non dimensional wall mass transfer coefficient such that $f_w > 0$ indicates wall suction and $f_w < 0$ indicates wall injection or blowing.

For the type of boundary layer flow under consideration the skin-friction coefficient, Nusselt number and Sherwood number are important parameters. They are described as follows.

By employing definition of wall shear stress $\tau_w = \mu(\partial u/\partial y)_{y=0}$ along with Fourier's law $q_w = -k(\partial T/\partial y)_{y=0}$ and Fick's law $J_s = -D(\partial c/\partial y)_{y=0}$ the non-dimensional forms of local skin-friction coefficient is $C_f = 2\,\mathrm{Re}^{-1/2} f''(0)$, local Nusselt number is $N_u = -2\,\mathrm{Re}^{1/2}\theta'(0)$ and local Sherwood number is $S_h = -2\,\mathrm{Re}^{1/2}\phi'(0)$, where $\mathrm{Re}_x = xU_\infty/\upsilon$ is the local Reynolds number.

It can be noted that the local parameters Ha_x, Gr_x, Gc_x, K_x, Q_x and Kr_x in the equations (2.12) - (2.14) are functions of x and generate local similarity solution. In order to have a true similarity solution all the parameters Ha_x, Gr_x, Gc_x, K_x, Q_x and Kr_x must be constant and we therefore assume

$$\sigma = \frac{b}{x}, \quad \beta = \frac{c}{x}, \ \beta^* = \frac{d}{x},$$

$$K^* = \frac{a}{x}, \ Q_0 = \frac{e}{x}, \quad Kr' = \frac{m}{x}$$

where *a, b, c, d, e* and *m* are the constants with appropriate dimensions.

III. SOLUTION OF THE PROBLEM

The non-linear boundary value problem given by equations (2.12) - (2.14) and boundary conditions (2.15) does not possess a closed form analytical solution. Therefore it has been solved numerically by using fourth order Runge-Kutta scheme together with Newton Raphson shooting method. First of all, writing higher order non-linear differential equations (2.12), (2.13) and (2.14) into simultaneous first order differential equations as follows.

Let $f = y_1$, $f' = y_2$, $f'' = y_3$, $\theta = y_4$, $\theta' = y_5$, $\varphi = y_6$, $\varphi' = y_7$.

Thus, the corresponding first order differential equations are

$$\frac{dy_1}{d\eta} = y_2,$$

$$\frac{dy_2}{d\eta} = y_3,$$

$$\frac{dy_3}{d\eta} = -\{\frac{1}{2} y_1 y_3 + Gr_x y_4 \cos\alpha + Gc_x y_6 Cos\alpha - (M_x + K_x) y_2\},$$

$$\frac{dy_4}{d\eta} = y_5,$$

$$\frac{dy_5}{d\eta} = \frac{-1}{(4R+1)}\{\frac{1}{2}\Pr y_1 y_5 + \Pr Q y_4\},$$

$$\frac{dy_6}{d\eta} = y_7,$$

$$\frac{dy_7}{d\eta} = -\{Sc(\frac{1}{2} y_1 - \tau y_5) y_7 - Scy_6(\tau \frac{dy_5}{d\eta} + Kr_x\},$$

subject to following initial conditions

$$y_1(0) = f_w, \ \ y_2(0) = 0, \quad y_4(0) = 1, \ y_6(0) = 1,$$

$$y_2(\infty) = 1, \ y_4(\infty) = 0, \ \ y_6(\infty) = 0$$

Then the set of above equations are transformed into initial value problem by applying the shooting technique (Jain *et al*. [44]). We have chosen a step size of $\Delta\eta$ = 0.01 to satisfy the convergence criterion of 10^{-6} in all cases. From the process of numerical computation, the skin-friction coefficient, Nusselt number and Sherwood number which are respectively proportional to $f''(0)$, $-\theta'(0)$, and $-\varphi'(0)$ are also sorted out and their numerical values are presented in a tabular form.

IV. RESULTS AND DISCUSSION

In order to get a physical insight into the problem, a parametric study is conducted to illustrate the effects of different governing parameters viz local magnetic field parameter *M*, the thermal Grashof number Gr_x, the modified Grashof number Gc_x, internal heat generation parameter *Q*, permeability of the porous medium *K*, the Prandtl number *Pr*, the Schmidt number *Sc*, the chemical reaction parameter *Kr*, the thermophoretic parameter τ and the non-dimensional wall mass transfer coefficient f_w and radiation parameter *R* upon the nature of flow and transport, the numerical results are depicted graphically in Figs. 2-26. Throughout the calculations, the parametric values are chosen as for *Gr* =*Gc*=0.87, *M*= 0. 1, *K*=0.01, α=30^0, *Pr*= 0.71, *Q* =0.5, *R*=1.0, f_w = 0.5, *Kr*=0.1, *Sc* = 0.6 τ = 0.1. All the graphs therefore correspond to these values unless specifically indicated on the appropriate graph. In order to ascertain the accuracy of the numerical results, the present study is compared with the previous study. The velocity profiles for *Gr* = 2.0, *Gc* = 2.0, *K*=0.5, *M*= 0.01, *Q* =0.5, α=30^0, *Pr*= 0.71, f_w = 0.5, *Sc* = 0.22. τ = 0.1, *R*=0, *K*r=0 are compared with the available solution of Nasir Uddin *et al.* [45] in Fig. 2. It is observed that the present results are in good agreement with that of Nasir Uddin *et al.* Numerical results for the skin-friction coefficient, the Nusselt number, the Sherwood number and the plate surface temperature for various values of physical parameters are reported in Tables.

The effect of magnetic parameter (*M*) on the velocity field is shown in Fig. 3. It illustrates that the velocity decreases with an increase in the magnetic parameter, because the magnetic parameter is found to retard the velocity at all points of the flow field. It is because that the application of transverse magnetic field will result in a resistive type force (Lorentz force) similar to drag force which tends to resist the fluid flow and thus reducing its velocity. Also, the boundary layer thickness decreases with an increase in the

magnetic parameter. Fig. 4 represents the effect of the magnetic parameter on the temperature. It is noticed that the temperature of the fluid increases as the magnetic parameter increases. This is due to the fact that the applied magnetic field tends to heat the fluid, and thus reduces the heat transfer from the wall.

Fig. 5 and Fig. 6 illustrate the effect of the thermal Grashof number (*Gr*) and mass (solutal) Grashof number (*Gc*) on the velocity field. The thermal Grashof number signifies the relative effect of the thermal buoyancy force to the viscous hydrodynamic force and the mass (solutal) Grashof number defines the ratio of species buoyancy force to the viscous hydrodynamic force in the boundary layer. It is observed that with an increase in *Gr* or *Gc*, there is an increase in the velocity. It is due to the fact that an increase in the values of *Gr* or *Gc* has the tendency to increase the thermal and mass buoyancy effects. Further, the velocity increases rapidly and suddenly falls near the boundary and then approaches the far field boundary condition due to favorable buoyancy force with an increase in *Gc*. Fig. 7 and Fig. 8 represents the temperature for different values of the Grashof number and modified Grashof number respectively. It is observed that the thermal boundary layer decreases with an increasing thermal Grashof number or modified Grashof number. The effect of buoyancy parameters (*Gr*, *Gc*) on the concentration field is illustrated in Fig. 9 and Fig. 10. It is noticed that concentration boundary layer thickness decreases with an increase in the thermal or solutal Grashof numbers. It is due to the fact that an increase in the values of Grashof number or modified Grashof number has the tendency to increase the mass buoyancy effect.

Fig. 11 illustrates the effect of permeability parameter (*K*) on the velocity. It is noticed that as the permeability parameter increases, the velocity decreases. The parameter *K* as defined in (2.11) is inversely proportional to the actual permeability K^* of the porous medium. An increase in *K* will therefore decrease the resistance of the porous medium (as the permeability physically becomes less with increasing K^*) which will tend to decelerate the flow and reduce the velocity. Fig. 12, display the effect of temperature across the boundary layer for different values of the permeability parameter. It is noticed that an increase in the permeability parameter leads to an increase in the fluid temperature.

Fig. 14 shows the effect of the Prandtl number (*Pr*) on the temperature. It is observed that, an increase in the Prandtl number results in decrease of the thermal boundary layer, and hence temperature decreases. Prandtl number signifies the ratio of momentum diffusivity to thermal diffusivity. In heat transfer problems, the Prandtl number controls the relative thickening of the momentum and thermal boundary layers. The reason is that, smaller values of *Pr* are equivalent to increase the thermal conductivities, when Prandtl number is small, heat is able to diffuse away from the heated surface more rapidly than for higher values of *Pr*. As *Pr* enhances, it can be seen from Fig. 13 that the velocity reduces. This is due to the fact that with an increase in *Pr*, rate of viscous diffusion exceeds the rate of thermal diffusion and hence it is seen that velocity decreases throughout the regime.

The positive value of (*Q*) represents heat source *i.e*. heat generation in the fluid. From Fig. 15, it is observed that due to increase in heat generation parameter enhances the thermal buoyancy force of driving force due to mass density variations which are coupled to the temperature distribution which in turn gives rises the velocity in the boundary layer. The effect of the heat generation parameter on the temperature is shown in Fig. 16. It is seen that with an increase in the heat generation parameter, the temperature increases. This is due to the fact that the presence of a heat source on the flow field, the thermal state of the fluid increases causing the thermal boundary layer to increase. The influence of heat generation parameter on concentration is shown in Fig. 17. It is seen that the concentration decreases as *Q* increase.

The influence of thermal radiation parameter *R* on the velocity and temperature is shown in Fig. 18 and Fig. 19. The radiation parameter defines the relative contribution of conduction heat transfer to thermal radiation transfer. It is obvious that, with an increase in the radiation parameter results an increase in both the velocity and temperature within the boundary layer.

The effect of chemical reaction parameter (*Kr*) on the concentration is presented in Fig. 20. It is observed that the species concentration decreases with an increase in the chemical reaction parameter. Physically this shows that an increase in chemical reaction parameter breaks up the bonds between the

atoms and thus the density of the species dilutes and thereby decreases the concentration of the fluid.

The effect of the Schmidt number (*Sc*) on the velocity, temperature and concentration are shown in Figs. 21-23, respectively. Moreover, the Schmidt number is an important parameter in heat and mass transfer processes as the Schmidt number embodies the ratio of momentum to mass diffusivity. The Schmidt number quantifies the relative effectiveness of momentum and mass transport by diffusion in the hydrodynamic (velocity) and concentration (species) boundary layers. Its effect on the species concentration has similarities to the Prandtl number effect on the temperature. As the Schmidt number increases the concentration decreases. This causes the concentration buoyancy effects to decreases yielding reduction in the fluid velocity resulting in less induced flow and higher fluid temperatures.

The influence of thermophoretic parameter (τ) on the concentration is shown in Fig. 24. It is seen that the concentration decreases with an increase of the thermophoretic parameter due to the small temperature difference between the hot fluid and the free stream.

Figs. 25-27 illustrate the effect of suction parameter (f_w>0) on the velocity, temperature and concentration. It is observed that with an increase in the suction parameter velocity, temperature and concentration decreases. This is due to the fact that with an increase in suction rate, more warm fluid is pushed towards the wall where the buoyancy forces acts to reduce the fluid velocity due to influence of high viscosity. This effect also reduces the wall sear stress. An increase in the suction parameter destroys the momentum transfer and stabilizes the boundary layer flow on the surface.

From Table 1, it is observed that the local skin-friction, Nusselt number and Sherwood number coefficient increase with an increase in the buoyancy forces (*Gc* or *Gr*). As the magnetic parameter (*M*) increases, the skin-friction, Nusselt number and Sherwood number decrease. It can be seen that the local skin-friction coefficient, Nusselt number and Sherwood number decrease with an increase in the porous medium parameter (*K*).It is noted that an increase in suction parameter (f_w>0) increase the skin friction coefficient, Nusselt number Sherwood number.

From Table 2, it is found that the local skin-friction coefficient, Nusselt number and Sherwood number decrease with an increase in the Prandtl number (*Pr*). It is noticed that the skin-friction and Sherwood number increase, where as Nusselt number decreases with an increase in the internal heat generation parameter (*Q*). It is observed that the skin-friction coefficient and Sherwood number increase, whereas Nusselt number decreases with an increase in the radiation parameter(*R*).

From Table 3, it is clear that both the skin friction coefficient and Nusselt number decrease while Sherwood number increases as the Schmidt number (*Sc*) or chemical reaction parameter (*Kr*) or thermophoretic parameter (τ) increases.

V. CONCLUSION

The present model helps us to understand numerically as well as physically the effect of the radiation and chemical reaction on a steady magneto hydrodynamic heat and mass transfer flow of laminar mixed convective boundary layer flow of viscous incompressible, electrically conducting fluid past an inclined porous plate with thermo diffusion. The set of governing equations and the boundary condition are reduced to ordinary differential equations with appropriate boundary conditions using similarity transformations. The resultant dimensionless equations are then solved numerically by shooting technique with Runge-Kutta scheme. A comparison with previously published work is performed and the results are found to be in good agreement. Based on the obtained results, the following conclusions may be drawn.

- The velocity, skin friction coefficient, rate of heat transfer as well as the rate of mass transfer decreases whereas the temperature increases with an increase in the magnetic parameter.
- As mass (solutal) Grashof number increases the velocity increases near the plate and then it decreases smoothly away from the plate, while velocity increases throughout the boundary layer with an increase in the thermal Grashof number.
- An increase in the mass (solutal) Grashof number or thermal Grashof number causes a fall in the temperature and concentration, whereas a rise in

the skin friction coefficient, rate of heat transfer, as well as rate of mass transfer.

- An increase in the permeability parameter reduces the velocity, skin friction coefficient, heat transfer coefficient and the mass transfer coefficient but enhances the temperature.
- An increase in the Prandtl number decreases all the physical quantities.
- The velocity, temperature as well as the skin friction coefficient and the mass transfer rate increases whereas the concentration and local heat transfer rate decreases with an increase in the heat generation or radiation parameter.
- With an increase in the heat generation parameter the concentration decreases.
- The velocity as well as concentration decreases while the temperature increase with an increase in the Schmidt number.
- There is a decrease in the concentration with an increase in the chemical reaction parameter or thermophoretic parameter
- With an increase in the local chemical reaction parameter or Schmidt number or thermophoretic parameter there is a decrease in the skin friction coefficient, Nusselt number and an increase in the Sherwood number.
- As the suction parameter increases, skin friction coefficient, Nusselt number and Sherwood number increase while the velocity, temperature and concentration decrease.

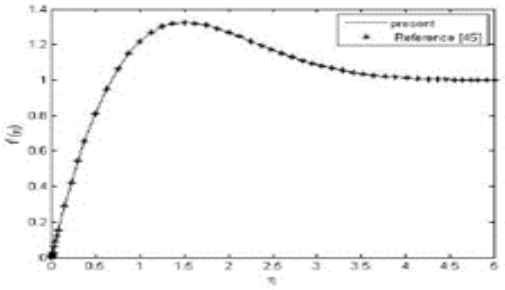


Fig. 2 Comparison of velocity distribution

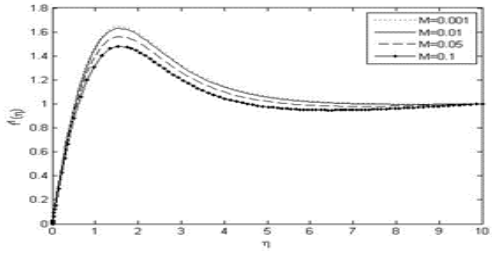


Fig. 3 Velocity profiles for different values of *M*

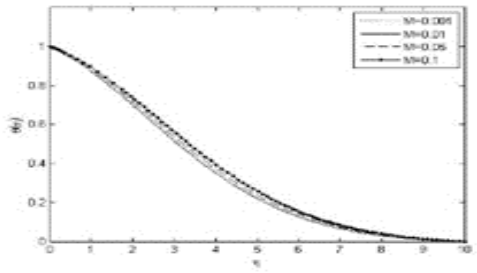


Fig. 4 Temperature profiles for different values of *M*

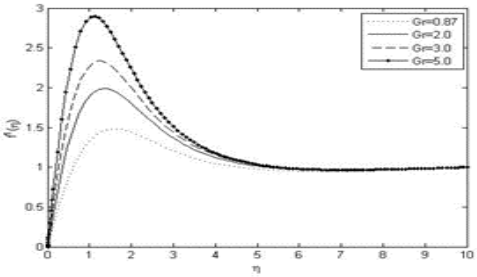


Fig. 5 Velocity profiles for different values of *Gr*

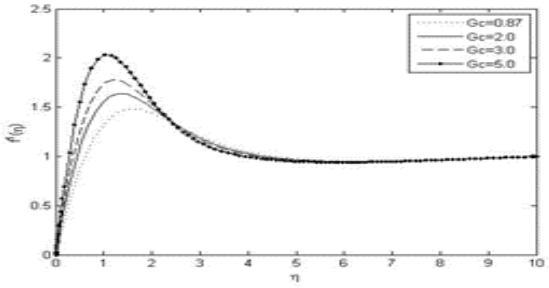


Fig. 6 Velocity profiles for different values of *Gc*

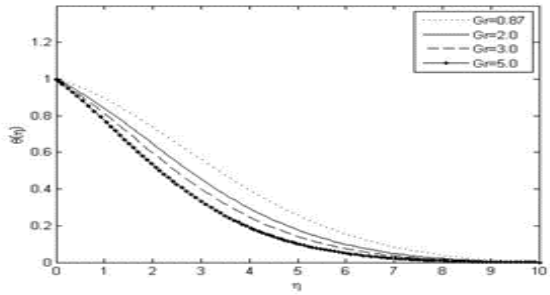


Fig.7 Temperature profiles for different values of *Gr*

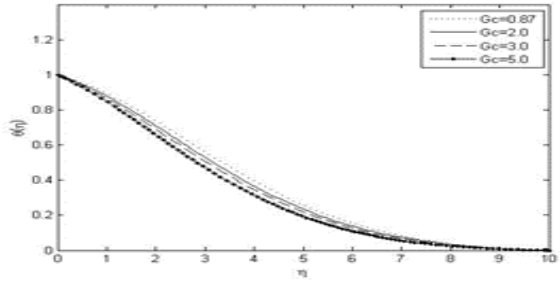


Fig. 8 Temperature profiles for different values *Gc*

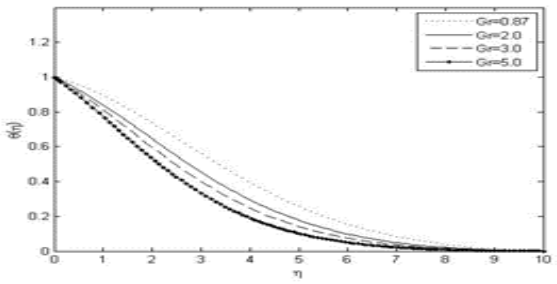


Fig. 9 Concentration profiles for different values of *Gr*

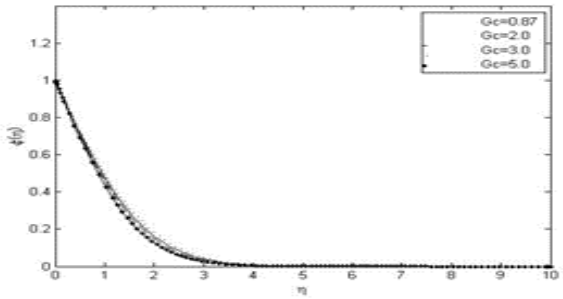


Fig. 10 Concentration profiles for different values of *Gc*

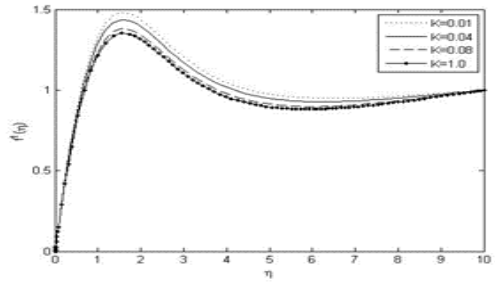


Fig. 11 Velocity profiles for different values of *K*

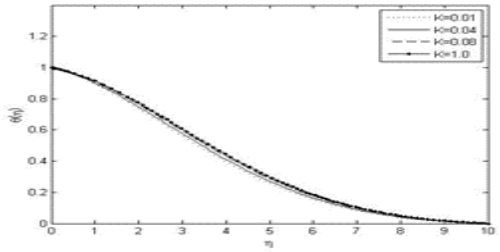


Fig. 12 Temperature profiles for different values of *K*

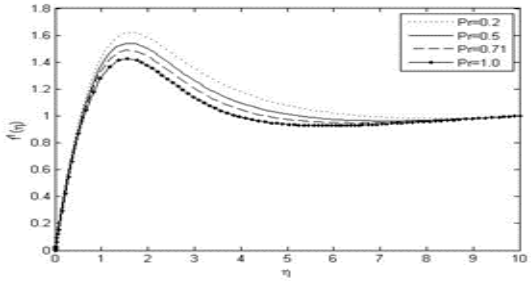


Fig. 13 Velocity profiles for different values of *Pr*

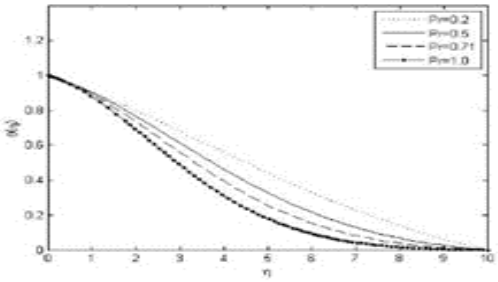


Fig.14 Temperature profiles for different values of *Pr*

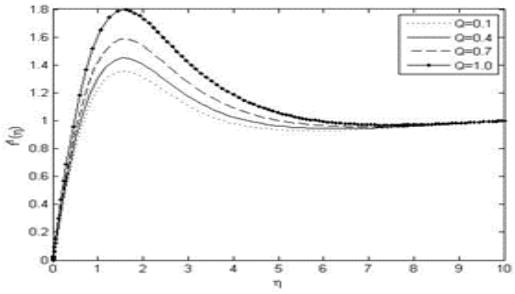


Fig. 15 Velocity profiles for different values of *Q*

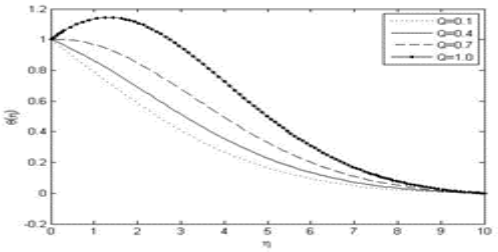


Fig. 16 Temperature profiles for different values of *Q*

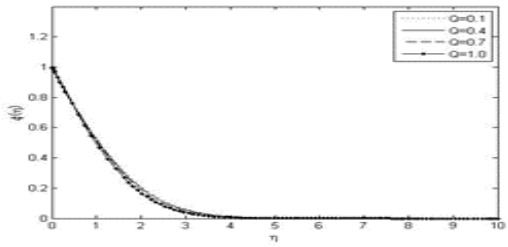


Fig. 17 Concentration profiles for different values of *Q*

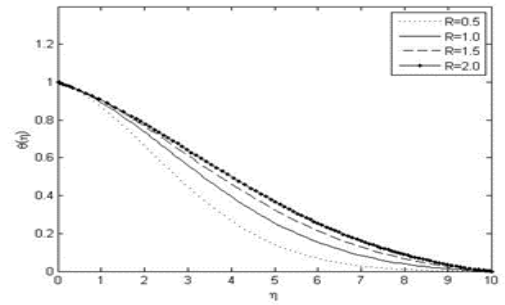


Fig. 18 Velocity profiles for different values of *R*

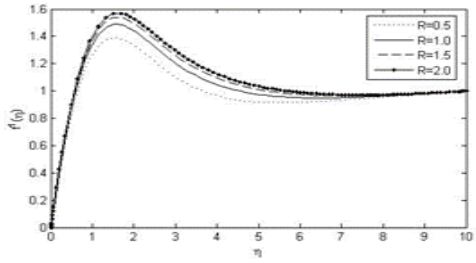


Fig. 19 Temperature profiles for different values of *R*

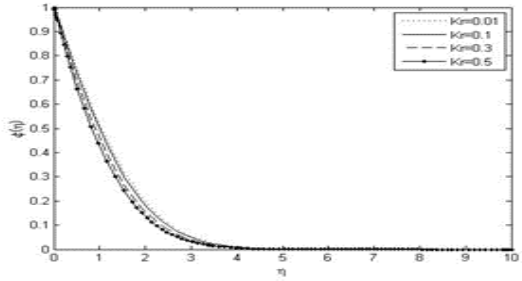


Fig. 20 Concentration profiles for different values of *Kr*

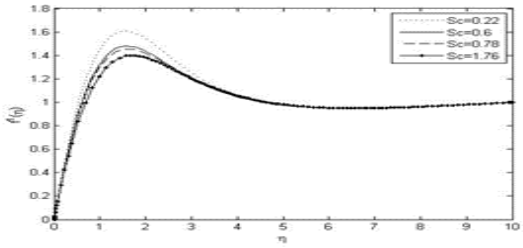


Fig. 21 Velocity profiles for different values of *Sc*

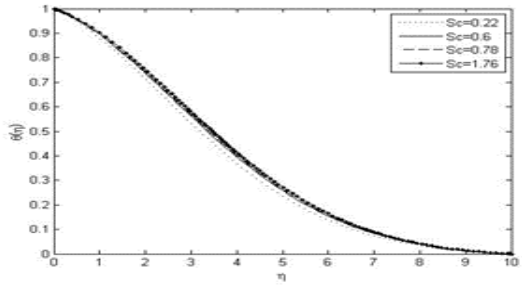


Fig. 22 Temperature profiles for different values of *Sc*

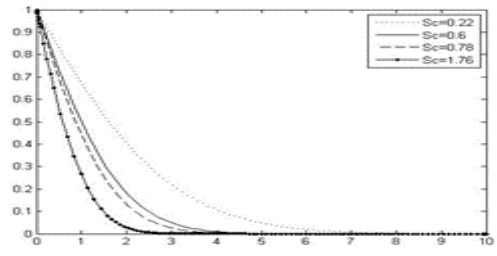


Fig. 23 Concentration profiles for different values of *Sc*

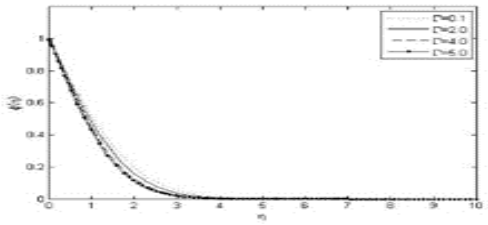


Fig. 24 Concentration profiles for different values of τ

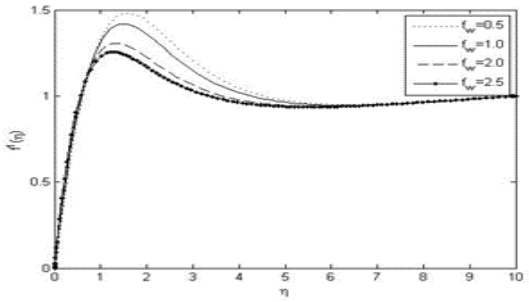


Fig. 25 Velocity profiles for different values of f_w

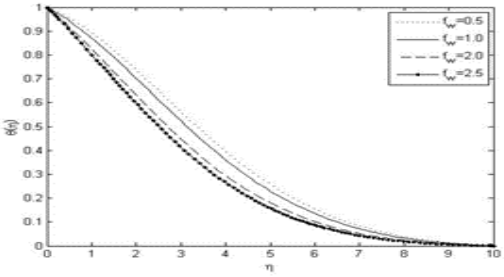


Fig. 26 Temperature profiles for different values of f_w

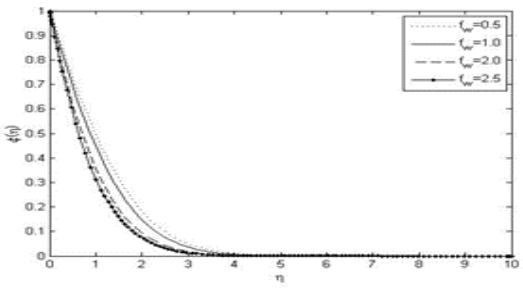


Fig. 27 Concentrations profiles for different values of f_w

Table 1: Numerical values of $f''(0)$, $-\theta'(0)$ and $-\varphi'(0)$ for Pr= 0.71, α=30^0, Q =0.5, R=1.0, f_w = 0.5, Kr=0.1, Sc = 0.6 τ = 0.1

Gc	*Gr*	*M*	*K*	f_w	$f''(0)$	$-\theta'(0)$	$-\varphi'(0)$
0.87	0.87	0.1	0.01	0.5	2.221793	0.074524	0.578133
2.0	0.87	0.1	0.01	0.5	2.899177	0.091296	0.605090
3.0	0.87	0.1	0.01	0.5	3.460697	0.103610	0.625349
5.0	0.87	0.1	0.01	0.5	4.508549	0.123744	0.659311
0.87	0.87	0.1	0.01	0.5	2.221793	0.074524	0.578133
0.87	2.0	0.1	0.01	0.5	3.356764	0.128842	0.639806
0.87	3.0	0.1	0.01	0.5	4.234310	0.159216	0.678375
0.87	5.0	0.1	0.01	0.5	5.801055	0.200977	0.735831
0.87	0.87	0.001	0.01	0.5	2.427690	0.097084	0.595850
0.87	0.87	0.01	0.01	0.5	2.407343	0.095025	0.594164

0.87	0.87	0.05	0.01	0.5	2.320923	0.085889	0.586849
0.87	0.87	0.1	0.01	0.5	2.221793	0.074524	0.578133
0.87	0.87	0.1	0.04	0.5	2.166794	0.067758	0.573137
0.87	0.87	0.1	0.08	0.5	2.098349	0.058820	0.566752
0.87	0.87	0.1	0.01	0.5	2.221793	0.074524	0.578133
0.87	0.87	0.1	0.01	1.0	2.402005	0.099446	0.678866
0.87	0.87	0.1	0.01	2.0	2.742168	0.153422	0.900122
0.87	0.87	0.1	0.01	2.5	2.903299	0.182384	1.019239

Table 2: Numerical values of $f''(0)$, $-\theta'(0)$ and $-\varphi'(0)$ for for $Gr = Gc = 0.87$, $M = 0.1$, $K = 0.01$, $\alpha = 30^0$, $f_w = 0.5$, $Kr = 0.1$, $Sc = 0.6$ $\tau = 0.1$.

Pr	*Q*	*R*	$f''(0)$	$-\theta'(0)$	$-\varphi'(0)$
0.2	0.5	1.0	2.347548	0.084355	0.546870
0.5	0.5	1.0	2.283498	0.075632	0.538743
0.71	0.5	1.0	2.236659	0.075288	0.533045
1.0	0.5	1.0	2.179124	0.077419	0.526031
0.71	0.1	1.0	2.088310	0.208997	0.524009
0.71	0.4	1.0	2.192459	0.113759	0.530353
0.71	0.7	1.0	2.345613	0.016754	0.539547
0.71	1.0	1.0	2.585153	0.214642	0.552725
0.71	0.5	0.5	2.147838	0.079146	0.522170
0.71	0.5	1.0	2.236659	0.075288	0.533045
0.71	0.5	1.5	2.281870	0.075569	0.538544
0.71	0.5	2.0	2.307403	0.077189	0.541692

Table 3: Numerical values of $f''(0)$, $\theta'(0)$ and $-\varphi'(0)$ for $Gr = Gc = 0.87$, $M = 0.1$, $K = 0.01$, $\alpha = 30^0$, $Pr = 0.71$, $Q = 0.5$, $R = 1.0$, $f_w = 0.5$

Kr	*Sc*	τ	$f''(0)$	$-\theta'(0)$	$-\varphi'(0)$
0.01	0.6	0.1	2.236659	0.075288	0.533045
0.1	0.6	0.1	2.221793	0.074524	0.578133
0.3	0.6	0.1	2.193005	0.073073	0.670121
0.5	0.6	0.1	2.168782	0.071884	0.753061
0.1	0.22	0.1	2.391037	0.088190	0.349239
0.1	0.6	0.1	2.221793	0.074524	0.578133
0.1	0.78	0.1	2.179728	0.071962	0.661986
0.1	1.76	0.1	2.056207	0.066037	1.030045
0.1	0.6	0.1	2.236659	0.075288	0.533045
0.1	0.6	2.0	2.208092	0.073471	0.572966
0.1	0.6	4.0	2.180499	0.071851	0.618500
0.1	0.6	5.0	2.167510	0.071144	0.642471

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UTILIZING DATA MINING TECHNIQUES FOR PREDICTING STUDENTS' ACADEMIC PERFORMANCE

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Abstract: In the real life of higher education, predicting students' academic performance remains a significant challenge. Employing statistical tools and data mining techniques has become essential to analyse and forecast students' paths through the educational process. This paper explores the utilization of data mining techniques, specifically focusing on the WEKA data mining software, to predict semester-wise student marks based on parameters within a given dataset. The dataset encompasses information from students across five courses within a single college over multiple semesters. By using data mining methodologies, educators can uncover hidden patterns within student data, facilitating a deeper understanding of the factors influencing academic success. This paper discusses the application of data mining techniques as a means to discover valuable insights and improve decision-making processes within the educational domain.

Keywords: Data mining techniques, WEKA tool, Clustering methods: Canopy, EM, Hierarchical, Simple-k means.

INTRODUCTION

Data mining is becoming a critical component in educational institutions and one of the most important areas of research, with the goal of extracting valuable information from large data sets. Educational data mining (EDM) is an essential study area that can help anticipate meaningful information from educational databases in order to improve educational performance, knowledge, and assessment of students' learning processes. Data mining, also known as knowledge discovery, is becoming increasingly important since it aids in the analysis of data from many viewpoints and its summarization into meaningful information.

1. What is Data Mining?

Data Mining is the process of extracting information from large amounts of data to uncover patterns, trends, and usable data that will help a business entity to make data-driven decisions.
Data mining is the process of automatically examining enormous amounts of information to discover trends and patterns that go beyond simple analysis techniques.
Data mining employs complex mathematical algorithms to analyze data segments and determine the likelihood of future events. Data mining is also known as Knowledge Discovery ofData(KDD).
Data mining is a procedure used by corporations to extract specific data from large datasets in order to address business challenges. It primarily converts raw data to useable knowledge.

Data Mining is related to Data Science in that it is performed by a person in a specific scenario, on a specific data collection, with a goal in mind. This process involves a variety of services, including text mining, web mining, audio and video mining, graphical data mining, and social media mining. It is accomplished with software that is either simple or highly specific. Outsourcing data mining allows for speedier completion of tasks while keeping operational expenses low. Specialized businesses can also employ new technology to obtain data that is impossible to find manually. There is a wealth of material available across multiple platforms, but relatively little knowledge is accessible. The most difficult challenge is to analyze the data and extract critical information that can be used to address a problem.



2. Data Mining Techniques:

Data mining is the use of sophisticated data analysis technologies to discover previously undiscovered, valid patterns and relationships in large data collections. These technologies can use statistical models, machine learning approaches, and mathematical algorithms like neural networks or decision trees. Thus, data mining includes both analysis and prediction.Professionals in data mining have dedicated their careers to better understanding how to process and draw conclusions from massive amounts of data, but what methods do they use to accomplishthis?

Association, classification, clustering, prediction, sequential patterns, and regression are some of the primary data mining techniques developed and employed in recent projects.



Classification technique:

This strategy is used to gather crucial and relevant data and metadata. This data mining technique aids in classifying data into several categories.
Data mining techniques can be classed using several criteria, as follows:
Data mining frameworks are classified based on the types of data sources mined.
This classification is based on the type of data handled. Examples include multimedia, spatial data, text data, time series data, and the World Wide Web.
Data mining frameworks are classified based on the database involved.
The classification is based on the data model used. For example. There are several types of databases, including object-oriented, transactional, and relational.

Classification of data mining frameworks according to the type of knowledge discovered:This classification is based on the sorts of knowledge obtained or data mining functionalities, such as discrimination, classification, clustering, and characterisation. Some frameworks are comprehensive and provide a variety of data mining features.
Classification of data mining frameworks based on approaches used:This classification is based on the data analysis approach used, such as neural networks, machine learning, genetic algorithms, visualization, statistics, data warehouse- or database-oriented, and so on.
The classification might also consider the extent of user participation engaged in the data mining process, such as query-driven systems, autonomous systems, or interactive exploratory systems.

2.Clustering:

Clustering is the partitioning of information into groups of interconnected things. Describing the data by a few clusters loses some specific details but improves overall performance. It models data using clusters. Data modelling approaches clustering from a historical perspective based on statistics, mathematics, and numerical analysis. Clusters are hidden patterns in machine learning, the search for clusters is unsupervised learning, and the architecture that follows is a data idea. Clustering performs exceptionally well in data mining applications. Examples include scientific data exploration, text mining, information retrieval, spatial database applications, CRM, web analysis, computational biology, medical diagnostics, and much more. In other words, clustering analysis is data.

3.Regression:

Regression analysis is a data mining procedure that identifies and analyzes the relationship between variables based on the existence of another factor. It is used to specify the likelihood of a particular variable. Regression is basically a method of

planning and modelling. For example, we may use it to forecast specific costs based on other variables such as availability, consumer demand, and competitiveness. It provides the exact link between two or more variables in a given data collection.

4. Association Rules:

This data mining technique aids in the discovery of a relationship between two or more things. It identifies a hidden pattern in the dataset.
Association rules are if-then statements that help to illustrate the likelihood of interactions between data items inside huge data sets in various types of databases. Association rule mining offers a variety of uses, including improving sales correlations in data or medical data sets.The algorithm works by assuming you have a variety of data. For example, make a list of the groceries goods you've purchased throughout the last six months. It measures the percentage of products purchased together. There are three main measurement techniques:

o Lift:

This measurement technique measures the accuracy of the confidence over how often item B is purchased.

(Confidence) / (item B)/ (Entire dataset) o Support:

This measurement technique measures how often multiple items are purchased and compared it to the overall dataset.

(Item A + Item B) / (Entire dataset) o Confidence:

This measurement technique measures how often item B is purchased when item A is purchased as well.

(Item A + Item B)/ (Item A)

5.Outer detection:

This type of data mining technique relates to the observation of data items in the data set, which do not match an expected pattern or expected behaviour. This technique may be used in various domains like intrusion, detection, fraud detection, etc. It is also known as Outlier analysis or outlier mining. The outlier is a data point that diverges too much from the rest of the dataset. The majority of the real-world datasets have an outlier. Outlier detection plays a significant role in the data mining field. Outlier detection is valuable in numerous fields like network interruption identification, credit or debit card fraud detection, detecting outlying in wireless sensor network data, etc.

6.Sequential Patterns:

The sequential pattern is a data mining technique that focuses on assessing sequential data in order to identify sequential patterns. It entails identifying interesting subsequences within a set of sequences, with the value of a sequence quantified using several parameters such as length, occurrence frequency, and so on. In other words, this data mining technique aids in the discovery or recognition of repeatable patterns in transaction data over time.
7.Prediction:

Prediction used a combination of other data mining techniques such as trends, clustering, classification, etc. It analyses past events or instances in the right sequence to predict a future event.

3. Advantages of Data Mining:

The Data Mining technique enables organizations to obtain knowledge-based data.

Data mining enables organizations to make lucrative modifications in operation and production.

Compared with other statistical data applications, data mining is a cost-efficient. o Data Mining helps the decision-making process of an organization.

It Facilitates the automated discovery of hidden patterns as well as the prediction of trends and behaviour.

It can be induced in the new system as well as the existing platforms.

It is a quick process that makes it easy for new users to analyse enormous amounts of data in a short time.

4 Data Mining Applications:

Data mining is generally utilized by businesses with high consumer demands, such as retail, communication, finance, and marketing firms, to assess pricing, consumer preferences, product placement, and the influence on sales, customer happiness, and corporate profitability. Data mining allows a shop to use point-of-sale records of client purchases to create items and promotions that will assist the company attract customers.

Weka Data Mining

Weka contains a collection of visualization tools and algorithms for data analysis and predictive modelling, together with graphical user interfaces for easy access to these functions. The original non-Java version of Weka was a Tcl/Tk front-end to (mostly third-party) modelling algorithms implemented in other programming languages, plus data preprocessing utilities in C and a make file-based system for running machine learning experiments.

This original version was primarily designed as a tool for analysing data from agricultural domains. Still, the more recent fully Java-based version (Weka 3), developed in 1997, is now used in many different application areas, particularly for educational purposes and research. Weka has the following advantages, such as:Free availability under the GNU General Public License.

Portability, since it is fully implemented in the Java programming language and thus runs on almost any modern computing platform.

A comprehensive collection of data and modelling techniques.

Ease of use due to its graphical user interfaces.

Weka supports several standard data mining tasks, specifically, data preprocessing, clustering, classification, regression, visualization, and feature selection. Input to Weka is expected to be formatted according to the Attribute-Relational File Format and filename with the arff extension.

All Weka's techniques are predicated on the assumption that the data is available as one flat file or relation, where a fixed number of attributes describes each data point (numeric or nominal attributes, but also supports some other attribute types). Weka provides access to SQL databases using Java Database Connectivity and can process the result returned by a database query. Weka provides access to deep learning with Deeplearning4j.

It is not capable of multi-relational data mining. Still, there is separate software for converting a collection of linked database tables into a single table suitable for processing using Weka. Another important area currently not covered by the algorithms included the Weka distribution in sequence modelling.

Farthest First

Farthest first find its variant of k-means, each cluster centre point furthermost from the existing cluster centre is placed by the k mean and this point must be positioned within the data area. So that it greatly speeds up the clustering in most cases but it needs less move and adjustment for their fast performance. It uses heuristic approach for finding its points. It's arbitrary point is p1, pick an another point p2 far from p1, pick pi to maximize the distance to the nearest of all centroid, the maximize the min dist(pi, p1), dist(pi,p2),...}.After all K representatives are chosen then we define the partition of data area D: cluster is Cj consists of all points closer to pj than to any other representative.

Filtered Cluster

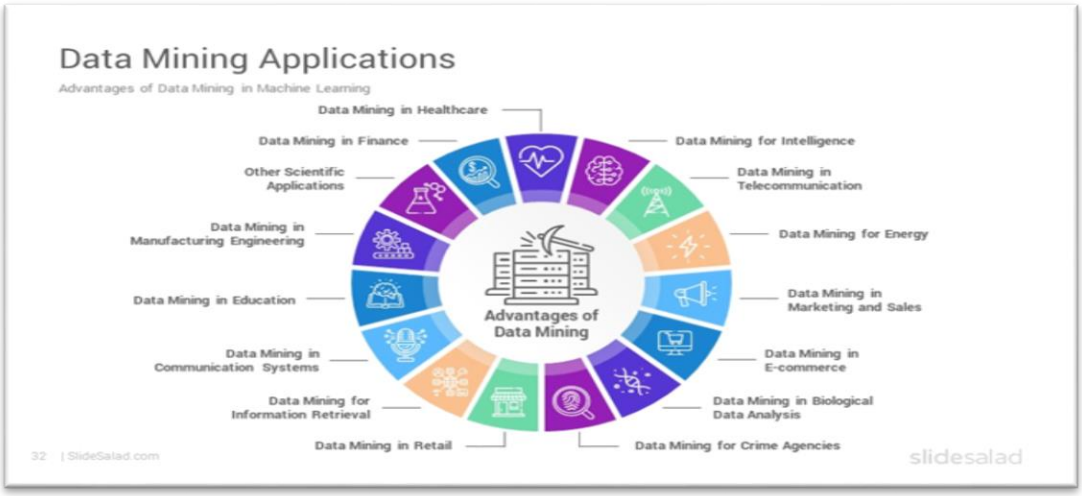
The filtered cluster algorithm is based on storing the multidimensional data points in a kd-tree. The process of the tree is like a binary tree approach, which represents a hierarchical subdivision of its data point set's bounding box using their axis and then splitting is aligned by hyperplanes. Each node of the kd-tree is associated with a closed box, called cell. The root's cell is the bounding box of the point in the dataset. If the cell contains at most one point, then it is declared to be a leaf. Then the finding points in the cell are then partitioned to one side or the other of this hyper plane. The resulting sub cells are the children of the original cell, this leads to a binary tree structure

Density Based Cluster

The DBSCAN is Density-Based clustering algorithms to find clusters based on density of data points in a region and it use only one input parameter for their process so minimal knowledge is required. Density-Based clustering is that for each instance of a cluster the neighbourhood of a given radius (Eps) has to contain at least a minimum number of instances (Min Pts). DBSCAN separates data points into three classes: 1) Core points: points the interior of a cluster, 2) Border points: points neighbourhood of a core point, 3) Noise points: points which is not a core point or a border point. To find a cluster, DBSCAN starts with an arbitrary instance (p) in data set (D) and retrieves all instances of D with respect to Eps and Min Pts.

Canopy Algorithm

Canopy Clustering is a very simple, fast and surprisingly accurate method for grouping objects into clusters. All objects are represented as a point in a multidimensional feature space. The algorithm uses a fast-approximate distance metric and two distance thresholds T1 > T2 for processing. The basic algorithm is to begin with a set of points and remove one at random. Create a Canopy containing this point and iterate through the remainder of the point set. At each point, if its distance from the first point is < T1, then add the point to the cluster. If, in addition, the distance is < T2, then remove the point from the set. This way points that are very close to the original will avoid all further processing. The algorithm loops until the initial set is empty, accumulating a set of Canopies, each containing one or more points. A given point may occur in more than one Canopy. Canopy Clustering is often used as an initial step in more rigorous clustering techniques, such as K-Means Clustering . By starting with an initial clustering, the number of more expensive distance measurements can be significantly reduced by ignoring points outside of the initial canopies.



5. Data mining in Education:

Education data mining is a new subject that focuses on developing tools to extract knowledge from data created in educational environments. EDM objectives are identified as validating students' future learning behaviours, researching the impact of educational support, and advancing learning sciences. Data mining may help an organization make precise decisions as well as forecast student outcomes. With the results, the school may focus on what and how to teach.



METHODOLOGY

There are numerous Machine learning algorithms in the literature and some of the important and popular algorithms based on Clustering.

1. Canopy clustering:

Canopy Clustering is a very simple, fast and surprisingly accurate method for grouping objects into clusters. All objects are represented as a point in a multidimensional feature space. The algorithm uses a fast-approximate distance metric and two distance thresholds T1 > T2 for processing.

Step-1: Go to WEKA software

Step-2: Select data by using open file.

Step-3: Go to cluster and select Canopy from choose option.

Step-4: Click start button to run the program.

2. EM Clustering:

For clustering, EM makes use of the finite Gaussian mixtures model and estimates a set of parameters iteratively until a desired convergence value is achieved.

Step-1: Go to WEKA software

Step-2: Select data by using open file.

Step-3: Go to cluster and select EM from choose option.

Step-4: Click start button to run the program.

3. Hierarchical Clustering:

Hierarchical clustering is mainly focussing on building of hierarchy of clusters, i.e., cluster tree and it is represented in a dendrogram. It is either merging smaller clusters into larger clusters or splitting larger clusters into smaller ones. A clustering of the data items is obtained through cutting a dendrogram at a desired level.

Step-1: Go to WEKA software

Step-2: Select data by using open file.

Step-3: Go to cluster and select Hierarchical from choose option.

Step-4: Click start button to run the program.

4. Simple-k means clustering:

K-means clustering is a simple unsupervised learning algorithm. In this, the data objects (‘n’) are grouped into a total of ‘k’ clusters, with each observation belonging to the cluster with the closest mean. It defines ‘k’ sets, one for each cluster k n (the point can be thought of as the centre of a one or two-dimensional figure). The clusters are separated by a large distance.

Step-1: Go to WEKA software

Step-2: Select data by using open file.

Step-3: Go to cluster and select simple k means from choose option.

Step-4: Click start button to run the program.

BACKGROUND

Here is the background tool required for our project.

We have used a data mining software named as WEKA for this project.

Required Software (WEKA) –

What is WEKA?

WEKA (Waikato Environment for Knowledge) Analysis it's a data mining/machine learning tool developed by Department of Computer Science, University of Waikato, New Zealand.

History of WEKA

In 1993, the University of Waikato in New Zealand began the development of the original version of Weka, which became a mix of Tcl/Tk, C, and make files.

In 1997, the decision was made to redevelop Weka from scratch in Java, including implementing modelling algorithms.

In 2005, Weka received the SIGKDD Data Mining and Knowledge Discovery Service Award.

In 2006, Pentaho Corporation acquired an exclusive licence to use Weka for business intelligence. It forms the data mining and predictive analytics component of the Pentaho business intelligence suite. Hitachi Vantara has since acquired Pentaho, and Weka now underpins the PMI (Plugin for Machine Intelligence) open-source component.

Features of Weka:



Weka has the following features, such as:

Preprocess:

Preprocessing data is a critical step in data mining. Because the majority of the data is raw, there is a possibility that it contains empty or duplicate entries, junk values, outliers, extra columns, or a different naming convention. All of this degrades the outcomes.
To make data cleaner, better, and more thorough, WEKA provides a broad set of filter choices. The tool supports both supervised and unsupervised activities. Here is a list of some operations for preprocessing.
Replace Missing with User Constant: to resolve the empty or null value issue.
Reservoir Sample: create a random subset of sample data.
Nominal to Binary: Converting data from nominal to binary.
Remove Percentage: To remove

Classify:

One of the most important activities in machine learning is classification, which involves assigning classes or categories to things. Classic examples of classification include labeling a brain tumor as "malignant" or "benign" or categorizing an email as "spam" or "not spam."
Following the selection of the appropriate classifier, we choose test choices for the training set. Some of the alternatives include:
Use the training set: the classifier will be tested using the same training set.
A given test set evaluates the classifier using a separate test set.
Cross-validation Folds: The classifier's performance is evaluated using cross-validation and the number of folds provided.
proportion split: The classifier will be evaluated using a given proportion of the data.
Aside from these, we can also utilize more testing options.

Cluster:

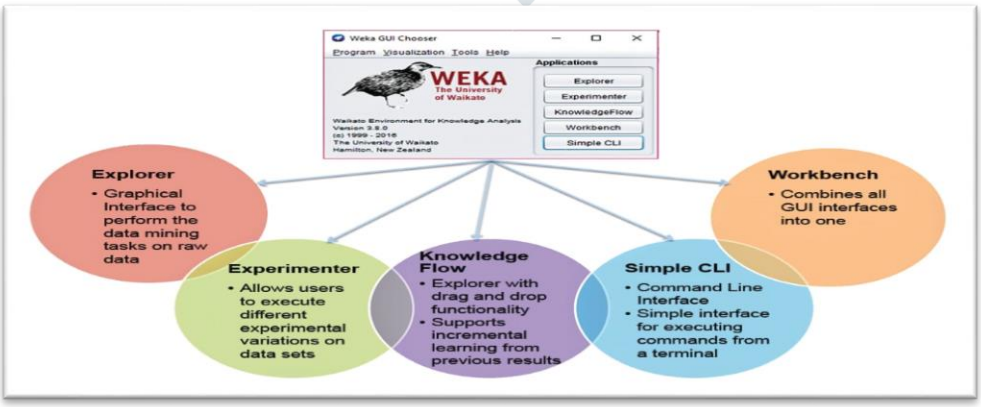
Clustering divides a dataset into groups/clusters based on certain commonalities. In this scenario, the items in the same cluster are identical but distinct from those in other clusters. Clustering can be defined as identifying customers who exhibit similar behaviors and arranging regions based on homogeneous land use.

Associate:

Association rules emphasize all of the relationships and connections between elements in a dataset. In a nutshell, it is an if-then expression that represents the likelihood of associations between data points. A typical example of association is the connection between the selling of milk and bread.
For association rule mining in this category, the tool includes the Apriori, Filtered Associator, and FP Growth algorithms.

Select Attributes:

Every dataset contains many attributes, yet some of them may not be particularly valuable. As a result, reducing extraneous details while retaining vital ones is critical for creating a good model.
Many attribute evaluators and search algorithms exist, including Best First, Greedy Stepwise, and Ranker.
Visualize:
The visualization tab contains a variety of plot matrices and graphs that display the model's discovered trends and mistakes.
Weka Requirements and Installation
We can install WEKA on Windows, Mac OS, and Linux. The current stable versions of Weka require at least Java 8 or above.



Main GUI, Five graphical user interfaces

"The Explorer" (exploratory data analysis)

"The Experimenter" (experimental environment)

"The Knowledge Flow" (new process model inspired interface)

Workbench

Simple CLI (Command prompt)

Offers some functionality not available via the GUI

Explorer:

The WEKA Explorer windows show different tabs starting with preprocessing. Initially, the preprocess tab is active, as first the data set is pre-processed before applying algorithms to it and exploring the dataset.

The tabs are as follows:

Preprocess: Choose and modify the loaded data.

Classify: Apply training and testing algorithms to the data that will classify and regress the data.

Cluster: Form clusters from the data.

Associate: Mine out the association rule for the data.

Select attributes: Attribute selection measures are applied.

Visualize: 2D representation of data is seen.

Status Bar: The bottommost section of the window shows the status bar. This section shows what is happening currently in the form of a message, such as a file being loaded. Right-click on this, Memory information can be seen, and also Run garbage collector to free up space can be run.

Log Button: It stores a log of all actions in Weka with the timestamp. Logs are shown in a separate window when the Log button is clicked.

WEKA Bird Icon: Present on the bottom right corner shows the WEKA bird with represents the number of processes running concurrently (by x.). When the process is running the bird will move around.

Experimenter:

The WEKA experimenter button allows the users to create, run, and modify different schemes in one experiment on a dataset. The experimenter has 2 types of configurations: Simple and Advanced. Both configurations allow users to run experiments locally and on remote computers.

The “Open” and “New” buttons will open a new experiment window that users can do.

Results: Set the result destination file from ARFF, JDFC, and CSV files.

Experiment Type: The user can choose between cross-validation and train/test.

percentage split: The user can choose between Classification and Regression-based upon the dataset and classifier used.

Datasets: The user can browse and select datasets from here. The relative path checkbox is clicked if working on different machines. The format of datasets supported is ARFF, C4.5, CSV, libsvm, bsi, and XRFF.

Iteration: The default iteration number is set to 10. Datasets first and algorithms first help in switching between dataset and algorithms so that algorithms can be run on all datasets.

Algorithms: New algorithms are added by “New Button”. The user can choose a classifier.

Save the experiment using the Save button.Run the experiment using the Run button.

Knowledge flow:

Knowledge flow shows a graphical representation of WEKA algorithms. The user can select the components and create a workflow to analyze the datasets. The data can be handled batch-wise or incrementally. Parallel workflows can be designed and each will run in a separate thread.

Weka Workbench:

The Weka Workbench is an environment that combines all of the GUI interfaces into a single interface.

It is useful if you find yourself jumping a lot between two or more different interfaces, such as between the Explorer and the Experiment Environment. This can happen if you try out a lot of what ifs in the Explorer and quickly take what you learn and put it into controlled experiments.

Weka Simple CLI:

Weka can be used from a simple Command Line Interface (CLI).

This is powerful because you can write shell scripts to use the full API from command line calls with parameters, allowing you to build models, run experiments and make predictions without a graphical user interface.

The Simple CLI provides an environment where you can quickly and easily experiment with the Weka command line interface commands.

The different components available are Data sources, Data savers, Filters, Classifiers, Clusters, Evaluation, and Visualization.

DESIGN AND IMPLEMENTATION

The following are the step-by-step process of our project evaluation.

Collection of data: We have a collected a data set contains the result of students of overall semesters. The data set contains 255 instances and 14 attributes.

Here is the sample of our data set which is in entered in MS-Excel and saved in 'CSV' format.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Sl. no	Gender	Place of study	Name of the student	Course	Hall ticket number	Semester -1	Semester -2	Semester-3	Semester -4	Semester -5	Semester -6	Total	Result
2	1	F	Tirupati	K.Ahalya	MPC	319003109	97	97	99	91	96	97	577	OUT STANDING
3	2	F	Tirupati	S.Anusha	MPC	319003110	74	72	93	83	83	89	494	EXCELLENT
4	3	F	Tirupati	A.Aswini	MPC	319003111	70	91	90	86	86	86	509	OUT STANDING
5	4	F	Tirupati	Y.Bhargavi	MPC	319003112	79	81	89	82	84	88	503	OUT STANDING
6	5	F	Tirupati	N.Chandrakala	MPC	319003113	73	76	89	82	80	86	486	EXCELLENT
7	6	F	Tirupati	P.Chennakrishnamma	MPC	319003114	93	92	92	97	87	90	551	OUT STANDING
8	7	F	Tirupati	D.Gayatri	MPC	319003115	96	88	94	84	90	88	540	OUT STANDING
9	8	F	Tirupati	P.Geetha	MPC	319003116	35	79	86	77	76	85	438	EXCELLENT
10	9	F	Tirupati	K.Geethapriya	MPC	319003117	65	35	76	71	35	77	359	GOOD
11	10	F	Tirupati	E.Haritha	MPC	319003118	88	81	89	88	85	84	515	OUT STANDING
12	11	F	Tirupati	P.Haseena	MPC	319003119	88	84	92	92	92	95	543	OUT STANDING
13	12	F	Tirupati	G.Janaki	MPC	319003120	93	95	91	85	86	89	539	OUT STANDING
14	13	F	Tirupati	M.Jyothi	MPC	319003121	77	81	87	79	75	82	481	EXCELLENT
15	14	F	Tirupati	L.Kalyani	MPC	319003122	94	88	92	91	96	91	552	OUT STANDING
16	15	F	Tirupati	V.Kaveri	MPC	319003123	79	83	90	83	84	84	503	OUT STANDING
17	16	F	Tirupati	T.Kavya	MPC	319003124	82	87	90	84	82	84	509	OUT STANDING
18	17	F	Tirupati	P.Krishna kumari	MPC	319003125	35	35	71	35	65	79	320	GOOD
19	18	F	Tirupati	B.Lakshmi	MPC	319003126	96	97	93	91	93	91	561	OUT STANDING
20	19	F	Tirupati	S.Latha	MPC	319003127	93	93	91	87	97	88	549	OUT STANDING
21	20	F	Tirupati	S.Madhavi	MPC	319003128	88	80	91	85	90	86	520	OUT STANDING
22	21	F	Tirupati	T.Navaneetha	MPC	319003129	89	87	92	87	93	93	541	OUT STANDING
23	22	F	Tirupati	P.Nikhitha	MPC	319003130	82	90	90	83	86	92	523	OUT STANDING
24	23	F	Tirupati	V.Nikhitha	MPC	319003131	75	87	93	90	88	90	523	OUT STANDING
25	24	F	Tirupati	M.Pavani	MPC	319003132	87	87	91	85	88	93	531	OUT STANDING
26	25	F	Tirupati	M.Poornamma	MPC	319003133	82	76	88	90	86	91	513	OUT STANDING
27	26	F	Tirupati	R.Ramya	MPC	319003134	98	91	94	90	96	97	566	OUT STANDING
28	27	F	Tirupati	J.Ramya	MPC	319003135	73	74	90	90	76	87	470	EXCELLENT

Preprocessing:

Data Pre-processing is the first step of evaluation of this paper. Now we will choose WEKA Explorer interface. Here the source data file is selected from local machine. After loading the data in explorer, we can refine the data by selecting different options which is known as 'data cleaning' and can also select or remove attributes as per our need

It's the nut shell about WEKA and its application in education system

CLUSTER ANALYSIS IN WEKA TOOL

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense) to each other than to those in other groups (clusters). It is a main task of exploratorydata mining, and a common technique for statistical data analysis, used in many fields, including pattern recognition,image analysis, information retrieval, bioinformatics, data compression, computer graphics and machine learning.

Besides the term clustering, there are a number of terms with similar meanings, including automatic classification, numerical taxonomy, bornology, typological analysis, and community detection. The subtle differences are often in the use of the results: while in data mining, the resulting groups are the matter of interest, in automatic classification the resulting discriminative power is of interest.

Cluster Algorithm using WEKA tool

Clustering is a task for which many algorithms have been proposed. No clustering technique is Universally applicable, and different techniques are in favour for different clustering purposes.

So, an understanding of both the clustering problem and the clustering technique is required to Apply a suitable method to a given problem. In the following, I describe general of a Clustering technique algorithm in weak tool show in figure.

Clustering is the method of dividing a set of abstract objects into groups. Points to Keep in Mind A set of data objects can be viewed as a single entity. When performing cluster analysis, we divide the data set into groups based on data similarity, then assign labels to the groups.

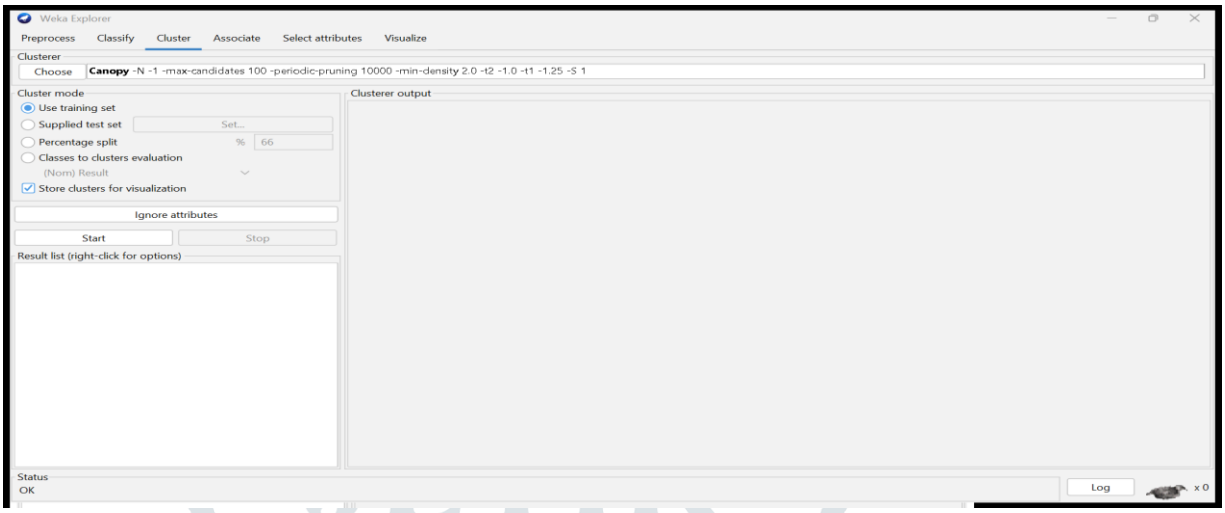
COMWEB Algorithm:

COBWEB is an incremental system for hierarchical conceptual clustering. COBWEB was invented by Professor Douglas H. Fisher, currently at Vanderbilt University. COBWEB incrementally organizes observations into a classification tree. Each node in a classification tree represents a class (concept) and is labelled by a probabilistic concept that summarizes the attribute-value distributions of objects classified under the node. This classification tree can be used to predict missing attributes or the class of a new object.

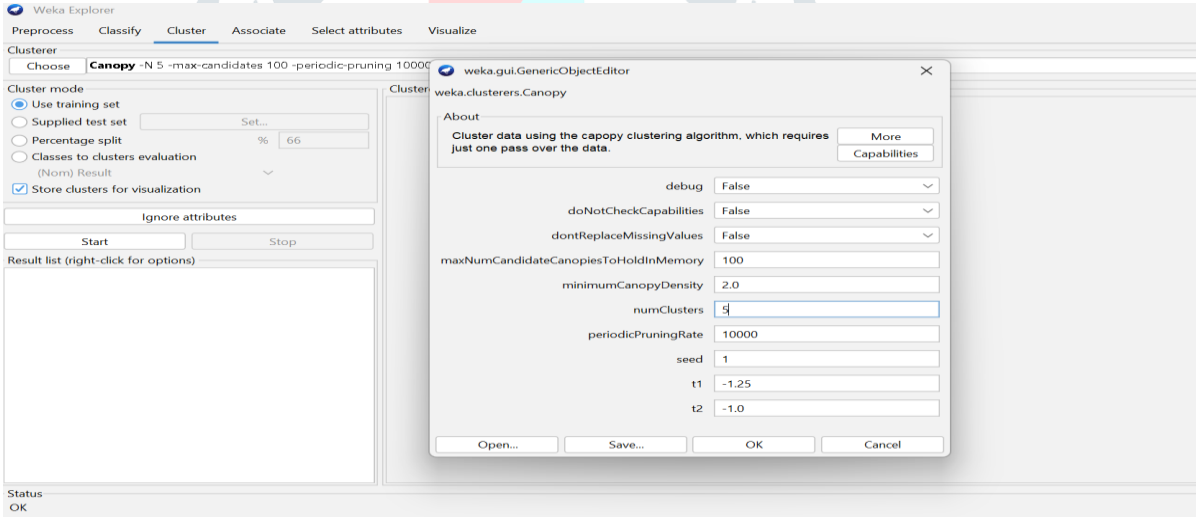
Steps to be followed:

Step 1: In the preprocessing interface, open the Weka Explorer and load the required dataset, and we are taking the scheme. raff dataset.

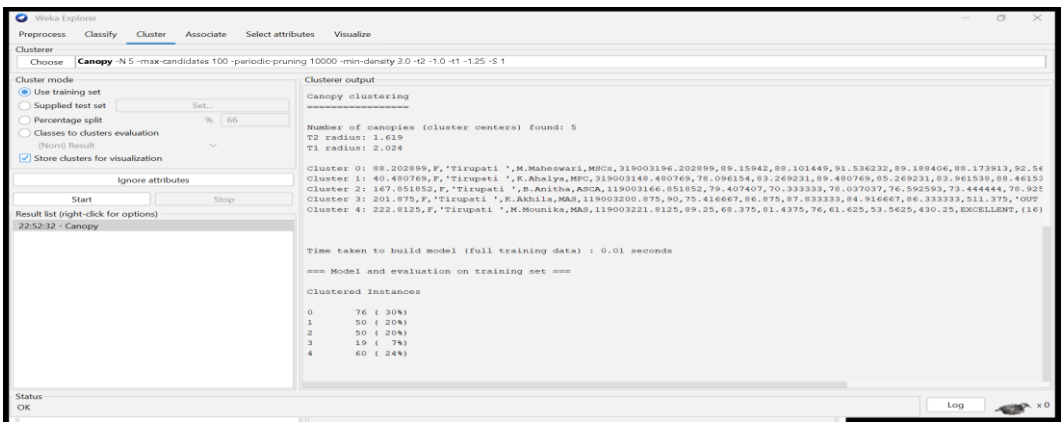
Step 2: Find the 'cluster' tab in the explorer and press the choose button to execute clustering. A dropdown list of available clustering algorithms appears as a result of this step and selects the canopy algorithm.



Step 3: Then, to the right of the choose icon, press the text button to bring up the popup window. We enter five for the number of clusters in this window and the seed value is one. The seed value is used to generate a random number that is used to make internal assignments of instances of clusters.

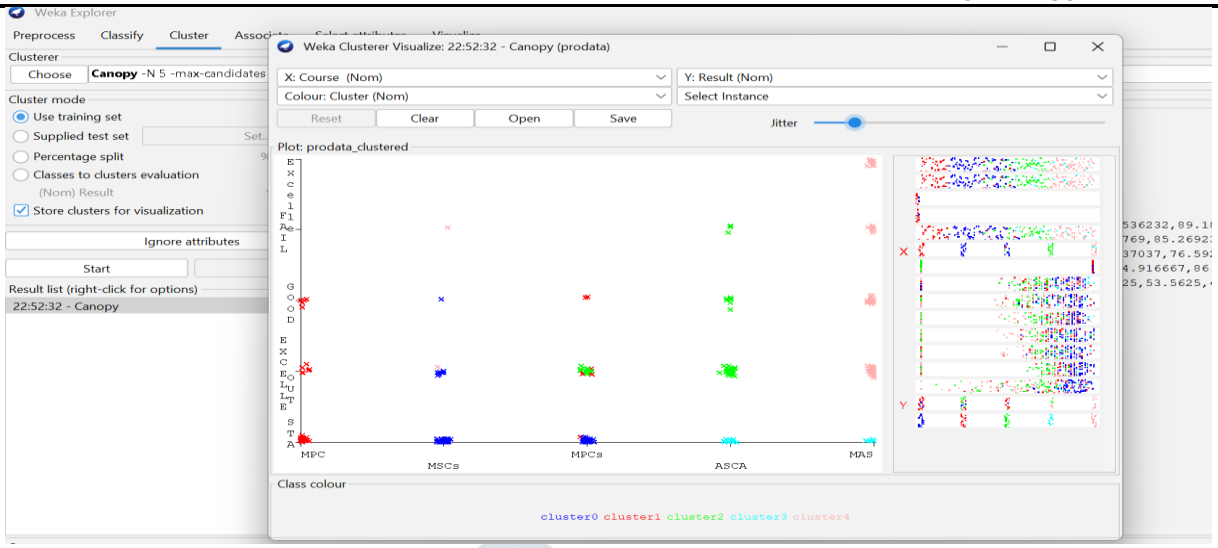


Step 4: One of the choices has been chosen. We must ensure that they are in the 'cluster mode' panel before running the clustering algorithm. The choice to use a training set is selected, and then the 'start' button is pressed.



The centroid of each cluster is shown in the result window, along with statistics on the number and percent of instances allocated to each cluster. Each cluster centroid is represented by a mean vector. This cluster can be used to describe a cluster.

Step 6: Another way to grasp the characteristics of each cluster is to visualize them. To do so, right-click the result set on the result. Selecting to visualize cluster assignments from the list column.



Step 7: In the Cluster visualization we choose Course on X-axis and Result no on Y-axis. Blue colour shows Cluster 0, Red colour shows Cluster 1, Green colour shows Cluster 2, Sky-blue colour shows Cluster 3, Light pink colour shows Cluster 4.

Output:

This canopy algorithm is tested with project dataset in WEKA tool; it produces five different clustered instance clusters 0: 76(30%), cluster 1: 50(20%), cluster 2: 50(20%), cluster 3: 19(7%), cluster 4: 60(24%), and Time taken to build model (full training data): 0.01 seconds.

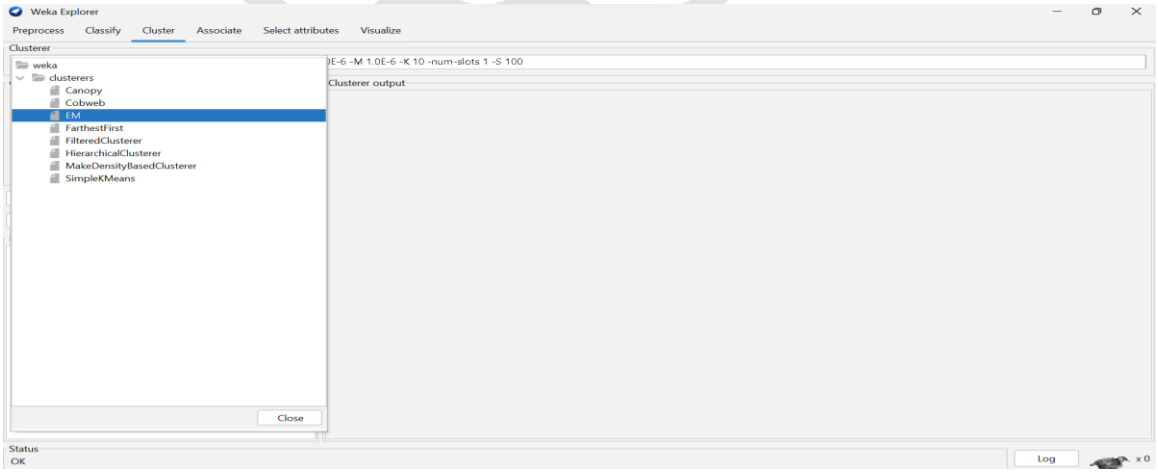
EM:

The EM algorithm (Dempster, Laird, & Rubin 1977) finds maximum likelihood estimates of parameters in probabilistic models. EM is an iterative method which alternates between two steps, expectation (E) and maximization (M). For clustering, EM makes use of the finite Gaussian mixtures model and estimates a set of parameters iteratively until a desired convergence value is achieved. The mixture is defined as a set of K probability distributions and each distribution corresponds to one cluster. An instance is assigned with a membership probability for each cluster.

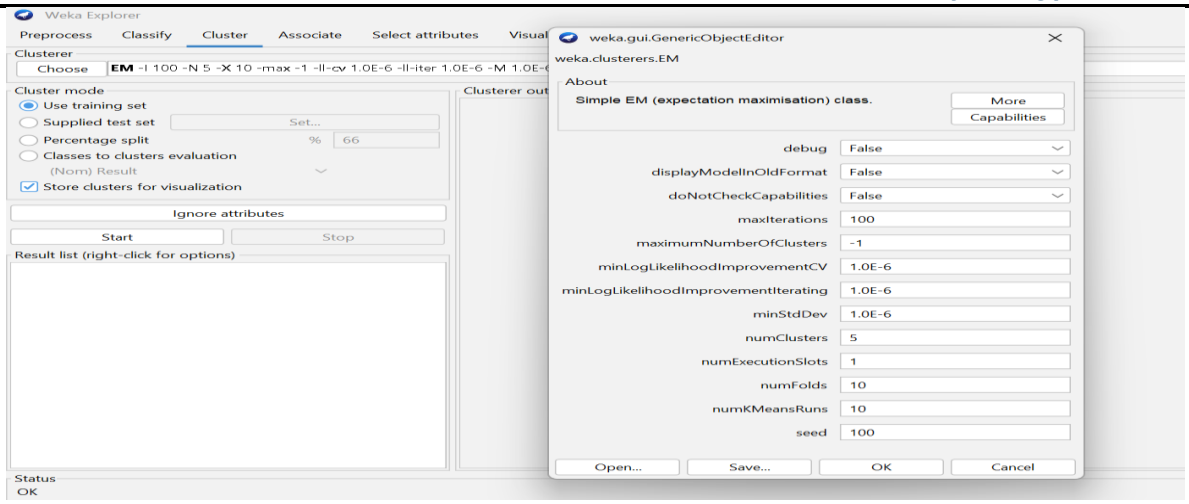
Steps to be followed:

Step 1: In the preprocessing interface, open the Weka Explorer and load the required dataset, and we are taking the project.arff dataset.

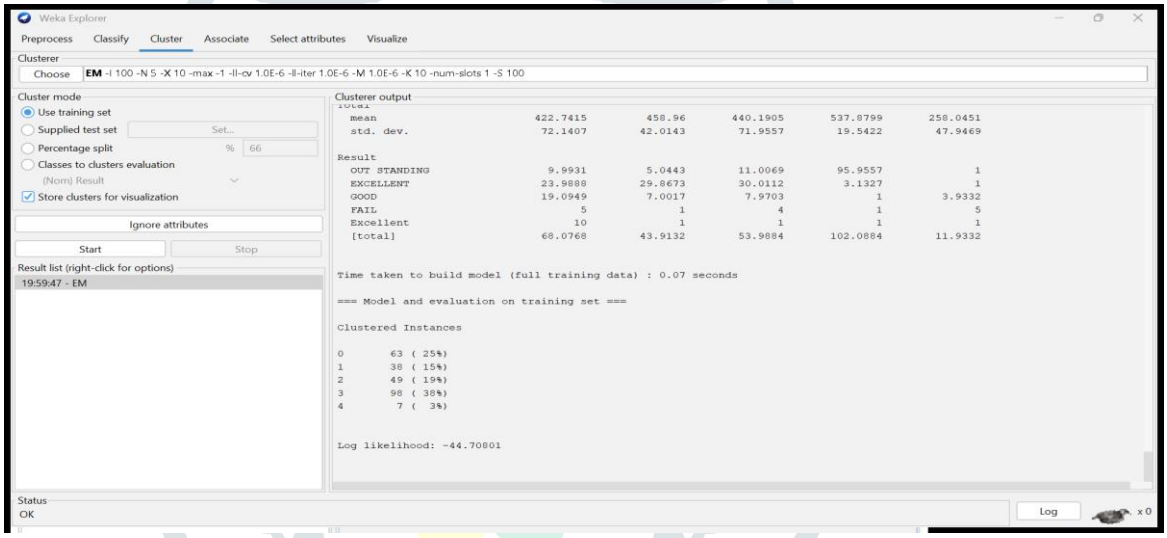
Step 2: Find the 'cluster' tab in the explorer and press the choose button to execute clustering. A dropdown list of available clustering algorithms appears as a result of this step and selects the EM algorithm.



Step 3: Then, to the right of the choose icon, press the text button to bring up the popup window. We enter five for the number of clusters in this window and the seed value is hundred. The seed value is used to generate a random number that is used to make internal assignments of instances of clusters.

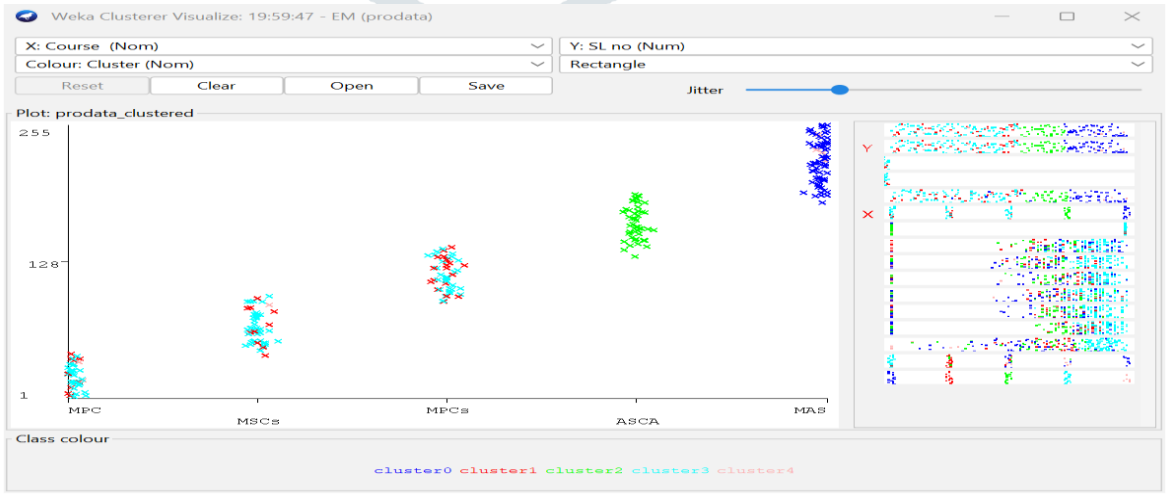


Step 4: One of the choices has been chosen. We must ensure that they are in the 'cluster mode' panel before running the clustering algorithm. The choice to use a training set is selected, and then the 'start' button is pressed.



Step 5: The centroid of each cluster is shown in the result window, along with statistics on the number and percent of instances allocated to each cluster. Each cluster centroid is represented by a mean vector. This cluster can be used to describe a cluster.

Step 6: Another way to grasp the characteristics of each cluster is to visualize them. To do so, right-click the result set on the result. Selecting to visualize cluster assignments from the list column.



Step 7: In the Cluster visualization we choose Course on X-axis and SL no on Y-axis.

Blue colour shows Cluster 0, Red colour shows Cluster 1, Green colour shows Cluster 2, Sky-blue colour shows Cluster 3, Light pink colour shows Cluster 4.

Output: This EM algorithm is tested with project dataset in WEKA tool. It produces five different clustered instance clusters 0: 63(25%), cluster 1: 38(15%), cluster 2: 49(19%), cluster 3: 98(38%), cluster 4: 7(3%), and Time taken to build model (full training data): 0.01 seconds.

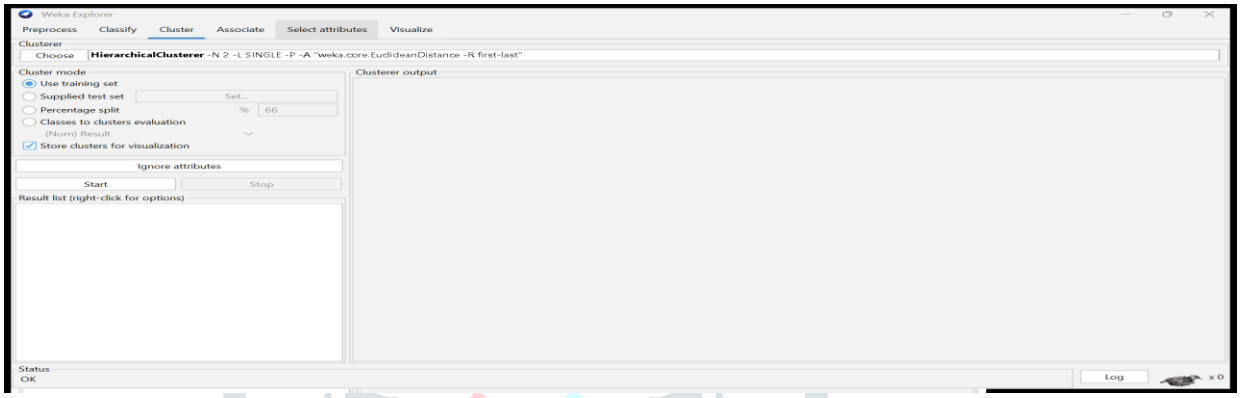
Hierarchical Cluster

Hierarchical clustering is mainly focussing on building of hierarchy of clusters, i.e., cluster tree and it is represented in a dendrogram. It is either merging smaller clusters into larger clusters or splitting larger clusters into smaller ones. A clustering of the data items is obtained through cutting a dendrogram at a desired level. A cluster tree is defined as "a tree showing a sequence of clustering with each clustering being a partition of the data set". Following are the general procedures for performing hierarchical clustering.

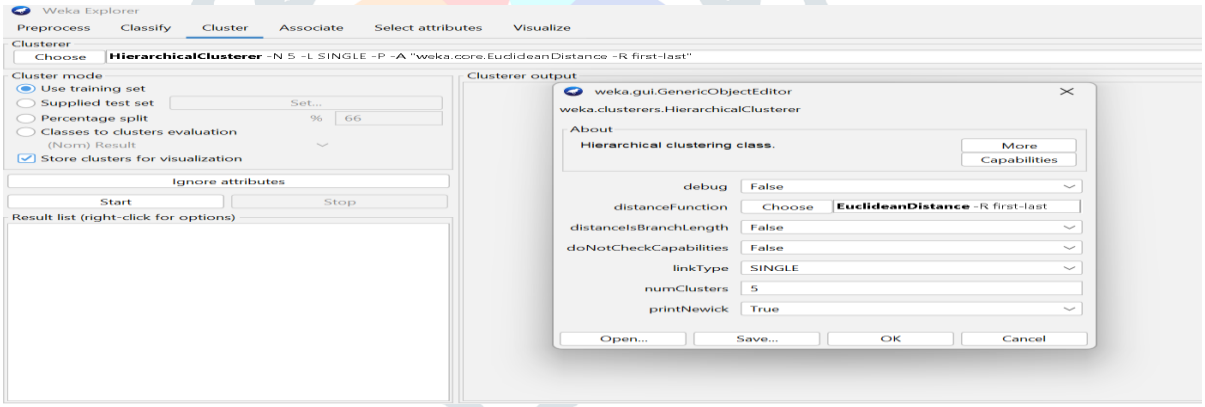
Steps to be followed:

Step 1: In the preprocessing interface, open the Weka Explorer and load the required dataset, and we are taking the project. arff dataset.

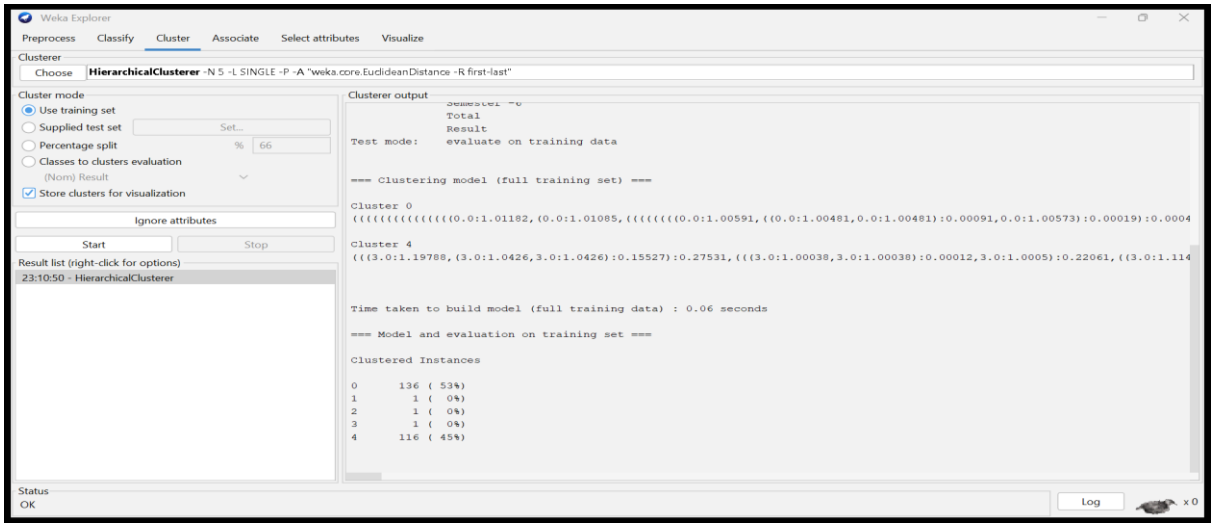
Step 2: Find the 'cluster' tab in the explorer and press the choose button to execute clustering. A dropdown list of available clustering algorithms appears as a result of this step and selects the Hierarchical Clustered algorithm.



Step 3: Then, to the right of the choose icon, press the text button to bring up the popup window. We enter five for the number of clusters in this window.



Step 4: One of the choices has been chosen. We must ensure that they are in the 'cluster mode' panel before running the clustering algorithm. The choice to use a training set is selected, and then the 'start' button is pressed.



Step 5: The centroid of each cluster is shown in the result window, along with statistics on the number and percent of instances allocated to each cluster. Each cluster centroid is represented by a mean vector. This cluster can be used to describe a cluster. Merging smaller clusters into larger clusters or splitting larger clusters into smaller ones.

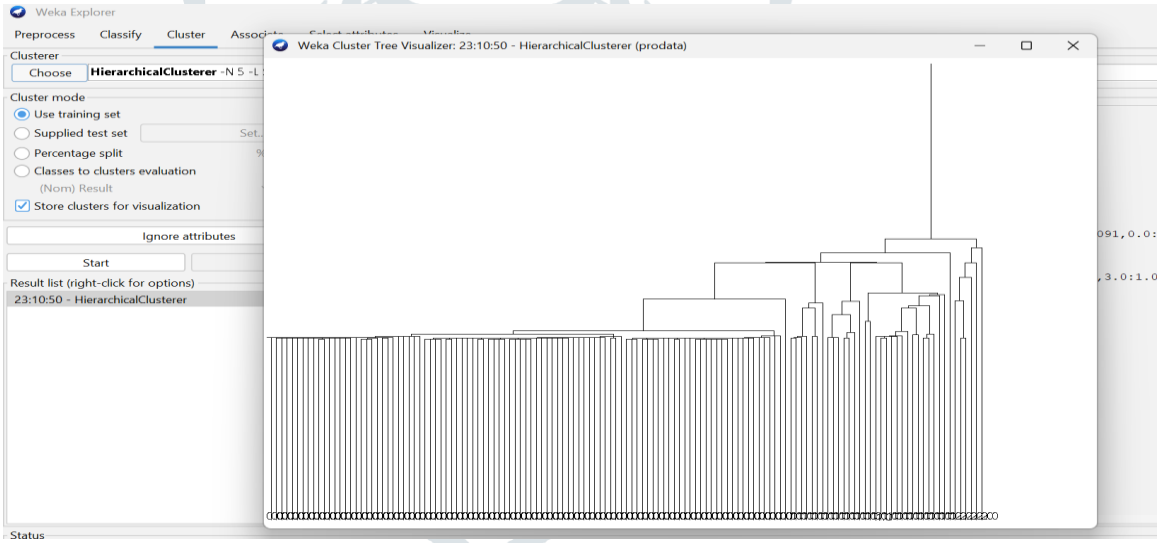
Step 6: Another way to grasp the characteristics of each cluster is to visualize them. To do so, right-click the result set on the result. Selecting to visualize cluster assignments from the list column.



Step 7: In the Cluster visualization we choose Course on X-axis and Total no on Y-axis.

Blue colour shows Cluster 0, Red colour shows Cluster 1, Green colour shows Cluster 2, Sky-blue colour shows Cluster 3, Light pink colour shows Cluster 4.

Visualization tree in hierarchical clustered:



Step 8: The above tree diagram shows that the hierarchical Clustering using 5 clusters. A cluster tree is defined as "a tree showing a sequence of clustering with each clustering being a partition of the data set".

Output: This Hierarchical Clustered algorithm is tested with project dataset in WEKA tool; it produces five different clustered instance clusters 0: 136(53%), cluster 1: 1(0%), cluster 2: 1(0%), cluster 3: 1(0%), cluster 4: 116(45%), and Time taken to build model (full training data): 0.06 seconds.

Simple-k means clustering:

K-means clustering is a simple unsupervised learning algorithm. In this, the data objects (‘n’) are grouped into a total of ‘k’ clusters, with each observation belonging to the cluster with the closest mean. It defines ‘k’ sets, one for each cluster k n (the point can be thought of as the centre of a one or two-dimensional figure). The clusters are separated by a large distance.

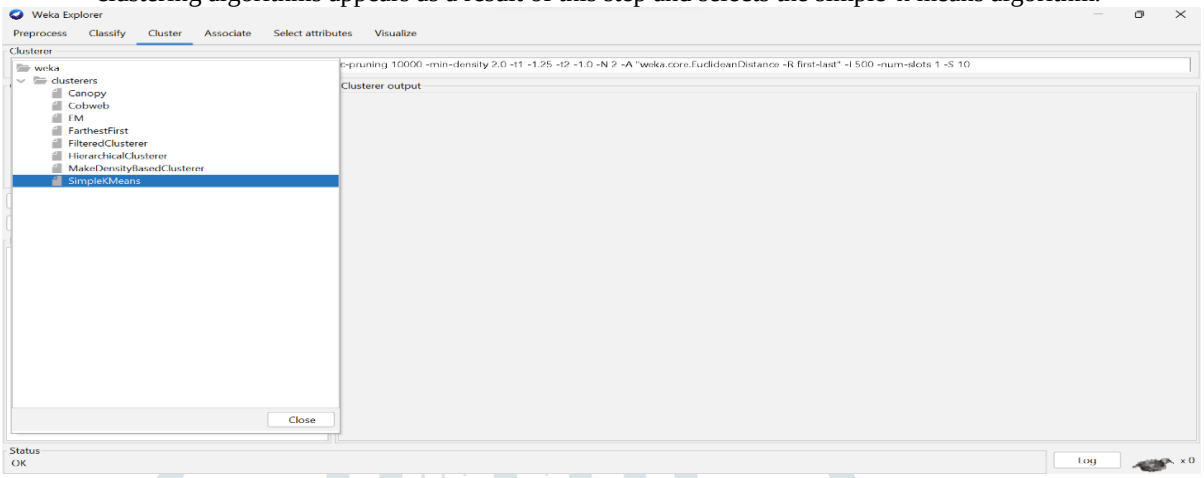
The data is then organized into acceptable data sets and linked to the nearest collection. If no data is pending, the first stage is more difficult to complete; in this case, an early grouping is performed. The ‘k’ new set must be recalculated as the barycentre’s of the clusters from the previous stage.

The same data set points and the nearest new sets are bound together after these ‘k’ new sets have been created. After that, a loop is created. The ‘k’ sets change their position step by step until no further changes are made as a result of this loop.

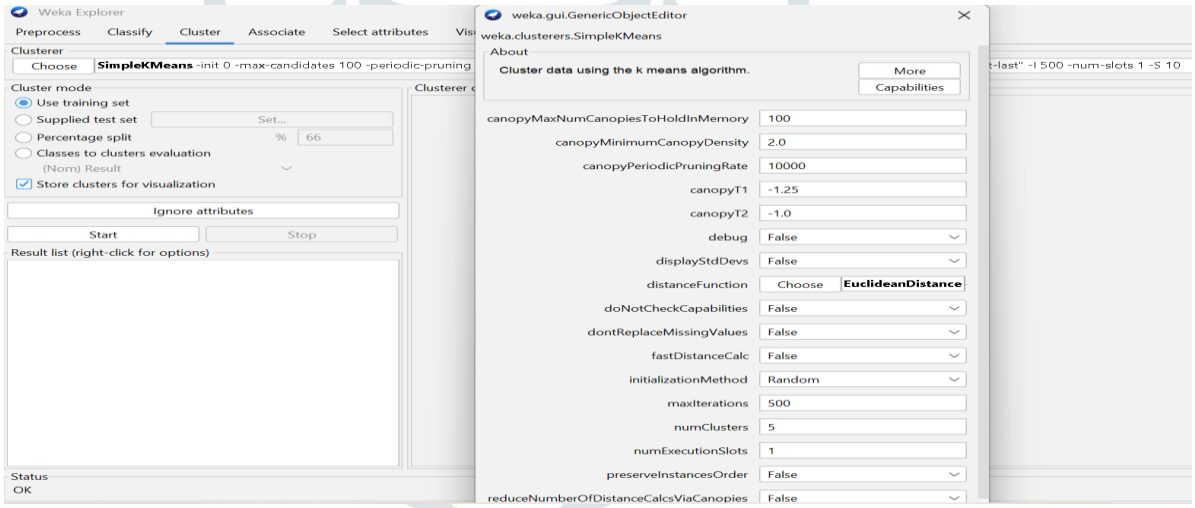
Steps to be followed:

Step 1: In the preprocessing interface, open the Weka Explorer and load the required dataset, and we are taking the project. Arff dataset.

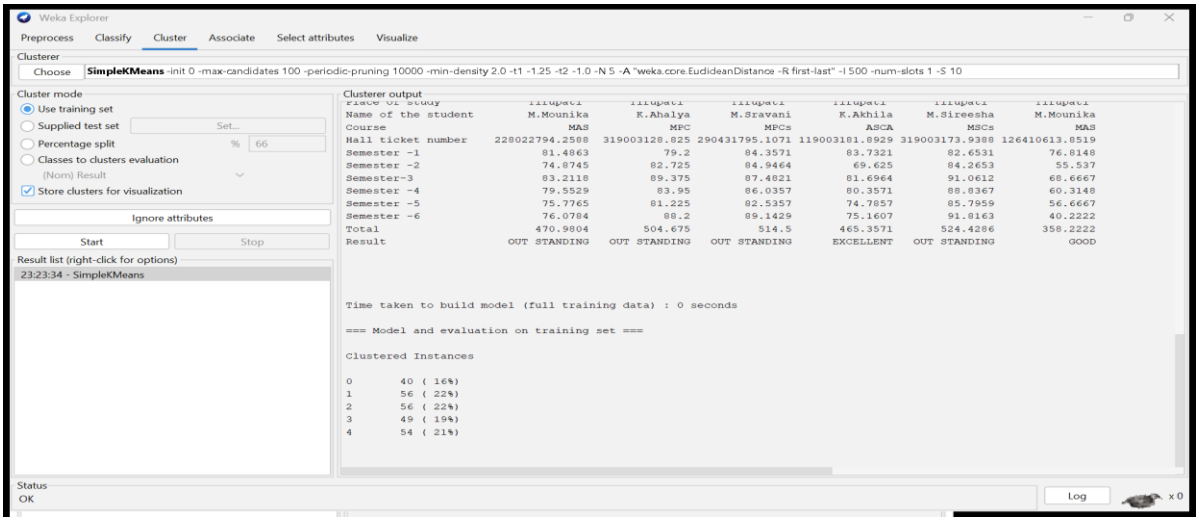
Step 2: Find the 'cluster' tab in the explorer and press the choose button to execute clustering. A dropdown list of available clustering algorithms appears as a result of this step and selects the simple-k means algorithm.



Step 3: Then, to the right of the choose icon, press the text button to bring up the popup window shown in the screenshots. We enter five for the number of clusters in this window.

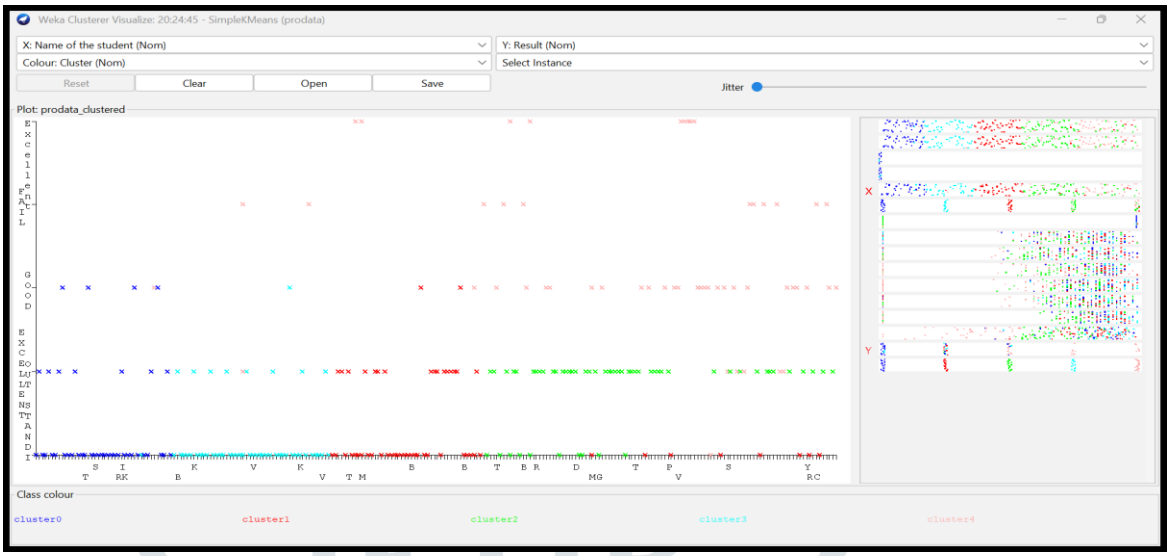


Step 4: One of the choices has been chosen. We must ensure that they are in the 'cluster mode' panel before running the clustering algorithm. The choice to use a training set is selected, and then the 'start' button is pressed.



Step 5: The centroid of each cluster is shown in the result window, along with statistics on the number and percent of instances allocated to each cluster. Each cluster centroid is represented by a mean vector. This cluster can be used to describe a cluster.

Step 6: Another way to grasp the characteristics of each cluster is to visualize them. To do so, right-click the result set on the result. Selecting to visualize cluster assignments from the list column.



Step 7: In the Cluster visualization we choose Name of the student on X-axis and Result no on Y-axis. Blue colour shows Cluster 0, Red colour shows Cluster 1, Green colour shows Cluster 2, Sky-blue colour shows Cluster 3, Light pink colour shows Cluster 4.

Output: K means clustering is a simple cluster analysis method. The number of clusters can be set using the setting tab. The centroid of each cluster is calculated as the mean of all points within the clusters. With the increase in the number of clusters, the sum of square errors is reduced. The objects within the cluster exhibit similar characteristics and properties. The clusters represent the class labels.

This Simple -k means Clusterer algorithm is tested with project dataset in WEKA tool; it produces five different clustered instance clusters 0: 40(16%), cluster 1: 56(22%), cluster 2: 56(22%), cluster 3: 49(19%), cluster 4: 54(21%), and Time taken to build model (full training data): 0 seconds.

RESULT ANALYSIS

Data Mining Techniques (Knowledge Discovery Database):

The KDD (Knowledge Discovery in Databases) paradigm is a step-by-step approach to identifying interesting patterns in enormous volumes of data. Data mining is a step in the process. The algorithms have good potential. Analytic tools for performance evaluation are demonstrated by examining results from a computer performance dataset. It is far easier to store data than to make sense of it. The ability to identify links in huge amounts of stored data can lead to improved analytical tactics in domains such as education, marketing, computer performance analysis, and data analysis in general. KDD addresses the difficulty of finding patterns in huge datasets. Traditionally, data was analyzed manually; however, there are human

The clustering process

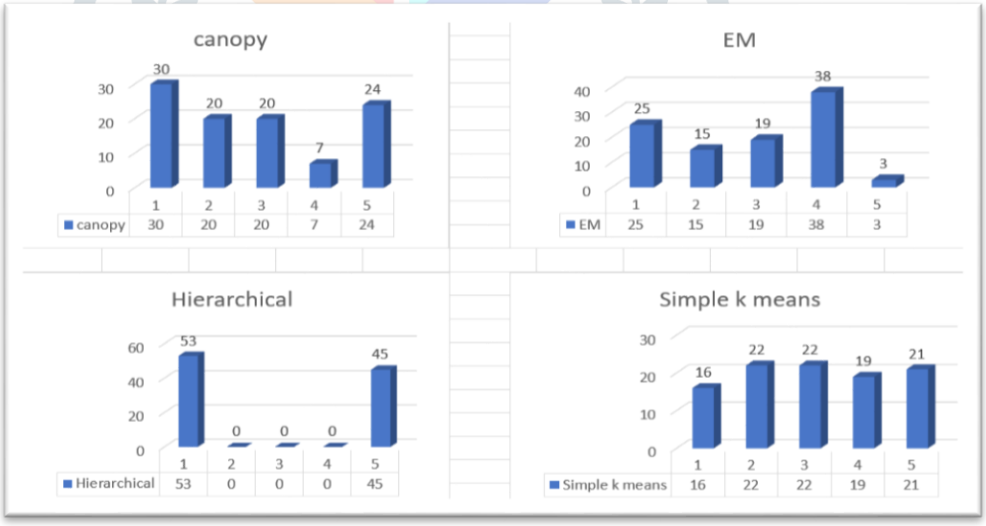
Clustering divides data into groupings of related things. Each cluster contains a variety of things that are both similar to one another and distinct to objects from other clusters. Various clustering algorithms are used to produce clusters. The Weka tool is used to evaluate various clustering techniques.

This paper compares the different Weka clustering algorithms to determine which algorithm is best suited to the users. Four clustering algorithms are compared: Canopy clustering algorithm, EM Algorithm, Hierarchical Algorithm, and Simple k-Means clustering algorithm. All of the algorithms discussed above are explained and analyzed using specific assessment parameters. These parameters include the number of clusters formed and clustered instances. The results of all four algorithms are generated.

The following table represents the analysis process of all four algorithms and the accuracy results are shown in table.

Clustering algorithm	No. of Clusters	Clustering instances
Canopy	5	76(30%) 50(20%) 50(20%) 19(07%) 60(24%)
EM	5	63(25%) 38(15%) 49(19%) 98(38%) 7(3%)
Hierarchical	5	136(53%) 1(0%) 1(0%) 1(0%) 116(45%)
Simple-k Means	5	40(16%) 56(22%) 56(22%) 49(19%) 54(21%)

In the above table, the Simple-k means clustering algorithm and EM Clustering Algorithm are showing good accuracy than another cluster algorithm.



The above chart shows the performance accuracy of the four-clustering based on different clustering metrics. This metrics shows that Simple-k means, EM algorithms are performing good accuracy result better than other clustering.

CONCLUSION

Data mining translates raw data into information so that predictions can be made. Cluster analysis is a technique for identifying clusters of data with similar features. WEKA has a variety of algorithms for cluster analysis, with simple means being the most commonly employed.

This work describes data mining in the educational context, specifically identifying students' performance trends using the clustering data mining technique. The detected trends are evaluated to provide useful and constructive recommendations to academic planners in higher education institutions to improve their decision-making process.

We conducted analyses using four clustering algorithms: the Canopy clustering algorithm, the EM algorithm, the Hierarchical algorithm, and the Simple k-Means clustering algorithm. All four algorithms give results based on similar items and times.

In future work the authors also interested in working in future on data of student's assessments for each course trying to know what kind of student succeed on what kind of courses. It may define what kinds of courses are adapted for every student's model who shares the same characteristics. It may also provide various multidimensional summary reports and redefine pedagogical learning paths.

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Falkner–Skan slip flow of non-Newtonian fluid over a moving and nonlinearly radiated wedge with variable heat source/sink and viscous dissipation

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Analyzed in this paper is an investigation of the impacts of the varying source of heat or thermal sink and viscous dissipation on Casson fluid flow from a moving wedge by considering thermal and momentum slips in a mathematical model. Regarding the regulation of concentration fields, we incorporated the Soret and Dufour phenomena. The outcomes are analyzed numerically by using the shooting technique. The governing parametric effects of the flow characteristics are revealed

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graphically. We also presented the local Sherwood and Nusselt number values for non-Newtonian fluid (Casson fluid) and Newtonian. It is discovered that the thermal and concentration boundary layer is more extensive in Casson fluid while equated with the Newtonian fluid. The thermal and mass transmission in Newtonian fluid is significantly larger than in non-Newtonian fluid. The heat source/sink, Eckert number and Dufour number boost the rate of thermal transport and depreciate the rate of mass transport for both the Newtonian and non-Newtonian fluid cases.

Keywords: Cross-diffusion effects; MHD; nonlinear thermal radiation; variable heat source/sink; viscous dissipation; wedge.

PACS numbers: 47.10.ab, 47.15.x, 47.65.d, 47.45.Gx, 52.65.Kj.

Nomenclature

β	:	Strength at the wall,
χ	:	Fluid concentration,
$\lambda = 2m/m+1$	:	Streamwise pressure gradient,
μ_B	:	Non-Newtonian fluid's plastic dynamic viscosity,
$\pi = e_{ij}e_{ij}, e_{ij}i, j$	:	deformation rate of the component,
p_y	:	Fluid yield stress,
π_c	:	Critical value,
M	:	Magnetic field,
λ	:	Wedge angle,
ε	:	Velocity slip,
δ	:	Thermal slip parameter,
$\mathrm{Re}_x = u_e x/\upsilon_f$	:	Reynolds number,
NODEs	:	Nonlinear ordinary differential equations,
TBL	:	Thermal boundary layer,
$B(x) = B_0 x^{(m-1)/2}$	:	Strength of applied magnetic field,
θ	:	Fluid temperature,
Ec	:	Eckert number,
Sr	:	Soret number,
T_ω	:	Surface temperature,
Df	:	Dufour number,
C_ω	:	Surface concentration,
Q_H	:	Heat source/sink,
Sc	:	Schmidt number,
C_p	:	Specific heat capacity,
T_∞	:	Ambient temperature,
C_s	:	Concentration susceptibility,
D_m	:	Coefficient of mass diffusivity,
Pr	:	Prandtl number,
σ^*	:	Stefan Boltzmann constant,
Nr	:	Radiation parameter,
ρ	:	Density,

C_∞ : Ambient fluid concentration,
k : Thermal conductivity.

1. Literature Survey

The Falkner and Skan measurement contributes significantly to the advancement of fluid mechanics. It was developed for assessing the flow regime caused by the pressure gradient in the free stream. The fundamental equation of Falkner–Skan with conditions attached $f(0) = \beta, f'(0) = \gamma$ and $f'(\infty) = 1$ is of the structure $f''' + ff'' + \lambda(1 - f'^2) = 0$, where $\beta = 0, \gamma = 0$ connotes the stationary, impermeable wedge flow. Scholars[1,2] provide a quick description of the Falkner–Skan equation. In progression, researchers[3–5] explained the fluid motion over a wedge with multiple properties. Mushtaq *et al.*[6] explored in more detail the computational remedy of nanofluid flow prompted by nonlinear heat radiation and outlined the complexities of nonlinear radiation. Mallikarjuna *et al.*[7] investigated the cross-diffusion consequences on flow through a porous medium convective cylinder. Lately, Turkyilmazoglu[8] described computationally the heat transfer property of the Falkner–Skan equation beyond a wedge with slip condition.

In recent days, researchers are concentrating on the theoretical study of thermal and mass transmission circulation including the movement of humidity and temperature among groves of fruit plants. The effects obtained are not noticed considering the lower magnitude when compared to the characteristics inspired by Fourier's and Fick's laws of diffusion. In juxtaposition, significant applications in diverse settings, including geosciences, petroleum industries, astrophysics and hydrological processes are noted. Because of this significance, primarily, Sparrow *et al.*[9] noticed the importance of cross-diffusion and discussed the prominence of such influences on heat transmission by considering a cylinder and introducing injection. They reported that the injection characteristics did not impede the velocity gradient and pressure movement until it reached the point of laminar disconnection.

Far ahead, researchers have made progressive work for Soret and Dufour attributes by observing the various media.[10–14] In this study, the researchers concluded that thermo diffusion and diffusion thermo properties aid in regulating the temperature and concentration of boundary layers. No-slip circumstance over the boundary surface is a renowned supposition in fluid dynamics and has shown a progressive output over the years. Though there are several circumstances where the no-slip condition was engaged, nevertheless, choosing different fluids (Newtonian or non-Newtonian or nanofluids) is not common. By the first principle, the motion is dispensed, but the partial slip and the tangential constituents of the velocity stress are nonzero at the boundary, which is considered in place of the usual no-slip condition. The numerous uses of microstructures like microvalves, pumps and hard disk drive nozzles are described by considering slip conditions near the wall. The partial slip-on flow over a stretching surface is directed by Yoshimura and Prudhomme.[15] Further,

Andersson[16] delivered a closed form explanation of the MHD flow through a stretching surface. Exact solutions for the Navier–Stokes equation are given by Wang.[17] Convinced by the specified uses and occurrences, the scholars[18–22] outlined the slip impact with different flow configurations and boundary conditions. This led them to the conclusion that slip controls the rate of mass and heat transmission. Upddhya *et al.*[23] explored the radiated magnetic flow in a suspension of ferrous nanoparticles over a cone with Brownian motion and thermophoresis. They observed the nonuniform heat source or sink act as a controlling parameter for the flow as well as heat transport phenomena. Upadhya *et al.*[24] studied the importance of entropy generation on Casson, micropolar and hybrid magneto-nanofluids in a suspension of cross-diffusion. They found the Casson fluid shows higher velocity field compared with micropolar and hybrid nanofluid. Mamatha *et al.*[25] analyzed the Arrhenius activation and zero mass flux conditions on nonlinear convective Jeffrey fluid over an electrically conducting and radiated sheet. They concluded that the buoyancy force initially near the boundary improves nanoparticle concentration but in ambient phase nanoparticle concentration is lowered. Recently, the authors considered various kinds of nanoparticles and provided the significance of nanoparticles elaborately from the authors.[26–38]

Persuaded by the prior literature and difficulties, the researchers plan to investigate the impact of varying heat source on the MHD radiative slip flow of Falkner–Skan viscoelastic fluid on a wedge in the existence of cross-diffusion. Validation of particular cases is prepared with the published outcomes and a good arrangement was found.

2. Mathematical Formulation

The thermo diffusion and diffusion thermo impacts on the magnetic-viscoelastic fluid flow over a wedge are considered with nonlinear radiation. The velocities and free stream at the wedge are assumed as $u_w(x) = U_w x^m$ and $u_e(x) = U_\infty x^m$. The variable thermal generation/absorption and reactive species are considered as $Q(x) = Q_0 x^{(m-1)/2}, k(x) = k_0 x^{(m-1)/2}$. The angle and total of the wedge are $\lambda = 2m/(m+1)$ and $\Omega = \lambda\pi$, respectively. The concentration constant temperature constant at the edge and free stream are assumed and are represented by T_w, T_∞ and C_w, C_∞, respectively. The detailed flow configuration is shown in Fig. 1.

An isotropic Casson fluid is a specified rheological classical model as follows[39]:

$$\tau^{1/n} = \tau_0^{1/n} + \mu\gamma^{.1/n}, \tag{1}$$

$$\tau_{i,j} = \begin{cases} 2(\mu_B + p_y/((2\pi)^{1/2})e_{ij}), & \pi > \pi_c, \\ 2(\mu_B + p_y/((2\pi)^{1/2})e_{ij}), & \pi < \pi_c. \end{cases} \tag{2}$$

The value of n is restricted to more than 1 due to its prominence in many manufacturing and production areas. Aforementioned to the assumptions of the governing equations as given by Ref. 39,

$$\frac{\partial^2 \xi}{\partial x \partial y} - \frac{\partial^2 \xi}{\partial y \partial x} = 0, \tag{3}$$

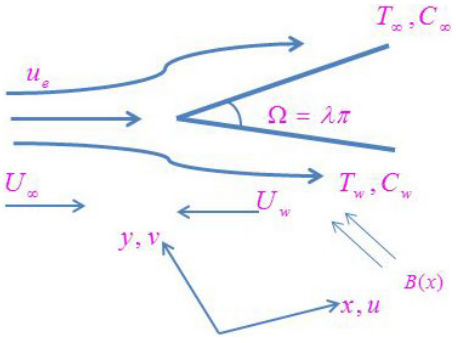


Fig. 1. (Color online) Configuration of model.

$$\left(\frac{\partial\xi}{\partial y}\frac{\partial^2\xi}{\partial x\partial y}-\frac{\partial\xi}{\partial x}\frac{\partial^2\xi}{\partial y^2}\right)=u_e\frac{du_e}{dx}+\upsilon\left(1+\frac{1}{\beta}\right)\frac{\partial^3\xi}{\partial y^3}-\frac{\sigma B(x)^2}{\rho}\left(u_e-\frac{\partial\xi}{\partial y}\right), \tag{4}$$

$$\left(\frac{\partial\xi}{\partial y}\frac{\partial T}{\partial x}-\frac{\partial\xi}{\partial x}\frac{\partial T}{\partial y}\right)=\frac{k}{\rho c_p}\frac{\partial^2 T}{\partial y^2}-Q(x)(T-T_\infty)-\frac{\mu}{\rho c_p}\left(1+\frac{1}{\beta}\right)\left(\frac{\partial T}{\partial y}\right)^2 + \frac{16\sigma^*}{3k^*\rho c_p}\frac{\partial}{\partial y}\left(T^3\frac{\partial T}{\partial y}\right)+\frac{D_m k_T}{c_s c_p}\frac{\partial^2 C}{\partial y^2}, \tag{5}$$

$$\left(\frac{\partial\xi}{\partial y}\frac{\partial C}{\partial x}-\frac{\partial\xi}{\partial x}\frac{\partial C}{\partial y}\right)=D_B\frac{\partial^2 C}{\partial y^2}+\frac{D_m k_T}{T_m}\frac{\partial^2 T}{\partial y^2}-k(x)(C-C_\infty). \tag{6}$$

The respective boundary constraints are

$$\left.\begin{aligned}&\frac{\partial\xi}{\partial y}=u_w(x)+l_1(x)u_y(y),\quad \frac{\partial\xi}{\partial x}=0,\quad T=T_w+\tau_1(x)T_y(y),\quad C=C_w \quad \text{at } y=0,\\ &\frac{\partial\xi}{\partial y}\to u_e,\quad T\to T_\infty,\quad C\to C_\infty, \qquad\qquad\qquad\qquad\qquad\qquad \text{as } y\to\infty,\end{aligned}\right\} \tag{7}$$

where $u=\frac{\partial\xi}{\partial y}, v=-\frac{\partial\xi}{\partial x}$, which satisfies the continuity equation. In the above equations, Casson fluid parameter, $\beta\to\infty$, represents the Newtonian fluid and $\beta>0$, $\beta<0$ signify the non-Newtonian fluid.

The succeeding similarity variables are as follows:

$$\left.\begin{aligned}&\xi=\left(\frac{2\upsilon x u_e}{m+1}\right)^{1/2}f(\zeta),\quad T=T_\infty(1+(\theta_w-1)\theta(\zeta)),\\ &\zeta=\left(\frac{(m+1)u_e}{2\upsilon x}\right)^{1/2}y,\quad \chi(\zeta)=\frac{C-C_\infty}{C_w-C_\infty},\quad \theta_w=\frac{T_w}{T_\infty}.\end{aligned}\right\} \tag{8}$$

Equations (4)–(7) are transformed using Eq. (8) as

$$\left(1+\frac{1}{\beta}\right)\frac{\partial^3 f}{\partial\zeta^3}-M\left(\frac{\partial f}{\partial\zeta}-1\right)+f\frac{\partial^2 f}{\partial\zeta^2}+\lambda\left(1-\left(\frac{\partial f}{\partial\zeta}\right)^2\right)=0, \tag{9}$$

$$\frac{\partial^2\theta}{\partial\zeta^2}+\Pr f\frac{\partial\theta}{\partial\zeta}+\Pr \mathrm{Df}\frac{\partial^2\phi}{\partial\zeta^2}+\frac{\partial^2\theta}{\partial\zeta^2}R(\theta_w-1)[1+(\theta_w-1)\theta]^3$$
$$+3R(\theta_w-1)^2\left(\frac{\partial\theta}{\partial\zeta}\right)^2[1+(\theta_w-1)\theta]^2+\left(1+\frac{1}{\beta}\right)\mathrm{Ec}\left(\frac{\partial^2 f}{\partial\zeta^2}\right)^2-Q_H\theta=0, \quad (10)$$

$$\frac{\partial^2\chi}{\partial\zeta^2}+\mathrm{ScSr}\frac{\partial^2\chi}{\partial\zeta^2}+\mathrm{Sc}f\frac{\partial\chi}{\partial\zeta}-\mathrm{Kr}\chi=0. \quad (11)$$

The reinvented boundary equations are

$$\left.\begin{aligned} &f=0, \quad \frac{\partial f}{\partial\zeta}=\gamma+\varepsilon\frac{\partial^2 f(\zeta)}{\partial\zeta^2}, \quad \theta=1+\delta\frac{\partial\theta(\zeta)}{\partial\zeta}, \quad \chi=1 \quad \text{at } \zeta=0,\\ &\frac{\partial f}{\partial\zeta}=1, \quad \theta=0, \qquad\qquad\qquad\qquad\qquad\quad \chi=0 \quad \text{as } \zeta\to\infty. \end{aligned}\right\} \quad (12)$$

The nondimensional constants are given by

$$\lambda=\frac{2m}{m+1}, \quad M=\frac{2\sigma B_0^2}{\rho U_\infty(m+1)}, \quad \Pr=\frac{\mu c_p}{\rho}, \quad \mathrm{Sc}=\frac{\upsilon}{D_B}, \quad \gamma=\frac{U_w}{U_\infty},$$
$$\mathrm{Ec}=\frac{U_\infty^2}{c_p(T_w-T_\infty)}, \quad \mathrm{Nr}=\frac{16\sigma^* T_\infty^3}{3kk^*}, \quad Q_H=\frac{2Q_0}{U_\infty(m+1)}, \quad \mathrm{Df}=\frac{D_m k_T(C_w-C_\infty)}{c_s c_p(T_w-T_\infty)},$$
$$\mathrm{Sr}=\frac{D_m k_T(T_w-T_\infty)}{T_m(C_w-C_\infty)}, \quad \varepsilon=l_1\sqrt{\frac{(1+m)u_e(x)}{2\upsilon x}}, \quad \delta=\tau_1\sqrt{\frac{(1+m)u_e(x)}{2\upsilon x}}, \quad \mathrm{Kr}=\frac{2k_0}{U_\infty(m+1)}. \quad (13)$$

For manufacturing attention, physical measures of the flow shear stress coefficient, Sherwood and Nusselt numbers are C_{fx}, Sh_x and Nu_x, respectively, and given by

$$\mathrm{Re}_x^{1/2}C_{fx}\sqrt{2/(m+1)}=\left(1+\frac{1}{\beta}\right)\frac{\partial^2 f(0)}{\partial\zeta^2}, \quad (14)$$

$$\mathrm{Re}_x^{-1/2}\mathrm{Nu}_x\sqrt{2/(m+1)}=-(Nr(\theta_w-1)[1+(\theta_w-1)\theta]^3)\frac{\partial\theta(0)}{\partial\zeta}, \quad (15)$$

$$\mathrm{Re}_x^{-1/2}\mathrm{Sh}_x\sqrt{2/(m+1)}=-\frac{\partial\varphi(0)}{\partial\zeta}. \quad (16)$$

3. Method of Solution

The NODEs of (9)–(11) with Eq. (12) are numerically utilized through Runge–Kutta (RK) and Newton's methods.[40–42] Primarily the set of NODEs is changed to a first-order DE with the help of the succeeding process:

$$G=y_1, \quad H=y_4, \quad P=y_6, \quad \text{similarly, we get } G'=y_2,$$
$$H'=y_5, \quad G''=y_3, \quad P'=y_7, \quad (17)$$

$$G'''=\{M(y_2-1)-y_1y_3-\lambda(1-y_2^2)\}(\beta/(\beta+1)), \quad (18)$$

$$H'' = \left\{ Q_H y_4 - \left(1 + \frac{1}{\beta}\right) \mathrm{Ec} y_3 - \mathrm{Pr}\, y_1 y_5 - \mathrm{Pr}\, \mathrm{Df} P'' - 3\mathrm{Nr}(\theta_w - 1) \times (1 + (\theta_w - 1) y_4)^2 y_5^2 \right\} \left(\frac{1}{1 + \mathrm{Nr}(1 + y_4(\theta_w - 1))} \right)^3, \tag{19}$$

$$P'' = \{ \mathrm{Kr} y_6 - \mathrm{Sc} y_1 y_7 - \mathrm{ScSr} H'' \}. \tag{20}$$

With boundary conditions as

$$\left.\begin{array}{llll} y_2 = \gamma + \varepsilon y_3, & y_1 = 0, & y_4 = 1 + \delta y_5, & y_6 = 1 \quad \text{at } \zeta \to 0, \\ y_2 = 1, & y_4 = 0, & y_6 = 0 & \text{as } \zeta \to \infty, \end{array}\right\}. \tag{21}$$

We estimate the variables of $y_3(0), y_5(0), y_7(0)$ mentioned at the initial condition. Integration of Eqs. (18)–(22) is accomplished through the application of the RK fourth-order technique. The consecutive iterative step length is to be chosen as 0.01.

Here $\zeta_{\max}$ is ζ at ∞ and picked a sufficiently large number so that the resulting answer demonstrates larger ζ than $\zeta_{\max}$. For computation purposes, we use MATLAB software, ode45 solver. The accuracy of the guess values $y_3(0), y_5(0), y_7(0)$ is verified by correlating the calculated values of $y_2(0), y_4(0), y_6(0)$ at $\zeta = \zeta_{\max}$ with their values given at $\zeta = \zeta_{\max}$. Instead, we performed Newton–Raphson (NR) technique to find accurate guess values. Utilizing the RK method, the derived equations are solved. The same procedure continued up to the settlement among the calculated values and specified conditions $\zeta = \zeta_{\max}$. In order to confirm the correctness of current solutions with Yih[42] and Mukhopadhyay *et al.*[39] solutions. We discovered substantial agreement with their outputs.

4. Results and Discussion

To attain a durable authorization of the mathematical model, physical explanations for nondimensional parameters θ, χ, local mass and thermal transmission rates are presented in graphical and tabular designs for numerous values of physical constraints for both cases of uplift and deplete flow. For the numeric solutions, the parametric values are as $\theta_w = 1.1$, $\mathrm{Sc} = 1$, $\mathrm{Nr} = 0.5$, $\mathrm{Kr} = Q_H = 0.1$, $\mathrm{Sr} = 0.3, \gamma = 0.2, \mathrm{Df} = 0.2, \mathrm{Pr} = 6.2, M = 2$. In these graphs, the solid lines and dashed lines specify the depleting and uplifting fluid flow over a wedge correspondingly.

Tables 1 and 2 show the changes in the coefficient of $\mathrm{Re}_x^{1/2} C_{fx} \sqrt{2/(m+1)}$ and $\mathrm{Re}_x^{-1/2} \mathrm{Nu}_x \sqrt{2/(m+1)}$ with diverse m and Pr values. The current explanations are associated with Mukhopadhyay *et al.*,[39] Yih[42] and Kuo[44] found an outstanding concurrent convergence. The advancement of m and Pr is seen to improve friction and heat transfer.

Figures 2–17 show the variations in velocity, concentration and temperature fields for distinct characteristics of δ, ε, Kr, Df, Ec, γ, Q_H, Sr and Nr, respectively. In Fig. 2, we examine the influence on temperature field due to thermal slip parameter (δ) for both Newtonian and non-Newtonian fluids. It is obvious that an increasing slip tends

Table 1. Comparison of local skin friction $\mathrm{Re}_x^{1/2} C_{fx} \sqrt{2/(m+1)}$ for various values of m when $\beta \to \infty, \mathrm{Df} = \delta = \mathrm{Nr} = \varepsilon = \mathrm{Sr} = \mathrm{Sc} = \mathrm{Kr} = \mathrm{Ec} = Q_H = 0$.

	$\left(\frac{d^2 f}{d\zeta^2}\right)_{\text{at } \zeta=0}$		
m	Mukhopadhyay *et al.*[39]	Yih[42]	Present results
−0.05	0.2138	0.2134	0.2137
0.0	0.3322	0.3332	0.3325
0.333	0.7575	0.7574	0.7575
1.0	1.2327	1.2325	1.2328

Table 2. Comparison of local Nusselt number $\mathrm{Re}_x^{-1/2} \mathrm{Nu}_x \sqrt{2/(m+1)}$ for various values of Pr when $\beta \to \infty, \mathrm{Du} = \tau = \mathrm{Nr} = L = \mathrm{Sr} = \mathrm{Sc} = \mathrm{Kr} = \mathrm{Ec} = Q_H = 0$.

	$\lambda = 0$		$\lambda = 2$	
Pr	Kuo[44]	Present results	Kuo[44]	Present results
0.72	0.4180	0.4178	0.5298	0.5296
1.0	0.4696	0.4696	0.6054	0.6052
30	1.4873	1.4873	2.1582	2.1580
100	2.2229	2.2229	3.2869	3.2873
1000	4.7901	4.7901	7.2225	7.2334

to improve the thermal boundary layer; this can hint to depreciate the thermal boundary layer. The impact of thermal slip-on χ distribution as shown in Fig. 3. It is noticed that slight variation on concentration and is diminished for larger values of δ. The impact of Q_0 on θ distribution is shown in Fig. 4. It is clear that higher values of

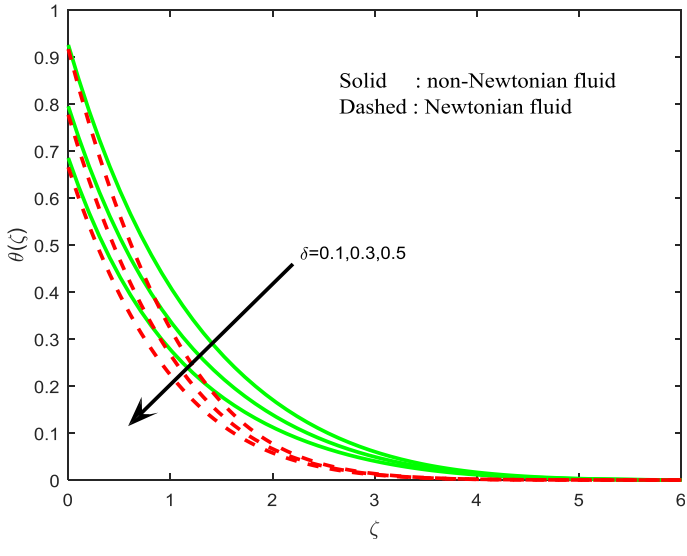


Fig. 2. (Color online) The profile of δ on temperature curves.

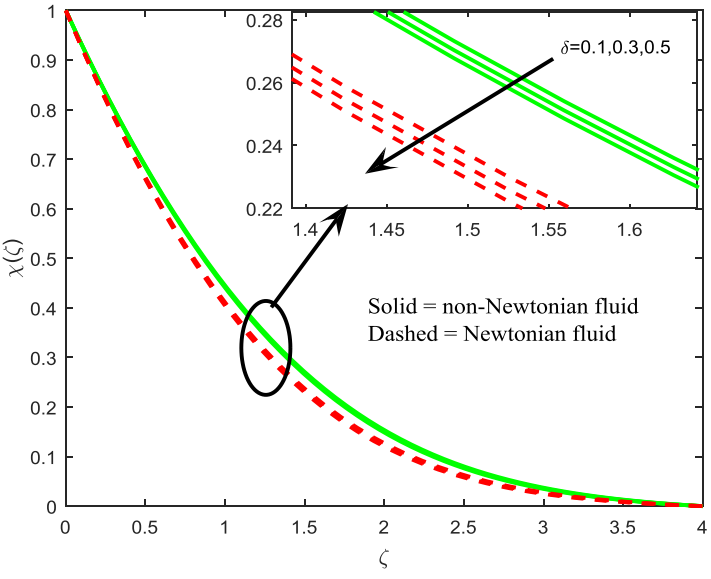


Fig. 3. (Color online) The profile of δ on concentration curves.

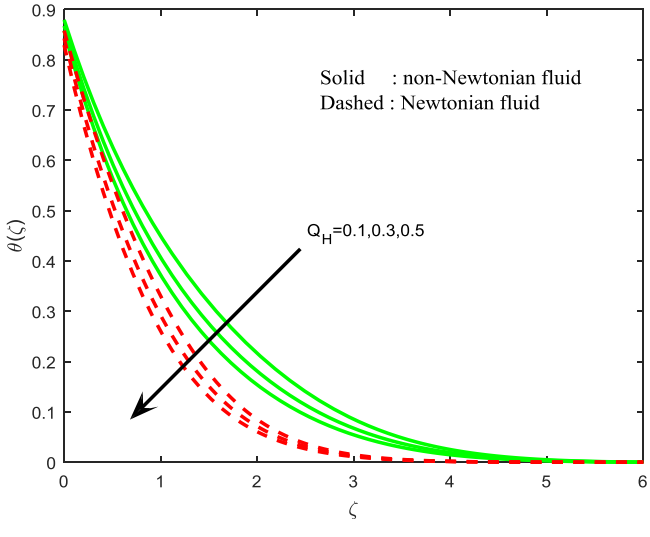


Fig. 4. (Color online) The profile of Q_H on temperature curves.

Q_H lead to a decrease in the θ profile due to heat absorption in the flow. From this it is noticed that the temperature distribution decreases with increase in Q_H in both Newtonian and non-Newtonian fluids. Different values of chemical reaction parameter Kr on temperature and concentration profiles are shown in Figs. 5 and 6. An increase in chemical reaction parameter will suppress the concentration of the fluid. Higher values of Kr amount to a fall in the chemical molecular diffusivity, that is, less

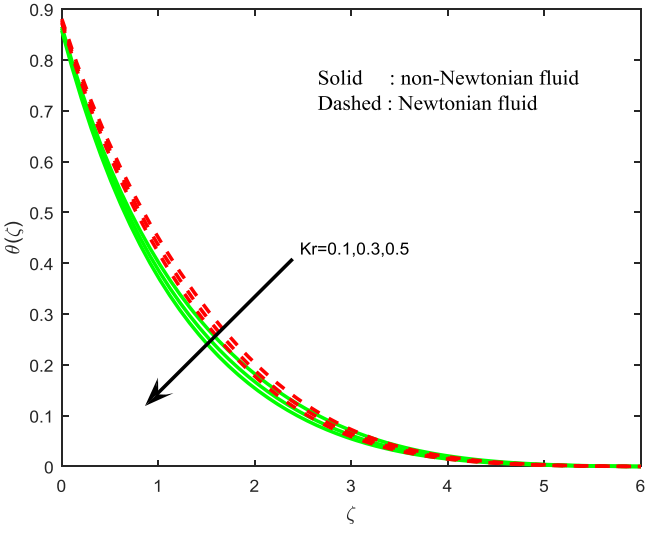


Fig. 5. (Color online) The profile of Kr on temperature curves.

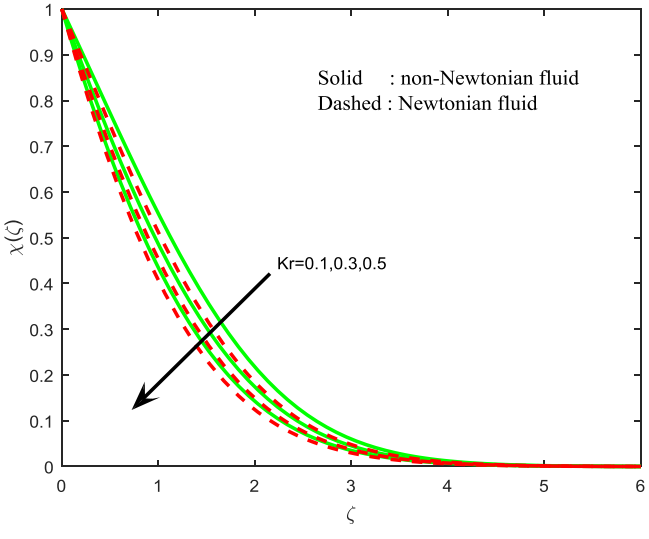


Fig. 6. (Color online) The profile of Kr on concentration curves.

diffusion. Therefore, they are obtained by species transfer. An increase in Kr will suppress species concentration. The concentration distribution decreases at all points of the flow field with the increase in the reaction parameter. The same trend can be observed in temperature distributions for both Newtonian and non-Newtonian fluid cases. Positive values of Eckert number reduce the dominance of interparticle diffuse interactions in the flow as seen decrement in temperature whereas the negative values of Ec improve the values of θ for Newtonian and non-Newtonian fluid flow

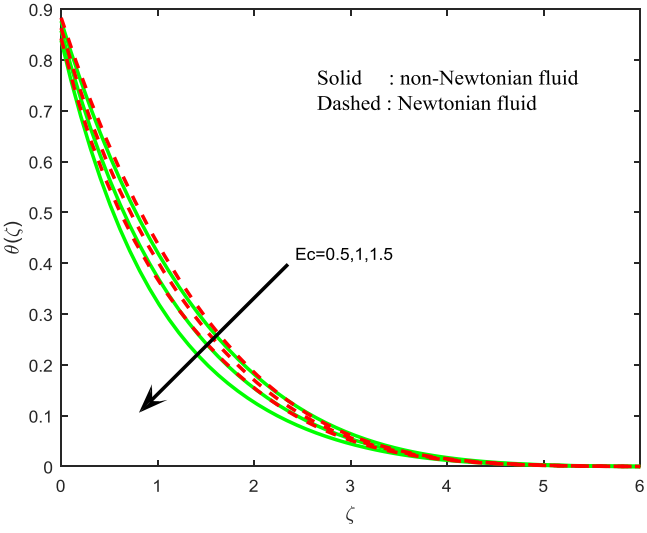


Fig. 7. (Color online) The profile of Ec on temperature curves.

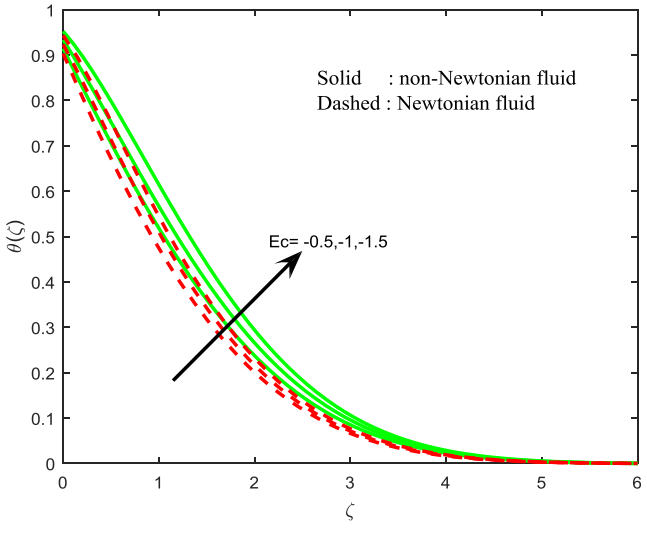


Fig. 8. (Color online) The profile of Ec on temperature curves.

cases. These plots are shown in Figs. 7 and 8. The impact of velocity slip-on θ and velocity fields is shown in Figs. 9 and 10. An increment in velocity slip decreases θ and raises the field u for both the non-Newtonian and Newtonian fluid cases. Generally, the higher values of slip thicken the boundary layer it causes to increase the fluid velocity and minimizes the thermal field. A growing component of Df, the mixed profiles are detected in θ profile where temperature decrement is observed near the wedge surface while contradictory behavior is detected as shown in Fig. 11. The

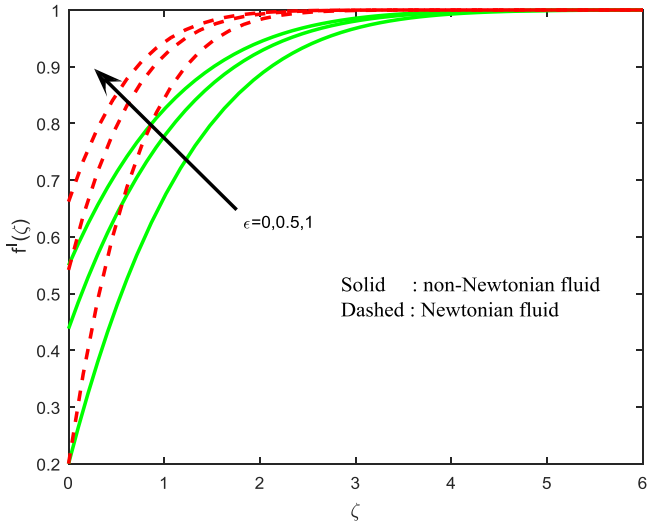


Fig. 9. (Color online) The profile of ε on velocity curves.

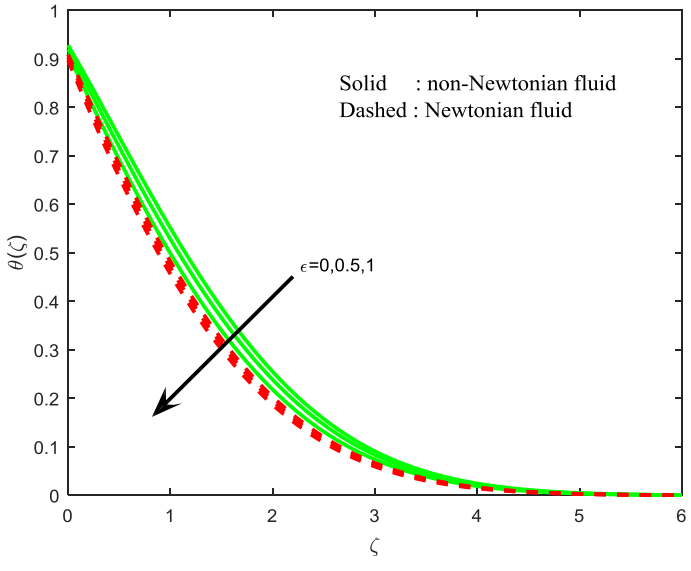


Fig. 10. (Color online) The profile of ε on temperature curves.

impacts of Sr on χ are displayed in Fig. 12. It is concluded that the uplift of Sr boosts the χ field for both types of fluid.

The influence of diffusion thermo parameter Df temperature distribution is shown in Fig. 11. It is noticed that the boundary layer thickness decreases in Newtonian fluid with increase in Df, but increases in non-Newtonian fluid case. Physically, Df clearly reduces the influence of species gradients on the temperature field, so that

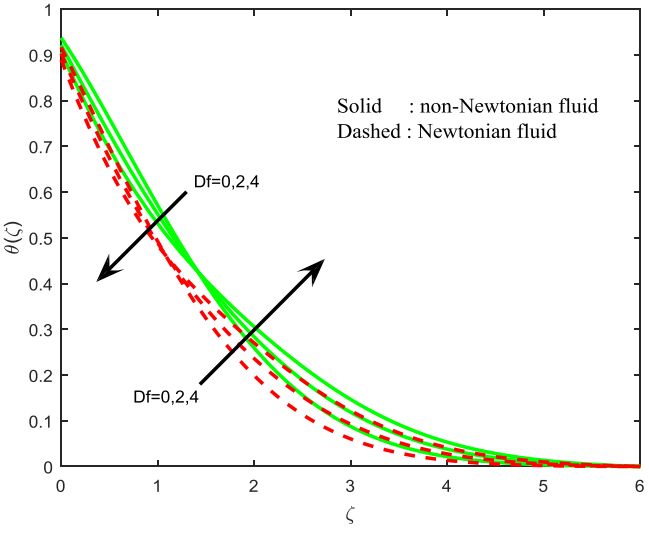


Fig. 11. (Color online) The profile of Df on temperature curves.

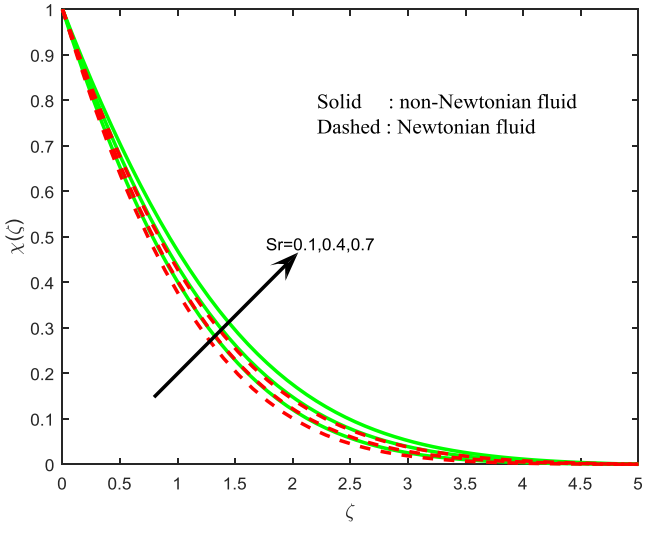


Fig. 12. (Color online) The profile of Sr on concentration curves.

temperature function values are clearly lowered and the boundary layer regime is cooled in Newtonian fluid.

The impact of radiation on temperature increases the temperature profile, since heat molecules are generated by radiation which develops temperature; this observation is drawn from Fig. 13, while the opposite phenomena can be observed in concentration distributions (Fig. 14) for both fluid cases. The impression of wedge parameter on θ, u and χ profiles is shown in Figs. 15–17. It is confirmed that the

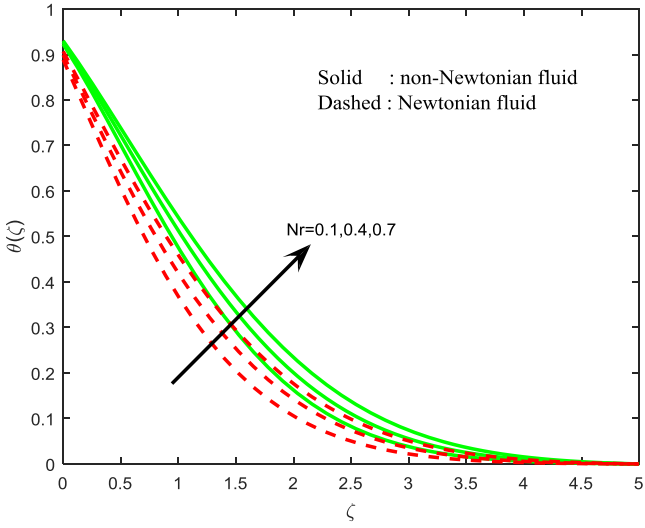


Fig. 13. (Color online) The profile of Nr on temperature curves.

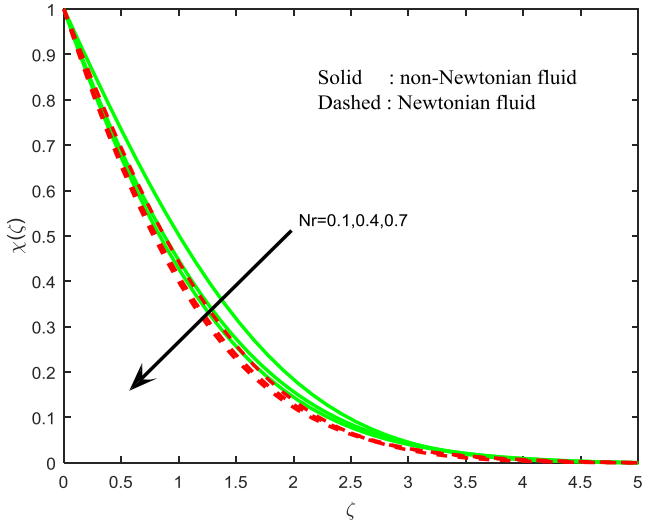


Fig. 14. (Color online) The profile of Nr on concentration curves.

escalating values of wedge constraint improve the velocity profile. Generally, an increasing value of wedge parameter keeps more burdens on the flow, this leads to progress in the values of u. Hence the values of θ and χ are reduced for enhanced wedge parameter for both Newtonian and non-Newtonian fluids.

Tables 3 and 4 show the impact of selected values of parameters on the friction factor $\mathrm{Re}_x^{1/2} C_{fx} \sqrt{2/(m+1)}$, rate of mass and heat transfer for both types of flows over a wedge. The effect of slip over the surface, the temperature jump and the

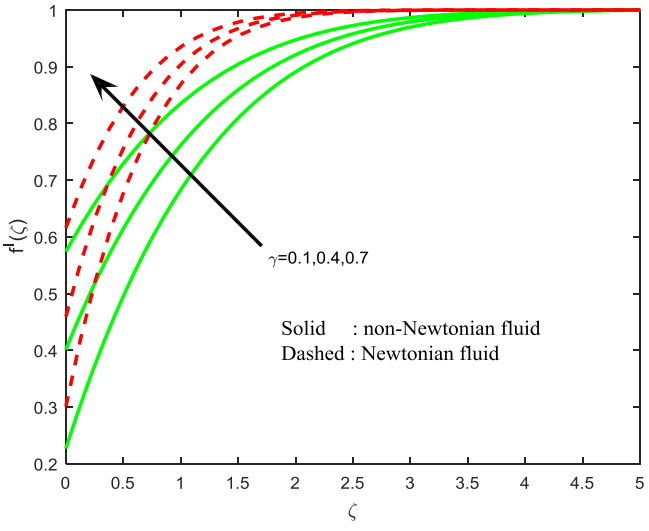


Fig. 15. (Color online) The profile of γ on velocity curves.

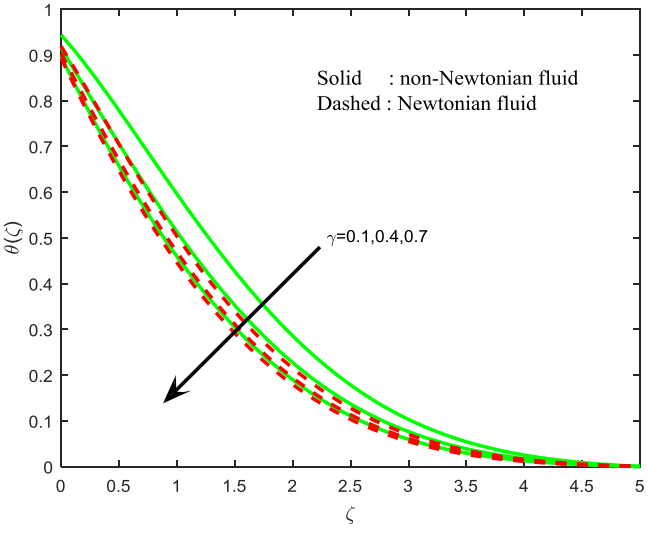


Fig. 16. (Color online) The profile of γ on temperature curves.

radiation parameter improve Sherwood number values for both cases. The heat source/sink, Eckert number and Dufour number boost the rate of thermal transport and depreciate the rate of mass transport for both the Newtonian and non-Newtonian fluid cases. Less influence of non-Newtonian fluids on the Nusselt number is observed when contrasted with the Newtonian fluid situation. The increasing values of velocity slip, chemical reaction and wedge parameter are leads to enhance the values of Nu_x and Sh_x. Due to the complex viscous nature of non-Newtonian fluid,

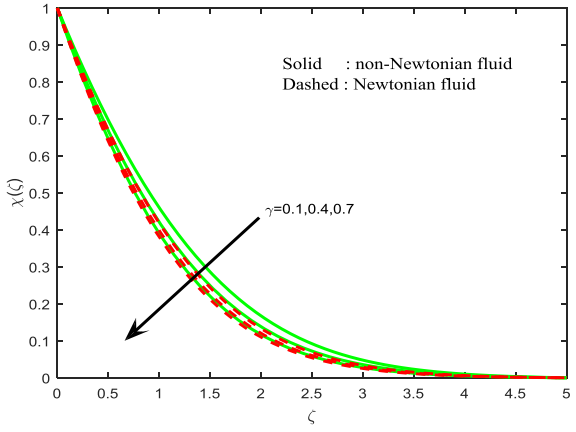


Fig. 17. (Color online) The profile of γ on concentration curves.

Table 3. Variations in skin friction coefficient for different nondimensional parameters.

										$\mathrm{Re}_x^{1/2} C_{fx} \sqrt{2/(m+1)}$	
δ	Q_H	Kr	Ec	ε	Ec	Df	Sr	Nr	γ	$\beta \to \infty$	$\beta > 0$
0.1										0.900899	0.569690
0.3										0.900899	0.569690
0.5										0.900899	0.569690
	0.1									0.900899	0.569690
	0.3									0.900899	0.569690
	0.5									0.900899	0.569690
		0.1								0.900899	0.569690
		0.3								0.900899	0.569690
		0.5								0.900899	0.569690
			0.5							0.900899	0.569690
			1							0.900899	0.569690
			1.5							0.900899	0.569690
				0						1.127697	0.651411
				0.5						0.683541	0.476239
				1						0.513444	0.388518
					−0.5					0.900899	0.569690
					−1					0.900899	0.569690
					−1.5					0.900899	0.569690
						0				0.900899	0.569690
						2				0.900899	0.569690
						4				0.900899	0.569690
							0.1			0.900899	0.569753
							0.4			0.900899	0.569753
							0.7			0.900899	0.569753
								0.1		0.900899	0.569753
								0.4		0.900899	0.569753
								0.7		0.900899	0.569753
									0.1	0.900899	0.632800
									0.4	0.900899	0.437834
									0.7	0.900899	0.226383

Table 4. Variations in local Nusselt $\mathrm{Re}_x^{-1/2}\mathrm{Nu}_x\sqrt{2/(m+1)}$ and Sherwood number $\mathrm{Re}_x^{-1/2}\mathrm{Sh}_x\sqrt{2/(m+1)}$ for various parametric attributes.

										$\mathrm{Re}_x^{-1/2}\mathrm{Nu}_x\sqrt{2/(m+1)}$		$\mathrm{Re}_x^{-1/2}\mathrm{Sh}_x\sqrt{2/(m+1)}$	
δ	Q_H	Kr	Ec	ε	Ec	Df	Sr	Nr	γ	$\beta\to\infty$	$\beta>0$	$\beta\to\infty$	$\beta>0$
0.1										0.833963	0.744991	0.729083	0.715532
0.3										0.743545	0.683101	0.738327	0.720763
0.5										0.669330	0.629571	0.746185	0.725476
	0.1									0.709822	0.602930	0.753734	0.742944
	0.3									0.749501	0.661828	0.743504	0.729898
	0.5									0.786463	0.712910	0.733893	0.718214
		0.1								0.596968	0.673701	0.507442	0.446240
		0.3								0.616288	0.692767	0.645186	0.593099
		0.5								0.636532	0.712910	0.764134	0.718214
			0.5							0.586036	0.617976	0.778124	0.742534
			1							0.687162	0.712910	0.750106	0.718214
			1.5							0.788823	0.808274	0.721936	0.693788
				0						0.365336	0.264619	0.716900	0.664222
				0.5						0.485145	0.399609	0.788192	0.736629
				1						0.515149	0.450554	0.808880	0.766441
					−0.5					0.484986	0.428193	0.774286	0.733203
					−1					0.384021	0.333362	0.739076	0.700216
					−1.5					0.283594	0.238974	0.704356	0.667778
						0				0.417442	0.313666	0.762403	0.706462
						2				0.485326	0.392099	0.739418	0.681690
						4				0.552879	0.469512	0.716841	0.657494
							0.1			0.437446	0.337254	0.834911	0.802113
							0.4			0.435561	0.334860	0.776273	0.725803
							0.7			0.433688	0.332481	0.718119	0.650153
								0.1		0.557817	0.387097	0.670355	0.580883
								0.4		0.504301	0.366637	0.712527	0.639820
								0.7		0.465191	0.349012	0.738818	0.676004
									0.1	0.405978	0.282036	0.739853	0.673137
									0.4	0.484490	0.423802	0.787663	0.750453
									0.7	0.536462	0.518520	0.825471	0.811252

higher local Nusselt number values are observed compared with the Newtonian fluid case. The rising values of Soret number and negative values of Eckert number minimize the rate of thermal and mass transport values for both the Newtonian and non-Newtonian fluid cases.

5. Conclusions

The nonlinear radiation with the dissipative system has sundry real-time uses like welding and nuclear security developments. Due to this, the radiative and dissipative impact on MHD Casson fluid flow on a moving wedge is considered. The results of governing physical problems are obtained by Newton's and RK's methods and are further shown in graphical and tabular forms. Due to the slip parameter domination, the Sherwood number and Nusselt number are higher in Newtonian fluid flow situation while related to the non-Newtonian fluid flow. Positive values of Eckert

number enhance the temperature field which deaccelerates with negative values of Eckert number.

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S. V. Siva Rama Raju and C. S. K. Raju contributed equally to this paper.

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UTILIZING DATA MINING TECHNIQUES FOR PREDICTING STUDENTS' ACADEMIC PERFORMANCE

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Abstract: In the real life of higher education, predicting students' academic performance remains a significant challenge. Employing statistical tools and data mining techniques has become essential to analyse and forecast students' paths through the educational process. This paper explores the utilization of data mining techniques, specifically focusing on the WEKA data mining software, to predict semester-wise student marks based on parameters within a given dataset. The dataset encompasses information from students across five courses within a single college over multiple semesters. By using data mining methodologies, educators can uncover hidden patterns within student data, facilitating a deeper understanding of the factors influencing academic success. This paper discusses the application of data mining techniques as a means to discover valuable insights and improve decision-making processes within the educational domain.

Keywords: Data mining techniques, WEKA tool, Clustering methods: Canopy, EM, Hierarchical, Simple-k means.

INTRODUCTION

Data mining is becoming a critical component in educational institutions and one of the most important areas of research, with the goal of extracting valuable information from large data sets. Educational data mining (EDM) is an essential study area that can help anticipate meaningful information from educational databases in order to improve educational performance, knowledge, and assessment of students' learning processes. Data mining, also known as knowledge discovery, is becoming increasingly important since it aids in the analysis of data from many viewpoints and its summarization into meaningful information.

1. What is Data Mining?

Data Mining is the process of extracting information from large amounts of data to uncover patterns, trends, and usable data that will help a business entity to make data-driven decisions.
Data mining is the process of automatically examining enormous amounts of information to discover trends and patterns that go beyond simple analysis techniques.
Data mining employs complex mathematical algorithms to analyze data segments and determine the likelihood of future events. Data mining is also known as Knowledge Discovery ofData(KDD).
Data mining is a procedure used by corporations to extract specific data from large datasets in order to address business challenges. It primarily converts raw data to useable knowledge.

Data Mining is related to Data Science in that it is performed by a person in a specific scenario, on a specific data collection, with a goal in mind. This process involves a variety of services, including text mining, web mining, audio and video mining, graphical data mining, and social media mining. It is accomplished with software that is either simple or highly specific. Outsourcing data mining allows for speedier completion of tasks while keeping operational expenses low. Specialized businesses can also employ new technology to obtain data that is impossible to find manually. There is a wealth of material available across multiple platforms, but relatively little knowledge is accessible. The most difficult challenge is to analyze the data and extract critical information that can be used to address a problem.



2. Data Mining Techniques:

Data mining is the use of sophisticated data analysis technologies to discover previously undiscovered, valid patterns and relationships in large data collections. These technologies can use statistical models, machine learning approaches, and mathematical algorithms like neural networks or decision trees. Thus, data mining includes both analysis and prediction.Professionals in data mining have dedicated their careers to better understanding how to process and draw conclusions from massive amounts of data, but what methods do they use to accomplishthis?

Association, classification, clustering, prediction, sequential patterns, and regression are some of the primary data mining techniques developed and employed in recent projects.



Classification technique:

This strategy is used to gather crucial and relevant data and metadata. This data mining technique aids in classifying data into several categories.
Data mining techniques can be classed using several criteria, as follows:
Data mining frameworks are classified based on the types of data sources mined.
This classification is based on the type of data handled. Examples include multimedia, spatial data, text data, time series data, and the World Wide Web.
Data mining frameworks are classified based on the database involved.
The classification is based on the data model used. For example. There are several types of databases, including object-oriented, transactional, and relational.

Classification of data mining frameworks according to the type of knowledge discovered:This classification is based on the sorts of knowledge obtained or data mining functionalities, such as discrimination, classification, clustering, and characterisation. Some frameworks are comprehensive and provide a variety of data mining features.
Classification of data mining frameworks based on approaches used:This classification is based on the data analysis approach used, such as neural networks, machine learning, genetic algorithms, visualization, statistics, data warehouse- or database-oriented, and so on.
The classification might also consider the extent of user participation engaged in the data mining process, such as query-driven systems, autonomous systems, or interactive exploratory systems.

2.Clustering:

Clustering is the partitioning of information into groups of interconnected things. Describing the data by a few clusters loses some specific details but improves overall performance. It models data using clusters. Data modelling approaches clustering from a historical perspective based on statistics, mathematics, and numerical analysis. Clusters are hidden patterns in machine learning, the search for clusters is unsupervised learning, and the architecture that follows is a data idea. Clustering performs exceptionally well in data mining applications. Examples include scientific data exploration, text mining, information retrieval, spatial database applications, CRM, web analysis, computational biology, medical diagnostics, and much more. In other words, clustering analysis is data.

3.Regression:

Regression analysis is a data mining procedure that identifies and analyzes the relationship between variables based on the existence of another factor. It is used to specify the likelihood of a particular variable. Regression is basically a method of

planning and modelling. For example, we may use it to forecast specific costs based on other variables such as availability, consumer demand, and competitiveness. It provides the exact link between two or more variables in a given data collection.

4. Association Rules:

This data mining technique aids in the discovery of a relationship between two or more things. It identifies a hidden pattern in the dataset.
Association rules are if-then statements that help to illustrate the likelihood of interactions between data items inside huge data sets in various types of databases. Association rule mining offers a variety of uses, including improving sales correlations in data or medical data sets.The algorithm works by assuming you have a variety of data. For example, make a list of the groceries goods you've purchased throughout the last six months. It measures the percentage of products purchased together. There are three main measurement techniques:

o Lift:

This measurement technique measures the accuracy of the confidence over how often item B is purchased.

(Confidence) / (item B)/ (Entire dataset) o Support:

This measurement technique measures how often multiple items are purchased and compared it to the overall dataset.

(Item A + Item B) / (Entire dataset) o Confidence:

This measurement technique measures how often item B is purchased when item A is purchased as well.

(Item A + Item B)/ (Item A)

5.Outer detection:

This type of data mining technique relates to the observation of data items in the data set, which do not match an expected pattern or expected behaviour. This technique may be used in various domains like intrusion, detection, fraud detection, etc. It is also known as Outlier analysis or outlier mining. The outlier is a data point that diverges too much from the rest of the dataset. The majority of the real-world datasets have an outlier. Outlier detection plays a significant role in the data mining field. Outlier detection is valuable in numerous fields like network interruption identification, credit or debit card fraud detection, detecting outlying in wireless sensor network data, etc.

6.Sequential Patterns:

The sequential pattern is a data mining technique that focuses on assessing sequential data in order to identify sequential patterns. It entails identifying interesting subsequences within a set of sequences, with the value of a sequence quantified using several parameters such as length, occurrence frequency, and so on. In other words, this data mining technique aids in the discovery or recognition of repeatable patterns in transaction data over time.
7.Prediction:

Prediction used a combination of other data mining techniques such as trends, clustering, classification, etc. It analyses past events or instances in the right sequence to predict a future event.

3. Advantages of Data Mining:

The Data Mining technique enables organizations to obtain knowledge-based data.

Data mining enables organizations to make lucrative modifications in operation and production.

Compared with other statistical data applications, data mining is a cost-efficient. o Data Mining helps the decision-making process of an organization.

It Facilitates the automated discovery of hidden patterns as well as the prediction of trends and behaviour.

It can be induced in the new system as well as the existing platforms.

It is a quick process that makes it easy for new users to analyse enormous amounts of data in a short time.

4 Data Mining Applications:

Data mining is generally utilized by businesses with high consumer demands, such as retail, communication, finance, and marketing firms, to assess pricing, consumer preferences, product placement, and the influence on sales, customer happiness, and corporate profitability. Data mining allows a shop to use point-of-sale records of client purchases to create items and promotions that will assist the company attract customers.

Weka Data Mining

Weka contains a collection of visualization tools and algorithms for data analysis and predictive modelling, together with graphical user interfaces for easy access to these functions. The original non-Java version of Weka was a Tcl/Tk front-end to (mostly third-party) modelling algorithms implemented in other programming languages, plus data preprocessing utilities in C and a make file-based system for running machine learning experiments.

This original version was primarily designed as a tool for analysing data from agricultural domains. Still, the more recent fully Java-based version (Weka 3), developed in 1997, is now used in many different application areas, particularly for educational purposes and research. Weka has the following advantages, such as:Free availability under the GNU General Public License.

Portability, since it is fully implemented in the Java programming language and thus runs on almost any modern computing platform.

A comprehensive collection of data and modelling techniques.

Ease of use due to its graphical user interfaces.

Weka supports several standard data mining tasks, specifically, data preprocessing, clustering, classification, regression, visualization, and feature selection. Input to Weka is expected to be formatted according to the Attribute-Relational File Format and filename with the arff extension.

All Weka's techniques are predicated on the assumption that the data is available as one flat file or relation, where a fixed number of attributes describes each data point (numeric or nominal attributes, but also supports some other attribute types). Weka provides access to SQL databases using Java Database Connectivity and can process the result returned by a database query. Weka provides access to deep learning with Deeplearning4j.

It is not capable of multi-relational data mining. Still, there is separate software for converting a collection of linked database tables into a single table suitable for processing using Weka. Another important area currently not covered by the algorithms included the Weka distribution in sequence modelling.

Farthest First

Farthest first find its variant of k-means, each cluster centre point furthermost from the existing cluster centre is placed by the k mean and this point must be positioned within the data area. So that it greatly speeds up the clustering in most cases but it needs less move and adjustment for their fast performance. It uses heuristic approach for finding its points. It's arbitrary point is p1, pick an another point p2 far from p1, pick pi to maximize the distance to the nearest of all centroid, the maximize the min dist(pi, p1), dist(pi,p2),...}.After all K representatives are chosen then we define the partition of data area D: cluster is Cj consists of all points closer to pj than to any other representative.

Filtered Cluster

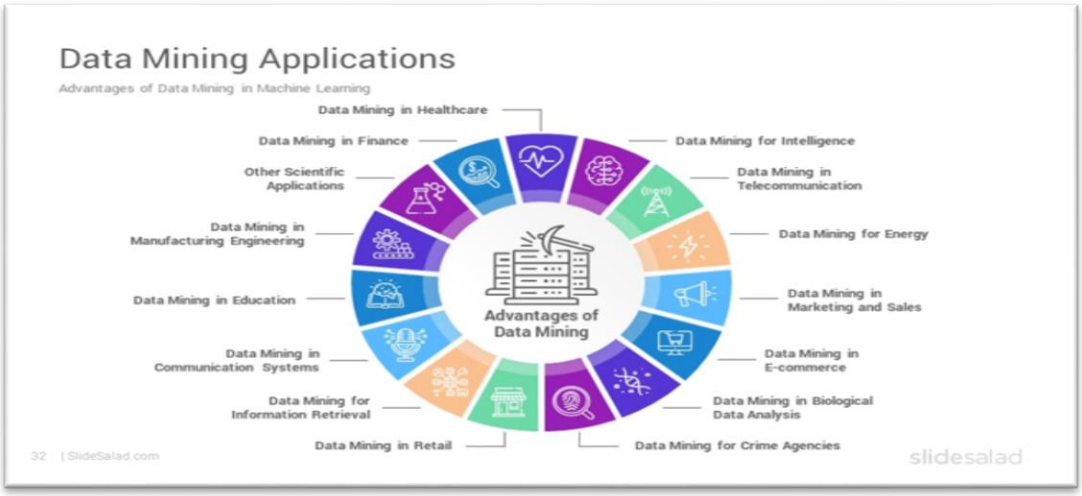
The filtered cluster algorithm is based on storing the multidimensional data points in a kd-tree. The process of the tree is like a binary tree approach, which represents a hierarchical subdivision of its data point set's bounding box using their axis and then splitting is aligned by hyperplanes. Each node of the kd-tree is associated with a closed box, called cell. The root's cell is the bounding box of the point in the dataset. If the cell contains at most one point, then it is declared to be a leaf. Then the finding points in the cell are then partitioned to one side or the other of this hyper plane. The resulting sub cells are the children of the original cell, this leads to a binary tree structure

Density Based Cluster

The DBSCAN is Density-Based clustering algorithms to find clusters based on density of data points in a region and it use only one input parameter for their process so minimal knowledge is required. Density-Based clustering is that for each instance of a cluster the neighbourhood of a given radius (Eps) has to contain at least a minimum number of instances (Min Pts). DBSCAN separates data points into three classes: 1) Core points: points the interior of a cluster, 2) Border points: points neighbourhood of a core point, 3) Noise points: points which is not a core point or a border point. To find a cluster, DBSCAN starts with an arbitrary instance (p) in data set (D) and retrieves all instances of D with respect to Eps and Min Pts.

Canopy Algorithm

Canopy Clustering is a very simple, fast and surprisingly accurate method for grouping objects into clusters. All objects are represented as a point in a multidimensional feature space. The algorithm uses a fast-approximate distance metric and two distance thresholds T1 > T2 for processing. The basic algorithm is to begin with a set of points and remove one at random. Create a Canopy containing this point and iterate through the remainder of the point set. At each point, if its distance from the first point is < T1, then add the point to the cluster. If, in addition, the distance is < T2, then remove the point from the set. This way points that are very close to the original will avoid all further processing. The algorithm loops until the initial set is empty, accumulating a set of Canopies, each containing one or more points. A given point may occur in more than one Canopy. Canopy Clustering is often used as an initial step in more rigorous clustering techniques, such as K-Means Clustering . By starting with an initial clustering, the number of more expensive distance measurements can be significantly reduced by ignoring points outside of the initial canopies.



5. Data mining in Education:

Education data mining is a new subject that focuses on developing tools to extract knowledge from data created in educational environments. EDM objectives are identified as validating students' future learning behaviours, researching the impact of educational support, and advancing learning sciences. Data mining may help an organization make precise decisions as well as forecast student outcomes. With the results, the school may focus on what and how to teach.



METHODOLOGY

There are numerous Machine learning algorithms in the literature and some of the important and popular algorithms based on Clustering.

1. Canopy clustering:

Canopy Clustering is a very simple, fast and surprisingly accurate method for grouping objects into clusters. All objects are represented as a point in a multidimensional feature space. The algorithm uses a fast-approximate distance metric and two distance thresholds T1 > T2 for processing.

Step-1: Go to WEKA software

Step-2: Select data by using open file.

Step-3: Go to cluster and select Canopy from choose option.

Step-4: Click start button to run the program.

2. EM Clustering:

For clustering, EM makes use of the finite Gaussian mixtures model and estimates a set of parameters iteratively until a desired convergence value is achieved.

Step-1: Go to WEKA software

Step-2: Select data by using open file.

Step-3: Go to cluster and select EM from choose option.

Step-4: Click start button to run the program.

3. Hierarchical Clustering:

Hierarchical clustering is mainly focussing on building of hierarchy of clusters, i.e., cluster tree and it is represented in a dendrogram. It is either merging smaller clusters into larger clusters or splitting larger clusters into smaller ones. A clustering of the data items is obtained through cutting a dendrogram at a desired level.

Step-1: Go to WEKA software

Step-2: Select data by using open file.

Step-3: Go to cluster and select Hierarchical from choose option.

Step-4: Click start button to run the program.

4. Simple-k means clustering:

K-means clustering is a simple unsupervised learning algorithm. In this, the data objects (‘n’) are grouped into a total of ‘k’ clusters, with each observation belonging to the cluster with the closest mean. It defines ‘k’ sets, one for each cluster k n (the point can be thought of as the centre of a one or two-dimensional figure). The clusters are separated by a large distance.

Step-1: Go to WEKA software

Step-2: Select data by using open file.

Step-3: Go to cluster and select simple k means from choose option.

Step-4: Click start button to run the program.

BACKGROUND

Here is the background tool required for our project.

We have used a data mining software named as WEKA for this project.

Required Software (WEKA) –

What is WEKA?

WEKA (Waikato Environment for Knowledge) Analysis it's a data mining/machine learning tool developed by Department of Computer Science, University of Waikato, New Zealand.

History of WEKA

In 1993, the University of Waikato in New Zealand began the development of the original version of Weka, which became a mix of Tcl/Tk, C, and make files.

In 1997, the decision was made to redevelop Weka from scratch in Java, including implementing modelling algorithms.

In 2005, Weka received the SIGKDD Data Mining and Knowledge Discovery Service Award.

In 2006, Pentaho Corporation acquired an exclusive licence to use Weka for business intelligence. It forms the data mining and predictive analytics component of the Pentaho business intelligence suite. Hitachi Vantara has since acquired Pentaho, and Weka now underpins the PMI (Plugin for Machine Intelligence) open-source component.

Features of Weka:



Weka has the following features, such as:

Preprocess:

Preprocessing data is a critical step in data mining. Because the majority of the data is raw, there is a possibility that it contains empty or duplicate entries, junk values, outliers, extra columns, or a different naming convention. All of this degrades the outcomes.
To make data cleaner, better, and more thorough, WEKA provides a broad set of filter choices. The tool supports both supervised and unsupervised activities. Here is a list of some operations for preprocessing.
Replace Missing with User Constant: to resolve the empty or null value issue.
Reservoir Sample: create a random subset of sample data.
Nominal to Binary: Converting data from nominal to binary.
Remove Percentage: To remove

Classify:

One of the most important activities in machine learning is classification, which involves assigning classes or categories to things. Classic examples of classification include labeling a brain tumor as "malignant" or "benign" or categorizing an email as "spam" or "not spam."
Following the selection of the appropriate classifier, we choose test choices for the training set. Some of the alternatives include:
Use the training set: the classifier will be tested using the same training set.
A given test set evaluates the classifier using a separate test set.
Cross-validation Folds: The classifier's performance is evaluated using cross-validation and the number of folds provided.
proportion split: The classifier will be evaluated using a given proportion of the data.
Aside from these, we can also utilize more testing options.

Cluster:

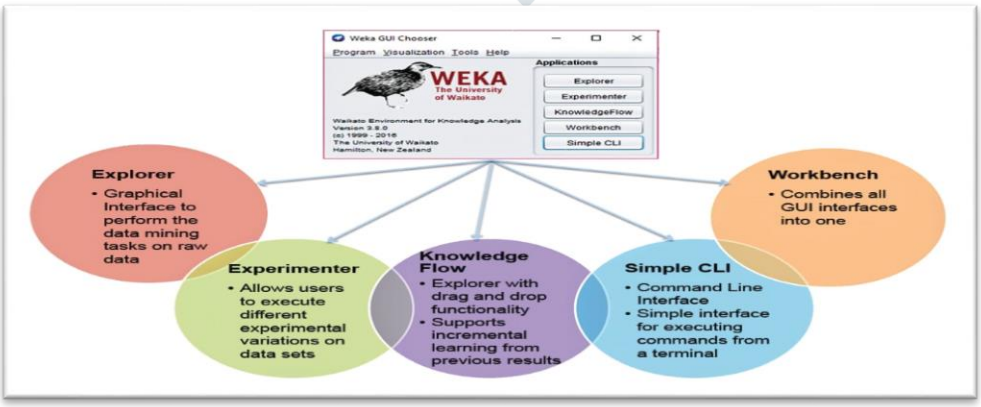
Clustering divides a dataset into groups/clusters based on certain commonalities. In this scenario, the items in the same cluster are identical but distinct from those in other clusters. Clustering can be defined as identifying customers who exhibit similar behaviors and arranging regions based on homogeneous land use.

Associate:

Association rules emphasize all of the relationships and connections between elements in a dataset. In a nutshell, it is an if-then expression that represents the likelihood of associations between data points. A typical example of association is the connection between the selling of milk and bread.
For association rule mining in this category, the tool includes the Apriori, Filtered Associator, and FP Growth algorithms.

Select Attributes:

Every dataset contains many attributes, yet some of them may not be particularly valuable. As a result, reducing extraneous details while retaining vital ones is critical for creating a good model.
Many attribute evaluators and search algorithms exist, including Best First, Greedy Stepwise, and Ranker.
Visualize:
The visualization tab contains a variety of plot matrices and graphs that display the model's discovered trends and mistakes.
Weka Requirements and Installation
We can install WEKA on Windows, Mac OS, and Linux. The current stable versions of Weka require at least Java 8 or above.



Main GUI, Five graphical user interfaces

"The Explorer" (exploratory data analysis)

"The Experimenter" (experimental environment)

"The Knowledge Flow" (new process model inspired interface)

Workbench

Simple CLI (Command prompt)

Offers some functionality not available via the GUI

Explorer:

The WEKA Explorer windows show different tabs starting with preprocessing. Initially, the preprocess tab is active, as first the data set is pre-processed before applying algorithms to it and exploring the dataset.

The tabs are as follows:

Preprocess: Choose and modify the loaded data.

Classify: Apply training and testing algorithms to the data that will classify and regress the data.

Cluster: Form clusters from the data.

Associate: Mine out the association rule for the data.

Select attributes: Attribute selection measures are applied.

Visualize: 2D representation of data is seen.

Status Bar: The bottommost section of the window shows the status bar. This section shows what is happening currently in the form of a message, such as a file being loaded. Right-click on this, Memory information can be seen, and also Run garbage collector to free up space can be run.

Log Button: It stores a log of all actions in Weka with the timestamp. Logs are shown in a separate window when the Log button is clicked.

WEKA Bird Icon: Present on the bottom right corner shows the WEKA bird with represents the number of processes running concurrently (by x.). When the process is running the bird will move around.

Experimenter:

The WEKA experimenter button allows the users to create, run, and modify different schemes in one experiment on a dataset. The experimenter has 2 types of configurations: Simple and Advanced. Both configurations allow users to run experiments locally and on remote computers.

The “Open” and “New” buttons will open a new experiment window that users can do.

Results: Set the result destination file from ARFF, JDFC, and CSV files.

Experiment Type: The user can choose between cross-validation and train/test.

percentage split: The user can choose between Classification and Regression-based upon the dataset and classifier used.

Datasets: The user can browse and select datasets from here. The relative path checkbox is clicked if working on different machines. The format of datasets supported is ARFF, C4.5, CSV, libsvm, bsi, and XRFF.

Iteration: The default iteration number is set to 10. Datasets first and algorithms first help in switching between dataset and algorithms so that algorithms can be run on all datasets.

Algorithms: New algorithms are added by “New Button”. The user can choose a classifier.

Save the experiment using the Save button.Run the experiment using the Run button.

Knowledge flow:

Knowledge flow shows a graphical representation of WEKA algorithms. The user can select the components and create a workflow to analyze the datasets. The data can be handled batch-wise or incrementally. Parallel workflows can be designed and each will run in a separate thread.

Weka Workbench:

The Weka Workbench is an environment that combines all of the GUI interfaces into a single interface.

It is useful if you find yourself jumping a lot between two or more different interfaces, such as between the Explorer and the Experiment Environment. This can happen if you try out a lot of what ifs in the Explorer and quickly take what you learn and put it into controlled experiments.

Weka Simple CLI:

Weka can be used from a simple Command Line Interface (CLI).

This is powerful because you can write shell scripts to use the full API from command line calls with parameters, allowing you to build models, run experiments and make predictions without a graphical user interface.

The Simple CLI provides an environment where you can quickly and easily experiment with the Weka command line interface commands.

The different components available are Data sources, Data savers, Filters, Classifiers, Clusters, Evaluation, and Visualization.

DESIGN AND IMPLEMENTATION

The following are the step-by-step process of our project evaluation.

Collection of data: We have a collected a data set contains the result of students of overall semesters. The data set contains 255 instances and 14 attributes.

Here is the sample of our data set which is in entered in MS-Excel and saved in 'CSV' format.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Sl. no	Gender	Place of study	Name of the student	Course	Hall ticket number	Semester -1	Semester -2	Semester-3	Semester -4	Semester -5	Semester -6	Total	Result
2	1	F	Tirupati	K.Ahalya	MPC	319003109	97	97	99	91	96	97	577	OUT STANDING
3	2	F	Tirupati	S.Anusha	MPC	319003110	74	72	93	83	83	89	494	EXCELLENT
4	3	F	Tirupati	A.Aswini	MPC	319003111	70	91	90	86	86	86	509	OUT STANDING
5	4	F	Tirupati	Y.Bhargavi	MPC	319003112	79	81	89	82	84	88	503	OUT STANDING
6	5	F	Tirupati	N.Chandrakala	MPC	319003113	73	76	89	82	80	86	486	EXCELLENT
7	6	F	Tirupati	P.Chennakrishnamma	MPC	319003114	93	92	92	97	87	90	551	OUT STANDING
8	7	F	Tirupati	D.Gayatri	MPC	319003115	96	88	94	84	90	88	540	OUT STANDING
9	8	F	Tirupati	P.Geetha	MPC	319003116	35	79	86	77	76	85	438	EXCELLENT
10	9	F	Tirupati	K.Geethapriya	MPC	319003117	65	35	76	71	35	77	359	GOOD
11	10	F	Tirupati	E.Haritha	MPC	319003118	88	81	89	88	85	84	515	OUT STANDING
12	11	F	Tirupati	P.Haseena	MPC	319003119	88	84	92	92	92	95	543	OUT STANDING
13	12	F	Tirupati	G.Janaki	MPC	319003120	93	95	91	85	86	89	539	OUT STANDING
14	13	F	Tirupati	M.Jyothi	MPC	319003121	77	81	87	79	75	82	481	EXCELLENT
15	14	F	Tirupati	L.Kalyani	MPC	319003122	94	88	92	91	96	91	552	OUT STANDING
16	15	F	Tirupati	V.Kaveri	MPC	319003123	79	83	90	83	84	84	503	OUT STANDING
17	16	F	Tirupati	T.Kavya	MPC	319003124	82	87	90	84	82	84	509	OUT STANDING
18	17	F	Tirupati	P.Krishna kumari	MPC	319003125	35	35	71	35	65	79	320	GOOD
19	18	F	Tirupati	B.Lakshmi	MPC	319003126	96	97	93	91	93	91	561	OUT STANDING
20	19	F	Tirupati	S.Latha	MPC	319003127	93	93	91	87	97	88	549	OUT STANDING
21	20	F	Tirupati	S.Madhavi	MPC	319003128	88	80	91	85	90	86	520	OUT STANDING
22	21	F	Tirupati	T.Navaneetha	MPC	319003129	89	87	92	87	93	93	541	OUT STANDING
23	22	F	Tirupati	P.Nikhitha	MPC	319003130	82	90	90	83	86	92	523	OUT STANDING
24	23	F	Tirupati	V.Nikhitha	MPC	319003131	75	87	93	90	88	90	523	OUT STANDING
25	24	F	Tirupati	M.Pavani	MPC	319003132	87	87	91	85	88	93	531	OUT STANDING
26	25	F	Tirupati	M.Poornamma	MPC	319003133	82	76	88	90	86	91	513	OUT STANDING
27	26	F	Tirupati	R.Ramya	MPC	319003134	98	91	94	90	96	97	566	OUT STANDING
28	27	F	Tirupati	J.Ramya	MPC	319003135	73	74	90	90	76	87	470	EXCELLENT

Preprocessing:

Data Pre-processing is the first step of evaluation of this paper. Now we will choose WEKA Explorer interface. Here the source data file is selected from local machine. After loading the data in explorer, we can refine the data by selecting different options which is known as 'data cleaning' and can also select or remove attributes as per our need

It's the nut shell about WEKA and its application in education system

CLUSTER ANALYSIS IN WEKA TOOL

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense) to each other than to those in other groups (clusters). It is a main task of exploratorydata mining, and a common technique for statistical data analysis, used in many fields, including pattern recognition,image analysis, information retrieval, bioinformatics, data compression, computer graphics and machine learning.

Besides the term clustering, there are a number of terms with similar meanings, including automatic classification, numerical taxonomy, bornology, typological analysis, and community detection. The subtle differences are often in the use of the results: while in data mining, the resulting groups are the matter of interest, in automatic classification the resulting discriminative power is of interest.

Cluster Algorithm using WEKA tool

Clustering is a task for which many algorithms have been proposed. No clustering technique is Universally applicable, and different techniques are in favour for different clustering purposes.

So, an understanding of both the clustering problem and the clustering technique is required to Apply a suitable method to a given problem. In the following, I describe general of a Clustering technique algorithm in weak tool show in figure.

Clustering is the method of dividing a set of abstract objects into groups. Points to Keep in Mind A set of data objects can be viewed as a single entity. When performing cluster analysis, we divide the data set into groups based on data similarity, then assign labels to the groups.

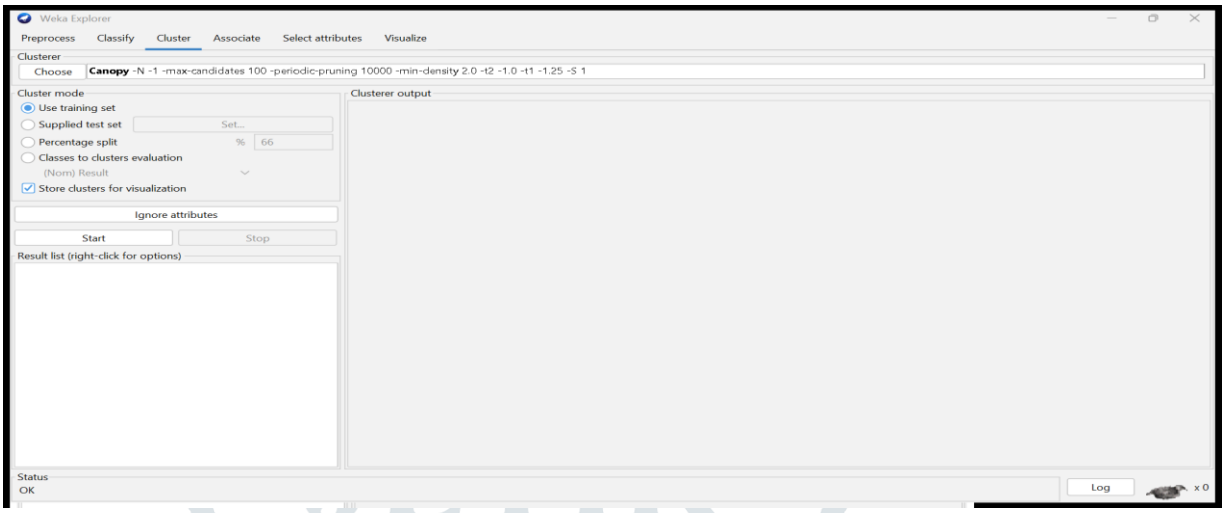
COMWEB Algorithm:

COBWEB is an incremental system for hierarchical conceptual clustering. COBWEB was invented by Professor Douglas H. Fisher, currently at Vanderbilt University. COBWEB incrementally organizes observations into a classification tree. Each node in a classification tree represents a class (concept) and is labelled by a probabilistic concept that summarizes the attribute-value distributions of objects classified under the node. This classification tree can be used to predict missing attributes or the class of a new object.

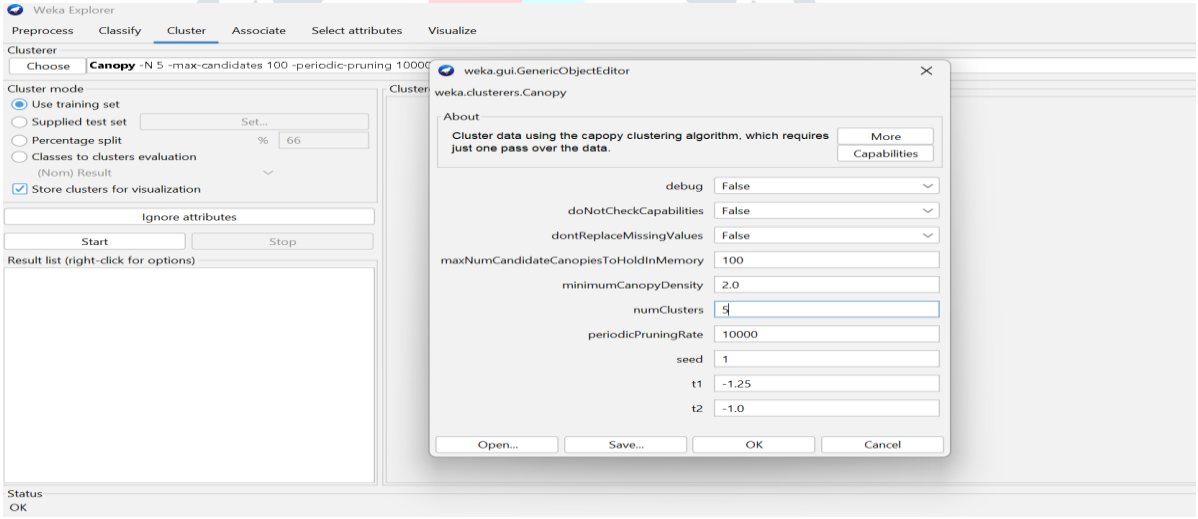
Steps to be followed:

Step 1: In the preprocessing interface, open the Weka Explorer and load the required dataset, and we are taking the scheme. raff dataset.

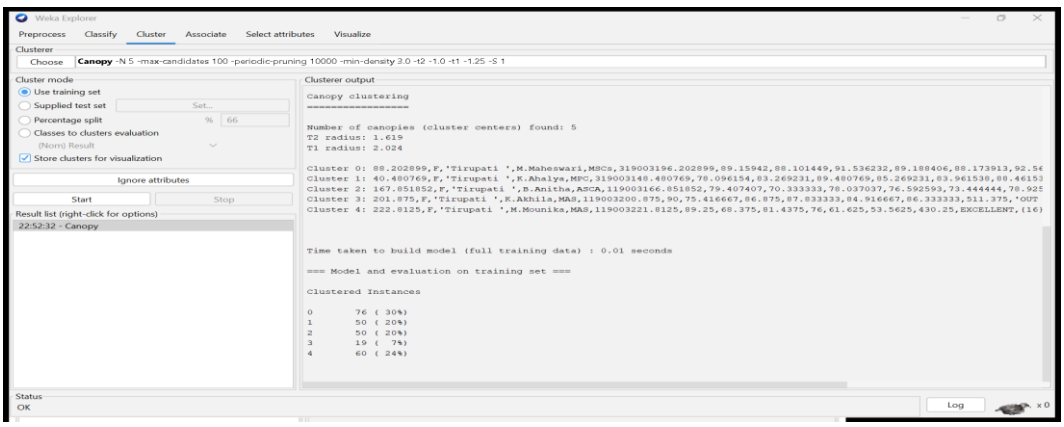
Step 2: Find the 'cluster' tab in the explorer and press the choose button to execute clustering. A dropdown list of available clustering algorithms appears as a result of this step and selects the canopy algorithm.



Step 3: Then, to the right of the choose icon, press the text button to bring up the popup window. We enter five for the number of clusters in this window and the seed value is one. The seed value is used to generate a random number that is used to make internal assignments of instances of clusters.

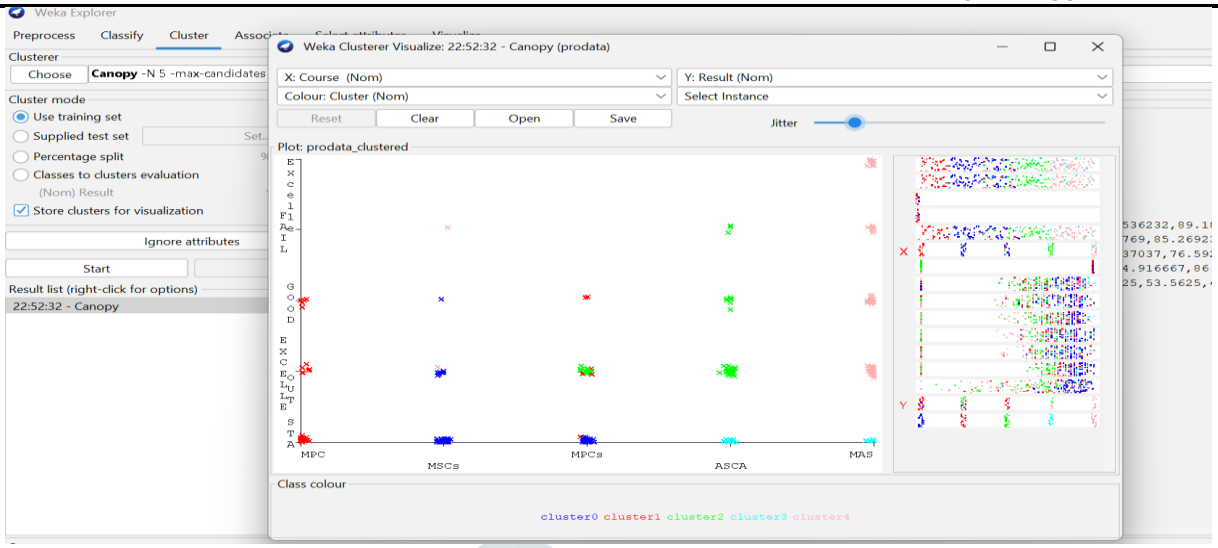


Step 4: One of the choices has been chosen. We must ensure that they are in the 'cluster mode' panel before running the clustering algorithm. The choice to use a training set is selected, and then the 'start' button is pressed.



The centroid of each cluster is shown in the result window, along with statistics on the number and percent of instances allocated to each cluster. Each cluster centroid is represented by a mean vector. This cluster can be used to describe a cluster.

Step 6: Another way to grasp the characteristics of each cluster is to visualize them. To do so, right-click the result set on the result. Selecting to visualize cluster assignments from the list column.



Step 7: In the Cluster visualization we choose Course on X-axis and Result no on Y-axis. Blue colour shows Cluster 0, Red colour shows Cluster 1, Green colour shows Cluster 2, Sky-blue colour shows Cluster 3, Light pink colour shows Cluster 4.

Output:

This canopy algorithm is tested with project dataset in WEKA tool; it produces five different clustered instance clusters 0: 76(30%), cluster 1: 50(20%), cluster 2: 50(20%), cluster 3: 19(7%), cluster 4: 60(24%), and Time taken to build model (full training data): 0.01 seconds.

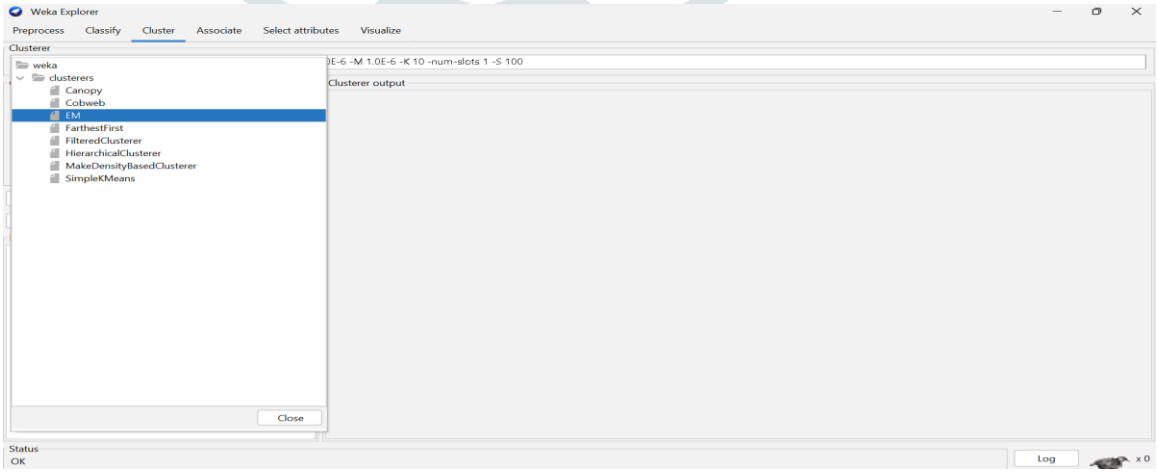
EM:

The EM algorithm (Dempster, Laird, & Rubin 1977) finds maximum likelihood estimates of parameters in probabilistic models. EM is an iterative method which alternates between two steps, expectation (E) and maximization (M). For clustering, EM makes use of the finite Gaussian mixtures model and estimates a set of parameters iteratively until a desired convergence value is achieved. The mixture is defined as a set of K probability distributions and each distribution corresponds to one cluster. An instance is assigned with a membership probability for each cluster.

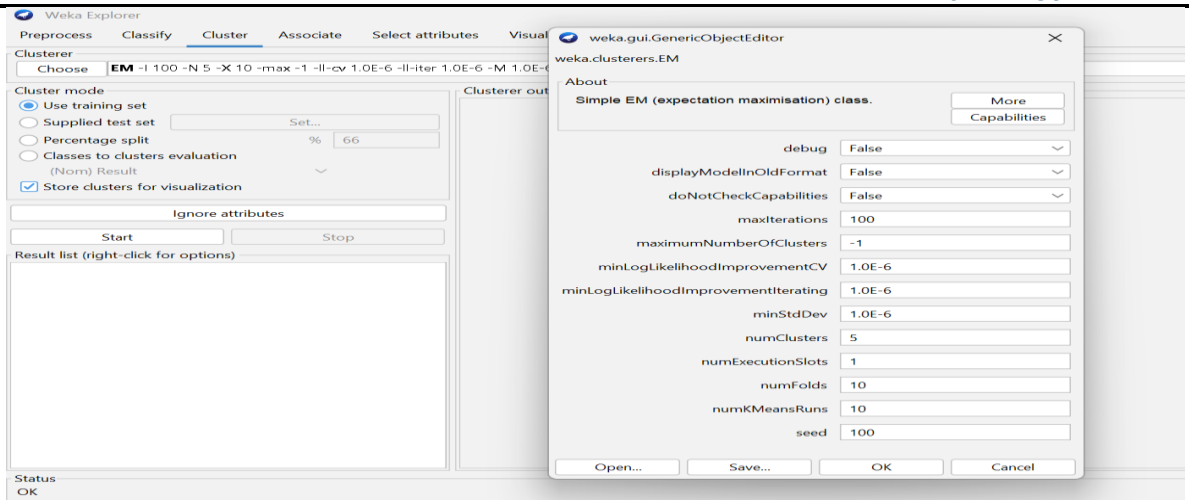
Steps to be followed:

Step 1: In the preprocessing interface, open the Weka Explorer and load the required dataset, and we are taking the project.arff dataset.

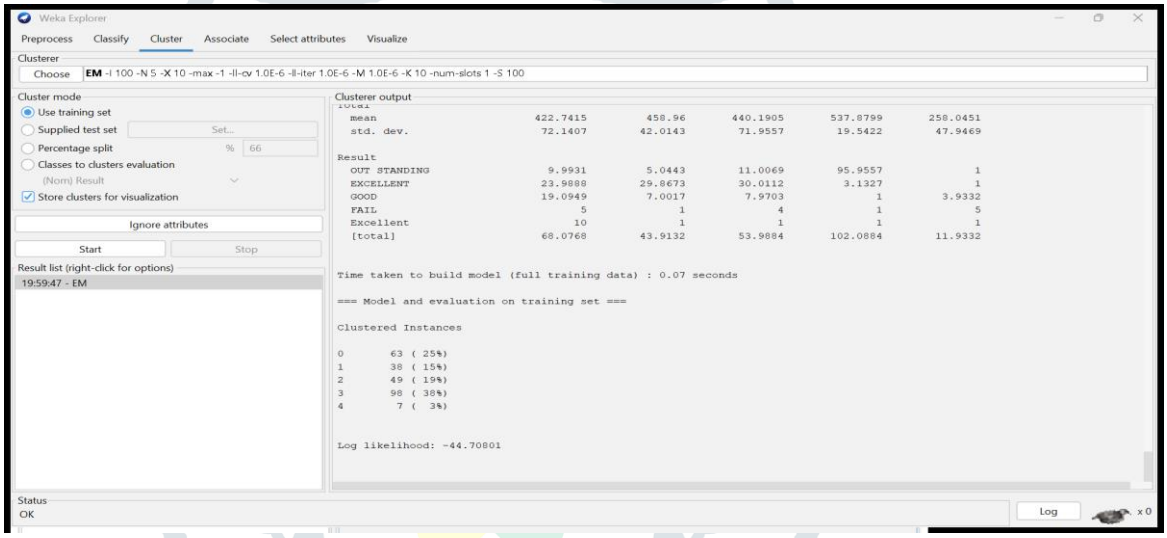
Step 2: Find the 'cluster' tab in the explorer and press the choose button to execute clustering. A dropdown list of available clustering algorithms appears as a result of this step and selects the EM algorithm.



Step 3: Then, to the right of the choose icon, press the text button to bring up the popup window. We enter five for the number of clusters in this window and the seed value is hundred. The seed value is used to generate a random number that is used to make internal assignments of instances of clusters.

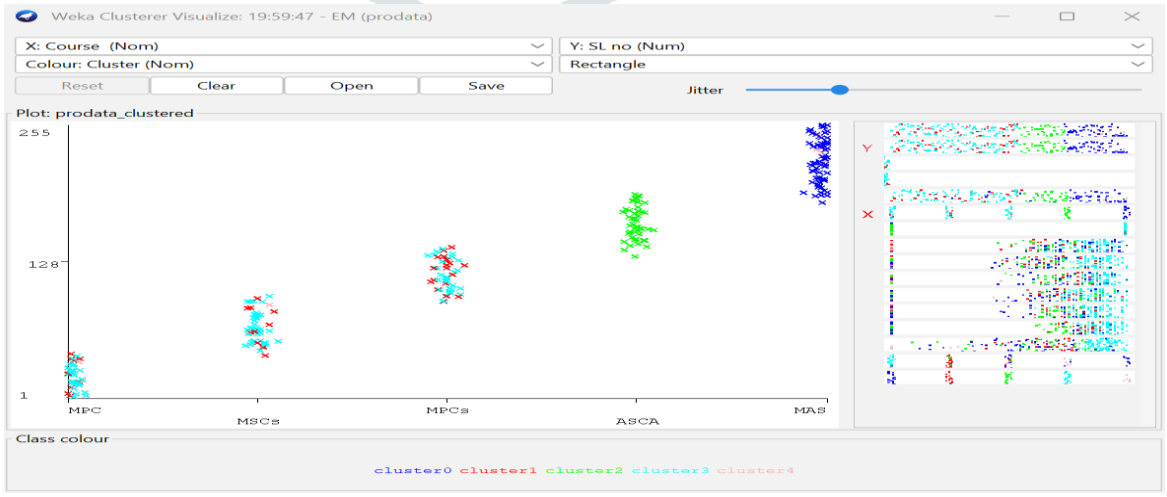


Step 4: One of the choices has been chosen. We must ensure that they are in the 'cluster mode' panel before running the clustering algorithm. The choice to use a training set is selected, and then the 'start' button is pressed.



Step 5: The centroid of each cluster is shown in the result window, along with statistics on the number and percent of instances allocated to each cluster. Each cluster centroid is represented by a mean vector. This cluster can be used to describe a cluster.

Step 6: Another way to grasp the characteristics of each cluster is to visualize them. To do so, right-click the result set on the result. Selecting to visualize cluster assignments from the list column.



Step 7: In the Cluster visualization we choose Course on X-axis and SL no on Y-axis.

Blue colour shows Cluster 0, Red colour shows Cluster 1, Green colour shows Cluster 2, Sky-blue colour shows Cluster 3, Light pink colour shows Cluster 4.

Output: This EM algorithm is tested with project dataset in WEKA tool. It produces five different clustered instance clusters 0: 63(25%), cluster 1: 38(15%), cluster 2: 49(19%), cluster 3: 98(38%), cluster 4: 7(3%), and Time taken to build model (full training data): 0.01 seconds.

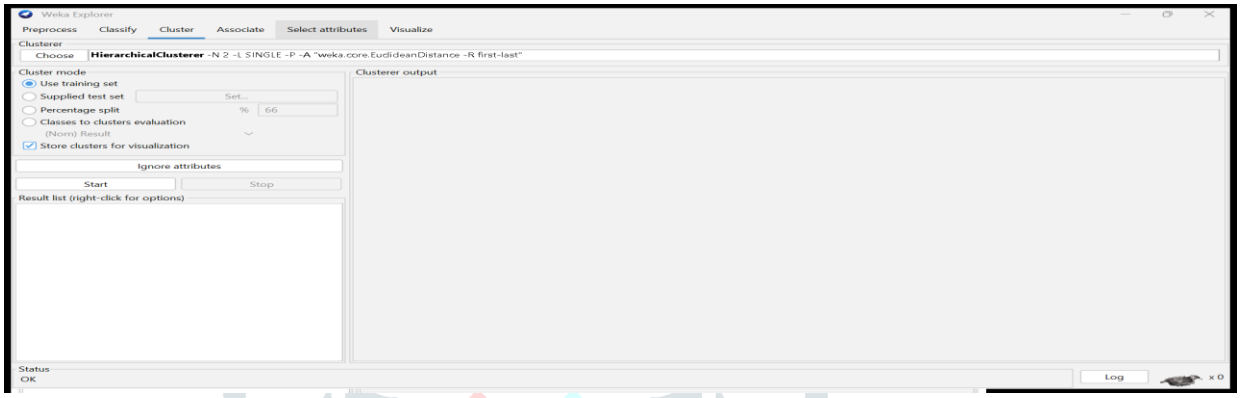
Hierarchical Cluster

Hierarchical clustering is mainly focussing on building of hierarchy of clusters, i.e., cluster tree and it is represented in a dendrogram. It is either merging smaller clusters into larger clusters or splitting larger clusters into smaller ones. A clustering of the data items is obtained through cutting a dendrogram at a desired level. A cluster tree is defined as "a tree showing a sequence of clustering with each clustering being a partition of the data set". Following are the general procedures for performing hierarchical clustering.

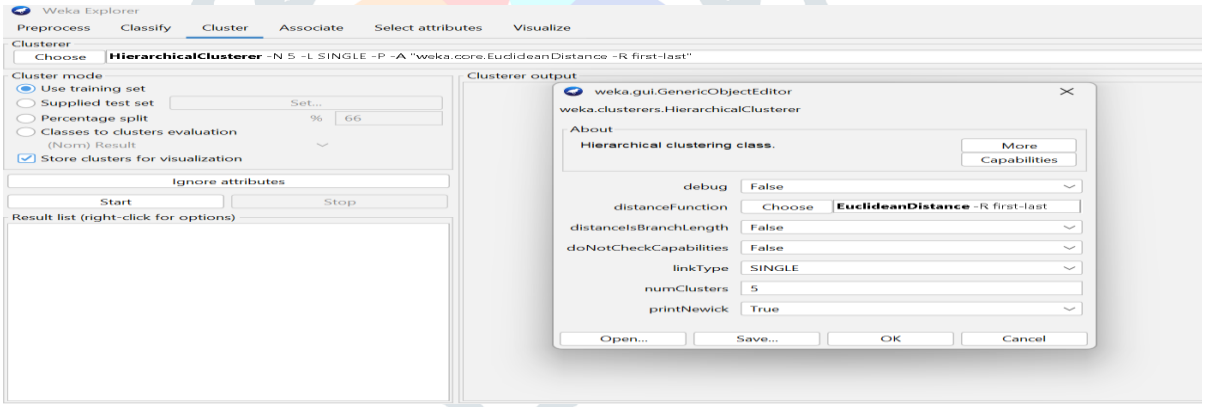
Steps to be followed:

Step 1: In the preprocessing interface, open the Weka Explorer and load the required dataset, and we are taking the project. arff dataset.

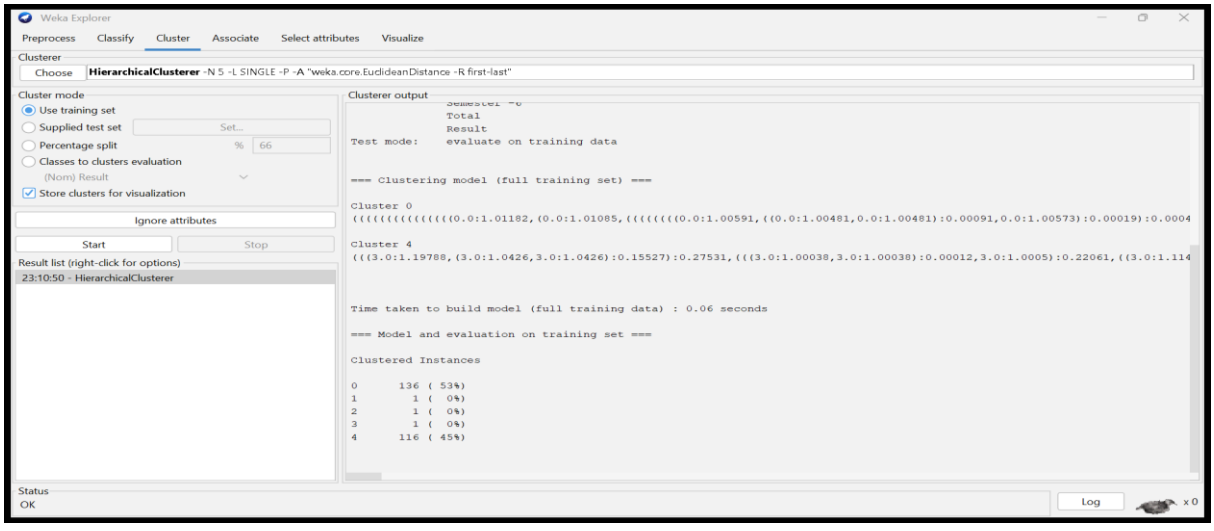
Step 2: Find the 'cluster' tab in the explorer and press the choose button to execute clustering. A dropdown list of available clustering algorithms appears as a result of this step and selects the Hierarchical Clustered algorithm.



Step 3: Then, to the right of the choose icon, press the text button to bring up the popup window. We enter five for the number of clusters in this window.



Step 4: One of the choices has been chosen. We must ensure that they are in the 'cluster mode' panel before running the clustering algorithm. The choice to use a training set is selected, and then the 'start' button is pressed.



Step 5: The centroid of each cluster is shown in the result window, along with statistics on the number and percent of instances allocated to each cluster. Each cluster centroid is represented by a mean vector. This cluster can be used to describe a cluster. Merging smaller clusters into larger clusters or splitting larger clusters into smaller ones.

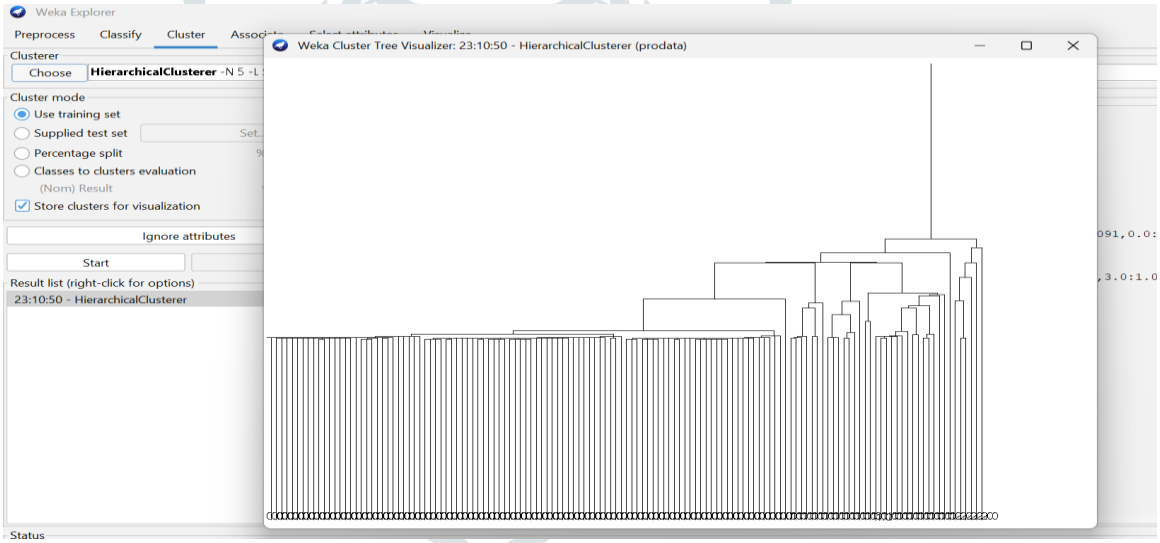
Step 6: Another way to grasp the characteristics of each cluster is to visualize them. To do so, right-click the result set on the result. Selecting to visualize cluster assignments from the list column.



Step 7: In the Cluster visualization we choose Course on X-axis and Total no on Y-axis.

Blue colour shows Cluster 0, Red colour shows Cluster 1, Green colour shows Cluster 2, Sky-blue colour shows Cluster 3, Light pink colour shows Cluster 4.

Visualization tree in hierarchical clustered:



Step 8: The above tree diagram shows that the hierarchical Clustering using 5 clusters. A cluster tree is defined as "a tree showing a sequence of clustering with each clustering being a partition of the data set".

Output: This Hierarchical Clustered algorithm is tested with project dataset in WEKA tool; it produces five different clustered instance clusters 0: 136(53%), cluster 1: 1(0%), cluster 2: 1(0%), cluster 3: 1(0%), cluster 4: 116(45%), and Time taken to build model (full training data): 0.06 seconds.

Simple-k means clustering:

K-means clustering is a simple unsupervised learning algorithm. In this, the data objects (‘n’) are grouped into a total of ‘k’ clusters, with each observation belonging to the cluster with the closest mean. It defines ‘k’ sets, one for each cluster k n (the point can be thought of as the centre of a one or two-dimensional figure). The clusters are separated by a large distance.

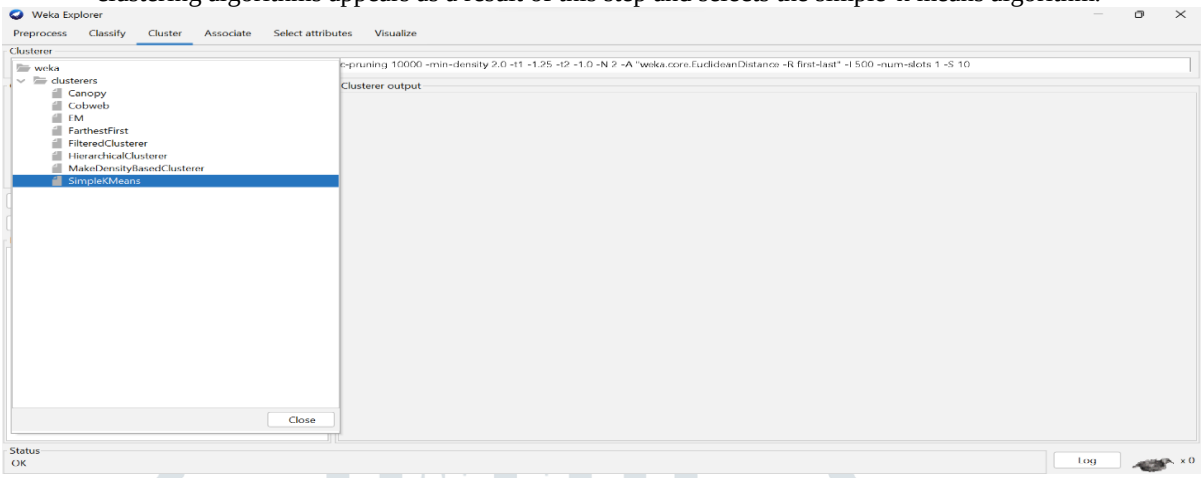
The data is then organized into acceptable data sets and linked to the nearest collection. If no data is pending, the first stage is more difficult to complete; in this case, an early grouping is performed. The ‘k’ new set must be recalculated as the barycentre’s of the clusters from the previous stage.

The same data set points and the nearest new sets are bound together after these ‘k’ new sets have been created. After that, a loop is created. The ‘k’ sets change their position step by step until no further changes are made as a result of this loop.

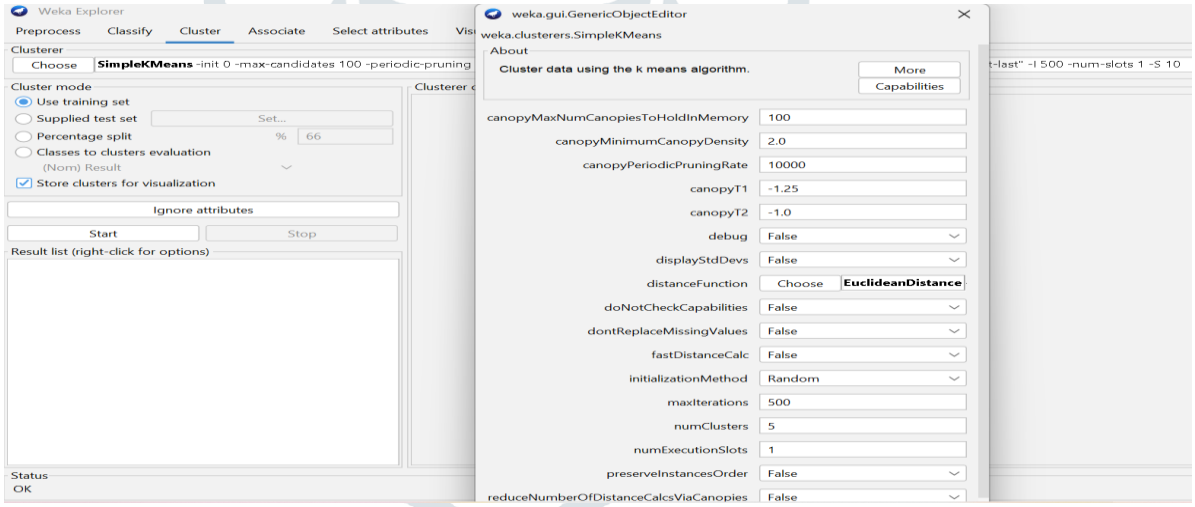
Steps to be followed:

Step 1: In the preprocessing interface, open the Weka Explorer and load the required dataset, and we are taking the project. Arff dataset.

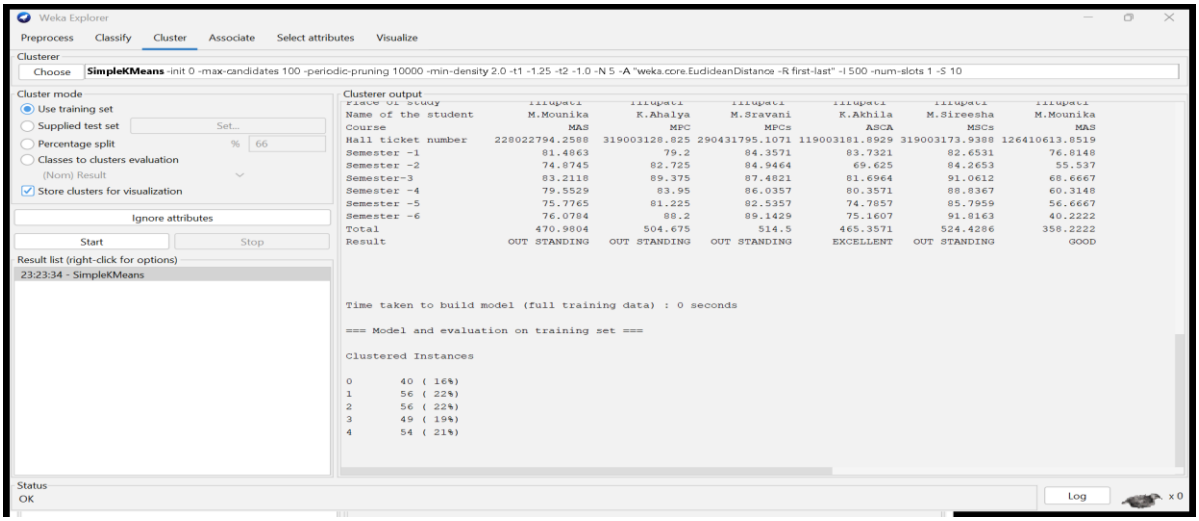
Step 2: Find the 'cluster' tab in the explorer and press the choose button to execute clustering. A dropdown list of available clustering algorithms appears as a result of this step and selects the simple-k means algorithm.



Step 3: Then, to the right of the choose icon, press the text button to bring up the popup window shown in the screenshots. We enter five for the number of clusters in this window.

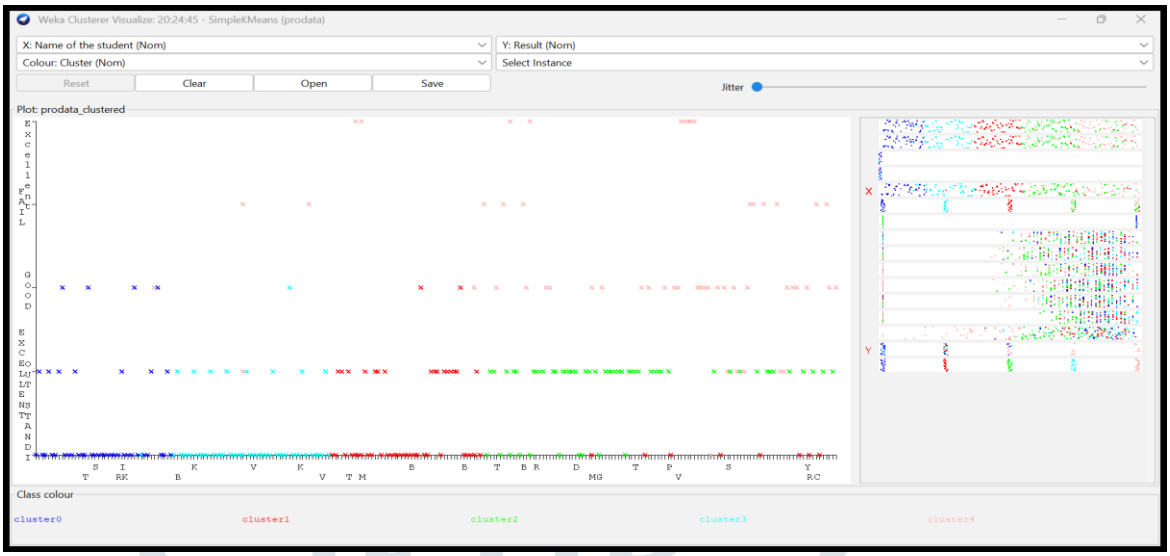


Step 4: One of the choices has been chosen. We must ensure that they are in the 'cluster mode' panel before running the clustering algorithm. The choice to use a training set is selected, and then the 'start' button is pressed.



Step 5: The centroid of each cluster is shown in the result window, along with statistics on the number and percent of instances allocated to each cluster. Each cluster centroid is represented by a mean vector. This cluster can be used to describe a cluster.

Step 6: Another way to grasp the characteristics of each cluster is to visualize them. To do so, right-click the result set on the result. Selecting to visualize cluster assignments from the list column.



Step 7: In the Cluster visualization we choose Name of the student on X-axis and Result no on Y-axis. Blue colour shows Cluster 0, Red colour shows Cluster 1, Green colour shows Cluster 2, Sky-blue colour shows Cluster 3, Light pink colour shows Cluster 4.

Output: K means clustering is a simple cluster analysis method. The number of clusters can be set using the setting tab. The centroid of each cluster is calculated as the mean of all points within the clusters. With the increase in the number of clusters, the sum of square errors is reduced. The objects within the cluster exhibit similar characteristics and properties. The clusters represent the class labels.

This Simple -k means Clusterer algorithm is tested with project dataset in WEKA tool; it produces five different clustered instance clusters 0: 40(16%), cluster 1: 56(22%), cluster 2: 56(22%), cluster 3: 49(19%), cluster 4: 54(21%), and Time taken to build model (full training data): 0 seconds.

RESULT ANALYSIS

Data Mining Techniques (Knowledge Discovery Database):

The KDD (Knowledge Discovery in Databases) paradigm is a step-by-step approach to identifying interesting patterns in enormous volumes of data. Data mining is a step in the process. The algorithms have good potential. Analytic tools for performance evaluation are demonstrated by examining results from a computer performance dataset. It is far easier to store data than to make sense of it. The ability to identify links in huge amounts of stored data can lead to improved analytical tactics in domains such as education, marketing, computer performance analysis, and data analysis in general. KDD addresses the difficulty of finding patterns in huge datasets. Traditionally, data was analyzed manually; however, there are human

The clustering process

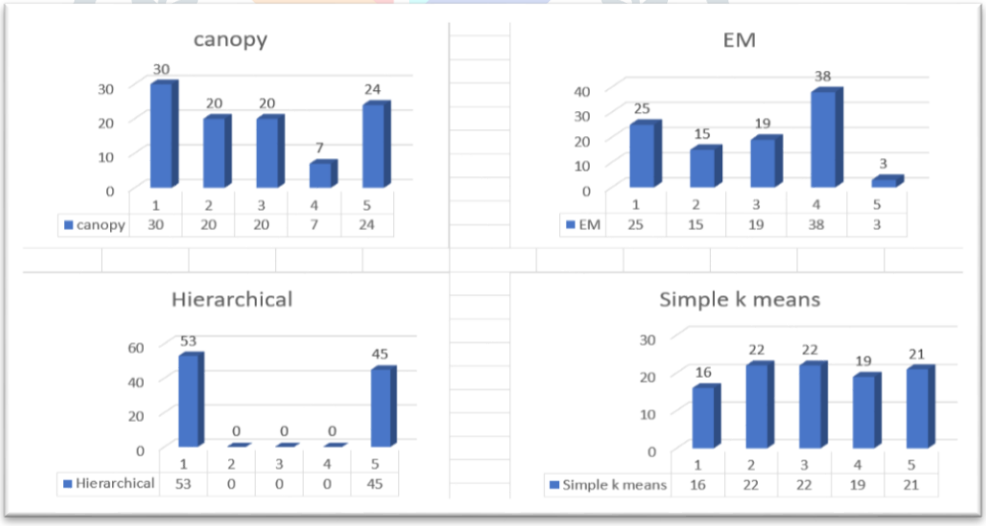
Clustering divides data into groupings of related things. Each cluster contains a variety of things that are both similar to one another and distinct to objects from other clusters. Various clustering algorithms are used to produce clusters. The Weka tool is used to evaluate various clustering techniques.

This paper compares the different Weka clustering algorithms to determine which algorithm is best suited to the users. Four clustering algorithms are compared: Canopy clustering algorithm, EM Algorithm, Hierarchical Algorithm, and Simple k-Means clustering algorithm. All of the algorithms discussed above are explained and analyzed using specific assessment parameters. These parameters include the number of clusters formed and clustered instances. The results of all four algorithms are generated.

The following table represents the analysis process of all four algorithms and the accuracy results are shown in table.

Clustering algorithm	No. of Clusters	Clustering instances
Canopy	5	76(30%) 50(20%) 50(20%) 19(07%) 60(24%)
EM	5	63(25%) 38(15%) 49(19%) 98(38%) 7(3%)
Hierarchical	5	136(53%) 1(0%) 1(0%) 1(0%) 116(45%)
Simple-k Means	5	40(16%) 56(22%) 56(22%) 49(19%) 54(21%)

In the above table, the Simple-k means clustering algorithm and EM Clustering Algorithm are showing good accuracy than another cluster algorithm.



The above chart shows the performance accuracy of the four-clustering based on different clustering metrics. This metrics shows that Simple-k means, EM algorithms are performing good accuracy result better than other clustering.

CONCLUSION

Data mining translates raw data into information so that predictions can be made. Cluster analysis is a technique for identifying clusters of data with similar features. WEKA has a variety of algorithms for cluster analysis, with simple means being the most commonly employed.

This work describes data mining in the educational context, specifically identifying students' performance trends using the clustering data mining technique. The detected trends are evaluated to provide useful and constructive recommendations to academic planners in higher education institutions to improve their decision-making process.

We conducted analyses using four clustering algorithms: the Canopy clustering algorithm, the EM algorithm, the Hierarchical algorithm, and the Simple k-Means clustering algorithm. All four algorithms give results based on similar items and times.

In future work the authors also interested in working in future on data of student's assessments for each course trying to know what kind of student succeed on what kind of courses. It may define what kinds of courses are adapted for every student's model who shares the same characteristics. It may also provide various multidimensional summary reports and redefine pedagogical learning paths.

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Applications of Partial Differential Equations in Fluid Physics

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Abstract:

Partial differential equations, or PDEs, assume a critical part in grasping and outlining different fluid physics peculiarities. They have an expansive scope of utilizations, from expecting weather patterns to consolidating ocean streams, fire cycles, and fluid streams into system plan. These equations oversee the way of behaving of fluid amounts like as speed, stress, temperature, and consistency. They portray complex collaborations like changes in precipitation, scattering, and fluid-solid associations. Partial differential equations are utilized to apply the developing methodology. The arrangement is equivalent to for the recently concentrated on examples of typical differential equations. There are two kinds of partial differential equations: nonlinear and straight. Some certifiable equations, for example, those in electrostatics, heat conduction, transmission lines, quantum mechanics, and wave hypothesis, feature the significance of partial differential equations (PDEs). To make sense of something other than one, two, or three pieces of the partial differential equations, we will check out at the speculative piece of those applications that utilization PDEs in this examination. In all parts of science and development, partial differential equations, or PDEs, are generally utilized. Partial differential equations handle most of genuine frameworks. A condition communicating a connection between a piece of no less than two free factors and the partial helpers of this cutoff concerning these free factors is known as a partial differential condition, or PDE.

Keywords: Partial Differential Equations, Fluid Physics, Stochastic Partial Differential Equations.

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NON - SPLIT PERFECT ODD VERTICES DOMINATING SET OF AN INTERVAL GRAPH USING AN ALGORITHM

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1.1. ABSTRACT:

Among the various applications of the theory of perfect domination [1], the most often discussed is communication network. There has been persistent in the algorithmic aspects of interval graphs in past decades spurred much by their numerous applications of interval graphs corresponding to interval families.

The research of the domination in graphs has been an evergreen of the graph theory. Its basic concept is the dominating set and the domination number. The theory of domination in graphs was introduced by O. Ore [4] and C. Berge [2]. A survey on results and applications of dominating sets was presented by E.J. Cockayane and S.T. Hedetniemi [3].

Non - split domination in graphs was introduced by V.R. Kulli [5] in 1997. They have studied these parameters for various standard graphs and obtained the bounds for them. The concept of restrained domination was introduced by J.A. Telle and A. Proskurowski [6], albeit indirectly, as a vertex partitioning problem. One application of domination is that of prisoners and guards.

In this chapter, we introduce an algorithm to find a non - split odd vertices perfect dominating set of an interval graph.

KEY WORDS : Interval graph, Dominating set, Non-split dominating set, Perfect dominating set, Perfect odd vertices dominating set.

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In this paper, we introduce an algorithm to find a split odd vertices perfect dominating set of an interval graph.

KEY WORDS : Interval graph, Dominating set, Split dominating set, Perfect dominating set, Perfect odd vertices dominating set.

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73 Is the Only Largest Prime Power Number and Composite Power Numbers

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Abstract: ***In natural numbers we don't have largest one till now. The X-power set of a prime number which has only prime numbers. In this we are introducing the largest one among such prime numbers and also, we are introducing the composite X-power set and composite power number. Along with this we are presenting the program for getting X -power set and order of X -power set of a positive integer. In this paper we have presented "There is no other prime power number which is greater than 73 and composite power numbers "or" 73 is the only largest prime power number and composite power numbers".***

Keywords: Numbers, sets, X-power set, prime X-power numbers, composite X-power numbers and Algorithm

1. Introduction

Number sets are collections of numbers classified as groups according to the values of their elements. One might say that set theory was born in late 1873, when Jonson, Philip (1972) made the amazing discovery that the linear continuum, that is, the real line, is not countable meaning that its points cannot be counted using the natural numbers read in the history of the set Theory by Tom M.Apostol [10]. Set theory is one of the greatest achievements of modern mathematics .The set theory , however , was founded by a single paper in 1874 by Georg Cantor "On a Property of the Collection of Real Algebraic Numbers " .A set wrote by Cantor, is a collection of definite and distinguishable objects perception or thought conceived as a whole. The objects are called elements or members or numbers of the set that is regarded as being a single object. To indicates that object x_1 is a number of a set X and we write $x_1 \in X$. A set may be defined by a membership rule or formula or by listing its numbers within braces. The order of a set means the number of elements or objects in the set. With the help of the set we can find the number of elements or numbers in the set .Order of set is also called cardinal number of the set . The notion of cardinality, as now understood which was formulated Georg Cantor the originator of set theory in 1874-1884.

A. Sudhakaraiah, A. Madhankumar, P. Gopi introduced in 2022 the newly concept " P_X- power set of Even And Odd Number of a Number 'X' " [1] . Set theory is the branch of mathematical logic that studies sets which can be informally described as collections of objects. Although objects of any kind can be collected into a set. The set theory as a branch of mathematics and the modern study of set theory was initiated by the German mathematicians Richard Dedekind and Georg Cantor in the 1970s. In particular, Georg Cantor is commonly considered the founder of the set theory. The positive integers are actually part of a large group of numbers called integers. Boyer's." Fundamental Steps in the Development of Numeration [3], all the Integers are the whole numbers both positive and negative.

As Set theory is the branch of mathematical logic that studies sets, the modern study of set theory was initiated by the German mathematicians Richard Dedekind and Georg Cantor in the 1870s. Set theory is the mathematical branch that studies the sets and their properties, the operations on sets. The beginning of the modern set theory was around 1870. Set theory is a fundamental branch for the entire mathematics as it is the base for many fields of Mathematics like Algebra, Topology, Probability and other branches of Sciences like biological, Chemical sciences. It gives also an essential foundation to the development of many concepts like infinity and many other sophisticated mathematical concepts. Set theory is used beyond that, it has numerous applications in other sciences like computer science and philosophy etc. In mathematics, the power set of a set S is the set of all subsets of S, including the empty set and S itself. The power set of S is variously denoted as P(S) or (S). The X-power set was introduced by Dr.A.Sudhakaraiah , A.Madhankumar,P.Gopi [2], also introducing composite power numbers as a part of continuation of the work .

2. Preliminaries

Perhaps, the main thing a power set is good to provide a universe for other things to take place in. For example, a lot of areas of math being by singling out certain subsets of a set X as special. Topology deals with open sets, measure theory deals with measurable sets. Also the new concept of two digits, three digits and so on the natural numbers equal to "two" focused by Dr.A.Sudhakaraiah , A. Madhan Kumar , 2021 [2]. As per the study of set theory set is the

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NON - SPLIT PERFECT EVEN VERTICES DOMINATING SET OF AN INTERVAL GRAPH USING AN ALGORITHM

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1.1 ABSTRACT

The research of the domination in graphs has been an evergreen of the graph theory. Its basic concept is the dominating set and the domination number. The theory of domination in graphs was introduced by O. Ore [3] and C. Berge [1]. A survey on results and applications of dominating sets was presented by E.J. Cockayane and S.T. Hedetniemi [2].

Non - split domination in graphs was introduced by V.R. Kulli [4] in 1997. They have studied these parameters for various standard graphs and obtained the bounds for them.

In this chapter, we introduce an algorithm to find a non - split even vertices perfect dominating set of an interval graph.

KEY WORDS : Interval graph, Dominating set, Non-split dominating set, Perfect dominating set, Perfect even vertices dominating set.

1.2 PRELIMINARIES

A graph $G=(V,E)$ is an interval graph if the vertex set V can be put into one-to-one correspondence with a set of intervals I on the real line R such that two vertices of G are joined by an edge in E if and only if their corresponding intervals in I have non-empty intersection. That is if $i = [a_i, b_i]$ and $j = [a_j, b_j]$, then i and j intersect means either $a_j < b_i$ or $a_i < b_j$. The set I is called an interval representation of G and G is referred to as the intersection graph of I. Also we say that the intervals contain both its end points and that no two intervals share a common end point. The intervals and vertices of an interval graph are one and the same thing. The

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73 IS THE ONLY LARGEST PRIME POWER NUMBER AND COMPOSITE POWER NUMBERS

OR

THERE IS NO OTHER PRIME POWER NUMBER WHICH IS GREATER THAN 73 AND COMPOSITE POWER NUMBERS

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Abstract: In natural numbers we don't have largest one till now. The X-power set of a prime number which has only prime numbers as it's elements, In this journal we are introducing the largest one among such prime numbers and also we are introducing the composite X-power set and composite power number. Along with this we are presenting the program for getting X - power set and order of X -power set of a positive integer.

Keywords: Numbers, sets, X-power set, prime X-power numbers, composite X-power numbers and Algorithm.

I. Introduction

Number sets are collections of numbers classified as groups according to the values of their elements. One might say that set theory was born in late 1873 , when he made the amazing discovery that the linear continuum , that is , the real line , is not countable , meaning that its points can not be counted using the natural numbers. Jonson , Philip (1972) , A History of the set Theory [10] . Set theory is one of the greatest achievements of modern mathematics .Set theory , however , was founded by a single paper in 1874 by Georg Cantor: " On a Property of the Collection of Real Algebraic Numbers " .A set wrote Cantor, is a collection of definite, distinguishable objects perception or thought conceived as a whole. The objects are called elements or members or numbers of the set. That is regarded as being a single object. To indicates that object x1 is number of a set X on write $x1 \in X$. A set may be defined by a membership rule or formula or by listing its numbers within braces. The order of a set means the number of elements or objects in the set. In the help of the set we can find the number of elements or numbers in the set .Order of set is also called cardinal number of the set . The notion of cardinality, as now understood was formulated Georg Cantor the originator of set theory in 1874-1884.

A.Sudhakaraiah , A.Madhankumar, P.Gopi introduced in 2022 the newly concept " P_X- power set of Even And Odd Number of a Number 'X' " [1] . Set theory is the branch of mathematical logic that studies sets , which can be informally described as collections of objects . Although objects of any kind can be collected into a set , set theory , as a branch of mathematics .The

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ROMAN DOUBLY CONNECTED DOMINATION NUMBER USING AN ALGORITHM OF AN INTERVAL GRAPH

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I.I. ABSTRACT:

A survey on results and applications of dominating sets was presented by E.J. Cockayane and S.T. Hedetniemi[1]. Among the various applications of the theory of domination, the most often discussed is communication network. There has been persistent in the algorithmic aspects of interval graphs in past decades spurred much by their numerous applications of interval graphs corresponding to interval families.

Today graph theory is one of the most flourishing branches of modern mathematics. Graphs are useful in enhancing the understanding of the organization and behavioral characteristics of complex system. The study of domination in graphs originated around 1850 has become the source of interest to the researchers.

Roman domination in graphs is introduced by Cockayne et.al [2,3] and they studied this concept for various graphs. In this paper we find doubly connected dominating set through the algorithm and prove the property of Roman doubly connected domination number.

INDEXED TERMS : Interval graph, Dominating set, Doubly connected dominating set, Roman domination number, Roman doubly connected domination number.

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ROMAN 4 - REGULAR DOMINATION NUMBER USING AN ALGORITHM OF A 4 – REGULAR GRAPH

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1.1. ABSTRACT:

A Roman dominating function on a graph G= (V, E) is a function f : V → {0, 1, 2} satisfying the condition that every vertex u for which f(u) = 0 is adjacent to at least one vertex v for which f(v) = 2. The weight of a Roman dominating function is the value f(V) = $\sum_{u \in V} f(u)$. The minimum weight of a Roman dominating function on a graph G is called the Roman domination number of G. A regular graph is a graph in which every vertex has the same degree. More specifically, a r-regular graph is a graph in which every vertex has degree r. Today graph theory is one of the most flourishing branches of modern mathematics. In this paper we will give the relationship between the Roman 4 - regular domination with 4 – Regular domination. This paper also gives the 4 – Regular dominating sets corresponding to the 4 – Regular graphs.

INDEXED TERMS :

Interval graph, Dominating set, 4 – Regular dominating set, Roman 4 – regular dominating set, 4 - regular domination number, Roman 4 – regular domination number.

1.2. PRELIMINARIES:

Domination is an area in graph theory with an extensive research activity. In 1998, a book [1] on domination has been published which lists 1222 papers in this area. In general, a dominating set in a graph is a set of vertices D such that each vertex is either in D or is adjacent to a vertex in D. A function $f : V \longrightarrow \{0, 1, 2\}$ having the property that for every vertex $v \in V$ with $f(v) = 0$, there exists a vertex $u \in N(v)$ with $f(u) = 2$, is called a Roman dominating function or just an RDF. The weight of an RDF f is the sum f(V) = $\sum_{u \in V} f(u)$. The minimum weight of a RDF on G is called the Roman domination number of G. The mathematical concept of Roman domination, was developed by Cockayne

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SOME CENTRALIZING THEOREMS ON GENERALIZED$(\alpha, 1)$- REVERSE DERIVATIONS IN SEMI PRIME RINGS

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ABSTRACT

Let R be a semiprime ring, F:R→R be a generalized $(\alpha, 1)$- reverse derivation associated with $(\alpha, 1)$ - reverse derivation d and H: R→R be a right α -centralizer. If (i) $F(uv) \pm H(uv) = 0$; (ii) $F(uv) \pm H(vu) = 0$; (iii) $F(u)F(v) \pm H(uv) = 0$; (iv) $F(uv) \pm H(uv) \in C_{\alpha,1}$; (v) $F(uv) \pm H(vu) \in C_{\alpha,1}$; (vi) $F(u)F(v) \pm H(uv) \in C_{\alpha,1}$, for all $u, v \in R$.

KEY WORDS: Semiprime Ring; Right α-centralizer; $(\alpha, 1)$ - Reverse Derivation; Generalized $(\alpha, 1)$ - Reverse Derivation.

AMS Subject Classification: 16N60; 16S20; 16W25; 16U80.

1. INTRODUCTION

The concept of reverse derivation was first time introduced by Herstien [3]. Aboubakr et.al. [1] generalized the concept of reverse derivations to generalized reverse derivations and provided a study of relationship between generalized reverse derivations and generalized derivations. Inspired by this, Tiwari et.al. [11] gave the notion of multiplicative (generalized) reverse derivations. Yenigul and Argac [12] studied prime and semiprime rings with α- derivations. Ibraheem [4] and Asma Ali et.al. [2] studied generalized reverse derivation on semiprime or prime rings. Jaya Subba Reddy et.al. Proved some results on reverse derivations, generalized (σ, τ) derivations in semiprime rings, properties of left

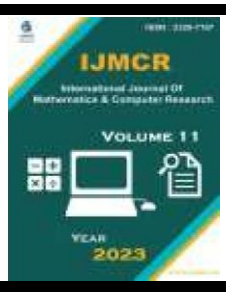
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Multiplicative (Generalized)-(σ, τ)-Reverse Derivations in Prime Rings

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ABSTRACT

Let R be a prime ring, I be a non-zero left ideal of R and σ, τ be a anti-automorphisms of R. Suppose F and H are two multiplicative (generalized)-(σ, τ)-reverse derivation associated with the mappings d and h respectively, on R. In this paper, we proved the following identities in prime rings: If (i) $F(xy) + \sigma(xy) = 0$; (ii) $F(xy) + \sigma(yx) = 0$; (iii) $F(xy) + F(y)F(x) = 0$; (iv) $F(xy) = \sigma(x)oH(y)$; (v) $F(xy) = [\sigma(x), H(y)]$; for all $x, y \in I$, where σ and τ are anti automorphisms on R.

KEYWORDS : Prime ring, (σ, τ)-reverse derivation, Multiplicative (Generalized) reverse derivation and Multiplicative (Generalized)-(σ, τ)-reverse derivation.

1. INTRODUCTION

In 1991, the concept of derivation was extended to generalized derivation by Bresar [3]. In 1991, Daif [5] introduced the concept of multiplicative derivation. In 1997, Daif and Tammam EL-Sagid [6] extended the concept of multiplicative derivation to multiplicative generalized derivation. In 2013, Dhara and Ali [7] introduced the concept of multiplicative (generalized)-derivation. In 1957, the concept of reverse derivation was first time introduced by Herstein [8]. Further Bresar and Vukman [4] studied the reverse derivations. In 2015, Aboubakr and Gonzalez [1] studied the relationship between generalized reverse derivation and generalized derivation on an ideal in semi prime rings. In 2017, Tiwari et.al [11] defined multiplicative (generalized) reverse derivation. In 2011, the concepts of (θ, φ)-reverse derivation and generalized (θ, φ)-reverse derivation has been introduced by Anwar Khaleel Faraj in [2]. In 2019, Nadeem ur Rehman et.al [10] proved some results on a note on multiplicative (generalized)- (α, β)-reverse derivations in prime rings. In 2022, Jaya Subba Reddy et.al [9] proved some results on a note on multiplicative (generalized)- (α, β)-reverse derivations on left ideals in prime rings. In this paper, we proved some results on multiplicative (generalized) (σ, τ)-reverse derivations in prime rings.

2. PRELIMINARIES

Throughout this paper R denote an associative ring with center Z. Recall that a ring R is prime if $xRy = \{0\}$ implies $x = 0$ or $y = 0$. For any $x, y \in R$, the symbol $[x, y]$ stands for the commutator $xy - yx$ and the symbol (xoy) denotes the anti-commutator $xy + yx$. A mapping $d: R \to R$ (not necessarily additive) is called a multiplicative derivation if $d(xy) = d(x)y + xd(y)$, for all $x, y \in R$. An additive mapping $d: R \to R$ is called a reverse derivation if $d(xy) = d(y)x + yd(x)$, for all $x, y \in R$. A mapping $d: R \to R$ (not necessarily additive) is called a multiplicative reverse derivation if $d(xy) = d(y)x + yd(x)$, for all $x, y \in R$. An additive mapping $d: R \to R$ is called a (σ, τ)-reverse derivation if $d(xy) = d(y)\sigma(x) + \tau(y)d(x)$, for all $x, y \in R$. A mapping $d: R \to R$ (not necessarily additive) is called a multiplicative (σ, τ)-reverse derivation if $d(xy) = d(y)\sigma(x) + \tau(y)d(x)$, for all $x, y \in R$. An additive mapping $F: R \to R$ is called a generalized reverse derivation, if there exists a reverse derivation $d: R \to R$ such that $F(xy) = F(y)x + yd(x)$, for all $x, y \in R$. A mapping $F: R \to R$ (not necessarily additive) is said to be a multiplicative (generalized)- reverse derivation of R, if there exists a map $d: R \to R$ (neither necessarily additive nor derivation) such that $F(xy) = F(y)x + yd(x)$, for all $x, y \in R$. A mapping $F: R \to R$ (not necessarily additive) is said to be a multiplicative (generalized)-(σ, τ)-derivation of R, if there

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SOME RESULTS IN PRIME RINGS WITH GENERALIZED REVERSE DERIVATIONS INVOLVING JORDAN INVOLUTION

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ABSTRACT

L*et R be a 2-torsion free prime ring and F be a generalized reverse derivation associated with a reverse derivation d of R. In this paper we establish some results regarding the commutativity of the ring R with Jordan involution.*

Key Words: *Reverse derivation, Generalized reverse derivation, Involution, Jordan involution, Reverse left multiplier.*

1. INTRODUCTION

Study of the structures of rings with certain types of algebraic conditions is of considerable interest among the algebraists. The concept of reverse derivation was instigated by Herstein in [7], when he was going through Jordan derivations in prime rings. Bresar and Vukman [9] have introduced the notion of a reverse derivation. Samman *et.al* [10] and Jaya Subba Reddy *et.al* [4 & 5] have proved some important results on reverse derivations in prime and semiprime rings. Later on, these studies are extended to generalized reverse derivations of prime rings. Several authors have proved some results on the commutativity of prime and semiprime rings admitting certain type of derivations with some conditions. Huang [12] proved some theorems on commutativity of prime rings with generalized reverse derivations. Further, investigation is turned on to rings with involutions and many authors have studied derivations in the context of prime and semiprime rings with involutions (viz., [1], [2], [8] and [9]). In 1991, Yood [3] introduced the concept of Jordan involution. Zemzami [11], proved some results on commutativity of prime rings with generalized derivations involving Jordan involutions. Recently, Jaya Subba Reddy [6] have proved certain commutativity theorems in rings with involutions involving generalized reverse derivations. In this paper, we study some results in prime rings with Jordan involution satisfying certain differential identities involving generalized reverse derivations.

2. PRELIMINARIES:

Throughout this paper R denote an associative ring with centre $Z(R)$. The symbol $[u, v] = uv - vu$ denote the commutator, $\forall\, u, v \in R$ and the anti-commutator is denoted by $u \circ v = uv + vu$, $\forall\, u, v \in R$. A ring R is 2-torsion free if $2u = 0$ yields $u = 0$. A ring R is said to be prime if $aRb = \{0\}$ implies $a = 0$ or $b = 0$. An additive map $d: R \longrightarrow R$ is said to be a reverse derivation if $d(uv) = d(v)u + v\,d(u)$, for all $u, v \in R$. An additive mapping $F: R \longrightarrow R$ is said to be a generalized reverse derivation if it satisfies $F(uv) = F(v)u + vd(u)$, where $d: R \longrightarrow R$ is an associated reverse derivation. An additive map $* : R \longrightarrow R$ is said to be an involution if it satisfies the conditions (i) $(uv)^* = v^*u^*$ (ii)$(u^*)^* = u$, for all $u, v \in R$. An additive map $* : R \longrightarrow R$ is said to be a Jordan involution if it satisfies the conditions (i) $(u^*)^* = u$ (ii) $(uv + vu)^* = u^*v^* + v^*u^*$, for all $u, v \in R$. Obviously every involution is a Jordan involution but the converse is not true. A ring equipped with involution is called a ring with involution or a *- ring. In a *- ring, an element 'u' is said to be Hermitian if $u^* = u$ and is said to be Skew–Hermitian if $u^* = -u$. An additive mapping $T: R \longrightarrow R$ is said to be reverse left (resp. right) multiplier if $T(uv) = T(v)u$ (resp. $T(uv) = vT(u)$) holds for all $u, v \in R$.

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Some Results of Generalized Reverse Biderivations on Prime Rings

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Abstract

Let R be a ring with center $Z(R)$. In the present paper, we obtain some results in connection with symmetric generalized reverse biderivations on prime ring R.

Keywords: Prime ring; Generalized biderivation; Generalized Reverse Biderivation; Bimultiplier; Reverse Bimultiplier.
2020 Mathematics Subject Classification: 16N60, 13N15.

1. Introduction

The concept of bi-derivation was introduced by Maksa in [8]. It is shown in [9] that bi-derivations are related to general solution of some functional equations. Some results concerning symmetric bi-derivations in prime rings can be found in [10,11,13]. Some theorems on symmetric generalized biderivations of prime ring are proved in [1,7]. Daif, Haetinger and Tammam El-Sayiad showed that any reverse biderivation on R prime ring is also a biderivation in [12]. Lateron, Many results have been found concerning reverse biderivations [2,6]. C.Jaya Subba Reddy et. al. [3–5,14], have studied some results concerning reverse biderivations on prime and semi prime rings. In the present paper, we obtain some results in connection with the symmetric generalized reverse biderivations on prime ring R.

2. Preliminaries

Let R be a ring and $Z(R)$ be its center. Remember that R is prime if $x_1Rx_2 = \{0\}$ implies $x_1 = 0$ or $x_2 = 0$ for any $x_1, x_2 \in R$. Also, R is semi-prime if $x_1Rx_1 = \{0\}$ implies $x_1 = 0$ for any $x_1 \in R$. For $x_1, x_2 \in R$, the notation $[x_1, x_2]$ denotes the commutator $x_1x_2 - x_2x_1$. Recall that a map D from $R \times R$ into R is termed symmetric if $D(x_1, x_2) = D(x_2, x_1)$ for all $x_1, x_2 \in R$. A symmetric biadditive map

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On Generalized Jordan (α,1) - Derivations in Semiprime Rings with Involution

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Abstract:- The purpose of this note is to prove the following result. Let R be a 2-torsion free semiprime *-ring and let α be an automorphism of R. If there exists an additive mapping $G: R \to R$ associated with a Jordan $(\alpha, 1)$-derivation d of R such that generalized Jordan $(\alpha, 1)$- derivation on R, then G is a generalized $(\alpha, 1)$-derivation on R. Further, some more related results are obtained.

Keywords*: Semiprime rings, Involution, Jordan (α, 1)- derivation, Generalized (α,1)- derivation, Generalized Jordan (α,1)- derivation.*

AMS Subject Classification: *16W10, 16W25, 16N60.*

1. Introduction

A notorious results due to Herstein [7], states that a Jordan derivation of a prime ring of characteristic not 2 must be a derivation. This result was extended to 2-torsion free semiprime rings by Cusack [5] and latterly, by Bresar [4]. Hvala [8] introduced the notion of a generalized derivations and Aashraf et.al. [18] have introduced the notion of a generalized Jordan derivations. Hence the concept of a generalized derivation (resp. generalized Jordan derivation) covers both the concepts of a derivation (resp. Jordan derivation) and a left centralizer (resp. left Jordan centralizer). Jaya Subba Reddy et. al. [9] proved some results generalized (σ, τ) derivations in semiprime rings, in [10] the authors have defined the notion of left $(\alpha, 1)$-derivations (resp. Jordan left $(\alpha, 1)$-derivations), [14, 15] Generalized $(\alpha, 1)$-derivations (resp. Generalized $(\alpha, 1)$-reverse derivations) on rings and also proved some results on $(\alpha, 1)$-reverse derivations on rings and rings with ideals (See [11-13&16]). Ali and Haetinger in [2] asserts that every generalized Jordan (θ, φ)-derivation on a 2-torsion free semiprime ring is a generalized (θ, φ)-derivation and also asserts that every Jordan α-centralizer on a 2-torsion semiprime ring is a α-centralizer. In [1] Albas proved that every Jordan α-centralizer on a 2-torsion semiprime ring is a α-centralizer under the condition $\alpha(Z(R)) = Z(R)$. Note that for I_R the identity map on R, an (I_R, I_R)-generalized Jordan derivation is called simply a generalized Jordan derivation. It is obvious to see that every generalized (θ, φ)-derivation on a ring is a generalized Jordan (θ, φ)-derivation. But the converse need not be true in general. Recently, Daif et.al. [6] and Ashraf et.al. [3] have proved that every generalized Jordan (θ, φ)-derivation on a 2-torsion free semiprime *-ring is a generalized (θ, φ)-derivation. Several authors have studied this problem in the setting of prime and semiprime rings ([17], [19] & [20]). The main purpose of this paper is to extend the over mentioned result for generalized Jordan $(\alpha, 1)$-derivation.

2. Preliminaries

Throughout the present paper, R will denote an associative ring with center Z(R). A ring R is 2-torsion free if whenever $2x = 0$, with $x \in R$, then $x = 0$. For any $x, y \in R$, the symbol $[x, y]$ stands for the commutator $xy - yx$. Recall that R is prime if $xRy = \{0\}$ implies either $x = 0$ or $y = 0$ and semiprime if $xRx = \{0\}$ implies $x = 0$, where $x, y \in R$. An additive mapping $x \to x^*$ satisfying $(xy)^* = y^*x^*$ and $(x^*)^* = x$ for all $x, y \in R$, is called an involution of R. A ring R equipped with an involution is called *-ring or ring with involution. An additive mapping $d: R \to R$ is called a $(\alpha, 1)$- derivation (resp. Jordan $(\alpha, 1)$- derivation) if $d(xy) = d(x)\alpha(y) + xd(y)$

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Centralizing and Commuting Jordan Generalized Reverse Derivations on Prime Rings

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Abstract:- Let R be a prime ring and d a derivation on R. If f is a Jordan generalized reverse derivation on R such that f is centralizing on left ideal U of R, then R is commutative.

Keywords*: Derivations, Jordan generalized derivation, Jordan generalized reverse derivations, Prime ring, centralizing and commuting.*

1. Introduction

H. E. Bell and W. S. Martindale III, [2] proved that a semiprime ring R must have a nontrivial central ideal, if it admits an appropriate endomorphism or derivation which is centralizing on U. Then R is commutative. M.Bresar [3] proved that some concrete additive mappings cannot be centralizing on certain subsets of non-commutative prime rings. He also described the structure of an arbitrary additive mapping which is centralizing on a prime ring. J. H. Mayne [8] had discussed about the existence of a non-trivial automorphism or derivation which is centralizing on a non-zero ideal in a prime ring and then shown that the ring is commutative. Asif Ali and Tariq Shah [1] has considered f as a generalized derivation on such that f is centralizing on a left ideal U of R. Jaya Subba Reddy et.al. [5-7], studied some results on centralizing and commutating left generalized derivations, $(\alpha, 1)$-reverse and generalized $(\alpha, 1)$-reverse derivations in rings. In this paper we extended some results on Jordan generalized reverse derivation on prime rings.

2. Preliminaries

Throughout this paper R will denote a prime ring and Z its center. A ring R is said to be a prime if $aRb = 0$ implies that either $a = 0$ or $b = 0$. An additive mapping $d: R \to R$ is said to be derivation if $d(xy) = d(x)y + xd(y)$, for all $x, y \in R$. A mapping f is said to be Jordan generalized reverse derivation if there exists a derivation d from R to R such that $f(x^2) = f(x)x + xd(x)$, for all x in R. A mapping f is said to be commuting on a left ideal U of R if $[f(x), x] = 0$, for all $x \in R$ and f is said to be centralizing if $[f(x), x] \in Z(R)$, for all $x \in R$.

Remark 2.1: For a nonzero element $a \in Z(R)$, $ab \in Z(R)$, then $b \in Z(R)$.

To prove the main results, we find it necessary to establish the following lemma.

Lemma 2.1: If f is an additive mapping from R to R such that f is centralizing on a left ideal U of R then for all $x \in U \cap Z(R)$, $f(x) \in Z(R)$.

Proof: Since f is centralizing on U, we have $x, y \in U \Rightarrow y + x \in U$.

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LEFT MULTIPLICATIVE GENERALIZED DERIVATIONS IN SEMIPRIME RINGS

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ABSTRACT

L*et R be a ring with center Z(R). An additive mapping F: R→R is said to be a left multiplicative generalized derivation if there exists a derivation d: R→R such that$F(xy) = xF(y) + d(x)y$ for all x, y ∈ R (the map d is called the derivation associated with F). In the present note we prove that if a semiprime ring R admits a generalized derivation F, d is the nonzero associated derivation of F, satisfying certain polynomial constraints on a nonzero ideal I, then R contains a nonzero central ideal.*

Keywords: *Semiprime ring, Prime ideal, Centralizer and Left multiplicative generalized derivation.*

1. INTRODUCTION

Bresar [2] introduced the notion of a generalized derivation in rings. In [1, 3, 7&8] have obtained commutativity of prime and semiprime rings satisfying certain polynomial constraints on suitable subsets of rings. In [3] Daif and Bell showed that if R is a semiprime ring, J is a nonzero ideal of R and d is a derivation of R such that d([x, y]) − [x, y] ∈ Z(R) for all x, y ∈ J, then J ⊆ Z(R). Recently, Shuliang in [8] proved that important results if F is a generalized derivation with associated derivation d, then either d = 0 or U ⊆Z(R) where R be a prime ring and U be a Lie ideal. Jaya Subba Reddy *et.al* in [4] has studied left multiplicative generalized derivations on semiprime rings. Many algebraists studied generalized derivation in the context of algebras on certain prime rings. By a left multiplicative generalized derivation on an prime ring if there exists a derivation *d: R→R* such that F(xy) = xF(y) + d(x)y, for all x, y ∈ R (the map d is called the derivation associated with F). In this paper we proved some results on left multiplicative generalized derivations in semiprime rings.

2. PRELIMINARIES

Throughout the paper R will denote an associative ring with center Z(R). A ring R is said to be prime ring (resp.semiprime) if aRb = {0} implies that either a = 0 or b = 0 (resp. aRa = {0} implies that a=0). We shall write for any pair of elements x, y ∈ R. $[x, y]$ the commutator $xy - yx$. We define xoy as $xy + yx$ for all x, y ∈ R. Basic commutator identities are $[x, yz] = y[x, z] + [x, y]z$ and $[xy, z] = x[y, z] + [x, z]y$. An additive mapping *d: R→R* is said to be derivation if d(xy) = d(x)y + xd(y), for all x, y ∈ R. An additive mapping *F: R→R* is said to be a generalized derivation if there exists a derivation *d: R→R* such that F(xy) = F(x)y + xd(y), for all x, y ∈ R. An additive mapping *F: R→R* is said to be a left generalized derivation if there exists a derivation *d: R→R* such that F(xy) = xF(y) + d(x)y, for all x, y ∈ R.

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SYMMETRIC GENERALIZED REVERSE $(\alpha, 1)^*$-BIDERIVATIONS IN $*$-RINGS

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Abstract

Let R be a ring and α be the endomorphism of R. In this paper, we introduce the notions of generalized reverse $(\alpha, 1)^*$-derivation and symmetric generalized reverse $(\alpha, 1)^*$-biderivation. It is to show that if a semiprime ring admits a generalized reverse $(\alpha, 1)^*$-derivation with an associated reverse $(\alpha, 1)^*$-derivation d, then d maps R into $Z(R)$ and also to show that if a non-commutative prime ring admits a generalized reverse $(\alpha, 1)^*$-derivation F with an associated reverse $(\alpha, 1)^*$-derivation d, then F is right α^*-multiplier on R. Analogous results have been proved for symmetric generalized reverse $(\alpha, 1)^*$-biderivation.

1. Introduction

In [1] Bresar and Vukman proved that if a prime $*$-ring R admits a $*$-derivation (resp. Reverse $*$-derivation) d, then either R is commutative or $d = 0$. Ashraf Ali in [11] extended the above mentioned results for semiprime $*$-rings in the setting of $(\alpha, \beta)^*$-derivations. Shakir Ali [12] proved that if a

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SOME STUDIES ON JORDAN $(\alpha, 1)^*$-BIDERIVATION IN RINGS WITH INVOLUTION

SK. HASEENA AND C. JAYA SUBBA REDDY*

Abstract. Let R be a ring with involution. In the present paper, we characterize biadditive mappings which satisfies some functional identities related to symmetric Jordan $(\alpha, 1)^*$-biderivation of prime rings with involution. In particular, we prove that on a 2-torsion free prime ring with involution, every symmetric Jordan triple $(\alpha, 1)^*$-biderivation is a symmetric Jordan $(\alpha, 1)^*$-biderivation.

AMS Mathematics Subject Classification : 16N60, 16U80, 16W25, 16W10.
Key words and phrases : Prime $*$-ring, involution, symmetric Jordan $(\alpha, 1)^*$-biderivation, symmetric Jordan triple $(\alpha, 1)^*$-biderivation.

1. Introduction

A famous result due to Herstein [10], states that a Jordan derivation of a prime ring of characteristic not 2 must be a derivation. Cusack [8] and Bresar [7] are extended the above results to 2-torsion free semiprime rings and also states that any Jordan triple derivation is a derivation. In [24], Vukman prove that every Jordan derivation on a 6-torsion free semiprime $*$-ring is a Jordan triple derivation of R. Ashraf Ali [2] and Rehman et.al. (see [21]& [18]) prove that on a 2-torsion free semiprime ring every (α, β)-derivation is a Jordan triple (α, β)-derivation. In [17] Liu and Shiue are prove that the converse of the above statement is true. Fosner and Ilisevic [9] generalized above mentioned result for 2-torsion free semiprime ring. Following [1], every $(\alpha, \beta)^*$-derivation $*$-ring is a Jordan triple $(\alpha, \beta)^*$ derivation but the converse is in general not true. Recently, in [4] Ali Shakir et.al. prove that every Jordan triple $(\alpha, \beta)^*$-derivation is a Jordan $(\alpha, \beta)^*$-derivation on a 6-torsion free semiprime $*$-ring R and also the first

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Orthogonal Symmetric Reverse Bi-(σ, τ)-Derivations in Semiprime Rings

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Abstract:- Suppose that $D_1$and D_2 are two symmetric reverse bi-(σ,τ)-derivations of a semi prime ring R. In this paper, we establish some equivalent conditions for the orthogonality between two symmetric reverse bi-(σ,τ)-derivations D_1, D_2 of R. We prove that D_1 and D_2 are orthogonal if and only if any one of the following conditions is satisfied (i) $D_1(u,v)\,D_2(v,w) + D_2(u,v)D_1(v,w) = 0$ (ii) $D_1D_2 = 0$ (iii) $D_1(u,v)D_2(v,w) = 0 = D_2(u,v)D_1(v,w)$ (iv) D_1D_2 is a bi- (σ,τ)-derivation, for all $u,v,w \in R$.

Keywords*: Semiprime ring, Reverse Biderivation, Reverse Bi-(σ,τ)-derivation, Orthogonal Reverse Bi-(σ,τ)-derivation*

1. Introduction

The concept of orthogonality for a pair of derivations of a semiprime ring was introduced by M. Bresar and J.Vukman [7] and they proved some equivalent conditions on derivations of semiprime rings to be orthogonal which are related to classical result of E. Posner [4]. M.N. Daif et al. [9] established some results concerning biderivations. C. Jaya Subba Reddy et al. [1,3] and M.N. Daif et al. [8] proved some results on the orthogonality of derivations, biderivations. K. Kaya et al. [5] and M.Ashraf [6] studied (σ,τ)-derivations in prime rings. The study of orthogonality of symmetric bi-(σ,τ)-derivations in semi prime rings was carried out by C.Jaya Subba Reddy et al. [2] and S.Srinivasulu et al. [10]. In the present paper, we extend the results related to symmetric bi-(σ,τ)-derivation established in [2] to symmetric reverse bi-(σ,τ)-derivations on orthogonality .

2. Preliminaries

Throughout this paper, R denotes an associative ring with centre Z(R). A ring R is said to be semiprime if $uRu = \{0\}$ implies $u = 0$. We say that R is 2-torsion-free if $2u = 0$, $\forall\, u \in R$, implies $u = 0$. An additive mapping $d: R \to R$ is said to be a derivation (respectively, reverse derivation) on R if $d(uv) = d(u)v + ud(v)$ (respectively, $d(uv) = d(v)u + vd(u)$ holds $\forall\, u,v \in R$. Suppose that σ and τ are automorphisms of R. An additive mapping $d: R \to R$ is said to be a (σ,τ)-derivation (respectively, reverse (σ,τ)-derivation) on R if $d(uv) = d(u)\sigma(v) + \tau(u)d(v)$ (respectively, $d(uv) = d(v)\sigma(u) + \tau(v)d(u)$, $\forall\, u,v \in R$.

A biadditive mapping $D: RX\,R \to R$ is called symmetric if $D(u,v) = D(v,u), \forall\, u,v \in R$. A symmetric biadditive mapping $D_1: RX\,R \to R$ is said to be a symmetric biderivation on R if $D_1(uv,w) = uD_1(v,w) + D_1(u,w)v$, $\forall\, u,v,w \in R$. A symmetric biadditive mapping $D_1: RX\,R \to R$ is said to be a symmetric bi-(σ,τ)-derivation (respectively, symmetric reverse bi-(σ,τ)-derivation) on R if $D_1(uv,w) = D_1(u,w)\sigma(\mathrm{v}) + \tau(\mathrm{u})D_1(v,w)$ (respectively, $D_1(uv,w) = D_1(v,w)\sigma(\mathrm{u}) + \tau(\mathrm{v})\,D_1(u,w)$) holds $\forall\, u,v,w \in R$. Two symmetric reverse bi-(σ,τ)-derivations are said to be orthogonal if $D_1(u,v)RD_2(v,w) = 0 = D_2(v,w)R\,D_1(u,v)$, for all $u,v,w \in R$.

We assume throughout the paper that R is a 2-torsion-free semi prime ring while σ and τ are automorphisms of R and d is a reverse (σ,τ)-derivation of R such that dτ = τd, σd = dσ. We also assume two symmetric reverse bi-(σ,τ)-derivations $D_1: RX\,R \to R$ and $D_2: RX\,R \to R$ such that $D_1\tau = \tau\,D_1$, $D_2\tau = \tau\,D_2$, $\sigma\,D_1 = D_1\sigma$. $\sigma\,D_2 = D_2\sigma$.

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Symmetric Generalized Bi-(σ, τ)-Reverse Derivations in Prime and Semiprime Rings

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Abstract: Let R be a 2-torision free prime and semiprime ring and G be a symmetric generalized bi-(σ, τ)- reverse derivation of R with associated symmetric bi-(σ, τ)- reverse derivation$B$. (i) If $G([x, y], [u, v]) = 0$ for all $x, y, u, v \in R$ (ii) If $G((xoy), [u, v]) = 0$ for all $x, y, u, v \in R$ (iii) If $G([x, y], (uov)) = 0$ for all $x, y, u, v \in R$ (iv) If $G\big((xoy), (uov)\big) = 0$ for all $x, y, u, v \in R$, then either R is commutative or G acts as a bi-multiplier.

Keywords: Prime ring, Semiprime ring, Symmetric bi-(σ, τ) -reverse derivation, Symmetric generalized bi-(σ, τ)-reverse derivation.

1. INTRODUCTION

The notion of reverse derivation has been introduced by Bresar and Vukman in [4] and the reverse derivations on semi prime rings have been studied by Samman and Alyamani in [13]. The concept of a symmetric bi-derivation has been introduced Maksa in [10], [11]. Ozturk and Jun in [12] have introduced the concept of symmetric bi-derivation of a near ring and studied some properties. The notion of generalized symmetric biderivations introduced by Argac [2]. Ceven and Ozturk in [5] introduce the concepts of symmetric bi-(σ, τ)-derivation of a near ring and gave some properties. In 2011, the concepts of (θ, φ)-reverse derivation and generalized (θ, φ)-reverse derivation has been introduced by Anwar Khaleel Faraj in [1]. In 2016, Jaya Subba Reddy et.al in [6, 8] has studied symmetric reverse bi-derivations on prime

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ORTHOGONALITY OF GENERALIZED REVERSE (σ, τ) DERIVATIONS IN SEMIPRIME Γ– RINGS

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ABSTRACT:
Suppose that M is a semiprime Γ-ring. σ, τ are automorphisms of M. An additive mapping M is termed as a reverse (σ, τ)-derivation if it satisfies $d(u\alpha v) = d(v)\alpha\sigma(u) + \tau(v)\alpha\, d(u)$, for all $u, v \in M$ and $\alpha \in \Gamma$. Moreover**,** an additive mapping $D : M \to M$ is termed a generalized reverse (σ, τ)- derivation if there exists a reverse (σ, τ)-derivation $d : M \to M$ such that $D(u\alpha v) = D(v)\alpha\sigma(u) + \tau(v)\alpha d(u)$, for all $u, v \in M$ and $\alpha \in \Gamma$. This paper aims to extend the findings regarding orthogonal (σ,τ) derivations and orthogonal generalized (σ,τ)-derivations in semiprime Γ-rings to include the study of orthogonal reverse (σ,τ)-derivations and orthogonal generalized reverse (σ,τ)-derivations.

KEYWORDS: Semiprime Γ-ring, Reverse (σ, τ)-Derivation, Generalized Reverse (σ, τ)-Derivation, Orthogonal Reverse (σ, τ)-Derivation, Orthogonal Generalized Reverse (σ, τ)-Derivation.

1.INTRODUCTION:

Nobusawa [15] initially introduced the concept of a Γ−ring, where Γ denotes an additive abelian group. Barnes extended the results of Nobusawa on Γ−ring in his work [16]. M.Bresar and J.Vukman [11] have introduced the concept of orthogonal derivations and extended a theorem of Posner [6]. M.Soyturk [13] extended these results to Γ−rings. N.Argac et al. [14] introduced the notion of orthogonality for a pair of generalized derivations in semiprime rings and provided several necessary and sufficient conditions for the orthogonality of such pairs. Samman and Alyamani [12] studied the orthogonal conditions for reverse derivations in semi prime rings. Ashraf and Jamal [9] introduced the concept of orthogonality for two derivations in Γ-rings and established various necessary and sufficient conditions for the orthogonality of two derivations. Later they introduced orthogonal generalized derivation in Γ-rings in [10] and obtained results pertaining to orthogonal generalized derivations. K.K. Dey et al. [8] explored the conditions for the orthogonality of reverse derivations in semiprime Γ-rings. A.Shakir and M.S.Khan studied orthogonal (σ, τ)-derivations in

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Orthogonal Generalized Symmetric Reverse Bi-(σ, τ)-Derivations of Semi Prime Ring

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Abstract:

Let R be a semi prime ring. Suppose that σ, τ are automorphisms on R. A symmetric bi-additive mapping $\delta_1: RX\ R \to R$ is said to be a generalized symmetric reverse bi-(σ,τ)-derivation on R if there exists a symmetric reverse bi-(σ,τ)-derivation D on R such that $\delta_1(uv, w) = \delta_1(v, w)\sigma(u) + \tau(\mathrm{v})\mathrm{D}(u, w)$ holds $\forall\ u, v, w \in R$. Let $[\delta_1, D_1]$ and $[\delta_2, D_2]$ be two generalized symmetric reverse bi-(σ,τ)-derivations of R with associated reverse bi-(σ, τ)-derivations D_1, D_2. In this paper, we establish some equivalent conditions for the orthogonality between two symmetric generalized reverse bi-(σ,τ)-derivations of semiprime ring R.

Keywords: Semiprime ring, Generalized reverse biderivation, Generalized reverse bi-(σ,τ)-derivation, Orthogonal biderivation.

1. INTRODUCTION:

The concept of orthogonal derivation was introduced by M. Bresar and J. Vukman [14] and proved some results on the orthogonal derivations of semiprime rings which were related to Posner's First Theorem [9]. Some results on (σ, τ)-derivations in prime rings were studied by M. Ashraf [13] and K. Kaya et al. [12] . J.C. Chang [11] introduced the notion of a generalized (α, β)-derivation of a ring R and investigated some properties of such derivations. Argac et al. [17] introduced the notion of orthogonality for a pair (D, d), (G, g) of generalized derivations on semiprime rings and gave several necessary and sufficient conditions for (D, d) and (G, g) to be orthogonal. O.Golbasi and N. Aydin [18] extended the results of Argac to orthogonal generalized (σ, τ)-derivations. Orthogonality of generalized (σ, τ)-derivations on ideals of semiprime rings was studied in [10]. Several studies were established on the orthogonality of derivations, biderivations by M.N. Daif et al. [15] and C. Jaya Subba Reddy et al. [2,4, 5]. A.Ali et al. [1] and M.N.Daif et al. [16] established some results on biderivations of prime and semiprime rings and the study of orthogonality of symmetric bi-(σ, τ)-derivations in semi prime rings was carried out in [3,6]. Recently, C. Jaya Subba Reddy et al. [7, 8] have studied orthogonal symmetric reverse bi-(σ,τ)-derivations in semi prime rings and orthogonal generalized reverse (σ, τ)- derivations in semiprime Γ-rings. In the present paper, we extended the results of orthogonality on generalized symmetric bi-(σ, τ)-derivations established in [6] to generalized symmetric reverse bi-(σ, τ)-derivations.

Reactive Extraction of Gluconic Acid Using Tri-n-octylamine in 1- Hexanol

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Abstract-Gluconic acid is an important carboxylic acid widely used in chemical, pharmaceutical, food and other industries. The growing importance of biological production (fermentation) expressed with new routes and increasing production rates, leads to look for technologies of downstream processing for product separation.

Tertiary amines are effective extractants for separation of carboxylic acid from dilute solutions. The basic principle of recovery of acid by tertiary amines is through reaction with extraction. Generally, amines are used in diluents to improve their physical properties and to provide salvation of the complexes formed by them with the acids. The recovery of Gluconic acid with Trioctylamine and 1-hexanol is carried out for different Concentrations of acid, Trioctylamine (TOA) and 1-Hexanol

Key words: Reactive Extraction, Gluconic Acid, Tri-n-Octyl amine, 1-hexanol

1. INTRODUCTION

The carboxylic acids like tartaric acid, formic acid, pyruvic acid, acetic acid, succinic acid propionic acid, lactic acid, citric acid, gluconic acid, malic acid etc., are produced using aerobic fermentation process from past few decades. Separation of carboxylic acids from fermentation broth is anintriguing task. Since the downstream processing of carboxylic acids not only account for up to 50-60% of the manufacturing cost but also generates a large amount of solid wastes. With the burgeoningemphasis of production of carboxylic acidfrom fermentation technology. It is significant to originate an efficient, eco-friendly and economical method to separate carboxylic acids from fermentation broth. Several separation techniques have been researched for the separation of carboxylic acids like membrane separation, solvent extraction, liquid-liquid extraction, ultrafiltration, reverse osmosis, distillation, dialysis, electrodialysis, adsorption and ion exchange. These separation methods have certain drawbacks such as efficiency is less, expensive, the intricacy of operation and utilization of energy is huge. Reactive extraction with a desirable organic solvent has proved to be an efficient method to separate carboxylic acids from fermentation broth.

Reactive extraction is a separation technique used to enhance the extraction of solute from the AP to the OP. The extractant molecule reacts with the solute molecule to form a reaction complex, which will stabilize in OP due to the hydrogen bonding with 1-hexanol and hydrophobic nature of complex Reactive extraction has variousrewardslikeenhanced reactor productivity, amelioratecontrol over pH in the bioreactor, reduces the downstream processing load, minimizes the solvent recovery cost, phase equilibrium enhanced and higher efficiency. Therefore, it has fascinated several scientists to research the process and the effect of distinct parameters like the effect of pH, effect of temperature, kinetics of extraction and concentration of acid, extractant and diluents.

Gluconic acid is a carboxylic acid (pentahydroxycaproic acid, $C_6H_{12}O_7$) is the oxidation product of glucose, naturally occurring in plants, fruits, wine (up to 0.25%), honey (up to 1%), rice, meat, vinegarand other natural sources.Gluconic acid is the largest commercially produced of fungal organic acids, from glucose. Demand for metal gluconates is steadily increasing due to their multiple applications in different industries.

In the current work, an investigation on the recovery of gluconic acid from aqueous solution was aimed by employing TOA in 1-hexanol. The equilibrium parameters such as K_D, E %, Z are evaluated using experimental data.

2. THEORY

The extraction process was analyzed through the K_D.The distribution coefficient (K_D) is defined as the ratio of total concentration of acid in all forms (partition, dimers & as complexes) in the organic phase to total concentration of all existing forms (ionized & un-ionized) in the aqueous phase by assuming no change in volume at equilibrium.

$$K_D = \frac{[\overline{GA}]_{total}}{[GA]_{total}}$$

Where, $[\overline{GA}]_{total}$= Concentration of acid in organic phase.
$[GA]_{Total}$= Concentration of acid in aqueous phase.

The extraction efficiency (E %) is defined as the proportion of gluconic acid concentration in the OP to the sum of gluconic acid concentration in organic andAP

$$E\% = \frac{K_D}{1+K_D} \times 100$$

The value of Z depends on the extractability of the acid (strength of the acid base interaction) and its aqueous concentration. The stoichiometry of the overall extraction equilibrium depends on the loading ratio in organic phase (Z). If the organic phase is not highly concentrated by acid, i.e., at very low loading ratios (Z < 0.5), 1:1 complex of acid and extractant is formed.

The extent to which organic phase (TOA+Decanol) can be loaded with carboxylic acid is expressed as the loading ratio, Z;

$$Z = \frac{[GA]_{Org}}{[T]_{Org}}$$

Where, $[GA]_{org}$= Concentration of acid in organic phase after extraction.
$[T]_{org}$= Concentration of TOA in organic phase before extraction.

3. MATRIALS AND METHODS

Materials

Gluconic Acid ($C_6H_{12}O_7$)(49-53 wt % of H_2O), molar mass 116.11 kg/kmol, density 1.134 g/ml at 250C, 97 % purity was procured from Sigma-Aldrich (India). TOA (N,N-dioctyloctan-1-amine) ($C_{24}H_{51}N$)a tertiary amine is a colour less liquid with the molecular weight of 353.66 g/mol, density 0.81 g/cm3at 200C, 98 % purity, was procured from Sigma-Aldrich (India). 1-Hexanol (Hexyl alcohol, $C_6H_{14}O$), molar mass 102.17 kg/kmol, density 0.814 g/ml at 250C, 98 % purity was used as a diluent was obtained from Sigma-Aldrich (India). Sodium Hydroxide (0.1 N of NaOH) used for volumetric analysis is of laboratory gradeused for titration. Phenolphthalein solution with pH range 8.2 to 10 was used as an indicator was procured from Ranbaxy, India. Distilled water was used to prepare the solutions of various initial concentrations of Gluconic acid solutions. The initial concentration of TOA in 1-hexanol was varied from 10% to 50% on volume basis. The aqueous phase consists of Gluconic acid and water and the organic phase consists of TOA and 1-hexanol.

Methods

Equilibrium Studies:

Optimum time was calculated (12 hours) to attain liquid-liquid equilibrium for both physical extraction and chemical extraction by analyzing the samples at regular intervals of time. The initial concentrations of gluconic acid were 0.0634, 0.12653, 0.1897, 0.25306, 0.31632 mol/L respectively**.**

Physical equilibrium:

For physical equilibrium, 20 ml of gluconic acid (AP) of different concentrations were taken in different conical flasks and 20 ml of 1-hexanol (OP) was added in each conical flask. Mechanical shakers were used to thoroughly mix both the phases for 12hrs at room temperature. The organic and aqueous phases were permitted to steady down in a separating funnel for 2 hours. A sample fromAP was titrated with 0.1N NaOH using Phenolphthalein as an indicator to measure the concentration of gluconic acid in the AP. Mass balance was used to calculate the concentration of gluconic acid in the OP.

Chemical equilibrium:

For chemical equilibrium, 20 ml of gluconic acid and 20 ml of 10 % TOA (0.2264 mol/L) in 1-hexanol was added in a conical flask. The non-miscible solution was kept in shakers for 12 hours and then allowed to settle for 2 hours. The gluconic acid concentration was determined from the aqueous phase by titrating a sample solution with 0.1N NaOH using Phenolphthalein as an indicator. The same procedure was repeated for 20%, 30% and 40% TOA.

4. RESULTS AND DISCUSSION

Data obtained from the experiments are tabulated and compared to know the amount of the gluconic acid extracted from aqueous solution using the physical and chemical equilibrium methods with different concentration of the TOA. From the equilibrium data, the K_D, E %, Z, are calculated as shown in Table 1 and Table 2.

Physical equilibrium

The most effective diluents are alcohols since they enhance the extraction of carboxylic acids. Therefore, 1-hexanol which is intermediate molecular weight alcohol is used as a diluent. The physical equilibrium data values for gluconic acid using 1-hexanol are shown in Table 1. It is observed that an increase in the initial concentration of acid increases the concentration of acid in both aqueous and organic phase. It is observed that distribution coefficient K_D decreases with increase in initial concentration of gluconic acid because the increase in concentration of acid in aqueous phase is higher than the concentration of acid in organic phase.

[GA]In Mol/L	[GA]Aq	[GA]Org	K_D	E%
0.03	0.01	0.019	1.9	65.517
0.06	0.02	0.03	1.5	60

0.12	0.04	0.046	1.15	53.48
0.18	0.06	0.055	0.916	47.807
0.2	0.07	0.06	0.857	46.149
0.3	0.13	0.07	0.538	34.98

Table 1:Physical equilibrium of water – Gluconic acid – 1-Hexanol

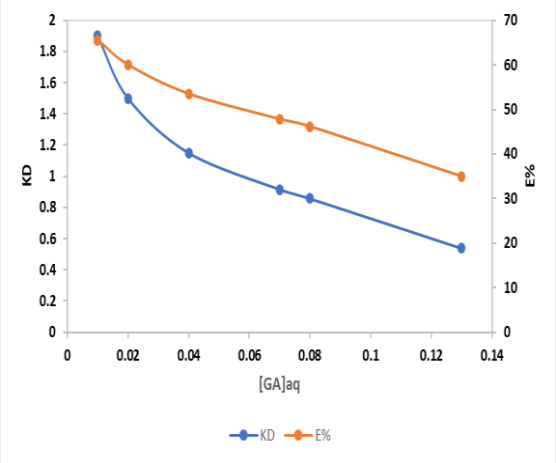


Fig 1: Equilibrium distribution of water – Gluconic acid – 1-Hexanol

Chemical equilibrium

The most effective diluents are alcohols since they enhance the extraction of carboxylic acids. Therefore, 1-hexanol which is intermediate molecular weight alcohol is used as a diluent. The chemical equilibrium data values for gluconic acid using 1-hexanol are shown in Table 2.

In this chemical equilibrium TOA is added 10-50%.It is observed that an increase in the initial concentration of gluconic acid increases the concentration of acid in both aqueous and organic phase. It is observed that distribution coefficient K_D decreases of Gluconic acid in aqueous phase $[HA]_{aq}$ because K_D is the ratio of concentration of acid in organic phase to the concentration of acid in aqueous phase. The chemical extraction distribution coefficient is found to be higher than physical extraction for all acid concentrations.
It is observed that extraction efficiency E% decreases, increases concentration of Gluconic acid in aqueous phase $[HA]_{aq}$ because E% is the ratio of concentration of acid in organic phase to the sum of acid concentration in aqueous and organic phase. It is observed that Loading Ratio Z increases with an increase in the concentration of acid in aqueous phase. The loading ratio decreases with an increase in the concentration of TOA because complexes involving more acid molecules are formed at lower concentrations of TOA.

10% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	2.11
0.02	0.0808	4.04	80.158	2.39
0.05	0.11514	2.3028	69.715	3.36
0.07	0.1313	1.8757	65.2258	3.76
0.11	0.15554	1.414	58.57	4.56
0.211	0.1818	0.8616	46.2827	4.83
20% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	1.95
0.02	0.0909	4.545	81.9657	2.26
0.05	0.1313	2.626	72.4214	3.25

0.07	0.14948	2.1354	68.106	3.58
0.11	0.1717	1.5609	60.951	4.32
0.211	0.19796	0.93819	48.405	4.64
30% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	1.83
0.02	0.10504	5.252	84.005	2.13
0.05	0.14746	2.9492	74.678	3.11
0.07	0.16968	2.424	70.79	3.39
0.11	0.18988	1.72618	63.318	4.14
0.211	0.21412	1.01478	50.36	4.49
40% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	1.74
0.02	0.1212	6.06	85.835	1.99
0.05	0.16564	3.3128	76.813	2.88
0.07	0.18584	2.6548	72.368	3.26
0.11	0.20604	1.87309	65.194	3.97
0.211	0.23028	1.09137	52.188	4.26
50% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	1.65
0.02	0.13332	6.666	86.955	1.84
0.05	0.1818	3.636	78.429	2.68
0.07	0.19998	2.8568	74.07	3.11
0.11	0.22624	2.0567	67.284	3.63
0.211	0.25048	1.1871	54.277	4.12

Table 2: Equilibrium for reactive extraction of gluconic acid with various concentrations of TOA (10-50%) in 1- hexanol

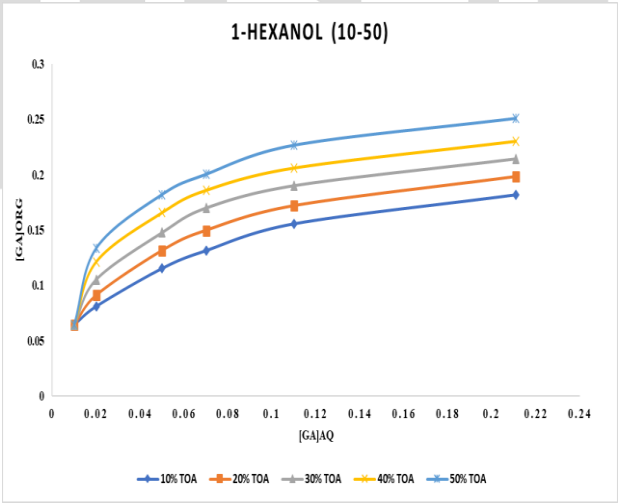


Fig 2: Equilibrium for reactive extraction of Gluconic acid with various concentrations of TOA in 1-Hexanol

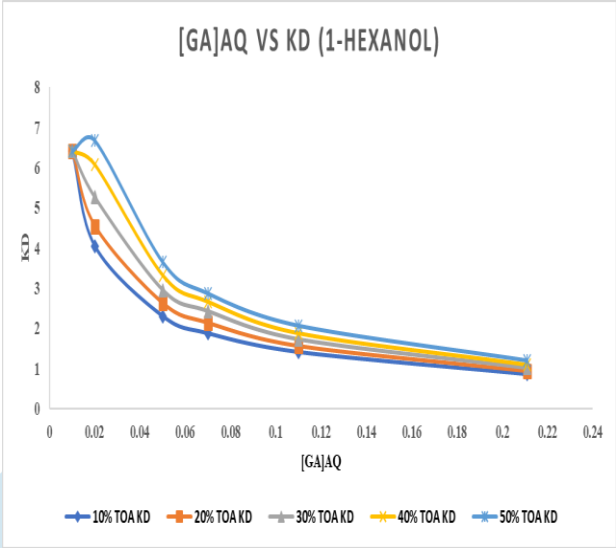


Fig 3: Effect of concentration of acid in aqueous phase on Distribution Coefficient with variable TOA Concentration in 1-Hexanol

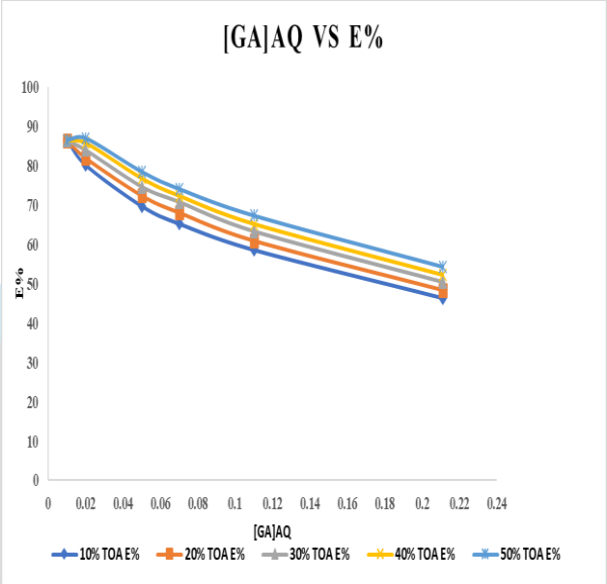


Fig 4: Effect of concentration of acid in aqueous phase on Extraction Efficiency with variable TOA Concentration in 1-Hexanol

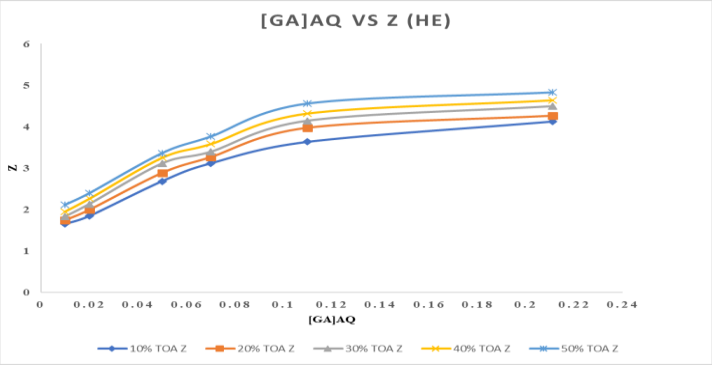


Fig 5: Effect of concentration of acid in aqueous phase on Loading Ratio (Z) with variable TOA concentration in 1-Hexanol

V. CONCLUSION

The experiments conducted for the reactive extraction of Gluconic acid with TOA in 1-hexanol were investigated. The key findings are as given below

- The physical and chemical equilibria for the extraction of gluconic acid by tri-n-octyl-amine in 1-hexanol are determined. The chemical extraction is found to be superior over to physical extraction.
- The optimum TOA concentration is found to be 50% at which K_D values for 1-hexanol is 6.66.
- The loading ratio Z decreases with an increase in TOA initial concentration in 1-hexanol is 4.83. It increases with an increase in concentration of acid in aqueous phase.
- The degree of extraction of acid increased with decreased in initial concentration of acid and increase in TOA concentration is 86.95%.

VI. NOMENCLATURE

K_DDistribution coefficient

E%Extraction efficiency or degree of extraction

ZLoading ratio

[GA] Concentration of Gluconic acid (mol/L)

[T] Concentration of Tri-n-octylamine (mol/L)

HEHexanol

Subscripts

aq aqueous phase

org organic phase

VII. ABBREVIATION

TOA Tri-n-octylamine

AP Aqueous phase

OP Organic phase

ICGA Initial concentration of Gluconic acid

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REMOVAL OF MALACHITE GREEN DYE FROM AQUEOUS SOLUTION USING LEMON LEAF POWDER AS AN ADSORBENT

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ABSTRACT

The majority of developing nations experience significant water contamination from textile sector wastewater. The use of low-cost, environmentally friendly adsorbents has been researched as a means of addressing problems of water contamination and high costs for waste - water treatment processes. Malachite green is an incredibly dangerous colour that not only damages mammalian cells but also has a key influence in the growth of liver cancers. The life cycle of aquatic creatures, plants, and people is hampered by dye released into bodies of water without sufficient treatment. In this study, the powdered lemon leaves are utilized for removal of the aniline green dye. By using batch-style setting and design of the experiment (the Box–Behnken technique) adsorbent has been investigated & have been developed to evaluate the process's critical factors, including agitation time, size of adsorbent, dosage of adsorbent, pH, initial concentration and temperature.

The acquired values were fitted with adsorption isotherms. Malachite green dye sequestration onto Lemon Leaf Powder was chosen using kinetic models. The results of the trials showed that employing powdered lemon leaves, malachite green could be removed to a maximum of 82.21%. Malachite green dye concentration of 50 mg/L, temp of solution 303 K, and dosage of adsorbent 20 g/L are the ideal parameters. Lemon leaf powders have a maximum sorption capacity (qmax) of 8.08 mg/g. The equilibrium was more accurately modelled using the Freundlich isotherm. When compared to other models, the data which fits the pseudo 2nd order kinetics model is better. Previously researchers had proved several low – cost materials such as wheat bran, marina alga, wood apple shell etc… In the current work, to remove malachite green dyes the efficacy of citrus lemon leaves is thoroughly done. The operating parameters that are optimized include dye solution concentration, initial solution pH, sorbent dose, and temperature. Studies on thermodynamics have demonstrated that the adsorption process was endothermic & spontaneous.

Keywords: Lemon leaves, Malachite Green dye, Concentration of dye solution, adsorbent dosage, agitation time, sorbent size.

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1. Introduction

In the modern world, one of the greatest environmental challenges is water contamination. Because of people and their activities, water resources, such as rivers, seas, and groundwater, have been contaminated (Dutta et al., 2011).There are many methods to pollute water, but spilling industrial waste water into water bodies is one of the most significant. Untreated sewage from households that is released into the environment is another significant source of pollution (Dizaj et al., 2015).Other sources include chemicals that are released from various operations and flow on the surface, as well

as fertilizers and pesticides that are released from agricultural activities. Industries release waste - water into water bodies without sufficient treatment, contaminating the water with heavy metals, chemicals, dyes, oils, and many other hazardous substances. The fact that contaminated drinking water has grown to be a serious worry for mankind today should give you a good idea of the terrible effects of water pollution. For the dye-contaminated wastewaters treatment, a number of different techniques have been tried, including adsorption, ion exchange, precipitation, coagulation and flocculation, and chemical oxidation. Due to its simplicity, cheap cost, high selectivity, and high efficiency, the adsorption approach has been shown to be a better separation & purification method. (Gupta et al., 2016)

Adsorption is a key step in the physiochemical treatment of wastewater, a procedure that may cheaply fulfil the increased effluent regulations and water reuse specifications of the present. The building of materials along the boundary between 2 phases is referred to as adsorption, which is a mass transfer technique. The substance that is being adsorbed is referred to as the "adsorbate," while the substance that is doing the adsorption is called "adsorbent". (Gupta et al., 2011; Santhi e t al., 2016); (Oyelude et al., 2018).The most important adsorption parameters are surface area for adsorption per unit volume, pH, chemical reactivity, and a decrease in surface tension. Previously researchers had proved several low – cost materials such as wheat bran, marina alga, wood apple shell etc… In this present study, lemon leaves have been used as adsorbent whose results showed good capacity of Malachite Green in a very short period of agitation, good and higher % removal adsorption compared to previous studies.

1.1 Malachite green:

It is an organic chemical which is used in aquaculture as an antibacterial and, controversially, as a colour. It may be dissolved in water, alcohol, ethanol, and methanol and is useful as a dye for materials including leather, silk, paper & wool (Hamdaoui et al., 2008). In 1992, Canadian officials concluded that consuming fish tainted with malachite green presented a serious health danger. A Class II health hazard designation was given to malachite green. Malachite green is still utilized for non-aquaculture activities in some nations with less stringent legal regulations due to its inexpensive manufacturing cost. (Rout & Jena, 2021) Malachite green was discovered in fish imported from China and Taiwan in 2005 by experts in Hong Kong and also by the US FDA in 2006 in seafood which was imported from countries like China, where the material is similarly forbidden for use in aquaculture. (Ismail et al., 2018; Khattri & Singh, 2009) Due to persistent malachite green contamination, the FDA prohibited the importation of numerous different seafood species in June 2007. Since 1983, the chemical has been prohibited in the US for use in foods. Malachite green is converted by animals to its leuco form (Zhang et al., 2008).

Malachite green is a harmful dye that not only has very poisonous qualities that harm mammalian cells but also has a significant role in the development of liver tumors. By preventing sunlight from penetrating into water bodies, dye spilled there impairs the life cycles of aquatic organisms and plants (Issa et al., 2014). They cause a shortage of dissolved oxygen as a result of an increase in the biological oxygen demand (BOD) to support aquatic life. Some colours can directly harm or hinder the chemical activity of certain substances because they are extremely cyanogenic. Dye has an impact on marine life and consequently the food cycle at low quantities (Kushwaha et al., 2014).

1.2 Lemon Leaf Powder (Adsorbent):

Nerve conditions including sleeplessness, jitters, and palpitations can be treated with lemon leaves. Valium and other artificial sedatives that have adverse effects can be replaced with lemon leaves as an excellent and superior option. Take the recipe every day for at least a month to receive the best results from lemon leaf. Blanched leaves can be useful to flavor drinks, wrap meat or shellfish, and roast, steam, or grill them. Thai cuisine frequently uses lemon leaves. They are used to wrap cheese in Italy. Lemon leaves are used in Greek roast pork dishes. Indians use lemon leaves to spice their curries. In their meat kabobs or sosatie, South Africans add lemon leaves. Many cultures use lemon leaves to flavour tea (Sarath Babu & Yamini, 2020; Shakoor & Nasar, 2016).

2. Experimental Method and Analysis

2.1 Method for preparing malachite Green stock solution

Malachite green stock solution containing 1000 mg/L (1000 ppm, w/v) of the dye is made by dissolving 1 g of the dye in 1 lt. of distilled water. For the tests, adequate dilution is used to create solutions with various dye concentrations. A 50 ml volumetric flask is filled to the mark with distilled water after 2.5 ml of a 1000 ppm Malachite green stock solution has been diluted. Similar to this, solutions with various dye conc's., including (50, 100, 150, 200, 250, and 300mg/L), are made. Aqueous solutions' pH can be changed to the required value by mixing 0.1N sulphuric acid and 0.1N NaOH solution. (Sartape et al., 2017; Shanthi & Mahalakshmi, n.d.).



Figure 1: Preparation of Malachite Green Stock Solution

2.2 Preparation of Lemon leaf powder

Dinnupativaripalli, in the Chittoor district, is where fresh lemon leaves from sweet lemon (local name: Mosambi; Scientific name: Limetta Lemon plant) were gathered. To get rid of any dust or other soluble materials, the gathered leaves are rinsed in tap water. After being divided into little pieces (between one and three centimeters), the leaves were dried in the sun. To get a particle size range of 80 (175m) to 200 (74m) of Lemon leaf powder, the dried pieces are ground and sieved using various B.S.S. standard sieves of mesh size. The powder is then packaged in a bottle. The powder is once again cleaned with distilled water to get rid of any contaminants that could have caused the color to be off, and it is then allowed to air dry. In a separate, airtight vial, the dried samples are kept for use in experiments (Kumar, 2007).

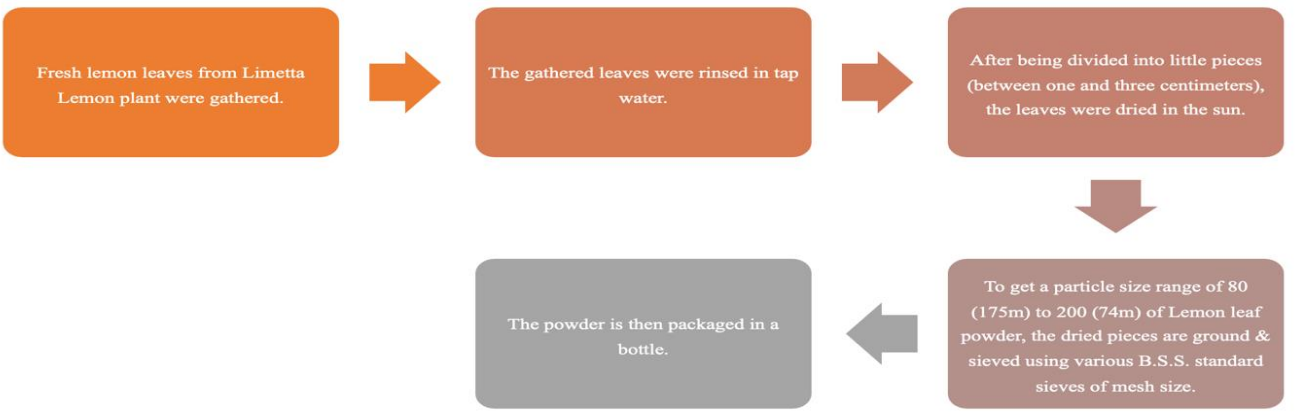


Figure 2: Preparation of lemon leaf powder

2.3 Adsorption study

The adsorption of color using powdered lemon leaves is researched utilizing the batch approach. The initial pH of the solution is set to the appropriate value by introducing solutions of 0.1N sodium hydroxide and 0.1N sulfuric acid to a series of labelled conical flasks containing 50 mg/L of dye solution. The flasks are shaken in an incubator shaker at a constant 120 rpm after being meticulously filled with 0.5 g of 74 mm-diameter adsorbent. Samples were collected, filtered, and the clean filtrate was analyzed using UV-Visible Spectroscopy over a period of time. (10, 20, 30,...140 and 150 min). Equation is used to determine the percentage of dye elimination (Ahmad & Kumar, 2010; Hameed et al., 2007).

$$\%Removal = \frac{C_O - C_f}{C_O} * 100$$

C_0 = Initial Dye solution concentration (mg/L); C_f = Final dye solution concentration (mg/L)

Initial concentration of dye in solution, dosage of adsorbent & temperature that is the effect of three factors, on dye removal is studied by using equation.

$$q_e = \frac{(C_0 - C_f) * V}{m}$$

q_e = The amount of dye adsorbed is calculated as per the amount of adsorbent (mg/g).

C_0 = Dye solution initial concentration (mg/L); C_f= Final concentration of dye solution (mg/L)

V= volume of dye solution (50 ml); m = adsorbent mass (g)

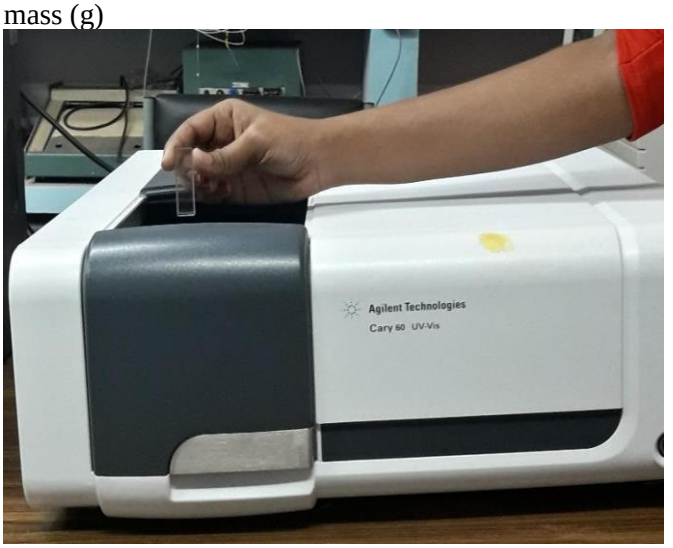


Figure: 3: UV Visible double beam



Figure 4: Incubator shaker

3. Results & discussion

Data collected from experimentation on the adsorption of aniline green using Lemon leaf powder is given section wise and discussed in this Chapter. The repeatability of the results is 3 – 4 times with $\pm$ 0.1 - $\pm$ 0.3.

3.1 Adsorption of Malachite green dye using Lemon leaf powder

Dye concentration in all the studies is obtained from UV-VIS spectrophotometer. Standard calibration curve – a plot of dye concentration Vs. absorbance, is as shown in figure 5.

3.2 Preliminary Studies – Particle Size, Contact time and pH:

Particle size influences adsorption significantly. Lower particle sizes are suitable for treatment as they offer more surface area and more binding sites. Therefore, the smallest particle size, limited by the ease of separation post-adsorption is to be used. In my study, a particle size of 74 µm (passing through 120 and retained by 200 mesh) is used in all experiments. For the identification of contact time to attain equilibrium, an experiment is conducted and the time course of adsorption is shown in figure 5.

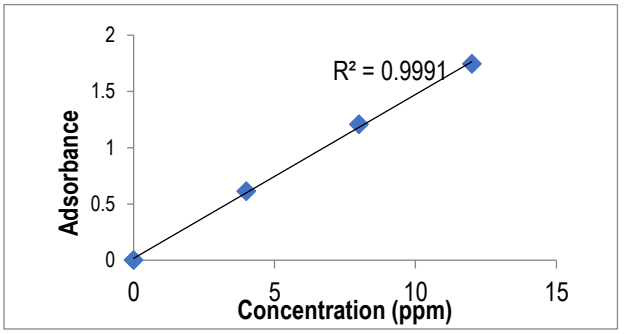


Figure 5: Malachite green calibration curve

Table 1: Experimental Conditions

V = 50 ml	C_o = 20 mg/L
d_p = 74µm	Rpm = 120
w = 10g/L	T = 303K

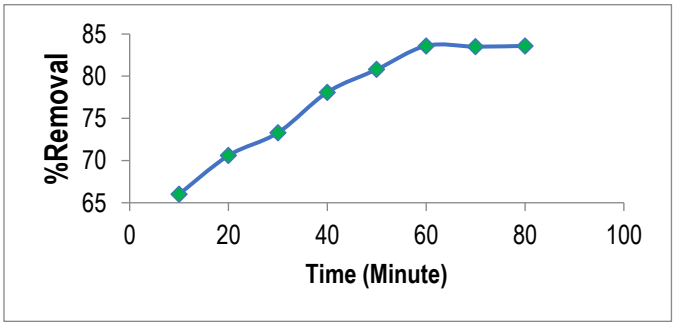


Figure 6: Agitation time vs % adsorption of Malachite green

Adsorption proceeds at a rapid rate and progressively slows increase as time passes. After some time, there is no change of removal is absorbed in graph so ultimately equilibrium is attained after a treatment period of 60 minutes. This is chosen as the optimum contact time. pH effect on adsorption is studied within a range of 2 to 10, and the results are plotted and shown as figure 6.

Table 2: Experimental Conditions

T=60min	Rpm=120
C_o= 20 mg/L	d_p = 74µm
w = 10g/L	T = 303K

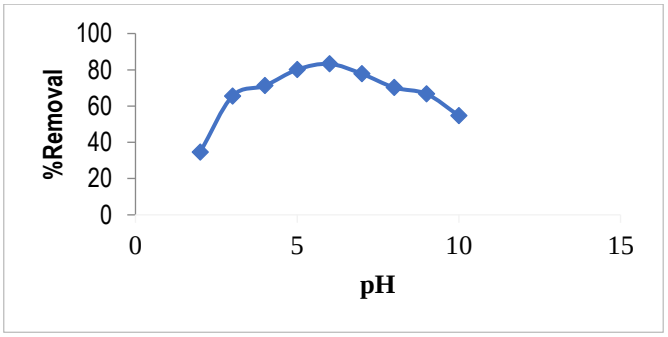


Figure 7: pH vs %Removal

From figure 7, the % of MG removal increased with increase in solution pH & subsequently decreased. This trend can be attributed to the favorable configuration of the active functional groups, resulting in a peak removal at a pH of 6.0. The following decrease is once again to distortion in the structure.

3.3 Optimization of Parameters and Model Development:

Thus, a particle size of 74 µm, a contact time of 60 minutes and pH of 6.0 are fixed for all the experiments. Three other major parameters, namely initial dye concentration, temperature and adsorbent dosage are optimized for the dye removal with leaf powder of Lemon, using a Box-Behnken design approach.

Dye concentration from 50 to 150 mg/L, dosage of adsorbent between 2 to 20 g/L and temperature from 293 to 313 K, are considered. Results of experiments conducted as per the said factorial design approach are tabulated as table 3.

Table 3: Box Behnken model results for Malachite green onto Lemon L

RUNS	Real(Coded) values			%Removal	
	Concentration mg/L (A)	Temperature K (B)	Dosage g/L(C)	Experiment	Predicted
1	100(0)	300(0)	11 (0)	79.8	79.2
2	100(0)	300(0)	11 (0)	79.8	79.2
3	100(0)	293 (-1)	2 (-1)	69.7	69.4
4	100(0)	313 (+1)	20 (+1)	80.3	79.84
5	100(0)	303 (0)	11 (0)	79.8	79.2
6	50(-1)	293 (-1)	11 (0)	67.6	67.6
7	50(-1)	313 (+1)	11(0)	73.8	73.6
8	150(+1)	313 (+1)	11 (0)	72.2	72.16
9	150(+1)	293 (-1)	11(0)	69.8	69.78
10	100(0)	313 (+1)	2 (-1)	73.4	73.4
11	150(+1)	303 (0)	2 (-1)	78.9	78.84
12	50(-1)	303 (0)	2 (-1)	60.97	60.97
13	100(0)	303 (0)	11 (0)	79.8	79.2
14	150(+1)	303 (0)	20 (+1)	66.02	66.15
15	**50(-1)**	**303 (0)**	**20 (+1)**	**82.2**	**82.14**
16	100(0)	293 (-1)	20 (+1)	69.7	69.54
17	100(0)	303 (0)	11 (0)	79.8	79.2

$$\% \text{ Removal} = 79.80 + 0.29*A + 2.68*B + 2.10*C - 0.95*AB - 8.53*AC + 1.36*BC - 5.29*A^2 - 3.66*B^2 - 2.48*C^2$$

A peak removal of 82.2% is realized experimentally. The data are fitted to yield a quadratic model, which is given as equation (27). The coefficients in the expression indicate the relative weight, each term carries and contributes to the total % removal. As per the model, the highest removal is 82.2%, which is very close to the experimental level.

A conclusion that a solution of 50 mg/L of Malachite green dye treated with 20 g/L *Lemon* leaf powder at a 6.0 pH and a temp of 303 K, yielded the highest removal of 82.2% and the corresponding model prediction is 82.14%. The results are further analyzed by variance analysis to understand the contribution of terms in the prediction. The outcome is shown in table. Table 3.

'F-statistics' value, with a low probability and high model F (198.6) value indicates the significance of the regression model. Based on (Prob>F) values, all terms are A, B, C, AB, AC, BC, A^2, B^2, and C^2 found to be significant. R^2 predicted is 0.9376, whereas R^2 adjusted is 0.9911; this represents a difference of 0.2 is both the signal and the permissible norm. Table 5 lists the three variables' optimal values from both the experiment and the model.

Table 4: ANOVA and regression coefficients

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	616.27	9	68.47	198.60	< 0.0001	significant
A-concentration	0.69	1	0.69	2.00	0.2000	
B-temperature	57.46	1	57.46	166.65	< 0.0001	
C-dosage	35.24	1	35.24	102.20	< 0.0001	
AB	3.61	1	3.61	10.47	0.0143	
AC	290.87	1	290.87	843.63	< 0.0001	
BC	7.40	1	7.40	21.46	0.0024	
A^2	117.99	1	117.99	342.22	< 0.0001	
B^2	56.29	1	56.29	163.25	< 0.0001	
C^2	25.97	1	25.97	75.34	< 0.0001	
Residual	2.41	7	0.34			
Lack of Fit	2.41	3	0.80			
Pure Error	0.000	4	0.000			
Cor Total	618.69	16				

R^2 (Adj) = 0.9911 and R^2 (Pred) = 0.9376

Table 5: Optimum Levels

Name of the variable	% Removal of Malachite green	
	Experimental	Calculated with optimum values
Concentration Of dye (C_o)mg/L	50	54.76
Sorbent Dosage (w), g/L	20	20.4
Temperature (T),K	303	301.5
% Removal	82.2	82.14

The experimentally determined values of the ideal operating conditions and those predicted by the model correspond very adequately.

3.3.1 Diagnostic model:

Figures 8 and 9 compare the actual percentage of malachite green removal to that predicted by the model, as well as the normal plots for residuals. Figures 5, 6, and 7 show surface contour plots of the interaction effects of three variables—malachite green concentration, adsorbent dosage, and temperature—to help viewers better comprehend the dependence.

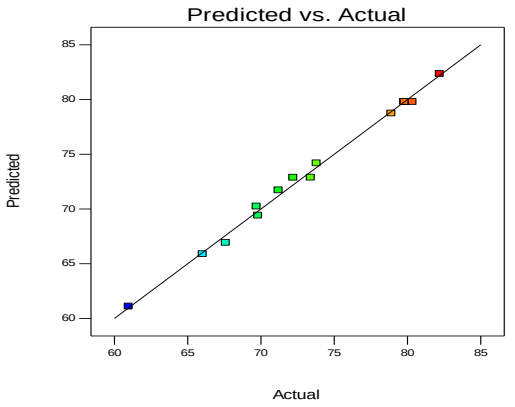


Figure 8

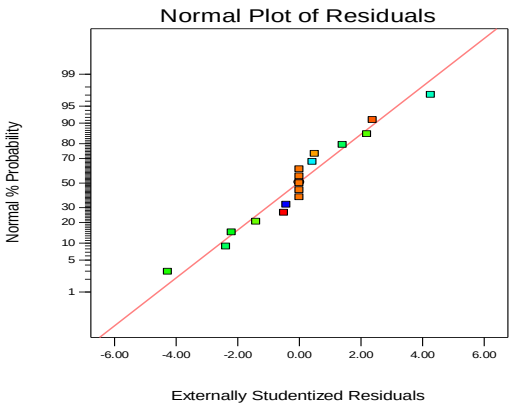


Figure 9

Actual (experimental values) values and the model predicted values are close, indicating a good fit of the experimental data to the mathematical model. The correlation coefficient between predicted $R^2$and adj R^2 (<0.2) are in reasonable agreement.

The residuals, the discrepancy between the experimental and observed responses, and the projected responses are all evaluated using the normal probability plots of the residuals. If the model is effective, the points on the normal probability plots of the residuals should form a straight line.

3.3.2 Three-dimensional (3D) response surfaces

Contour plots or response surface for the measured response are shown in figures 10, 11 & 12 these plots will provide better understanding of the interactive manner in which the independent variables would affect the dependent variable. Three independent variables make up the regression model in this study's work; two of these variables are kept at their current levels, yielding a total of three response 3D plots.

From figure 10 it is apparent that % removal increases as temperature increases (293-313K). Dependence on adsorbate concentration is showing the same trend as shown with temperature. With more adsorbent in the system, the number of binding sites also increases and hence a better removal is recorded. From figure 11 it is apparent that % removal increases as adsorbent dosage increases. Dependence on adsorbate concentration is showing the same trend as shown with temperature. With more adsorbent in the system, the number of binding sites also increases and hence a better removal is recorded. From figure 12 it is apparent that % removal increases as temperature increases (293-313K). Dependence on adsorbate dosage is showing the same trend as shown with temperature. With more adsorbent in the system, the binding sites number also increases and hence a better removal is recorded.

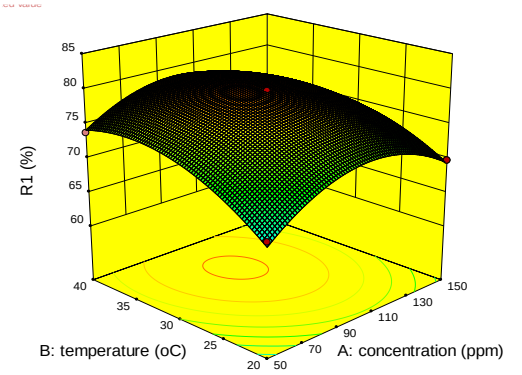


Figure 10: Surface contour plot of Temperature – Initial concentration –% Removal

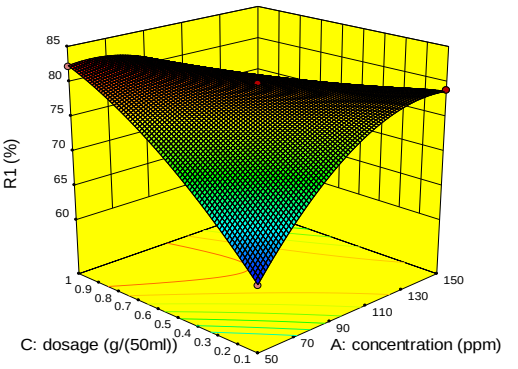


Figure 11: Surface contour plot of concentration– Dosage – % Removal

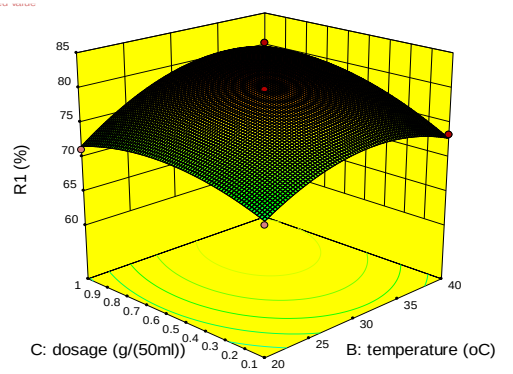


Figure 12: Surface contour plot of Temperature–Dosage –% Removal

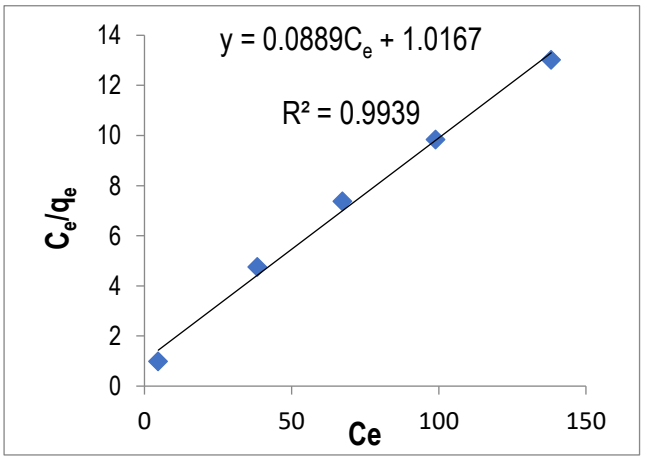
3.4 Adsorption isotherms

The equilibrium data are represented in four standard isotherm models -Langmuir isotherm model, Temp k in isotherm model, Freundlich isotherm model & D – R model obtained at the optimized conditions for adsorption of malachite green dye are Co of 50 mg/L, dosage of adsorbent: 20 g/L, pH of 6.0, time of 60 minutes and temperature of 303K for different Malachite green dye concentrations (50,100…. 300 mg/L). The resulting plots are shown in Figures 13 (i) – 13 (ii) & 14 (iii) – (iv). The graph depicts the equation for the straight line fit and the corresponding correlation coefficient. With a higher correlation coefficient of 0.9979, Freundlich isotherm is shown to be the best model for adsorption data, followed by Langmuir. Temkinand D-R model with correlation coefficients of 0.9939, 0.9954 and 0.9048respectively.

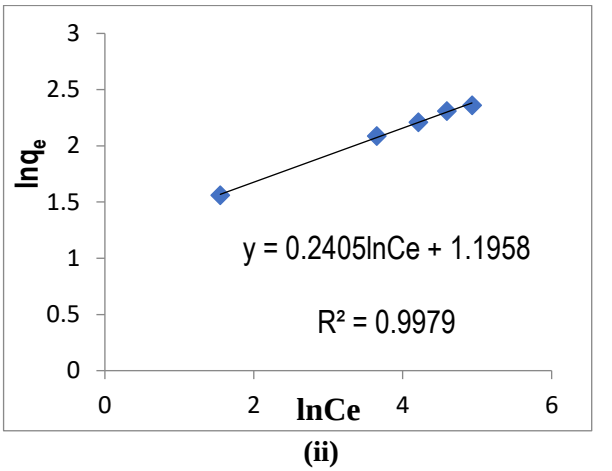
Table 6: Comparision of adsorption capacities with other low - cost adsorbents

Adsorbent	q_{max} (mg/g)	References
Thuya lignin	3.55	(Mohammed Saber et al., 2022)
Saw dust	7.84	(Chaimaa Bouyahia et al., 2023)
Algerian date stones	4.9	(KHELIFI O et al., 2016)

The amount of adsorption (q_{max}) of MB by was compared with other adsorbents reported in the literature, which are listed Table 6. The comparative study shows that the efficiency of the studied adsorbent can be used as an alternative to the usual adsorbents.



(i)



(ii)

Figure 13: Adsorption isotherm plots of MG (i) Langmuir (ii) Freundlich

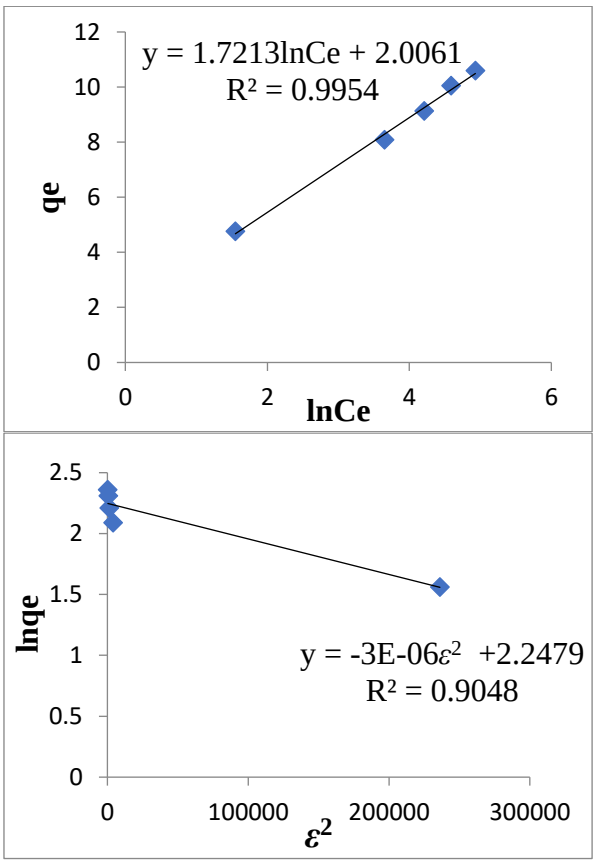
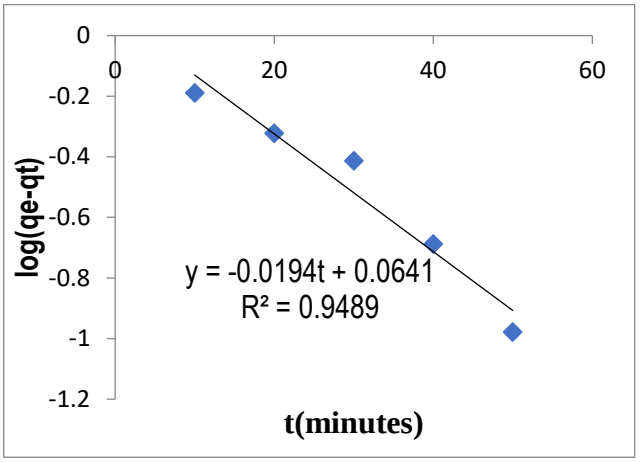


Figure 14: Adsorption isotherm plots of MG (i) Temkin (ii) D-R model

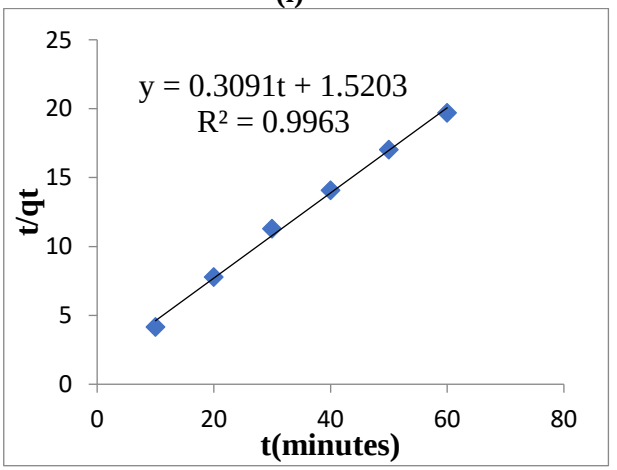
This suggests that single binding site, possibly formed by same functional groups are involved in the formation of the adsorption sites. The maximum dye uptake capacity (q_{max}) is 11.25mg/g as observed from the plots. A separation factor (R_L) of 0.709, (< 1) indicates favorable adsorption.

3.5 Adsorption Kinetics

The four kinetic models used are Pseudo 1st order, pseudo 2nd order, intra – particle diffusion, Elovich model. In the present study, kinetic evaluation is carried out with the data obtained at the following conditions: C_0= 50 mg/L, w = 20 g/L, T = 303 K, pH = 6 and t = 60 min. Necessary plots for analysis are as shown in figure 15 (i) – 15 (iv).

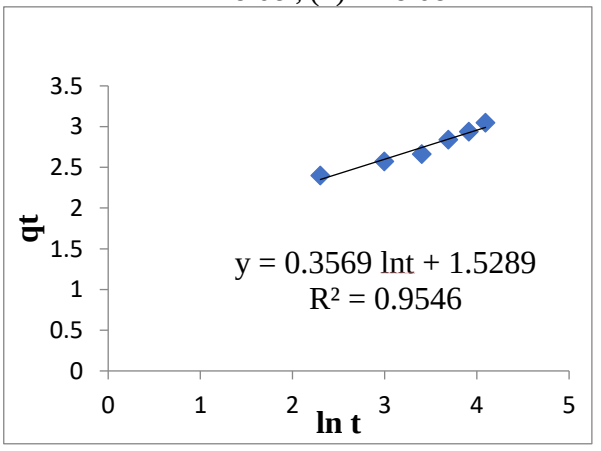


(i)

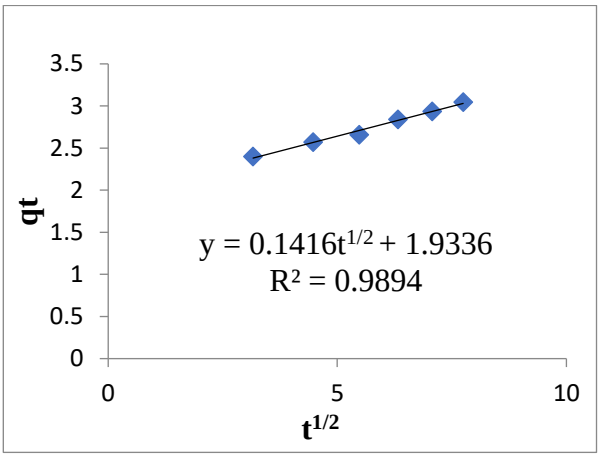


(ii)

Figure 15: MG adsorption kinetic graphs (i) Pseudo 1st order, (ii) 2nd order



(iii)



(iv)

Figure 15: MG adsorption kinetic graphs (iii) Elovich model, (iv) Intra-particle diffusion model

Pseudo second order model describes the adsorbate-adsorbent interactions better because regression coefficient is higher when compared to other kinetic model, suggesting that the bond formation is facilitated sharing of electrons.

3.6 Thermodynamics of adsorption process

It is of interest to estimate the energy implications of an operation. Three thermodynamic parameters - enthalpy change (ΔH), entropy change (ΔS) and Gibbs free energy change (ΔG) reveal the nature of the energy changes associated with a particular operation. These thermodynamic properties are obtained using the experimental data over the temperatures of 293-333 K., other conditions being time = 60 min, C_o= 50 mg/L, pH = 6.0, w = 20 g/L . The Van't Hoffs plot for the adsorption data is shown in Figure 16.

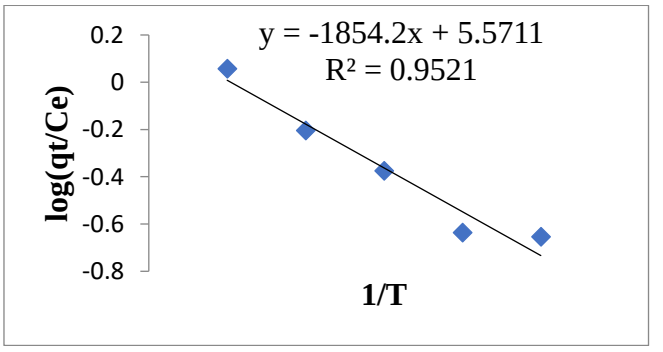


Figure 16: Van't Hoff's plot of adsorption of malachite green on Lemon L

$$lnK_d = \frac{-\Delta H^0}{RT} + \frac{\Delta S^0}{R}$$

Conditions

Co=50mg/L	t=60min
w=20g/L	pH=6

S.NO	TEMPERATURE (K)	ΔG (KJ/mol)	ΔH (KJ/mol)	ΔS (J/mol. K)
1	293	14.04	15.41	46.32

Enthalpy's positive value signifies that the process is endothermic. The adsorption benefits from a greater temperature. Even the experimental findings, which show that elimination rises as temperature rises, confirm this. Gibbs free energy change is negative, which suggests that the adsorption is spontaneous. Malachite green was absorbed onto Lemon L, and a positive entropy change (46.32 J/mol-K) revealed spontaneous dye binding and an rise in randomness at the solid/solution interface.

In future cost analysis studies can be done and different waste material like rice husk, sugarcane bagass etc. This lemon leaves powder adsorbent may be used by applying acid – base treatment to remove these dyes. Lemon leaves are also used to remove binary mixture which consists of malachite green. Lemon leaves are cost effective and easily available sorbent so we can use this in activated carbon form or ash powder to remove malachite green dye.

4. Conclusion

In the current work, to remove malachite green dyes the efficacy of citrus lemon leaves is thoroughly explored, and the results are promising. The operating parameters that are optimized include dye solution concentration, initial solution pH, sorbent dose, and temperature. The results of the trials showed that employing powdered lemon leaves, malachite green could be removed to a maximum of 82.21%. Malachite green dye concentration of 50 mg/L, temperature of solution 303 K, and dosage of adsorbent 20 g/L are the ideal parameters. Lemon leaf powders have a maximum sorption capacity (q_{max}) of 8.08 mg/g.

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Comparative Study Of Bioplastics Using Corn Starch, Rice Starch & Coconut Fibre

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Abstract

With the world's growing need for plastics and the resulting environmental damage, a suitable environmentally acceptable alternative, such as bioplastics/biodegradable plastics, is becoming highly significant. Corn and rice starch all contain lots of starch and can be used as bio polymers. Usage of bio polymers not only reduces pollution but also provides a new scope to the future generations. The project objective is to synthesise various bio polymers by altering their composition and conducting a comparative study using characterisation techniques suchas FTIR , and assessing physical and chemical parameters such as biodegradation, water absorption, and solubility & chemical reactivity, thickness, density & tensile strength.

Abbreviations: BP – Bioplastic; PVC - Polyvinyl chloride; BOD– Biochemical Oxygen Demand;

1. Introduction

Plastics are made by polymerization of complex organic materials and these can be made intothin films by the application of heat and pressure [1]. The usage of plastic is increasing day today in many fields like in packaging, school, office, pharmaceuticals, lamination due to the advantage of they being flexible, transparent, low weight, cost effective, insulation properties and resistant to microbial degradation. Today most of the plastic which is available has cross

– linkages which include wide variety of plastics like PVC, polyesters, propylene, polyethylene, polystyrene [2]. All the above specified plastics have great tensile strength but are causing the landfill deposition problems, toxicity, deposition in water bodies thereby increasing the BOD and adversely affects the biodiversity [3].

The raw resources such as vegetable fats and oils, straw, sawdust, wood chips, agricultural andfood waste, etc. are typically included in biomass. To generate bioplastics, biomass—which iscreated by photosynthesis from atmospheric carbon dioxide—is harvested to extract ingredients like cellulose, starch, hemicellulose, lignin, or plant oil. [4].

Plastics which are produced or prepared from renewable resources like potatoes, bana, sugar, corn algae and which are partially biodegradable or compostable are known as bioplastics.

Bioplastics are basically classified into 2 different categories. They are biodegradable and bio

– based plastics.

- Bio based plastics: Bio means the materials which are partly derived from biomass i.e.,plants. Biomass used for bioplastics from plants are sugarcane, cellulose, rice, corn starch etc…
- Biodegradable plastics: These are the plastics which decompose into organic matter andgases like CO_2 in a particular time and decompose. However the decomposition doesn't depend on the resource but instead it depends on the chemical structure linkages [5,6].

The bioplastics are basically prepared by using cellulose and starch. Cellulose and starch are not plastics but we can turn them into sheets and plastics by using various different techniqueslike casting, mixing, injection, extrusion, moulding etc. [7,8] Starch and its additives are produced from various different potato & its peel, corn, rice etc… Due to its neutral & non – reactive property these are not just food industry but are also used

in various applications likein pharmaceuticals [9].

Pure starch is white in colour. There is no distinct flavor or smell to the starch powder. Moreover, alcohol or cold water cannot dissolve pure starch. It is semi-permeable to carbon dioxide, biologically absorbable, and non-toxic. Starch contains two different types of molecules: branching amylopectin and linear and helical amylose [10]. Pliability, user- friendliness, and most crucially, degradation tractability are the qualities of the materials that are made utilizing banana peels. These days, having a viable bioplastic material as a substitutefor traditional plastics is essential [11].

The goal of this research is to use starch that has been separated from rice and corn starch to create bioplastics [12]. This would be extremely helpful for developing nations where the economy is significantly impacted by environmental issues. It was discovered that the bioplastics made from leftover coconut oil, corn, and rice starch had qualities similar to those of commercial packaging materials already on the market [13].

2. Methodology

2.1 Extraction Of Starch From Rice And Corn Starch SolutionChemicals required: Corn powder, distilled water, rice Apparatus: Beaker (200ml), motar and pestle

Procedure: Corn starch solution can be obtained by dissolving 20grams of corn powder inrequired amount of distilled water. We add distilled water till it reaches 100ml.

We obtain rice starch solution by boiling rice in water for 30min, filtering the starchy waterand then we boil it to reduce its volume to 50% [14].



Figure 1: Procedure for Extraction of Starch from Rice & Corn Powder

2.2 Extraction Of Fibre From Coconut Oil Cake

Chemicals/materials required: Coconut oil cake, distilled water, Whitman filter paper, motar and pestle

Procedure: 300gm of coconut oil waste should be kept in 800ml of distilled water. The waste kept should be boiled for 30min. The water is then decanted off and the sludge is left out on filter paper for drying for 30min at room temperature. After drying for 30min, peels were pureed using motar and pestle to form a fine paste. [15]



Figure 2: Procedure for Extraction of fibre from Coconut Oil Waste

2.3 Preparation Of Bioplastic Film

Chemicals required/Materials required: coconut oil cake, rice and corn starch obtained from above, aq. acetic acid.

Apparatus: Beaker, magnetic stirrer, petri dish, aluminium foil, hot plate

Procedure: The composition of coconut oil waste, rice and corn starch composition are variedaccordingly as shown in table 2. The necessary amount of composite starch solution can be obtained by adding 5 ml of aqueous acetic acid to a beaker and stirring it for 10 minutes at 180rpm. After that, the mixture is cooked for 15 minutes at 220^0C while being constantly stirred. The cooked mixture should then be transferred to a petri dish coated with aluminium foil, let to dry at room temperature for 24 hours, and then heated once again for two hours at 85^0C in the oven. Before taking the bioplastic out of the foil, it should be given enough time to cool. [14].

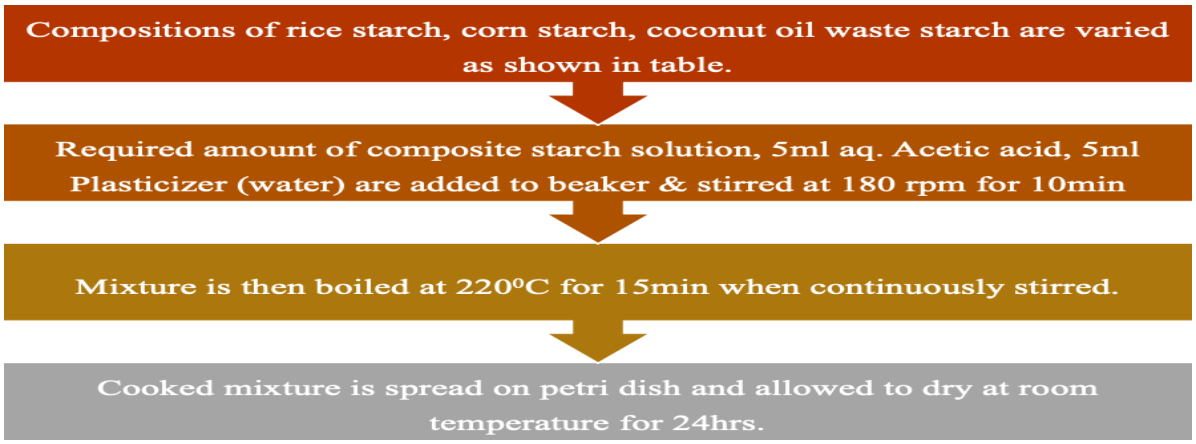


Figure 3: Preparation Of Bioplastic FilmTable 2: Varying Concentrations

	Coconut oil waste (ml)	Corn Starch(ml)	Rice Starch(ml)
BP 1	0	40	0
BP 2	0	0	40
BP 3	40	0	0
BP 4	16	12	12

3 Results

3.1 Biodegradability Test

Initial weight (W_O) of bioplastic was taken and then buried in soil for 5 days withoutdisturbing. After 5 days again the weight of bioplastic (W) was taken.

$$Biodegradability\% = \frac{W - Wo}{Wo} * 100$$

From the Table 3 it is clear that biodegradability of bioplastics prepared using corn starch & coconut oil cake had good degradability percentage compared to the one's prepared using rice starch. We can also observe that percentage of BP 1 & BP 4 are almost the same with a little difference. Films got completely degraded after 30 days.

Table 3: Percentage Of Bioplastic Sheet Degradation In Soil

Sample	Biodegradability%
BP 1	83.3%
BP 2	56.89%
BP 3	70%
BP 4	89.23%

3.2 Water Absorption Test

Initial weigh the sample (W_O) and immerse it in 50ml distilled water. After 24hrs filter the water and weigh the sample (W).

$$Absorption\% = \frac{W - Wo}{Wo} * 100$$

The presence of hydrophilic compounds in the films may be determined by looking at their solubility. Moreover, the bioplastic films made from rice and corn starch were better at absorbing water. This is because water molecules are drawn to the hydroxyl group in starch, and starch granules are broken apart during the gelatinization process, allowing water to permeate.

Table 4: Water Absorption % Capacity Of Bioplastic Sheets

Sample	Water Absorption%
BP 1	668.63%
BP 2	449.514%
BP 3	323.44%
BP 4	100.652%

3.3 Film Thickness

The bioplastic film thickness was measured using a screw micro meter with an accuracy of 0.001mm. 5 x 2.5 cm bioplastic sheet was taken and then thickness was measured in 5 places which includes 4 corners and middle of the film. Finally average thickness was taken.

Table 5: Thickness Of Bioplastic Sheets

Sample	Average Thickness
BP 1	0.527
BP 2	1.032
BP 3	1.058
BP 4	0.984

3.4 Density

Prepared samples were weighed on electronic weighing balance machine and respectivedensities were determined. Each sheet was cut into 5 x 2.5cm.

$$Density = \frac{Mass}{Volume} = \frac{Mass}{Area * Thickness}$$

Table 6: Density Of Bioplastic Sheets

Sample	Mass (g)	Average Thickness (cm)	Volume (cm^3)	Density (g/cm^3)
BP 1	0.0733	0.0527	0.6587	0.1112
BP 2	0.1508	0.1032	1.2900	0.1168
BP 3	0.1532	0.1058	1.3225	0.1158
BP 4	0.1366	0.0984	1.2300	0.1110

We can also observe that rice starch bioplastic has high density compared to any other sheets.The higher density indicates compact arrangement of polymer chains.

3.5 Tensile Strength

Tensile strength was measured using a RT-201A Plastic Thin Film Tensile Test (ASTM D882).Each sheet was cut into 5 x 2.5cm. The results from the table tells us that tensile strength decreases due to which there would be a increase in flexibility of bioplastics sheets. Increase in flexibility tell us the reducing intermolecular forces. Apart from intermolecular forces, reduction in tensile strength can be due to composition, heating & stirring.

Table 7: Tensile Strength Of Bioplastic Sheets

Sample	Tensile Strength (MPa)
BP 1	10.698
BP 2	11.216
BP 3	19.865
BP 4	13.130

3.6 Solubility Test & Chemical Resistance

Immerse bioplastic in different solvents for 48hrs. High acidity has an impact on every film that was created which can be seen in tables 8–11 . They may have absorbed the solvent and become softer in the alkali as a result of the acid in the film reacting and neutralising. Any bioplastic film didn't show its affect when placed in ketone. Only coconut oil cake has shownit's effect when placed in ethyl alcohol & acetic acid. It's observed that plastic film got softened

Table 8: Solubility Test Of BP 1

Solvents Used	Completely Soluble	Partially Soluble	Incompletely Soluble
Ammonia		+	
Sulphuric Acid	+		
Acetone			+
Acetic Acid			+
Ethyl Alcohol			+

Table 9: Solubility Test Of BP 2

Solvents Used	Completely Soluble	Partially Soluble	Incompletely Soluble
Ammonia		+	
Sulphuric Acid	+		
Acetone			+
Acetic Acid			+
Ethyl Alcohol			+

Table 10: Solubility Test Of BP 3

Solvents Used	Completely Soluble	Partially Soluble	Incompletely Soluble
Ammonia		+	
Sulphuric Acid	+		
Acetone			+
Acetic Acid			+
Ethyl Alcohol			+

Table 11: Solubility Test Of BP 4

Solvents Used	Completely Soluble	Partially Soluble	Incompletely Soluble
Ammonia			+
Sulphuric Acid	+		
Acetone			+
Acetic Acid		+	
Ethyl Alcohol		+	

3.7 FTIR Spectra

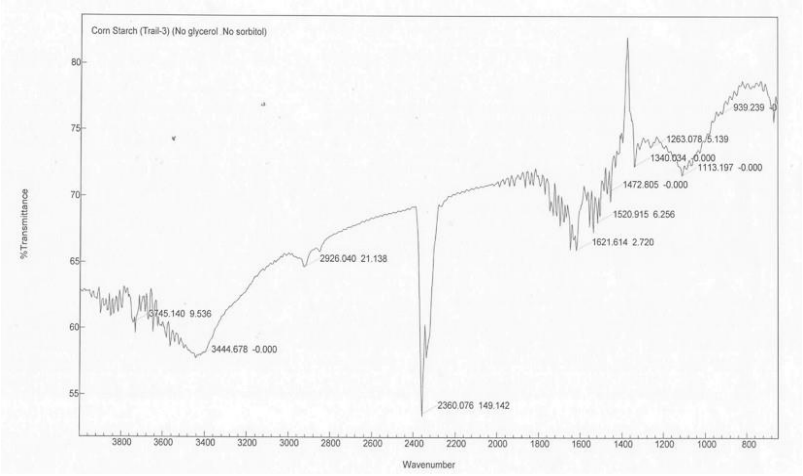


Figure 4: FTIR Spectra Of BP 1

FTIR spectroscopy was used to ascertain the possible chemical interactions in the films. From figure 20 we can observe that the sharp peak at 3745.140 cm^{-1} indicates the single bond region. The broad peak at 3444.678 cm^{-1} indicated the presence of carboxylic acid O–H stretch, confirming the interaction of different –OH groups in the starch and polylactic acid blends. C
– H stretching in alkene groups is confirmed by the broad peak 2926 cm^{-1} and sharp peak at 2360.076 cm^{-1}. The peak at 1621.614 cm^{-1} shows us the C = C stretching in conjugated alkenes.

The narrow peak at 1263cm^{-1} indicates the presence of amines and amides. The peak at 939.239cm^{-1} tells us about the presence of vinyl terminals (-CH = CH2).

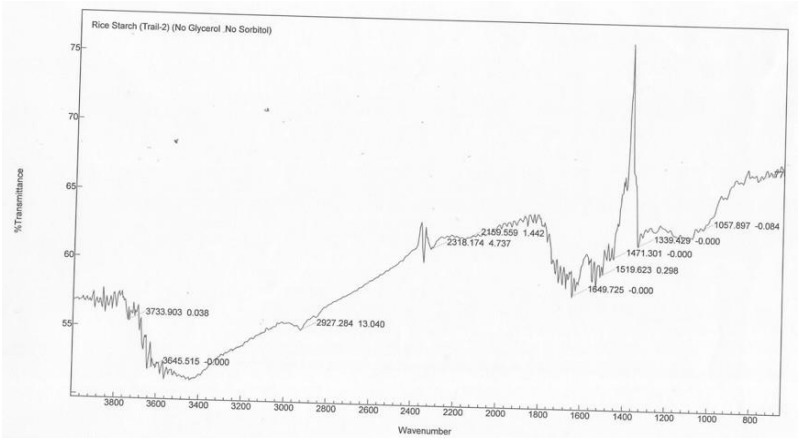


Figure 5: FTIR Spectra Of BP 2

From figure 21 we can observe that the sharp peak at 3733.903 cm^{-1} indicates the single bond region. The broad peak at 3645.515 cm^{-1} indicated the presence of carboxylic acid O–H stretch,confirming the interaction of different –OH groups in the starch and polylactic acid blends. C
– H stretching in alkene groups is confirmed by the broad peak 2927.264 cm^{-1} and sharp peak at 2318.174.076 cm^{-1}. The peak at 1649.725 cm^{-1} shows us the C = C stretching in conjugated alkenes. The peak at 1057.897 cm^{-1} tells us about the C – O stretching in ethers & esters.

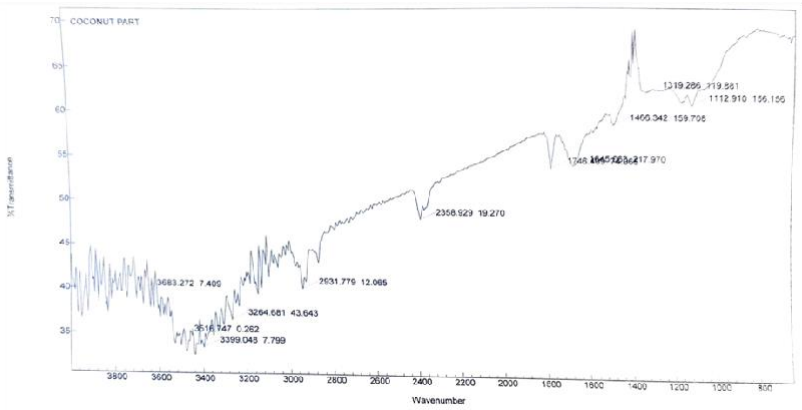


Figure 6: FTIR Spectra Of BP 3

From figure 22 we can observe that the sharp peak at 3683.273cm^{-1}, 3516.747cm^{-1},3399.799cm^{-1} indicates the single bond region. The broad peak at 2931.779 cm^{-1} and narrow peak at 1319.285cm^{-1} indicated the presence of absorption band for long chain liner aliphatic compounds. C – H stretching in alkene groups is confirmed by sharp peak at 2358.929 cm^{-1}. The peak at 1645.063 cm^{-1} shows us the C = C stretching in conjugated alkenes. The peak at 1112.910 cm^{-1} tells us about the presence of hydroxyl group.

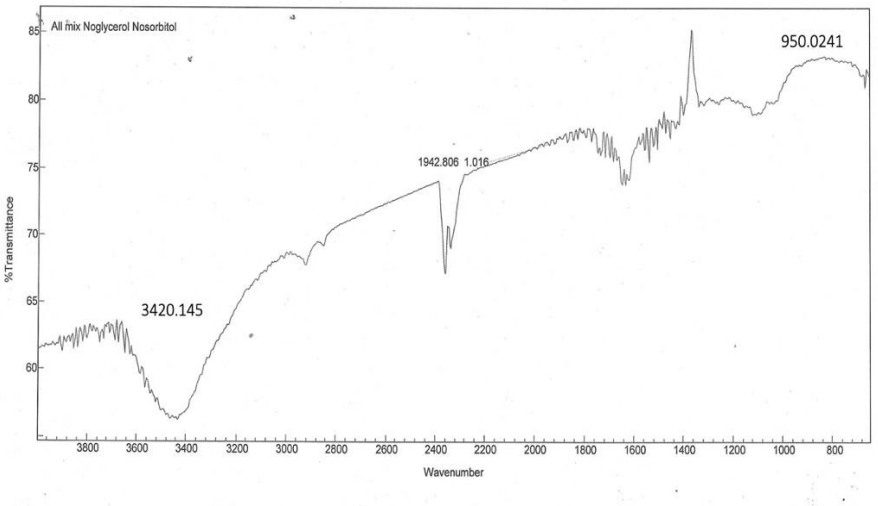


Figure 7: FTIR Spectra Of BP 4

From figure 7 we can observe that the broad peak at 3420.145 cm^{-1} indicated the presence of carboxylic acid O–H stretch, confirming the interaction of different –OH groups in the starch and polylactic acid blends. The peak at 1942.806 cm^{-1} shows us the C = C stretching in conjugated alkenes. The broad peak at 950.0241 cm^{-1} tells us about the presence of vinyl terminals (-CH = CH2).

3.8 pH

Bioplastics were kept in 50ml distilled water & continuously stirred in magnetic stirrer for about 24hrs and then pH was measured using pH meter. It was observed that all the bioplasticsheets pH ranged between 6 – 8.

4 Conclusion

Bioplastic sheets are obtained by varying the concentrations of plasticizers and also by usage of various different starch & fibre based products Soil degradability of rice – corn – coconut oil waste is highest ie., 89.23%. pH calculated after addition of bioplastic in 50ml of water is ranging b/w 6 – 8 this tells us that bioplastic doesn't harm any aquatic life or cannot cause any water pollution. FTIR spectra tells us the presence of organic & inorganic compounds. Tensilestrength of coconut oil waste cake is highest which is about 19.865MPa. As an excellent alternative to plastics derived from petroleum and an effective means of reducing the issue of plastic pollution, all of the bioplastics that were generated were environmentally benign and biodegradable.

5 Future Scope

Biodegradable biopolymers can be synthesised from a wide range of renewable organic raw materials found in flora, fauna, algae, and microorganisms. These materials are abundant, low-cost, and do not interfere with the production of food and feed. Therefore, more research is needed to determine the best raw materials for the synthesis of biodegradable biopolymers. Bioplastics' low moisture resistance hinders their growth and wider use; therefore, further study is needed to find agents that can give bioplastics hydrophobic qualities, which will increase their moisture resistance. It is necessary to do research on various waste materials to ascertain their effectiveness as reinforcing filler in bioplastics. Bioplastics may potentially be commercially viable if they are made from cheap basic substances.

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Recovery of Propionic Acid from Aqueous Phase using Alamine 336 in 1 - Octanol by Reactive Extraction

B. Sarath Babu, Priyanka Seerla Venkata

Abstract: ***The by-products of carboxylic acids are useful in chemical industry, pharmaceutical industry, preservations, drug delivery towards a more economical energy efficient technology. Physical and chemical equilibria results are presented as equilibrium distribution, distribution co -efficient, extraction efficiency, loading ratio and volume percentage by varying concentrations. The distribution of propionic acid between aqueous phase and organic phase reaches equilibrium over a concentration range of 0.009 kmol/m^3 – 0.055 kmol/m^3. The optimum TOA concentration is found to be 40% at which K_D value for 1 - octanol is 16.7. The modified separation increases with decrease in TOA & acid concentration and alamine loading with acid Z decreases with increase in alamine concentration in 1 – octanol. Optimum extraction efficiency is 43.82% for a conc. of 40% TOA at 0.2 kmol/m^3***

Keywords: Carboxylic Acids, Propionic Acid, 1 – Octanol, Alamine – 336, Reactive Extraction, Loading Ratio, Equilibrium Distribution, Efficiency, Modified Separation.

Abbreviations: TOA, (T) – Tri - n - Octyl Amine; [PA] – Propionic Acid; K_D – Distribution Co – efficient; Z – Loading Ratio; S – Separation Factor;

Units: [PA] – Kmol/m^3

I. INTRODUCTION

Carboxylic acids which include propionic acid, succinic acid, lactic acid can be recovered or extracted by traditional methods which involves processes like acidification, crystallization and acidification by ion-exchange resins. However, the rapid industrialization of recent decades has resulted in a reduction or depletion of natural resources, and the growing concern for the environment has prompted a search for clean and environmentally friendly technologies [1]. The recovery of carboxylic acids, which provide a complex functional group of a solute from aqueous solution, using the reactive extraction method has become popular in recent years [2].

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Propionic acid is obtained mainly by three chemical routes [3][17]: Oxidation of propanol:

$$\text{Propanol} + O_2 \longrightarrow \text{Propionic acid}$$

$$CH_3CH_2CH_2OH + O_2 \longrightarrow CH_3CH_2COOH$$

Oxidation of propanol

$$\text{Propanol} + [\,O\,]\ (H_2SO_4/\ KMnO_4) \longrightarrow CH_3CH_2COOH$$

Hydrolysis of esters:

$$X\ \text{Propionate} + H_2O \longrightarrow \text{propionic acid} + \text{alcohol}$$

$$CH_3CH_2COO - X + H_2O \longrightarrow CH_3CH_2COOH + X - OH$$

Propionic acid can also be commercially produced by oxidation of liquid phase propane or propionaldehyde. Propionic acid production by fermentative and chemical processes has not been economically competitive. Therefore it has not been used commercially [4]. Reactive extraction uses extractants from three different groups. There are several of them, such as solvation with carbon- and phosphorus-bonded oxygen-bearing extractants, proton transfer or ion-pairing creation with large molecular weight aliphatic amines and their salts, as well as others [5]. Tertiary amines have good extractabilities for carboxylic acids due to their higher molecular weight, high viscous and corrosive property [6]. Active & inactive diluents are two different categories of diluents. The extraction is improved by a variety of polar, active, proton- or electron-donating solvents [7]. Tertiary aliphatic amines are one of the several extractants for reactive extraction that are frequently utilised in the reactive extraction of carboxylic acids. Chain length aliphatic amines are rather poorly soluble in water without losing any extractant [8][13][14][15][16]. They are also thermostable, making distillation a viable method for regeneration. In general, tertiary amines are preferred to primary or secondary amines. With carboxylic acid, secondary amines may possibly form amides, losing both the product and the extractant [9 – 10].

Selecting the appropriate extractant is crucial for a reactive extraction procedure. he selectivity for the product in comparison to water and a high capacity for the product are its two most crucial properties. The separation factor and distribution coefficient serve as representations of these two needs. In order to overcome the solute's low activity in the aqueous phase, the binding between the extractant and the solute should also be robust, but not so strong as to make regeneration difficult or impossible [11]. This paper includes reactive extraction of propionic acid using alamine – 336 in 1 – octanol.

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II. EXPERIMENTAL PROCEDURE

A. Materials

Alamine 336 (TOA) (98%), Propionic acid (99%), diluent 1-octanol (ACS Reagent (99%)). The solutions of various propionic acid concentrations were made using distilled water. Titration is done using NaOH and phenolphthalein indicator.

B. Apparatus

100 ml standard flask ,25 ml standard flask ,125 ml separating funnel, pH meter, rotating shakers, beakers, pipette, measuring jar.

C. Procedure

Initially 25 ml aqueous solution of required acid concentration was prepared in a conical flask. To this 25 ml of 1-octanol (organic phase) without tertiary amine was added for physical equilibrium. For chemical equilibrium the required quantity of tertiary amine ie., 10% (0.2066kmol/m^3), 20% (0.4132 kmol/m^3), 30% (0.6198 kmol/m^3), 40% was taken in the 1-octanol. Experiments on physical and chemical equilibria were performed at 30°C, or normal temperature. Propionic acid's starting concentration was adjusted from 0.05 to 0.4 kmol/m3. Tri-octyl-amine concentrations of 10% (0.2066 kmol/m^3), 20% (0.4132 kmol/m^3), 30% (0.6198 kmol/m^3), and 40% in 1-octanol were studied at concentrations of 0.05, 0.1, 0.2, 0.3, and 0.4 kmol/m^3 of propionic acid.

Equal amounts (25 ml) of both aqueous and organic solutions are used in extraction experiments, which are run for 12 hours at a constant room temperature. At least two hours were given for the mixture to settle at the same temperature. pH of the aqueous phase was determined using a pH metre. Propionic acid aqueous solutions range in pH from 2.65 to 3.13. Based on the variations in densities, the organic and aqueous phases were separated after settling. A sample of 2 ml is used to estimate the quantity of acid in the aqueous phase using potentiometric titration with 0.05 N NaOH solutions & phenolphthalein as an indicator. The organic phase's acid concentration was estimated using mass balance. Different pH values from 3 to 7 were used in the chemical equilibrium studies [12].

III. RESULTS & DISCUSSION

A. Physical Equilibria

Equilibrium data are produced utilising 1-octanol as a diluent for the propionic acid physical extraction from the aqueous phase. Figure 1, 2 show the distribution of propionic acid between aqueous phase and the organic phase, at equilibrium, over the concentration range of 0.05 kmol/m^3 - 0.4 kmol/m^3. 1 – Octanol is polar in nature. $[PA]_{aq}$ increases with increase in $[PA]_{org}$.

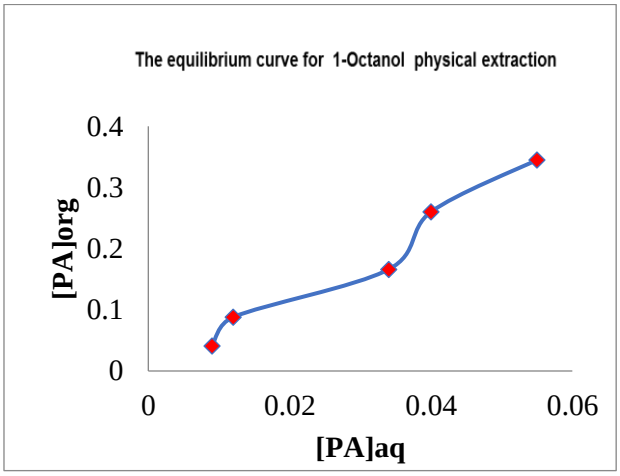


Fig. 1: Physical Equilibrium of (Water – Propionic Acid –1-Octanol)

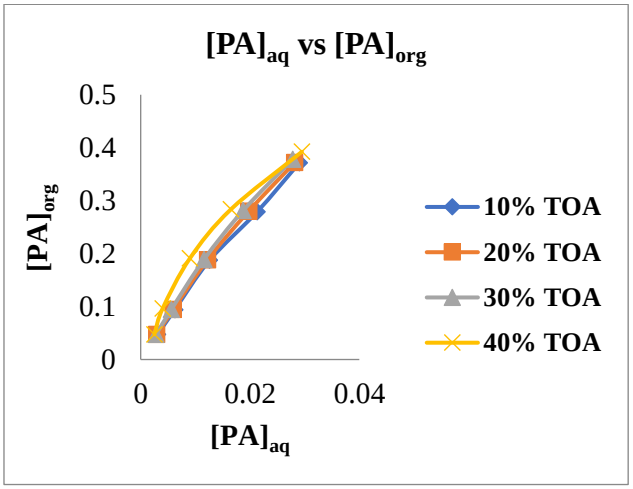


Fig. 2: Equilibrium for Reactive Extraction

Figure 1 shows in organic phase the variation of acid with aqueous phase for different concentrations of propionic acid from 0.05 kmol/$m^3$to 0.4 kmol/m^3in 1-octanol. It is observed that the increase in initial concentration of propionic acid increases the acid concentration in both aqueous phase and organic phase. This indicates that the extraction was clearly impacted by the tri-n-octyl amine in 1-octanol. At any acid concentration, with increasing tri-n-octyl amine concentration, more acid was extracted from aqueous solutions.

The physical extraction figure 1 show that the acid in organic phase for 0.05. 0.1, 0.2, 0.3, and 0.4 kmol/m^3initial concentration of propionic acid are 0.04, 0.088, 0.166, 0.26 and 0.345kmol/m^3 respectively.

The chemical extraction figure 2 show that the acid in organic phase for the same initial concentrations of propionic acid and 10% TOA are 0.0469, 0.0937, 0.1874, 0.2789, and 0.372 kmol/m^3respectively.

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B. Chemical Equilibria

a. Distribution Coefficient

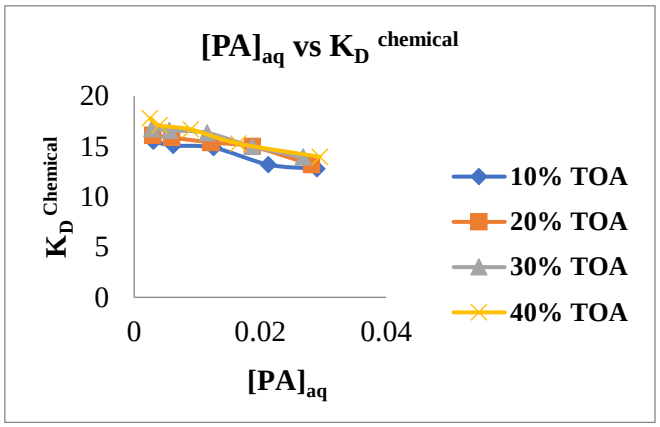


Fig. 3: Effect of Aqueous Concentration $[PA]_{aq}$ on $K_D^{Chemical}$

Alcohols are active diluents by inter molecular hydrogen bonding and also is 1-octanol is insoluble in water due to which the amount of acid extracted at any initial acid concentration from aqueous solution increases with increasing amine concentration and decreasing acid concentration. This can be clearly seen in figure 3.

b. Extraction efficiency

Propionic acid concentration in aqueous medium has an impact on extraction effectiveness, as shown in Figure 4. When the propionic acid concentration is reduced, the level of extraction dramatically increases. The influence of aqueous concentration on extraction efficiency has been studied using various TOA concentrations, and it has been shown that the extraction efficiency improved as tri-n-octyl amine concentrations rose. This is brought on by the fact that when TOA concentration rises, the acid concentration in the aqueous phase decreases.

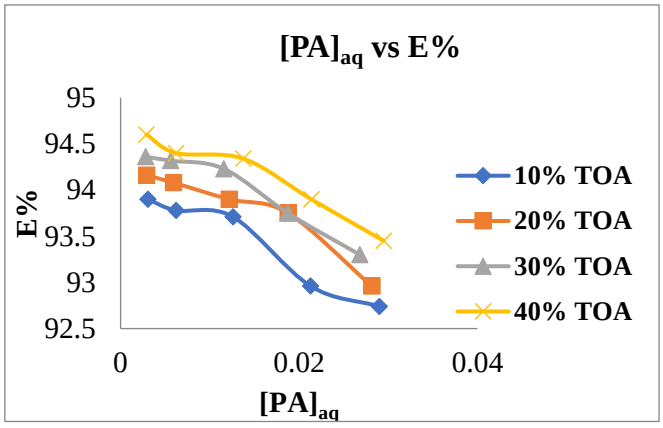


Fig. 4: Effect of Aqueous Concentration on Extraction Efficiency

c. Loading ratio

The stoichiometry of the entire extraction method is determined by the loading ratio, Z, in the organic phase.

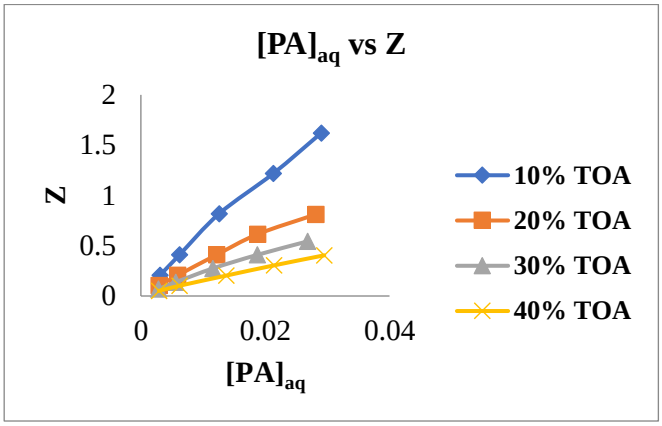


Fig. 5: Effect of Aqueous Concentration on Loading Ratio

It can be seen in Figure 5 that the loading ratio (Z) declined as tri-n-octyl amine concentrations increased. Only when complexes comprising more acid molecules form at lower tri-n-octyl amine concentrations does this occur. It is obvious that complexes containing a single amine develop since loading decreases as tri-n-octyl amine concentration increases.

d. Effect of volume percentage of TOA

The distribution coefficient first increased then decreased, It has increased for chemical extraction ($K_D^{Chemical}$) from 10 – 40% and decreased from 40 - 60% TOA in 1-octanol. The 40 volume % of TOA is considered to be the optimum because high K_D is obtained. Propionic acid is one of the by products from fermentation and effluent industries. The acid amine complex involve with a few acid molecules at higher concentrations of tri-n-octyl amine.

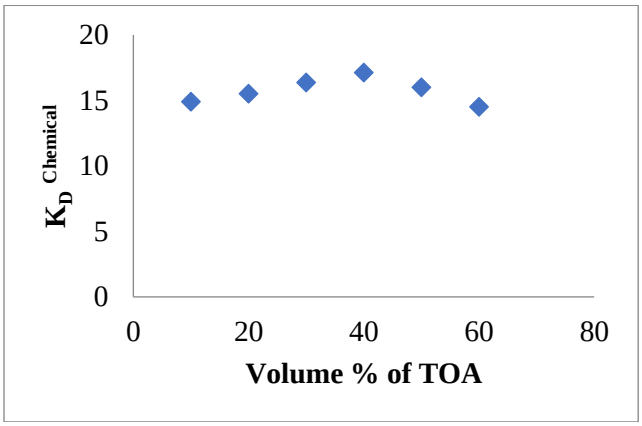


Fig. 6: Effect of Volume % for Extraction of 0.2 kmol/m3 Propionic Acid

e. Effect of pH

pH was calculated using pH meter. Propionic acid extraction employing 40% TOA in 1-octanol is shown in figure 7. Since the pH of the fermentation broth changes as acid is created, it is crucial to research how pH affects the extraction of propionic acid at varied pH values. It is discovered that extraction is relatively low at pH 5 of acid when pH is changed from 3.0 to 7.

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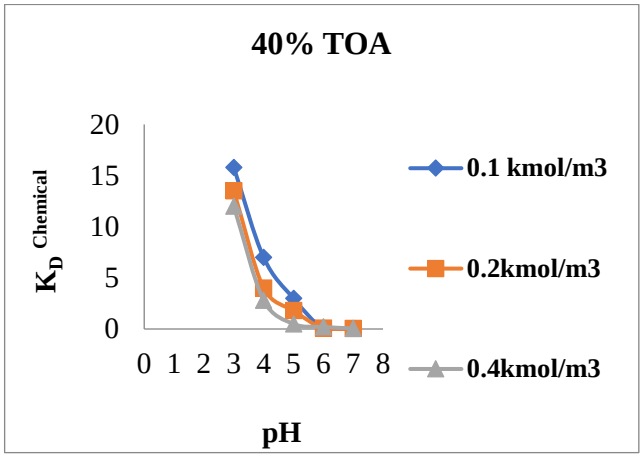


Fig. 7: Effect of pH

The cause is greater pH levels. Acid is mostly present in its dissociated state, while TOA only removes acid in its undissociated form. As a result, K_D Chemical is quite low. For a 30% TOA in 1-octanol, it can be shown that a rise in pH causes a progressive reduction in K_D Chemical with almost no extraction at pH 6. For 40% TOA in 1-octanol, however, K_DChemical decreases sharply when pH is raised above natural pH; beyond that, the reduction is more gradual and slower. The most likely explanation for this is that when pH rises, the proportion of undissociated acid decreases. The excessive amount of TOA present caused the existing bonding sites to become cluttered, which resulted in a very low acid partition from the aqueous phase.

f. Modified Separation Factor

From figure 9 the S_f observed is 0.5172 at initial concentration of acid 0.1 kmol/m^3 and TOA concentration of 30% in 1-octanol. From figure 10 for same concentration of acid and 40% TOA in 1-octanol, the S_f is found 0.5157 which is lower that 30% TOA concentration.

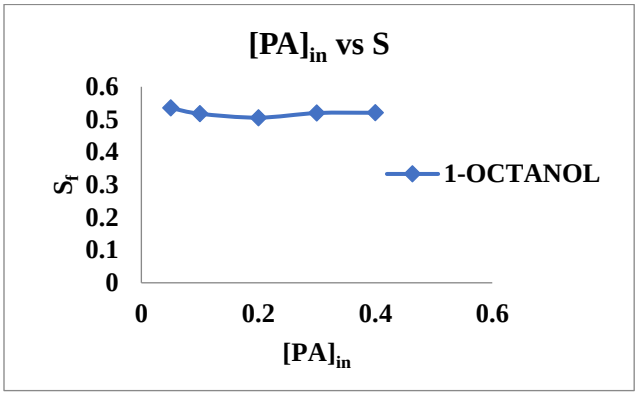


Fig. 8: Effect of acid concentration ([PA]in) on Sf using 30% Alamine

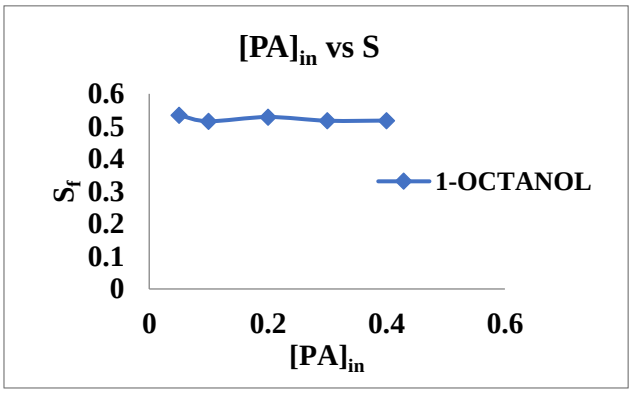


Fig. 9: Effect of acid conc. ([PA]in) on Sf using 40% alamine

Figures 8 & 9 depict how the modified separation factor affects the initial acid concentration. With increasing acid content, a reduction in the relative proportion between physical interaction and chemical reaction, indicated by S, was seen. While loading was observed to decrease with higher TOA concentrations in 1-octanol.

Table 1: Physical Equilibrium of (Water – Propionic Acid –1-Octanol)

$[PA]_{aq}$	$[PA]_{org}$
0.009	0.041
0.012	0.088
0.034	0.166
0.04	0.26
0.055	0.345

Table 2: Equilibrium for Reactive Extraction of Propionic Acid

10% (T)		20% (T)		30% (T)		40% (T)	
$[PA]_{aq}$	$[PA]_{org}$	$[PA]_{aq}$	$[PA]_{org}$	$[PA]_{aq}$	$[PA]_{org}$	$[PA]_{aq}$	$[PA]_{org}$
0.00305	0.04695	0.00292	0.04708	0.0028	0.0472	0.0025	0.0475
0.00621	0.09378	0.00592	0.09408	0.0056	0.0944	0.004	0.096
0.01259	0.1874	0.01219	0.1878	0.01158	0.18884	0.009	0.191
0.0213	0.2789	0.01876	0.28124	0.01874	0.28126	0.0165	0.2835
0.029	0.3710	0.02816	0.37184	0.0268	0.3732	0.02949	0.3705

Table 3: Effect of Aqueous Concentration on KD With Varying TOA Concentration In 1-Octanol

10% (T)		20% (T)		30% (T)		40% (T)	
$[PA]_{aq}$	$K_D$chemical	$[PA]_{aq}$	$K_D$chemical	$[PA]_{aq}$	$K_D$chemical	$[PA]_{aq}$	$K_D$chemical
0.00305	15.5	0.00292	16.12	0.0028	16.75	0.0025	17.8
0.00621	15.09	0.00592	15.89	0.0056	16.6	0.004	17.1
0.01259	14.89	0.01219	15.4	0.01158	16.35	0.009	16.7
0.0213	13.2	0.01876	14.99	0.01874	15.01	0.0165	15.3
0.029	12.78	0.02816	13.2	0.0268	13.94	0.02949	13.97

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Table 4: Effect of Aqueous Concentration on Extraction Efficiency

10% (T)		20% (T)		30% (T)		40% (T)	
$[PA]_{aq}$	E%	$[PA]_{aq}$	E%	$[PA]_{aq}$	E%	$[PA]_{aq}$	E%
0.00305	93.90	0.00292	94.16	0.0028	94.36	0.0025	94.6
0.00621	93.78	0.00592	94.08	0.0056	94.318	0.004	94.4
0.01259	93.71	0.01219	93.9	0.01158	94.23	0.009	94.34
0.0213	92.96	0.01876	93.75	0.01874	93.75	0.0165	93.9
0.029	92.74	0.02816	92.96	0.0268	93.3	0.02949	93.45

Table 5: Effect of Aqueous Concentration on Loading Ratio

10% (T)		20% (T)		30% (T)		40% (T)	
$[PA]_{aq}$ Kmol/m^3	Z	$[PA]_{aq}$ Kmol/m^3	Z	$[PA]_{aq}$ Kmol/m^3	Z	$[PA]_{aq}$ Kmol/m^3	Z
0.00305	0.2050	0.00292	0.1028	0.0028	0.0687	0.0025	0.051
0.00621	0.4095	0.00592	0.2054	0.0056	0.1374	0.004	0.1023
0.01259	0.8184	0.01219	0.4099	0.01158	0.2743	0.009	0.2033
0.0213	1.2179	0.01876	0.6139	0.01874	0.4094	0.0165	0.3041
0.029	1.6200	0.02816	0.8120	0.0268	0.543	0.02949	0.4045

Table 6: Effect of pH on KDChemical for different acid Conc. of Propionic Acid using 40% TOA

$[PA]_{in}$	pH	$[PA]_{aq}$	$[PA]_{org}$	$K_D^{chemical}$
0.1	3	0.00489	0.0951	19.45
	4	0.00943	0.09057	8.8
	5	0.0227	0.07727	2.9
	6	0.053	0.0474	0.09
	7	0.095	0.00476	0.05

$[PA]_{in}$	pH	$[PA]_{aq}$	$[PA]_{org}$	$K_D^{chemical}$
0.2	3	0.0133	0.1867	14
	4	0.02597	0.17402	6.6
	5	0.04762	0.15238	3.2
	6	0.18349	0.01651	0.09
	7	0.19048	0.009524	0.05

$[PA]_{in}$	pH	$[PA]_{aq}$	$[PA]_{org}$	$K_D^{chemical}$
0.4	3	0.0308	0.3692	12
	4	0.05479	0.3452	6.3
	5	0.08333	0.3167	3.8
	6	0.36697	0.03303	0.0-9
	7	0.3809	0.01905	0.05

IV. CONCLUSION

Propionic acid is obtained by reactive extraction using alamine 336 in 1 – Octanol. Physical and chemical equilibria for propionic acid by Tri – n octyl amine in 1 - Octanol as a diluent have been determined. . The optimum TOA concentration is found to be 40% at which K_D value for 1 - octanol is 16.7. The modified separation increases with decrease in TOA & acid concentration and loading of TOA with acid Z decreases with increase in TOA concentration in 1 – octanol. Optimum extraction efficiency is 43.82% for a conc. of 40% TOA at 0.2 kmol/m^3. In future different carboxylic acids can be extracted using alamine 336 or aliquat in different diluents due to the high applications of carboxylic acids in various different fields.

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	Not relevant
Authors Contributions	All authors have equal participation in this article.

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Reactive Extraction of Gluconic Acid Using Tri-n-Octylamine in 1- Octanol

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Abstract- ***Reactive extraction is a separation method which is used for the recovery of carboxylic acids from fermentation broth. Gluconic acid is a carboxylic acid which is used in chemical, pharmaceutical and food industries. Tertiary amines are effective extractants for separation of carboxylic acid from dilute solutions. An Adequate combination of extractant and diluent will provide a high yield. The reactive extraction of Gluconic acid with Trioctylamine and 1-octanol is carried out for different Concentrations of acid, Trioctylamine (TOA) and 1-octanol at room temperature. From the physical and chemical equilibrium experimental results, the distribution coefficient (K_D), extraction efficiency (E %), loading ratio (Z) are calculated. It was found that physical extraction provided less yield compared to chemical extraction. A maximum K_D was obtained as 3.57 using 40% TOA (0.02 mol/L) while 78.13 % of the gluconic acid was extracted. By increasing the initial concentration of gluconic acid increased the concentration of gluconic acid in both phases. As the concentration of TOA increases from* **10 to 40 % (0.0229mol/L to 0.02 mol/L),** ***the distribution coefficient and extraction efficiency also increases.***

Key words: Reactive Extraction, Gluconic Acid, Tri-n-Octyl amine, 1-octanol

I. INTRODUCTION

Gluconic acid is a carboxylic acid. Gluconic acid (pentahydroxycaproic acid, $C_6H_{12}O_7$) is the oxidation product of glucose, naturally occurring in plants, fruits, wine (up to 0.25%), honey (up to 1%), rice, meat, vinegar and other natural sources. Gluconic acid is the largest commercially produced of fungal organic acids, from glucose. Demand for metal gluconates is steadily increasing due to their multiple applications in different industries.

The separation and purification of Gluconic acid from fermentation broth is inefficient by conventional methods like adsorption, distillation, solvent extraction, reverse osmosis, ion exchange, ultra filtration etc. Reactive extraction is a separation method which is used to enhance the extraction of solute from the Aqueous Phase to the Organic Phase. The extractant molecule reacts with the solute molecule to form a reaction complex, which will stabilize in Organic Phase due to the hydrogen bonding with 1-Octanol and hydrophobic nature of complex. Reactive extraction has various rewards like enhanced reactor productivity, control over pH in the bioreactor, reduces the downstream processing load, and minimizes the solvent recovery cost and higher efficiency. In the current work, an investigation on the recovery of Gluconic acid from aqueous solution was conducted by using TOA in 1-Octanol. The equilibrium parameters are studied such as K_D, E %, Z using experimental data.

II. THEORY

The extraction process was analyzed by using the Distribution Coefficient K_D. The distribution coefficient (K_D) is defined as the ratio of total concentration of acid in all forms in the organic phase to total concentration of all existing forms in the aqueous phase. Consider that no change in volume at equilibrium.

$$K_D = \frac{[\overline{GA}]_{total}}{[GA]_{total}}$$

Where, $[\overline{GA}]_{total}$= Concentration of acid in organic phase. $[GA]_{total}$= Concentration of acid in aqueous phase.

The extraction efficiency (E %) is defined as the proportion of Gluconic acid concentration in the

Organic Phase to the sum of Gluconic acid concentration in organic phase and Aqueous Phase.

$$E\% = \frac{K_D}{1+K_D} \times 100$$

The value of Z depends on the extractability of the acid i.e. strength of the acid base interaction and its aqueous concentration. The stoichiometry of the overall extraction equilibrium depends on the loading ratio in organic phase (Z). If the organic phase is not highly concentrated by acid, i.e., at very low loading ratios (Z < 0.5), 1:1 complex of acid and extractant is formed.

The extent to which organic phase (TOA+Octanol) can be loaded with carboxylic acid is expressed as the loading ratio, Z;

$$Z = \frac{[GA]_{org}}{[T]_{org}}$$

Where, $[GA]_{org}$= Concentration of acid in organic phase after extraction.

$[T]_{org}$= Concentration of TOA in organic phase before extraction.

III. MATERIALS AND METHODS

Materials

Gluconic Acid (pentahydroxycaproic acid ,$C_6H_{12}O_7$) (49-53 wt % of H_2O), molar mass 196.16 kg/kmol, density 1.134 g/ml at 25^0C, 97 % purity was procured from Sigma-Aldrich (India). TOA (N,N-dioctyloctan-1-amine) ($C_{24}H_{51}N$) a tertiary amine is a colour less liquid with the molar mass 353.66 g/mol , density 0.81 g/cm3 at 20^0C, 98 % purity, was procured from Sigma-Aldrich (India). 1-octanol, molar mass 130.23 g/mol, density 0.827 g/ml at 250C, 98 % purity was used as a diluent was obtained from Sigma-Aldrich (India). Phenolphthalein solution with pH range 8.2 to 10 was used as an indicator was procured from Ranbaxy, India. Distilled water was used to prepare the solutions of various initial concentrations of Gluconic acid solutions. 0.1 N of NaOH and phenolphthalein indicator used for titration. The initial concentration of TOA in 1-octanol was varied from 10% to 50% on volume basis. The aqueous phase consists of Gluconic acid and water and the organic phase consists of TOA and 1-Octanol.

Methods

Equilibrium Studies:

Optimum time was calculated (12 hours) to attain liquid-liquid equilibrium for both physical extraction and chemical extraction by analyzing the samples at regular intervals of time. The initial concentrations of Gluconic acid were 0.03, 0.0634, 0.12653, 0.1897, 0.25306, 0.31632 mol/L respectively.

Physical equilibrium:

For physical equilibrium, 20 ml of Gluconic acid (AP) of different concentrations were taken in different conical flasks and 20 ml of 1-octanol (OP) was added in each conical flask. Mechanical shakers were used to mix both the phases for 12hrs at room temperature. The organic and aquennnous phases were allowed to steady down in a separating funnel for 2 hours. A sample from aqueous phase was titrated with 0.1N NaOH using Phenolphthalein as an indicator to measure the concentration of Gluconic acid in the Aqueous Phase. By using Mass balance calculated the concentration of Gluconic acid in the Organic Phase.

Chemical equilibrium:

For chemical equilibrium, 20 ml of gluconic acid and 20 ml of 10 % TOA (0.2264 mol/L) in 1-octanol was added in a conical flask. The immiscible solution was kept in shakers for 12 hours and then kept under separation for 2hours. The Gluconic acid concentration was determined from the aqueous phase by titrating a sample solution with 0.1N NaOH using Phenolphthalein as an indicator. The same procedure was repeated for 10%, 20%, 30% and 40% TOA.

IV. RESULTS AND DISCUSSION

Data obtained from the experiments are tabulated and compared to know the amount of the Gluconic acid extracted from aqueous solution using the physical and chemical equilibrium methods with different concentration of the TOA. From the equilibrium data, the K_D, E %, Z, are calculated as shown in Table 1 and Table 2.

Physical equilibrium

The most effective diluents are alcohols since they enhance the extraction of carboxylic acids. Among those 1-octanol is the one alcohol which is used as a diluent here for extraction of Gluconic acid. The physical equilibrium data values for Gluconic acid using 1-octanol are shown in Table 1.

$[GA]_{in}$ mol/L	$[GA]_{aq}$ mol/L	$[GA]_{org}$ mol/L	K_D	E%
0.03	0.01	0.018	1.80	64.29
0.06	0.02	0.023	1.15	53.49
0.12	0.04	0.039	0.98	49.37
0.18	0.07	0.049	0.70	41.18
0.2	0.08	0.054	0.68	40.30
0.3	0.13	0.056	0.43	30.11

Table 1: Physical equilibrium of Gluconic acid & 1-octanol

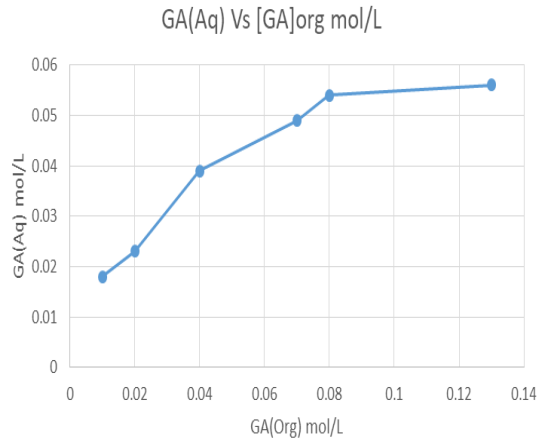


Figure 1 physical extraction equilibrium curves for extraction of Gluconic acid using 1-octanol

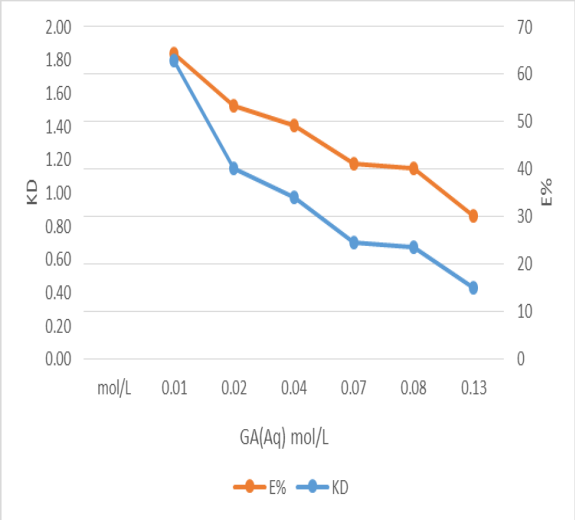


Fig 1: Equilibrium distribution of water -Gluconic acid &1-octanol

Chemical equilibrium

The Chemical Extraction of Gluconic Acid was studied with 1-Octanol in the presence of Tri-octylamine solution. Reaction extraction of Gluconic acid with five different concentrations of TOA in 1-octanol revealed that the amount of Gluconic acid extracted in both Aqueous Phase and Organic Phase is directly proportional to the ICLA The phase equilibrium data of octanol was measured by varying the Gluconic Acid concentration in feed phase in the range of 0.03-0.3 mol L^{-1}.The maximum K_D was obtained is using 40% TOA (mol/L). As the concentration of TOA increased from 10%-40%, K_D and E% Increased.

10% TOA				
[GA]aq	[GA]org	K_D	E%	Z
0.012	0.013	1.08	52.00	0.5677
0.03	0.03	1.00	50.00	1.3100
0.06	0.05	0.83	45.45	2.1834
0.09	0.07	0.78	43.75	3.0568
0.12	0.08	0.67	40.00	3.4934
0.16	0.09	0.56	36.00	3.9301
20% TOA				
[GA]aq	[GA]org	K_D	E%	Z
0.01	0.02	2.00	66.67	0.8811
0.025	0.04	1.60	61.54	1.7621
0.055	0.06	1.09	52.17	2.6432
0.085	0.08	0.94	48.48	3.5242
0.1	0.09	0.90	47.37	3.9648
0.15	0.1	0.67	40.00	4.4053
30% TOA				
[GA]aq	[GA]org	K_D	E%	Z
0.005	0.015	3.00	75.00	0.7009
0.02	0.04	2.00	66.67	1.8692
0.05	0.065	1.30	56.52	3.0374
0.08	0.085	1.06	51.52	3.9720
0.09	0.09	1.00	50.00	4.2056
0.15	0.11	0.73	42.31	5.1402
40% TOA				
[GA]aq	[GA]org	K_D	E%	Z
0.007	0.025	3.57	78.13	1.2500
0.01	0.035	3.50	77.78	1.7500
0.04	0.07	1.75	63.64	3.5000
0.08	0.09	1.13	52.94	4.5000
0.095	0.1	1.05	51.28	5.0000
0.15	0.12	0.80	44.44	6.0000

Table 2: Equilibrium for reactive extraction of Gluconic acid with various concentrations of TOA in 1- octanol

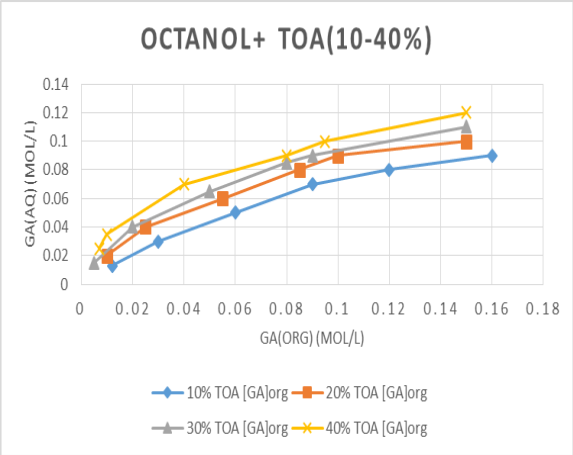


Fig 2: Equilibrium for reactive extraction of Gluconic acid with various concentrations of TOA in 1-octanol

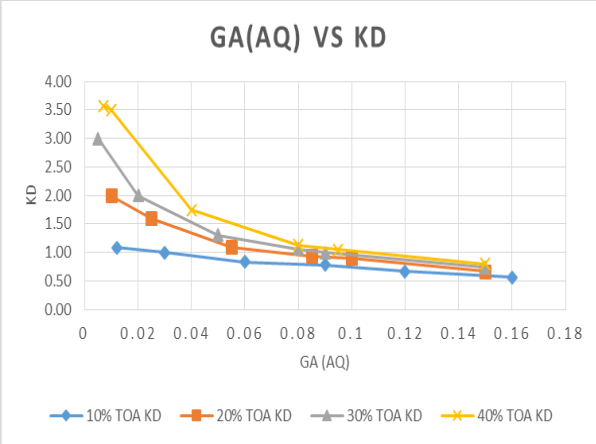


Fig 3: Effect of concentration of acid in aqueous phase on Distribution Coefficient with variable TOA Concentration in 1-octanol

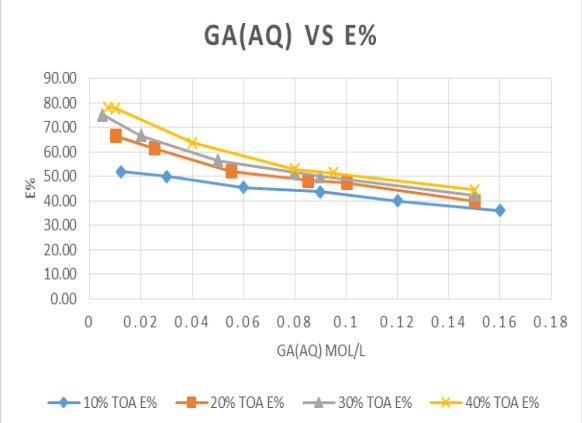


Fig 4: Effect of concentration of acid in aqueous phase on Extraction Efficiency with variable TOA Concentration in 1-octanol

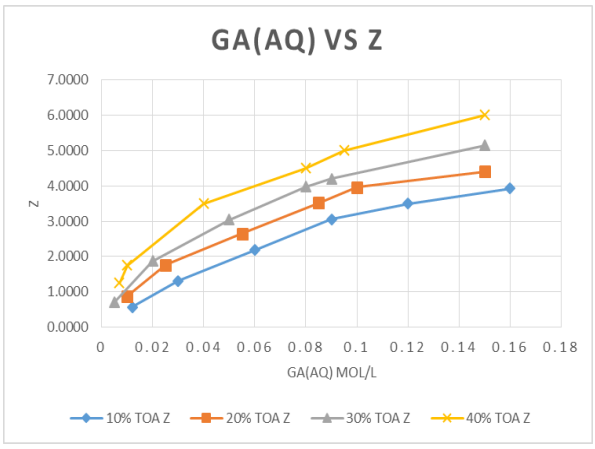


Fig 5: Effect of concentration of acid in aqueous phase on Loading Ratio (Z) with variable TOA concentration in 1-octanol

V. CONCLUSION

The Reactive extraction of Gluconic acid using TOA in 1-octanol experiment was conducted. The key findings are as given below Chemical extraction was found to have high distribution coefficient and extraction efficiency than Physical extraction. The distribution coefficient and extraction efficiency decrease with increase in acid concentration. The loading ratio of TOA with acid Z increases with increasing in Gluconic acid concentration. The optimum TOA concentration is found to be 40% at K_D values for 1-octanol is 3.57

VI. NOMENCLATURE

K_D distribution coefficient
E% extraction efficiency
Z loading ratio
[GA] Concentration of Gluconic acid (mol/L)
[T] Concentration of Tri-n-octylamine (mol/L)
Subscripts
aq aqueous phase
org organic phase

VII. ABBREVIATION

TOA Tri-n-octylamine
AP Aqueous phase
OP Organic phase
ICGA Initial concentration of Gluconic acid

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Data Driven Methodology for Battery RUL Prediction Using Machine Learning Algorithms

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***Abstract*:** With the rapid development of new energy electric vehicles, the demand for batteries is increasing. The battery management system (BMS) plays a crucial role in the battery-powered energy storage system. Lithium-ion batteries are the primary power source in electric vehicles, and the prognosis of their Remaining Useful life is vital for ensuring the safety, stability, and long lifetime of electric vehicles. Remaining useful life (RUL) prognostics based on data-driven methods has become a focus of research. The development of a machine-learning method with high accuracy, high generalization, and strong robustness for evaluating battery health states is essential in the field of battery health management. Current research on data-driven methodologies using Machine Learning Algorithm is summarized in this paper. The parameters such as voltage, current and temperature values are taken as dataset. A Naive Bayes (NB) Algorithm and Gradient Boosting (GB) Algorithm is proposed for RUL prediction of batteries and the Error analysis of the model is carried out to optimize the battery's performance parameter. The statistical indicators like MAE, MSE and RMSE are selected to assess numerically the prediction results. The experimental consequences revealed that the presented Methods give better results than other Machine learning techniques considering various performance criteria.

Index Terms: *Remaining useful life prediction, Machine learning Algorithms, lithium-ion batteries, Naive Bayes, Gradient Boosting and Data-Driven.*

I. INTRODUCTION

When it comes to both storing and producing energy, lithium-ion batteries are crucial. The usage of lithium-ion batteries in the transportation, communication, and aerospace industries is already widespread due to its better energy density, less weight, and longer charge and discharge cycle. The performance of the lithium-ion battery will degrade or perhaps fail as a result of the intricate physical and chemical changes that occur during the use process, which could pose a serious risk to public safety and cause significant financial losses. As a result, the question of how to effectively manage the prognosis and health of lithium-ion batteries has gained popularity and has been the subject of extensive research. The amount of time between the present and the end of a system's or asset's useful life is known as the RUL. Operational research has utilised the RUL concept extensively. The lithium-ion battery's RUL forecast is based on the number of cycles and battery capacity that will pass the failure threshold from the current cycle. By analysing the likelihood of battery failure and limiting safety concerns to achieve high efficiency and robustness, the RUL of a lithium-ion battery may be accurately assessed. The RUL of the battery is calculated using the remaining useable charges and discharge cycles before the threshold value is reached, or the value after which the battery is no longer regarded as safe to operate. Figure 1 Shows the principle of RUL Prediction. Remaining useful life (RUL) is an estimation of the length of time an item, component, or system is estimated to be able to function according to its intended purpose before requiring repair or replacement.

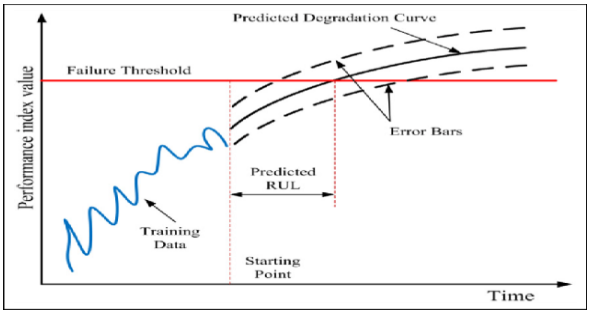


Fig 1: Principal of RUL Prediction

Remaining useful life prediction for lithium-ion battery storage system [1] Proposed the RUL prediction of lithium-ion batteries. Many techniques have been proposed and implemented to model the degradation of these complex systems, from which two approaches have arisen i.e, model-based approaches and data-driven approaches. Various model-based and data-driven-based and hybrid-based methods for RUL prediction of lithium-ion batteries have been comprehensively evaluated. The analysis considers various aspects such as classifications, methods, characteristics, contributions, advantages, disadvantages, and research gaps. Generally, the main steps involved for RUL prediction is summarized in Figure. 2 including a three-stages procedure. In the first stage, various sensors are utilized to capture the characteristics of the battery such as the voltage, current, SOC, and temperature. Then, the battery capacity is estimated in Stage 2 by model-based method, data-driven method, or other approaches.

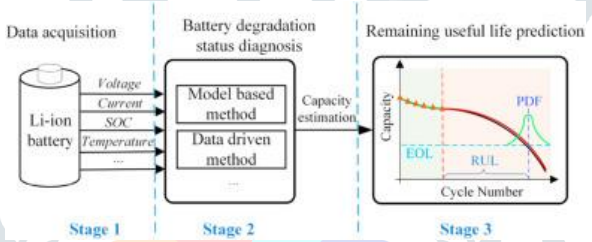


Fig 2: Procedure for RUL prediction

[2] The model assumes that solvent diffuses through the SEI (solid electrolyte interphase) and undergoes a two-electron reduction at the carbon SEI interface. The kinetics of the reduction reaction at the SEI–electrolyte interface and the solvent diffusivity are seen to be the most important parameters governing SEI formation. The capacity loss is seen to be a function of the thickness of the SEI layer and is seen to vary linearly over time. In [3], A Thevenin model with one RC branch is presented in which all the model parameters are constant. When this equivalent circuit models are used to estimate battery aging, model parameters include lots of internal battery parameters and resistance aging parameters. Moreover, model-based methods exhibit poor real-time performance characteristics.

It is to investigate advanced battery management technologies for the estimation, monitoring, and control of battery states, associated modelling techniques, thermal and charging/discharging management for optimized life, performance, and range. To improve the quality of battery and safe operation, battery management system is employed. [4] The main objective of this work is to design and optimize the Battery Management System including a lithium-ion battery model. In [5] new data-driven approaches to lithium-ion battery RUL prediction and SOH monitoring are made possible. This study describes a neural network-based approach that combines extensive.For the purpose of predicting RUL and monitoring SOH in lithium-ion batteries, a short-term memory (LSTM) network with particle swarm optimisation and an attention mechanism is used.

In order to enhance the performance of online SOH prediction, the proposed semi-supervised learning framework has successfully made the best use of a large amount of unlabeled data.[6] Proposeda capacity of unlabeled data is subsequently estimated using an ILLR-based technique based on the four attributes. The ILLR-based method offers the distributions of the estimated capacity in addition to the estimated capacity itself.[7] Presents RUL-RVE, a Python tool for the assessment of Remaining Useful Life (RUL). Physical systems are normally subject to degradations that ultimately lead to failure; therefore, prognostic technologies are crucial to estimate the lifetime of the system to be monitored. Since RUL is frequently random and unknowable, it must be inferred from information that is currently available, such as data from condition and

health monitoring. The RUL has become more well-known recently as a result of the quick development of condition and health monitoring techniques.Nevertheless, because of its complex interactions with observable health data. As a result, current modelling advancements for RUL estimation. [8] review's main focus is on statistical data-driven methodologies that only use readily accessible historical observed data and statistical models. The methods are divided into two main categories of models: those that rely on knowledge about the asset's state that has been directly seen and those that do not.

Data-driven methods have been getting more and more attention towards the prediction of RUL as machine learning and artificial intelligence have developed so quickly. Also, a lot of performance information about lithium-ion batteries may be gleaned through real-world uses. This made the groundwork for using data-driven techniques to forecast the lithium-ion batteries' ageing life [9]. Compared with the other model-based methods, data-driven methods are of nonparametric, and do not consider the electrochemical principles to some extent. Thus, degradation models of lithium-ion batteries are developed with various mapping and regression techniques and tools. The systems use merit measurements to control battery performance. The performance and condition of the battery are estimated using data like the state-of-health (SOH) and state-of-charge (SOC). In [10] suggested a clever way to look at the aforementioned factors utilising a data-driven strategy. To estimate these values, we employ a machine learning technique that separates important features from the discharge curves.

RUL prediction based on Machine learning Algorithm modelling has made rise to numerous studies. Machine learning-based approaches have often provided a better performance than statistical approaches in terms of accuracy although more computational power is required. The proposed paper we have aimed to focus on A Naive Bayes (NB) and Gradient Boosting (GB) Machine Learning Algorithm for RUL prediction of batteries and the Error analysis of the model is carried out to optimize the battery's performance parameter.

The other sections of this paper are prepared as follows: Section II explains about the RUL Prediction Method Analysis. Section III Presents the Exposition of Machine Learning Algorithms. Section IV Presents Proposed work. Section V shows the experiment results of our proposed method. Section VI finally a conclusion is given.

II. RUL PREDICTION METHOD ANALYSIS

A review on prognostics approaches for remaining useful life of lithium-ion battery summarizes the approaches used in Li-ion battery RUL estimation. [11] Generally, the approaches for RUL estimation are divided into model-based and data driven.

DATA DRIVEN METHODS:

While the mechanisms and propagation rules of battery degradation are still unknown, data-driven techniques use past monitoring data directly to anticipate the degradation tendency of a battery. This approach develops a mathematical model or derives weight parameters based solely on training data, as opposed to adopting a particular physics-based model. This approach is more adaptable and useful because it does not need creating a complicated physics-based model, and it has garnered considerable interest from researchers all over the world. Based on whether they are based on data-driven methodologies, three categories of battery RUL prediction have been identified as shown in Figure 3 below

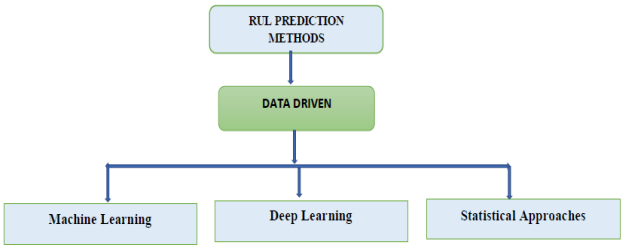


Fig 3: Data Driven RUL Method

Machine Learning Algorithms: Machine learning approaches can estimate battery RUL based on various measurements, such as current, voltage, and temperature, and, therefore, can be used at various operating conditions. The widespread use of data-driven residual life prediction in the field of equipment is encouraged by the continual improvement in the equipment's ability to continuously detect and monitor itself throughout its life cycle. Currently, the lithium-ion battery's data-driven prediction technique. RUL for batteries typically uses a solitary time-series forecasting model.[12] The prediction method's robustness and generalizability are insufficient. It needs more work to increase the prediction's robustness and accuracy. According to the predictions' outcomes, immediate preventive maintenance steps must be implemented to guarantee a reliable supply of electricity at all times. This study proposes an integrated learning method based on monitoring data to suit the lithium battery degradation model forecast their RUL. The relevance vector machine (RVM), the random forest (RF), the elastic net (EN), the autoregressive model (AR), and the long short-term memory (LSTM) Network are the five fundamental learners that make up the ensemble learning approach, which aims to improve prediction performance. In the ensemble learning approach, the final lithium battery prediction result is obtained by finding and determining the optimal weights of the basic learners using the genetic algorithm (GA). Battery cycle life study through relaxation and forecasting the lifetime via machine learning [13] GPR is a kernel-based probabilistic machine learning technique that has recently gained attention in battery lifetime prognosis. The Gaussian process is typically sensitive to inconsistent data. It is difficult to predict the state of charge (SoC) with battery management systems that are durable and reliable for electric vehicles. Predicting SoC estimation with significantly less degradation is exceedingly difficult because battery degradation is typically a non-linear process.[14] uses six machine learning algorithms to estimate the SoC of lithium-ion battery systems for use in electric car applications. The applied techniques are ensemble bagging (EBa), ensemble boosting, support vector machine (SVM), linear regression (LR), Gaussian process regression (GPR), and artificial neural network (ANN). To improve the battery's performance parameter, the model's error analysis is done.

Deep Learning Algorithms: One of the fields of machine learning known as "deep learning" developed from artificial neural networks and is characterised by several nonlinear processing layers (ANN). The deep network design of DL allows for the full collection of representative information from raw input data by stacking numerous layers on top of one another. In numerous domains, including image identification, audio recognition, and natural language processing, DL models have attracted significant attention and achieved notable successes. However, in the area of RUL prediction, it has not yet been completely utilised. Many studies using DL approaches for machine health monitoring have been conducted, but there are currently very few that concentrate on the use of DL for RUL prediction. Accurate RUL prediction can prevent fatal failures, lower maintenance costs, and dramatically increase the operational safety and reliability of industrial systems or components. In [15] research, RUL prediction is briefly introduced, and state-of-the-art DL techniques are reviewed in terms of four exemplary deep architectures: auto-encoder, deep belief network (DBN), convolutional neural network (CNN), and recurrent neural network. The deep learning approach increases remaining usable life forecast accuracy while decreasing the amount of time needed for characteristic testing, potentially increasing the power profitability of predictive energy management. In order to anticipate the remaining useful life, this article reviews, categorises, and compares various adaptive mathematical models on deep learning techniques. In [16] The modelling ability features are determined, and the adaptive prediction methods are categorised as a result. To evaluate various modelling accuracy in the deep learning calculation process, several criteria are provided. The most important characteristics of successful life prediction are employed to make pertinent deductions and recommendations, and the highly accurate deep convolutional neural network–extreme learning machine technique is chosen to be applied for the stable remaining life.[17] Although Multilayer Perceptron (MLP) has been used to forecast RUL, its network structure prevents it from automatically picking up salient features. This research proposes a unique deep convolutional neural network (CNN) based regression approach for estimating the RUL. Although CNN has been used for other tasks like speech recognition, computer vision, and natural language processing, this is the first attempt to use CNN for RUL estimate in prognostics.

Statistical model: Statistical model predicts the damage initiation and progression according to the previous inspection results on similar machines. This method does not need knowledge on the ageing mechanism, while it requires a large number of effective data set. Among them, autoregressive (AR), autoregressive and moving average (ARMA), autoregressive integrated moving average (ARIMA) models are widely used for the modelling and prediction of the time series data. In [18] a novel hybrid Elman-LSTM method for battery remaining useful life prediction by combining the empirical model decomposition algorithm and long short-

term memory and Elman neural networks. The empirical model decomposition algorithm is employed to decompose the recorded battery capacity verse cycle number data into several sub-layers. Comprehensive battery test datasets have been collected and used for model parameterization and performance evaluation.[19] SOC and SOH co-estimation scheme is proposed based on the fractional-order calculus. First, a fractional-order equivalent circuit model is established and parameterized using a Hybrid Genetic Algorithm/Particle Swarm Optimization method.

III. EXPOSITION OF MACHINE LEARNING ALGORITHMS

Machine Learning algorithms are the programs that can learn the hidden patterns from the data, predict the output, and improve the performance from experiences on their own. More complicated patterns of data can be learned and recognised by machine learning algorithms. Based on experience, various apps' system data. The most effective way for forecasting is machine learning, which gathers historical data throughout the life cycle. Additionally, by adaptively improving network parameters, they are appropriate for extremely nonlinear systems and approach the genuine state of the system. These techniques do, however, inevitably have their limitations. The main flow of machine learning is depicted in Figure 4.

Machine Learning Algorithm can be broadly classified into three types:

1. Supervised Learning Algorithms
2. Unsupervised Learning Algorithms
3. Reinforcement Learning algorithm

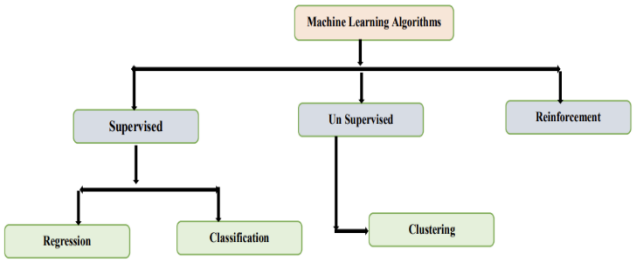


Fig 4: Flow of Machine Learning Algorithms

Supervised Learning Algorithms: In supervised learning, the machine is expected to deliver known outcomes. The training data is already supplied with predefined labels or outcomes. The algorithm has to identify matching characteristics or common features among training data that reference predefined labels/outcomes. Post-training, the same features/attributes are compared to label unknown data. The two most common learning problems are usually solved by supervised learning are classification and regression. Classification deals with labelling input data with predefined labels. Regression deals with deriving outcomes of unknown input data based on learned correlations between training data and known outcomes. The derived outcome is a numerical value or result.

Some of the common machine learning algorithms that fall under supervised learning include K Nearest Neighbor, Random Forest, Logistic Regression, Decision Trees, and Back Propagation Neural Network.

Unsupervised Learning: In unsupervised learning, the machine is expected to deliver unknown outcomes. The machine is exposed to unlabelled raw data samples and it must deduce structures present in the input data. This is usually done mathematically by either extracting similarities or removing redundancies. The outcome of machine learning is not a class/label or a numerical output; instead, the output is delivered by grouping similar data samples or identifying the odd ones.

Some of the common problems solved through unsupervised learning are clustering, association rule mining, and dimensionality reduction. Some of the common machine learning algorithms that fall under unsupervised learning include K-Means Clustering, Apriori Algorithm, KNN, Hierarchal Clustering, Singular

Value Decomposition, Anomaly Detection, Principal Component Analysis, Neural Networks, and Independent Component Analysis.

Reinforcement learning algorithms: In reinforcement learning, a system called an agent is developed to interact in a specific environment so that its performance for executing certain tasks improves from the interactions. The agent starts from a predefined initial set of policies, rules, or strategies and then is exposed to a specific environment in order to observe the environment and its current state. Based on its perception of the environment, it selects an optimal policy/strategy and performs actions. In response to every action, the agent gets feedback from the environment in the form of a reward or penalty. It uses the penalty/reward to update its policy/strategy and again interacts with the environment to repeat actions. Some of the common machine learning algorithms that fall under reinforcement learning include Q-Learning.

IV. RECOMMENDED ML ALGORITHMS

In the proposed work two supervised machine learning algorithms i.e, Gradient Boosting from Regression and Naïve Bayes from classification are compared for the RUL Prediction:

A. Gradient Boosting Regression:

In Machine Learning, we use gradient boosting to solve classification and regression problems. It is a sequential ensemble learning technique where the performance of the model improves over iterations. This method creates the model in a stage-wise fashion. It infers the model by enabling the optimization of an absolute differentiable loss function. As we add each weak learner, a new model is created that gives a more precise estimation of the response variable. The gradient boosting algorithm requires the below components to function as shown in Figure 5.

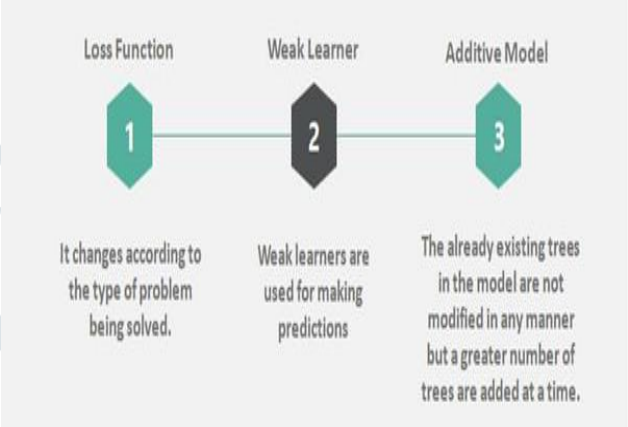


Fig 5: Gradient Boosting Functions

1. **Loss function**: To reduce errors in prediction, we need to optimize the loss function. Unlike in AdaBoost, the incorrect result is not given a higher weightage in gradient boosting. It tries to reduce the loss function by averaging the outputs from weak learners.

2. **Weak learner**: In gradient boosting, we require weak learners to make predictions. To get real values as output, we use regression trees. To get the most suitable split point, we create trees in a greedy manner, due to this the model overfits the dataset.

3. **Additive model**: In gradient boosting, we try to reduce the loss by adding decision trees. Also, we can minimize the error rate by cutting down the parameters. So, in this case, we design the model in such a way that the addition of a tree does not change the existing tree.

The state of charge estimation of lithium-ion battery systems by using an extreme gradient boosting algorithm for electric vehicles application, which acquires the nonlinear relationship model can with offline training. [20] The gradient boosting algorithm is the tree on based learning, which effectively performs and speeds. Voltage-time data used as an input of this system from the partial constant current phase; the proposed

algorithm improves the accuracy of predicting the relevant. Additionally, no initial state of charge is required in our proposed method; thus, estimating the state of charge can consider each battery state. Gradient Boosting Tree is a type of ensemble where additional trees are added at each stage to compensate the shortcoming of the existing model. These models are generally employed where features are too heterogeneous.[21] In this model of Gradient Boosting Regressor we have used Huber loss function in loss function parameter. X Consider a training set (x_i, y_i) (where i = 1, 2, 3.....N) and a differential loss function (i.e. 'deviance' in this case) L(y_i, z), where z is the predicted value. Initialize the model as

$$f_0(x) = argmin_z \sum_{i=1}^{i=n} L(y_i, z) \qquad (1)$$

For each observation in each tree calculate the gradient which is given by

$$\theta_{jm} = argmin_z \sum L(y, z + f(x_i)) \qquad (2)$$

Now, update the model of the succeeding tree with the gradient of the previous tree. This is given by

$$f_m(x) = f_{m-1}(x) + \sum_{j=1}^{j=Jm} l_{jm} * I \qquad (3)$$

for each x which belongs to the region of that tree (i.e. R_{jm}) The overall output is given by $f_m(x)$.

B. **Naïve Bayes**: The NB model assumes every predictor variable is independent. Thus, this means that it uses Bayes' Theorem in a naive way, which means it is a special case of a Bayesian Network. NB uses Bayesian statistics, which is based on Bayes' Theorem. It predicts the class of a test case with values T = a_1, a_2, a_3, . . . , a_n by choosing the class ci , which optimizes as shown in equation below by maximizing it . In Equation (4) P(c_i |T) denotes the conditional probability of class ci given test case T.

$$P(c_i|T) = \frac{P(T,c_i)}{P(T)} = \frac{P(c_i).P(T|c_i)}{P(T)} \qquad (4)$$

In this model, the probability estimation of each class is provided by the training set. As the model tries to maximize Equation (4), the denominator is reduced as much as possible so it can be removed from the equation as it does not have a direct contribution to the prediction process.

In addition, NB classifier is able to calculate the joint probability P(T|c_i) by assuming that all the attributes are conditionally independent given the class c_i. Therefore, Equation (5) shows how the model calculates the joint probability. This shows that the predictions made by the model depend only on the values of P(c_i) and P(a_j |c_i).

$$P(T|c_i) = P(a_1, a_2, \ldots\ldots a_n, c_i)$$

$$\approx P(c_i)P(a_1|c_i)P(a_2|c_i)P(a_n|c_i) \qquad (5)$$

$$= P(c_i).\prod_{j=1}^{n} P(a_j|c_i)$$

The main advantage of using NB is that it only needs small datasets for training. Moreover, training the model is fast and is not time-consuming. A naive Bayes (NB) model is proposed for RUL prediction of batteries under different operating conditions. [22] It is shown in this analysis that under constant discharge environments, the RUL of Li-ion batteries can be predicted with the NB method, irrespective of the exact values of the operating conditions. The case study shows that the NB generates stable and competitive prediction performance over that of the support vector machine (SVM). Robust Remaining Useful Life Prediction for Li-ion Batteries a Naïve Bayesian Classifier was shown in the figure 6 below. In [23] presents an empirical procedure for predicting robust remaining useful life (RUL) using a naïve Bayesian classifier (NBC) with time as the response.

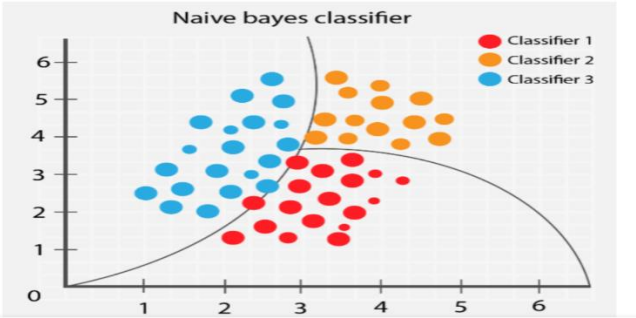


Fig 6: Naïve bayes classifier

The method is illustrated using public data for predicting Li-ion battery RUL to end-of-life (EOL). A battery life prediction is obtained using the capacity values up to the prediction time. The root mean squared error (RMSE) is used for performance evaluation. The prediction performance of the NBC is compared with that of a support vector machine (SVM). Thus, Naive Model assumes every predictor variable is independent. Thus, this means that it uses Bayes Theorem in a naive way, which means it is a special case of a Bayesian Network.

V. EXPERIMENTAL RESULTS

A. Lithium-ion battery Data set

In the early days of lithium-ion batteries, the lifetime of the battery was short. Consequently, accelerated aging tests are needed to obtain battery aging data in a short period of time, with different charge-discharge rates, and ambient temperature being the most commonly selected stress factors. However, conducting battery aging tests is time consuming, and extracting battery features from different aging cycles requires a complex and expensive signal acquisition system. Therefore, battery aging data are required to construct an RUL prediction algorithm and validate its stability and accuracy. Therefore, many researchers have utilized publicly available battery datasets to verify their RUL prediction algorithms. The Hawaii Natural Energy Institute examined 14 NMC-LCO 18650 batteries with a nominal capacity of 2.8 Ah, which were cycled over 1000 times at 25°C with a CC-CV charge rate of C/2 rate and discharge rate of 1.5C.

In [24] The publicly available databases for battery life cycles do not provide ready-to-use data for this project. Although they contain different variables such as voltage (V), current (A), time (S), discharge and charge capacity (Ah), and charge and discharge energy (Wh), not all of them can be used for this project. The objective is to use only voltage, current, and time as inputs. Nonetheless, employing these variables directly as inputs is not feasible since they provide meaningless information and are not sufficient to create a model. Therefore, they need to be treated and manipulated as a base to develop new features which the neural network will train with.

B. Performance Error Indices

Regression ML methods deal with predicting a target value using independent variables. [25] Most of the works conducted so far in the areas of engineering applications only utilized a few of the above Performance Fitness and Error Matrices.The bulk of here viewed works continue to incorporate traditional metrics such as MSE and RMSE as primary indicators of adequacy of the regression-based models.

Mean Absolute Error (MAE): Measures the Difference Between two Continuous variables. It also uses a similar scale to input data. It can also be used to compare series of different scales.

$$\text{MAE}=\frac{\sum_{i=1}^{n}|E_i|}{n} \qquad (6)$$

Mean Square Error (MSE): Measures the average of the squares of the errors. It is scale dependent and the values are closer to zero present adequate state.

$$\text{MSE} = \frac{\sum_{i=1}^{n} E_i^2}{n} \qquad (7)$$

Root Mean Square Error (RMSE): Root Square of average squared error. It is scale dependent, A lower value for RMSE is favourable. Highly dependent on fraction of data used.

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} E_i^2}{n}} \qquad (8)$$

C. RUL prediction frame work

There are three necessary steps that have to be followed to build an RUL prediction model, in particular, model selection, reconstruction, and prediction. Model Selection is an important step which involves dedicated experience in selecting the appropriate ML algorithm from a set of models based on data characteristics. model selection involves examining four main criteria, in particular, data availability, data complexity, data drift, and model complexity. Model reconstruction a set of well-defined steps of training to generalize the prediction model over both training and unseen samples. Predicting the Remaining Useful Life (RUL) one of the most important indicators to detect the component's failure before it effectively occurs.

D. **Effect of training set size on prediction performance**

In this paper, different observations are used for training the data and three separate observations are used for testing. It is well known that the size of training set used affects the test performance of a method accuracy on the training set increases. The testing prediction accuracy also increases, until the noises in the training set are also modelled (overfitting). After this point, the testing prediction accuracy decreases with increase in training set size, although the training prediction accuracy continues to increase. Table 1 shows Comparison of NB & GB performance error indices. The average RMSE of the NB is lower than that of the GB for training set sizes of three or more.

Table1: Comparison of NB & GB performance error indices

Machine Learning Algorithm	MAE	MSE	RMSE	TIME
NAÏVE BAYES	4.644	54.543	7.385	0.024
GRADIENT BOOSTING	4.984	57.447	7.579	2.564

Fig 7,8 & 9 shows the testing performance and Performance Error Indices of the Naive Bayes and Gradient Boosting Method when the data set is trained.

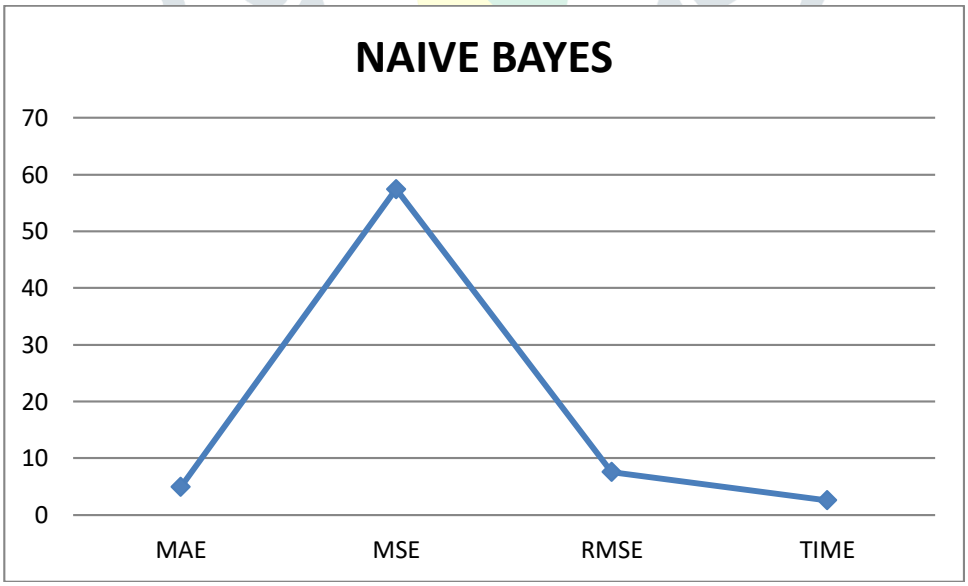


Fig 7: Plot of Naive Bayes

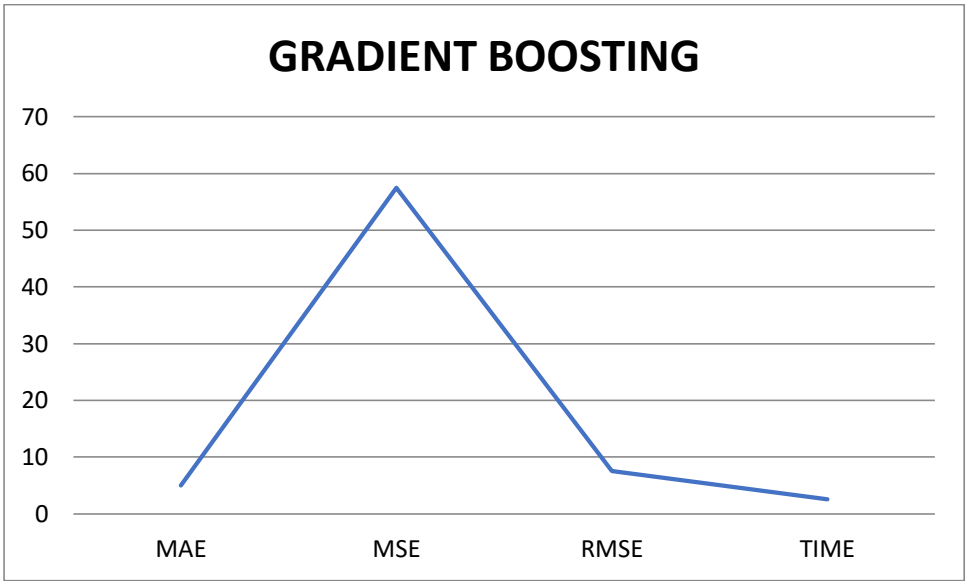


Fig 8: Plot of Gradient Boosting

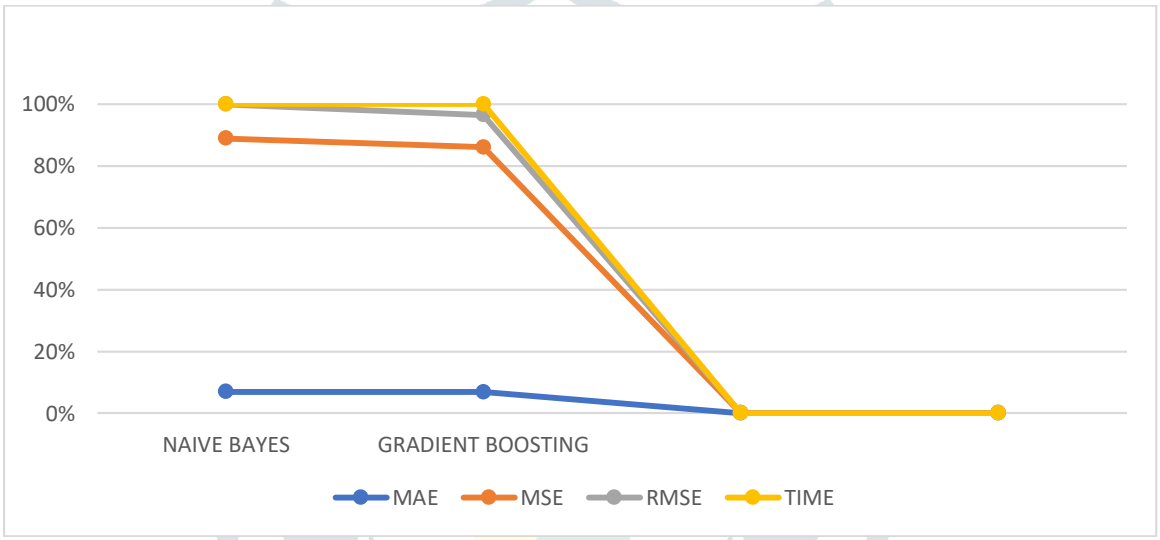
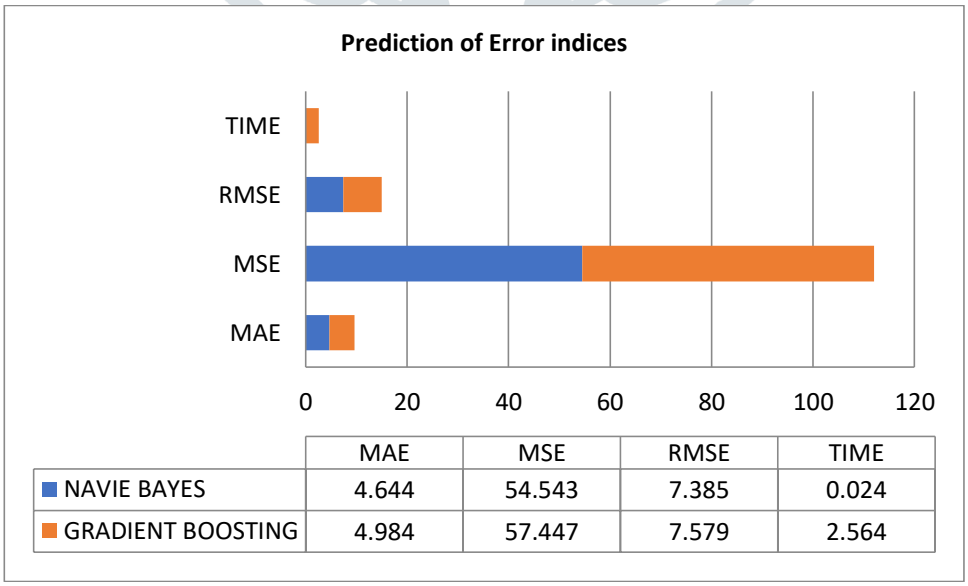


Fig 9: RUL prediction Analysis for performance error indices

Table 2: Prediction of Error indices



	MAE	MSE	RMSE	TIME
NAVIE BAYES	4.644	54.543	7.385	0.024
GRADIENT BOOSTING	4.984	57.447	7.579	2.564

However, the probability estimates of the NB are utilized in the RUL prediction so bias introduced by any deviations from the linked independence assumption is reflected in the accuracy of the final RUL predictions. These results show the robustness of the NB method at different times and with the batteries data set. Although

the NB produces close-to actual battery life predictions in less than of total battery life. Over all, the prediction performance of the NB is more stable and practical than that of the GB in this case study.

VI CONCLUSION

An empirical Procedure for Producing Robust and Practical RUL Predictions Using the Data Driven Machine Learning Algorithms. Using time as the Response, Stable and Accurate Predictions were Obtained with a simple and efficient method and the Transformation to RUL is Straight forward. The method was illustrated using Hawaii Natural Energy Institute data set to predict RUL For Lithium-ion Battery. In this Paper we have Proposed a new data driven methods of Machine Learning Algorithms for Prediction of RUL using Naive Bayes (NB) and Gradient Boosting (GB) method which is simple and efficient. Stable and accurate RUL Predictions over time are obtained for batteries under different operating conditions. A Comparison of Naive Bayes (NB) Algorithm and Gradient Boosting (GB) Algorithm is proposed for RUL prediction of batteries and the Error analysis of the model is carried out to optimize the battery's performance parameter. Thus, the statistical indicators like MAE, MSE and RMSE are Calculated and the results show that NB generates competitive prediction performance over the GB.

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Production of biodiesel from Palmolein oil, Ricebrane oil, Neem oil and their yield comparison

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***Abstract*— Biofuel production from renewable sources is widely considered to be one of the most sustainable alternatives to petroleum sourced fuels and a viable means for environmental sustainability. Biodiesel is an alternative fuel similar to conventional or 'fossil' diesel. Biodiesel can be produced from vegetable oil, animal oil/fats and waste cooking oil. The process used to convert these oils to Biodiesel is called transesterification. The largest possible source of suitable oil comes from oil crops such as palm, rice, neem, ground nut etc. Biodiesel has many environmentally beneficial properties. The main benefit of Biodiesel is that it can be described as 'carbon neutral', this property of Biodiesel may helpful in the future carbon border adjustment tax. Biodiesel is biodegradable and completely non-toxic, meaning spillages represent far less of a risk than fossil diesel spillages. Biodiesel has a higher flash point than fossil diesel and so is safer in the event of a crash. Present study focuses on production of biodiesel from Palm olein oil, Rice brane oil, Neem oil and their yield comparison. All the experiments were carried out in batch mode. To produce Biodiesel, oils are heated to 60 ^{0}C and (1:4, 1:5, 1:6, 1:7, 1:8) oil to methanol molar ratio, containing 0.5g KOH catalyst, added to heated oil and stirred to 60 min. The fuel properties of produced biodiesel such as density, flash point, fire point, kinematic viscosity was analyzed and compared to conventional diesel, biodiesel and acid value, % free fatty acid, saponification value, ester values are founded.**

***Index Terms*—Biodiesel, Batch process, Palm olein oil, Rice brane oil, Neem oil, Catalyst.**

I. INTRODUCTION

Transesterification of vegetable oils was conducted as early as 1853 by Scientists, E. Duffy and J. Patrick, many years before the first diesel engine became functional. Rudolf Diesel (1858–1913) prime model, a single 3 m (10ft) iron cylinder with a fly wheel at its base, run on its power for the first time in Augsburg, Germany, on August 10, 1893. In remembrance of this event, August 10 has been declared ―International Biodiesel Day (Lin et al., 2011). Diesel later demonstrated his engine and received the Grand Prix (highest prize) at the World Fair in Paris, France in 1900.

This engine stood as an example of Diesel 's vision because it was powered by peanut oil a biofuel, though not biodiesel, since it was not trans-esterified. He believed that the utilization of biomass fuel was the real future of his engine. In a 1912 speech Diesel said, ―The use of vegetable oils for engine fuels may seem insignificant today but such oils may become, in the course of time, as important as petroleum and coal-tar product of the present time. During the 1920s, diesel engine manufacturers altered their engines to utilize the lower viscosity of petrol diesel (a fossil fuel) which was much cheaper to produce, rather than vegetable oil.

Scientists are currently researching ways to produce biodiesel using new feed stocks that are less limited by the availability of land. For example, some types of algae can produce oil. Energy crops could also be grown on land that is not suitable for food crops, such as soil that is too acidic or too salty, that has too many minerals or is too shallow, or that is in danger of eroding. In these cases, energy crops might help stabilize and restore this land.

Scientists are also experimenting with producing fuel from feed stocks such as inexpensive, non-edible biomass (agricultural residue, waste from the wood products industry, and switch grass and other grasses) that can be converted into a diesel replacement. While it is a fairly simple process to convert vegetable oil or animal fat into biodiesel, the conversion of cellulosic feed stocks to fuel is more complicated and more expensive. To produce a hydrocarbon fuel, the biomass is generally first converted into a synthetic gas using high heat. Then the gas can be converted into a liquid diesel fuel.

II. BENEFITS OF BIODIESEL

- It is a renewable fuel that can be derived from soybean oil, vegetable oils, animal fats and algal oils, used cooking oil can even be recycled to produce the bio fuels.
- At the tailpipe, biodiesel emits 4.7 % more CO2 than petroleum diesel. However, if biomass carbon is accounted for separately from fossil-derived carbon one can conclude that biodiesel reduces emissions of carbon monoxide (CO) by approximately 50 % emission and carbon dioxide by 78% on a net lifecycle basis because the carbon in biodiesel emissions is recycled from carbon that was in the atmosphere, rather than the carbon introduced from petroleum that was sequestered in the earth 's crust.
- Biodiesel contains fewer aromatic hydrocarbons: benzo fluoranthene: 56 % reduction; Benzopyrenes: 71 % reduction.
- It is a domestic product that lessens the dependence on foreign oil and produces jobs for the economy.
- Biodiesel can reduce by as much as 20 % the direct (tailpipe) emission of particulates, small particles of solid combustion products, on vehicles with particulate filters, compared with Low-Sulphur (<50 ppm) diesel. Particulate emissions as the result of production are reduced by around 50 %, compared with fossil-sourced diesel. (Beer et al, 2004).

- Biodiesel has a higher cetane rating than Petro-diesel, which can improve performance and clean up emissions compared to crude Petro-diesel (with cetane lower than 40).
- Since biodiesel is more often used in a blend with petroleum diesel, there are fewer formal studies about the effects on pure biodiesel in unmodified engines and vehicles in day-to-day use. Fuel meeting the standards and engine parts that can withstand the greater solvent properties of biodiesel is expected to—and in reported cases does—run without any additional problems than the use of petroleum diesel.
- The flash point of biodiesel (100-170 0C) is significantly higher than that of petroleum diesel (55-65 0C) or gasoline (-23 0C) which makes it safer to handle. The gel point of biodiesel varies depending on the proportion of different types of esters contained.

III. BIODIESEL PRODUCTION IN A BATCH REACTOR BY USING TRANSESTERIFICATION PROCESS

The transesterification process is a reaction between triglycerides in the vegetable and alcohol which produces the biodiesel (mono alkali ester) and glycerol. [A. Rajalingam et al J. Chem. Pharm. Res., 2016]

Biodiesel is obtained through transesterification reaction of palm olein oil, rice brane oil, neem oil by methanol, using potassium hydroxide as a catalyst. The reaction is taking place in a batch reactor.

THEORY

Biodiesel production is gaining increasing attention since in principle can reduce more CO2 emissions significantly. It has also many other environmental advantages. The most common way to obtain biodiesel is the transesterification reaction of vegetable oils in the presence of a low molecular weight alcohol and a catalyst. The transesterification reaction involves the exchange of organic groups R1, R2, R3 belonging to a glyceride with the organic group of an alcohol R'.

The transesterification reaction: R1, R2, R3 is a mixture of various fatty acid chains. The alcohol used for producing biodiesel is usually methanol (R′ = CH3). The overall process is normally a sequence of three consecutive steps, which are reversible reactions. In the first step, diglyceride is obtained from triglycerides, from diglyceride monoglyceride is produced and in the last step from monoglycerides glycerin is formed. In all these reactions fatty acid methyl esters (FAME) are produced. However, an excess of alcohol is usually more appropriate to improve the reaction towards the desired product [8].

Reaction Mechanism

The mechanism of the base-catalyzed transesterification of vegetable oils is shown below. The first step is the reaction of the base with the alcohol, producing an alkoxide and the protonated catalyst. The nucleophilic attack of the alkoxide at the carbonyl group of the triglyceride generates a tetrahedral intermediate, from which the alkyl ester and the corresponding anion of the diglyceride are formed. The latter deprotonates the catalyst and reacts with a second molecule of alcohol starting a new catalytic cycle. Diglycerides and monoglycerides are converted by the same mechanism to a mixture of alkyl esters and glycerin.

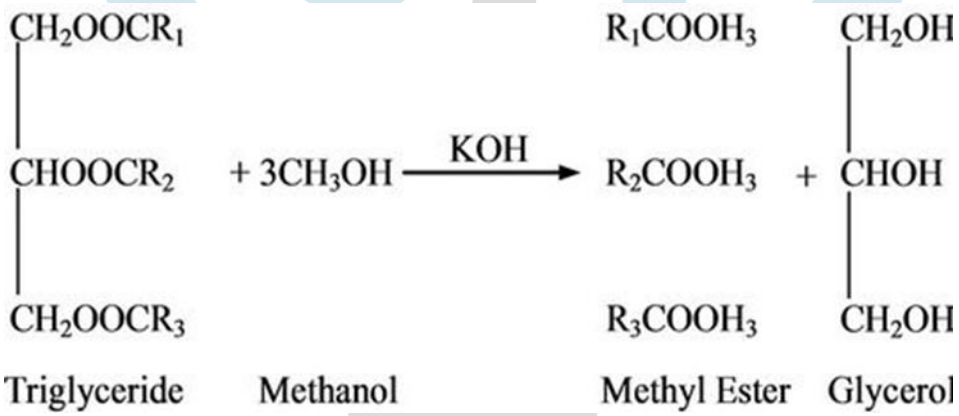


Figure : Mechanism of the alkali-catalyzed transesterification of vegetable oils [24].

Alkaline-catalyzed transesterifications proceed at considerably higher rates than acid catalyzed transesterifications. Due to this fact and also because alkaline catalysts are less corrosive to industrial equipment, most commercial transesterifications are conducted with alkaline catalysts [11].

Materials

Palm olein oil, Rice brane oil, Neem oil, Methanol, Potassium hydroxide (KOH) in pellets, Concentrated sulfuric acid, Phenolphthalein indictor, Ethanol, 0.1N KOH, 0.5N Hydrochloric Acid, 0.5N Alcoholic Potassium Hydroxide

Methods

The two steps procedure should be carried out for the production of biodiesel.

The following steps are involved

1. Acid pretreatment
2. Base catalyzed transesterification

Acid pretreatment (acid catalyzed esterification)

The 250 ml crude oil was measured and heated at 60 0C for about 10 minutes then mixed with methanol which is 60% w/w of oil. To the mixture 1.2 % w/w of concentrated H2SO4 was added. The resultant mixture was then stirred for 1hr then it was allowed to settle for 2h. The pretreated oil was separated from the methanol water phase at the top.

This step is not necessary for oils contain <1% free fatty acids.

Base catalyzed transesterification

The experiments were carried out in a batch wise manner in 500ml flask containing 250ml of the acid pretreated oil. Then oil heated to 60 0C on a heating plate. The oil to alcohol molar ratios was maintained 1:4, 1:5, 1:6, 1:7 1:8. The catalyst KOH taken 0.5g and kept constant for all runs. KOH pellets are dissolved in the methanol as that of the respective molar ratios. This solution is added to heated pretreated oil. The reaction time maintained was 1h. This procedure was repeated for above mentioned molar ratios.

Experimental conditions:

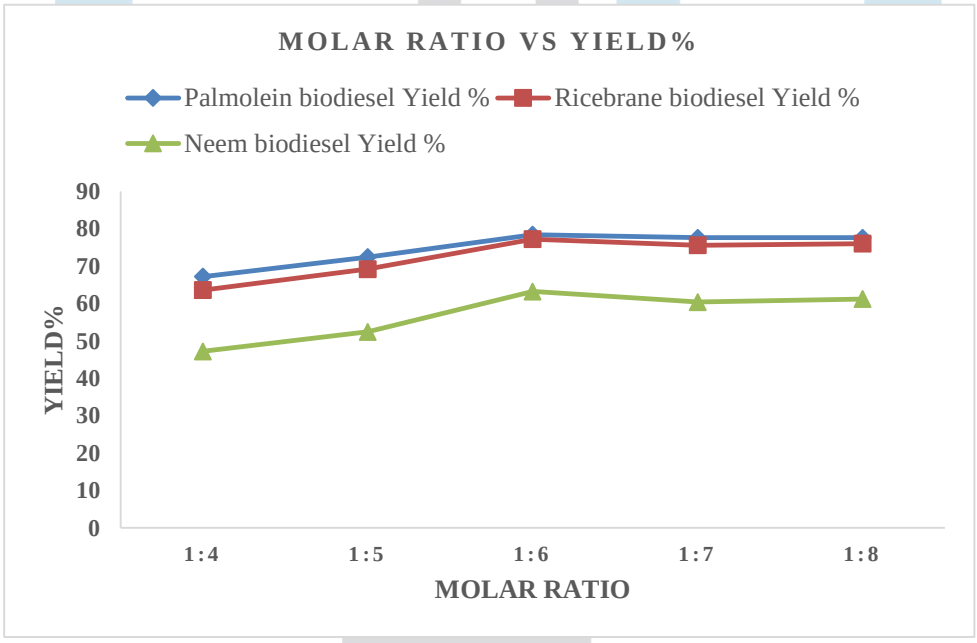
- 250ml of oil heated to 60 0C ,
- Oil to methanol molar ratios maintained 1:4, 1:5, 1:6, 1:7 1:8,
- Catalyst KOH 0.5g constant for all runs,
- Reaction time maintained was 1h.
- Separation time 24hrs.

Key parameters such as Density, Flash point, Fire point, Viscosity, Acid value, Saponification number, Ester value, and yield% of Biodiesel produced from Palm olein oil, Rice brane oil and neem oil are studied and compared with conventional diesel and biodiesel values of EN 14214 properties.

IV. RESULTS

Yield %:

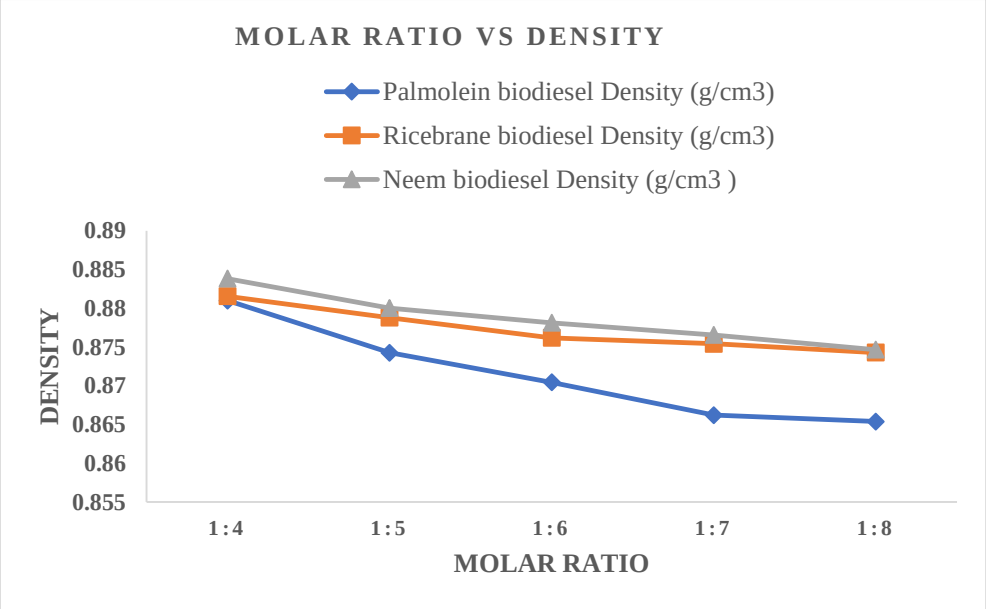
We got highest yield from Palm olein oil biodiesel compared to Rice brane, Neem biodiesel samples. In terms of yield % Palm olein oil is preferred for the biodiesel production. By increasing molar ratio yield % decreased, because of increasing glycerol formation at higher methanol ratio.



Graph : Effect of molar ratio on Yield %

Density

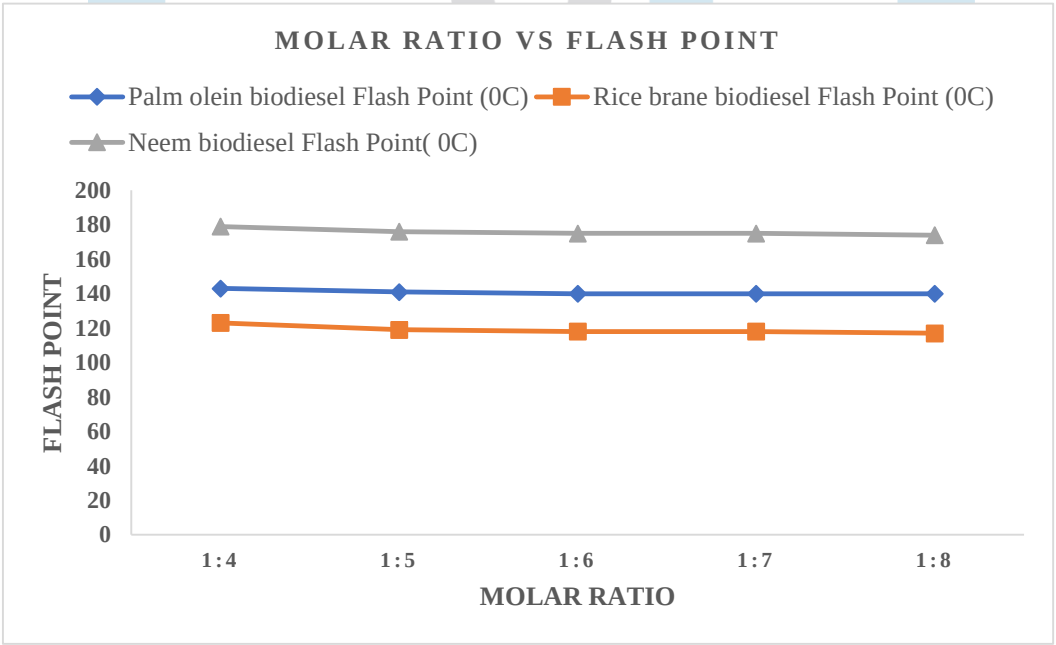
Density of diesel is 0.832 (g/cm3), biodiesel density is 0.88(g/cm3), here all biodiesel samples met the conventional values and biodiesel from neem oil denser than the remaining biodiesel samples, because neem oil that we used here have the high-density value compared to the palm olein oil and rice brane oil. When we consider density parameter, palm olein oil and rice brane oil are preferred compared to neem oil. At higher molar ratios the density of biodiesel samples are decreased because of higher alcohol presence.



Graph : Effect of molar ratio on density

Flash Point

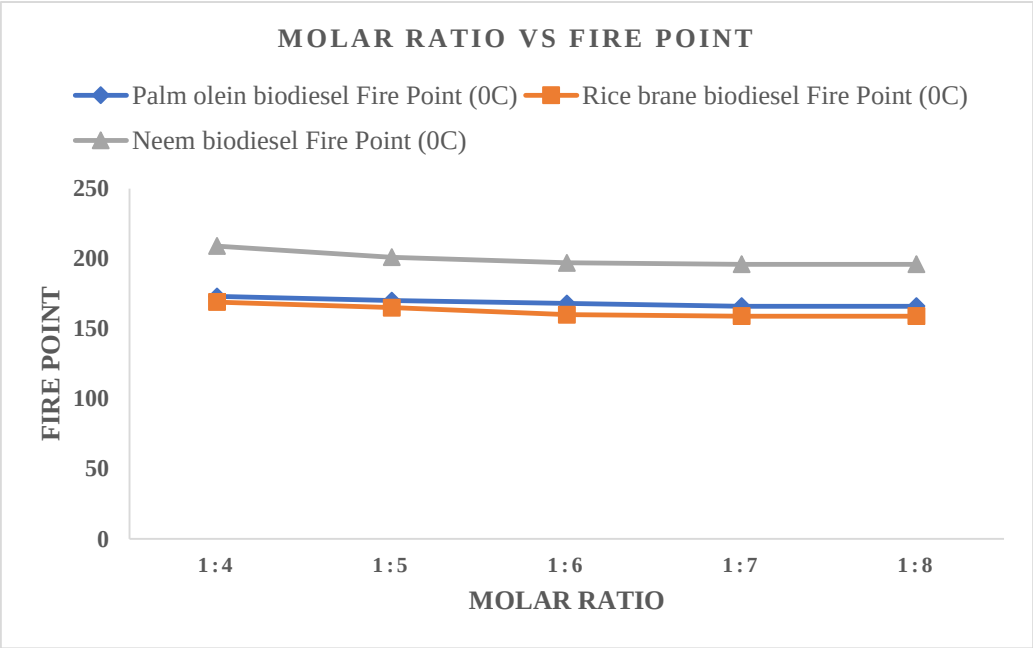
Diesel flash point range 55-65 0C, biodiesel flash point 100-170 0C. Rice brane biodiesel has the lower flash point temperature compared to the remaining two oils biodiesel samples. Rice brane oil preferred in terms of flash point.



Graph : Effect of molar ratio on flash point

Fire point

Diesel fire point is 90 0C, Biodiesel fire point is 164-175 0C, biodiesel from rice brane oil has the lowest fire point temperature compare to the remaining sample. when we consider the fire point rice brane oil is preferred for the biodiesel production.

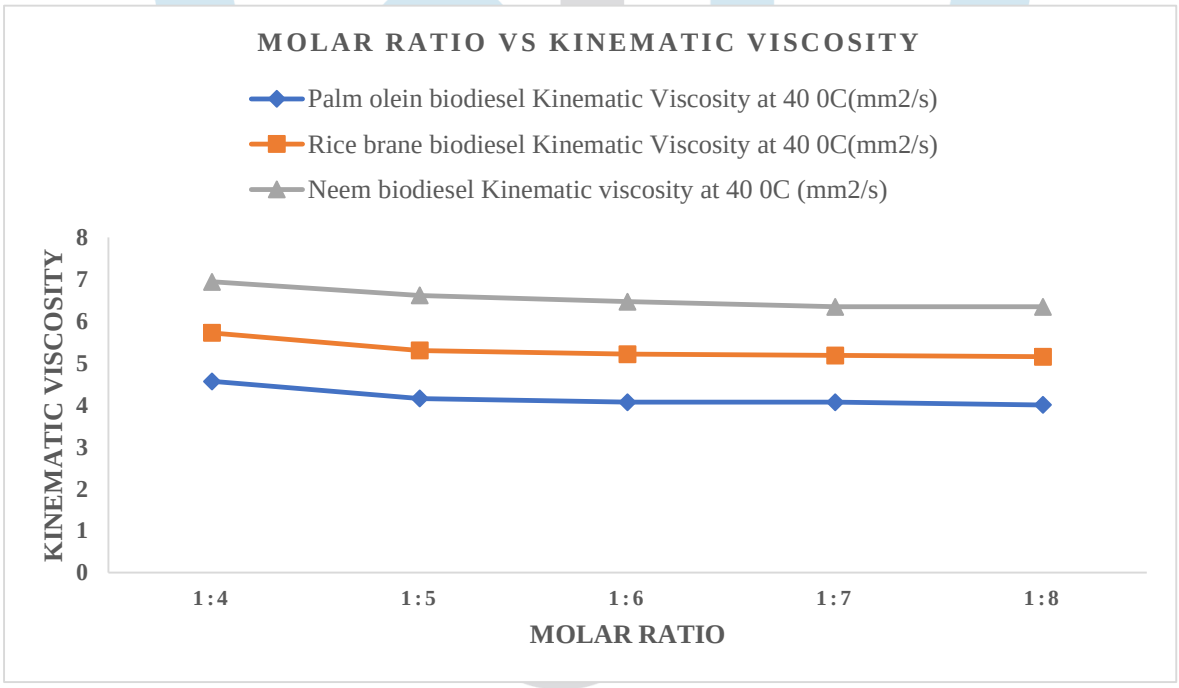


Graph : Effect of molar ratio on fire point

Kinematic Viscosity

Diesel viscosity at 40 0C is 2.2 (mm2/s), Biodiesel viscosity range 1.9 – 6.0 mm2/s.

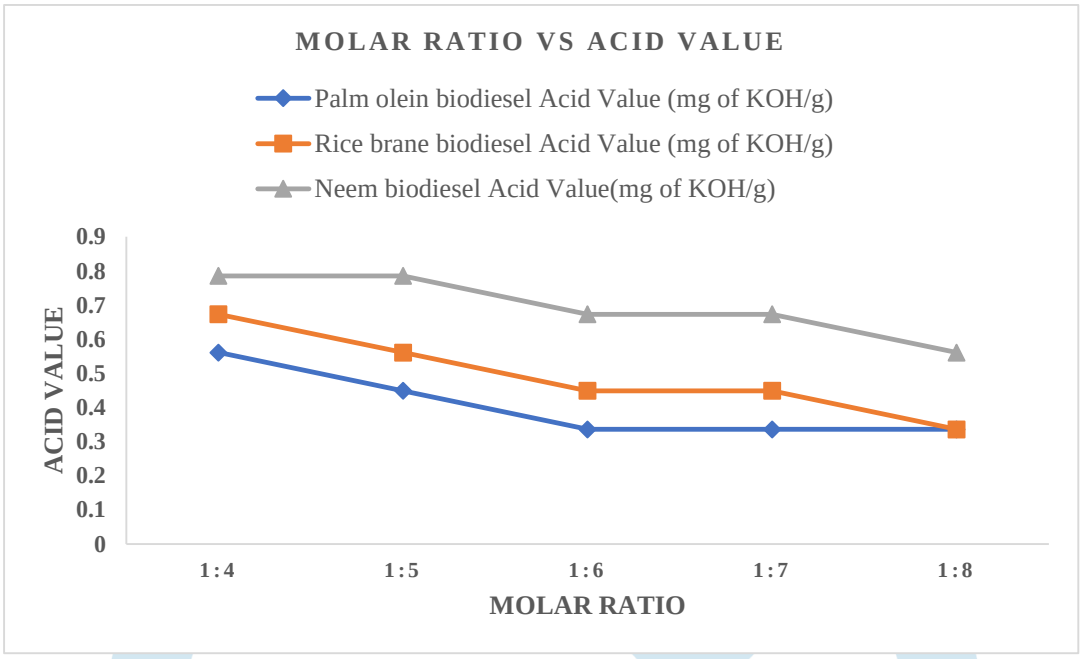
Palm olein biodiesel samples have the lowest kinematic viscosity compared to rice brane, neem biodiesel samples. In terms of kinematic viscosity palm olein oil is preferred for the biodiesel production.



Graph : Effect of molar ratio on Kinematic viscosity

Acid Value

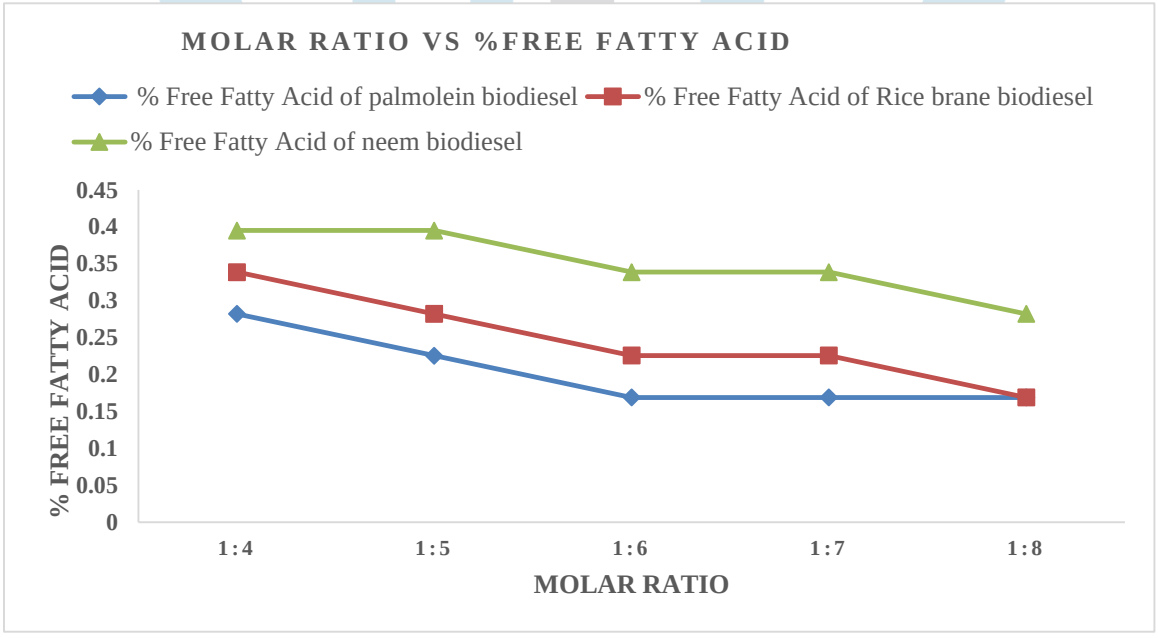
Acid values of produced biodiesel samples at various molar ratios. Acid values for palm olein, rice brain biodiesel samples are lower compared to neem biodiesel samples. In terms of acid value palm olein, rice brane oils are preferred.



Graph : Acid Value of Biodiesel samples

% Free Fatty Acid

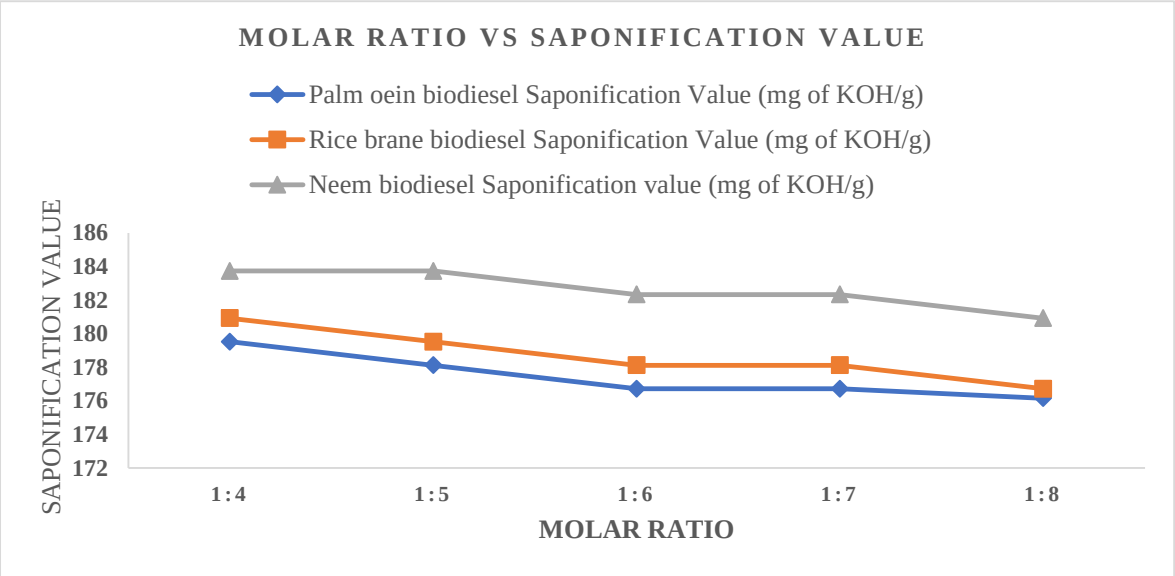
% Free Fatty Acid values of produced Biodiesel samples at various Molar Ratios. % free fatty acid of palm olein, rice brane biodiesel samples are lower than neem biodiesel samples. In terms of free fatty acid palm olein, rice brane oils are preferred for the biodiesel production.



Graph : % Free fatty acid values of Biodiesel samples

Saponification value

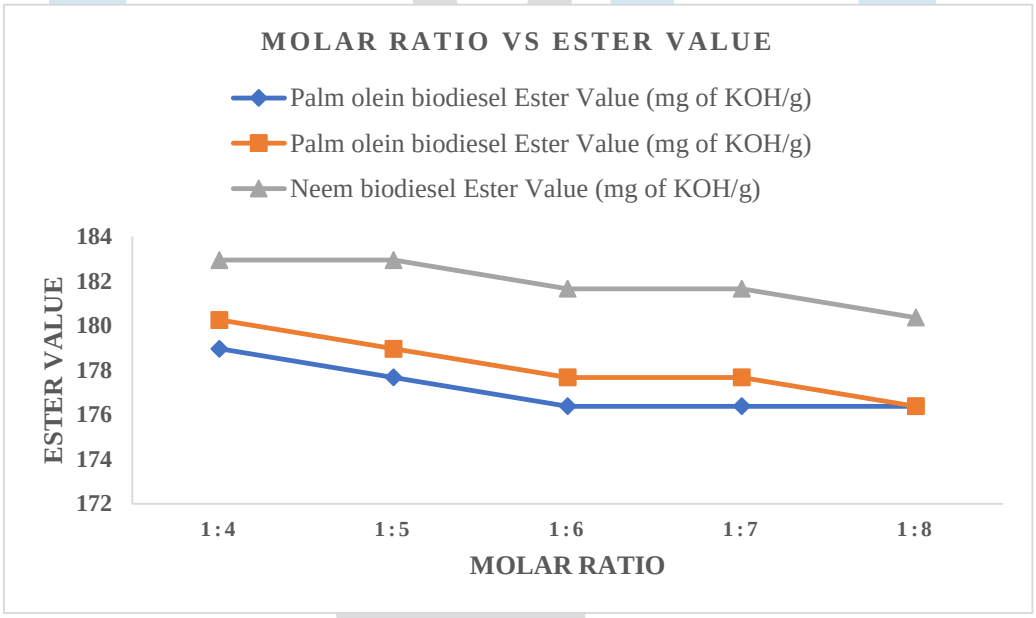
Saponification values of Biodiesel samples produced at different molar ratios. Saponification value of palm olein biodiesel is lower than the rice brane, neem biodiesel samples. In terms of saponification value palm olein oil is preferred for the biodiesel production



Graph : Saponification values of Biodiesel samples

Ester value

Ester value of biodiesel produced at different molar ratios. Ester values of palm olein, rice brane biodiesel samples are lower than neem biodiesel. In terms of ester value palm olein, rice brane oils are preferred for the production of biodiesel.



Graph : Ester Value of Biodiesel samples

V. CONCLUSION

The results obtained shows that palm olein oil is effective in Biodiesel production compared to rice brane oil and neem oil. Effect of molar ratio on Yield %, Density, Flash Point, Fire Point, Kinematic Viscosity were studied and the data was interpreted. Maximum Yield % was achieved at Palm olein oil 1:6 molar ratio. Acid Values, % Free Fatty Acid, Saponification values, Ester values are studied and the obtained values are tabulated. All the Biodiesel samples met the EN14214 Density, Flash Point, Fire Point, Kinematic Viscosity standards.

- By varying molar ratio maximum yield of Palm olein biodiesel 78.4%, Rice brane biodiesel 77.2%, Neem biodiesel 63.2% obtained at 1:6 molar ratio.
- Increasing in molar ratio results in decrease in biodiesel Density, Flash Point, Fire Point, Kinematic Viscosity properties.
- Minimum Acid Value 0.336 (mg of KOH/g) obtained at 1:8 molar ratio of Palm olein, Rice brane biodiesel.
- Minimum % Free Fatty Acid value 0.169 obtained at 1:6, 1:7, 1:8 molar ratios of Palm olein biodiesel
- Minimum Saponification Value 176.15 (mg of KOH/g), Ester value 176.378 (mg of KOH/g) obtained at 1:8 molar ratio of Palm olein oil, Rice brane oil.

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Data Driven Methodology for Battery RUL Prediction Using Machine Learning Algorithms

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***Abstract*:** With the rapid development of new energy electric vehicles, the demand for batteries is increasing. The battery management system (BMS) plays a crucial role in the battery-powered energy storage system. Lithium-ion batteries are the primary power source in electric vehicles, and the prognosis of their Remaining Useful life is vital for ensuring the safety, stability, and long lifetime of electric vehicles. Remaining useful life (RUL) prognostics based on data-driven methods has become a focus of research. The development of a machine-learning method with high accuracy, high generalization, and strong robustness for evaluating battery health states is essential in the field of battery health management. Current research on data-driven methodologies using Machine Learning Algorithm is summarized in this paper. The parameters such as voltage, current and temperature values are taken as dataset. A Naive Bayes (NB) Algorithm and Gradient Boosting (GB) Algorithm is proposed for RUL prediction of batteries and the Error analysis of the model is carried out to optimize the battery's performance parameter. The statistical indicators like MAE, MSE and RMSE are selected to assess numerically the prediction results. The experimental consequences revealed that the presented Methods give better results than other Machine learning techniques considering various performance criteria.

Index Terms: *Remaining useful life prediction, Machine learning Algorithms, lithium-ion batteries, Naive Bayes, Gradient Boosting and Data-Driven.*

I. INTRODUCTION

When it comes to both storing and producing energy, lithium-ion batteries are crucial. The usage of lithium-ion batteries in the transportation, communication, and aerospace industries is already widespread due to its better energy density, less weight, and longer charge and discharge cycle. The performance of the lithium-ion battery will degrade or perhaps fail as a result of the intricate physical and chemical changes that occur during the use process, which could pose a serious risk to public safety and cause significant financial losses. As a result, the question of how to effectively manage the prognosis and health of lithium-ion batteries has gained popularity and has been the subject of extensive research. The amount of time between the present and the end of a system's or asset's useful life is known as the RUL. Operational research has utilised the RUL concept extensively. The lithium-ion battery's RUL forecast is based on the number of cycles and battery capacity that will pass the failure threshold from the current cycle. By analysing the likelihood of battery failure and limiting safety concerns to achieve high efficiency and robustness, the RUL of a lithium-ion battery may be accurately assessed. The RUL of the battery is calculated using the remaining useable charges and discharge cycles before the threshold value is reached, or the value after which the battery is no longer regarded as safe to operate. Figure 1 Shows the principle of RUL Prediction. Remaining useful life (RUL) is an estimation of the length of time an item, component, or system is estimated to be able to function according to its intended purpose before requiring repair or replacement.

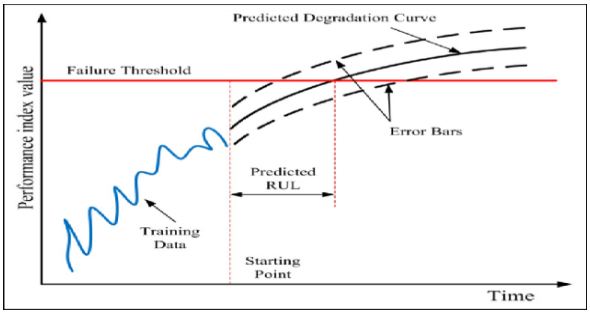


Fig 1: Principal of RUL Prediction

Remaining useful life prediction for lithium-ion battery storage system [1] Proposed the RUL prediction of lithium-ion batteries. Many techniques have been proposed and implemented to model the degradation of these complex systems, from which two approaches have arisen i.e, model-based approaches and data-driven approaches. Various model-based and data-driven-based and hybrid-based methods for RUL prediction of lithium-ion batteries have been comprehensively evaluated. The analysis considers various aspects such as classifications, methods, characteristics, contributions, advantages, disadvantages, and research gaps. Generally, the main steps involved for RUL prediction is summarized in Figure. 2 including a three-stages procedure. In the first stage, various sensors are utilized to capture the characteristics of the battery such as the voltage, current, SOC, and temperature. Then, the battery capacity is estimated in Stage 2 by model-based method, data-driven method, or other approaches.

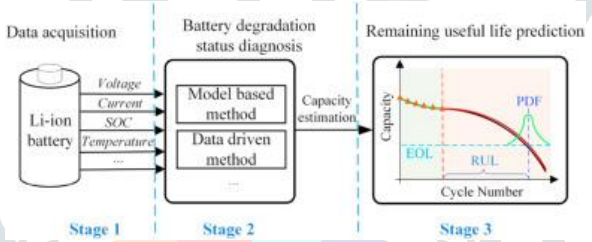


Fig 2: Procedure for RUL prediction

[2] The model assumes that solvent diffuses through the SEI (solid electrolyte interphase) and undergoes a two-electron reduction at the carbon SEI interface. The kinetics of the reduction reaction at the SEI–electrolyte interface and the solvent diffusivity are seen to be the most important parameters governing SEI formation. The capacity loss is seen to be a function of the thickness of the SEI layer and is seen to vary linearly over time. In [3], A Thevenin model with one RC branch is presented in which all the model parameters are constant. When this equivalent circuit models are used to estimate battery aging, model parameters include lots of internal battery parameters and resistance aging parameters. Moreover, model-based methods exhibit poor real-time performance characteristics.

It is to investigate advanced battery management technologies for the estimation, monitoring, and control of battery states, associated modelling techniques, thermal and charging/discharging management for optimized life, performance, and range. To improve the quality of battery and safe operation, battery management system is employed. [4] The main objective of this work is to design and optimize the Battery Management System including a lithium-ion battery model. In [5] new data-driven approaches to lithium-ion battery RUL prediction and SOH monitoring are made possible. This study describes a neural network-based approach that combines extensive.For the purpose of predicting RUL and monitoring SOH in lithium-ion batteries, a short-term memory (LSTM) network with particle swarm optimisation and an attention mechanism is used.

In order to enhance the performance of online SOH prediction, the proposed semi-supervised learning framework has successfully made the best use of a large amount of unlabeled data.[6] Proposeda capacity of unlabeled data is subsequently estimated using an ILLR-based technique based on the four attributes. The ILLR-based method offers the distributions of the estimated capacity in addition to the estimated capacity itself.[7] Presents RUL-RVE, a Python tool for the assessment of Remaining Useful Life (RUL). Physical systems are normally subject to degradations that ultimately lead to failure; therefore, prognostic technologies are crucial to estimate the lifetime of the system to be monitored. Since RUL is frequently random and unknowable, it must be inferred from information that is currently available, such as data from condition and

health monitoring. The RUL has become more well-known recently as a result of the quick development of condition and health monitoring techniques.Nevertheless, because of its complex interactions with observable health data. As a result, current modelling advancements for RUL estimation. [8] review's main focus is on statistical data-driven methodologies that only use readily accessible historical observed data and statistical models. The methods are divided into two main categories of models: those that rely on knowledge about the asset's state that has been directly seen and those that do not.

Data-driven methods have been getting more and more attention towards the prediction of RUL as machine learning and artificial intelligence have developed so quickly. Also, a lot of performance information about lithium-ion batteries may be gleaned through real-world uses. This made the groundwork for using data-driven techniques to forecast the lithium-ion batteries' ageing life [9]. Compared with the other model-based methods, data-driven methods are of nonparametric, and do not consider the electrochemical principles to some extent. Thus, degradation models of lithium-ion batteries are developed with various mapping and regression techniques and tools. The systems use merit measurements to control battery performance. The performance and condition of the battery are estimated using data like the state-of-health (SOH) and state-of-charge (SOC). In [10] suggested a clever way to look at the aforementioned factors utilising a data-driven strategy. To estimate these values, we employ a machine learning technique that separates important features from the discharge curves.

RUL prediction based on Machine learning Algorithm modelling has made rise to numerous studies. Machine learning-based approaches have often provided a better performance than statistical approaches in terms of accuracy although more computational power is required. The proposed paper we have aimed to focus on A Naive Bayes (NB) and Gradient Boosting (GB) Machine Learning Algorithm for RUL prediction of batteries and the Error analysis of the model is carried out to optimize the battery's performance parameter.

The other sections of this paper are prepared as follows: Section II explains about the RUL Prediction Method Analysis. Section III Presents the Exposition of Machine Learning Algorithms. Section IV Presents Proposed work. Section V shows the experiment results of our proposed method. Section VI finally a conclusion is given.

II. RUL PREDICTION METHOD ANALYSIS

A review on prognostics approaches for remaining useful life of lithium-ion battery summarizes the approaches used in Li-ion battery RUL estimation. [11] Generally, the approaches for RUL estimation are divided into model-based and data driven.

DATA DRIVEN METHODS:

While the mechanisms and propagation rules of battery degradation are still unknown, data-driven techniques use past monitoring data directly to anticipate the degradation tendency of a battery. This approach develops a mathematical model or derives weight parameters based solely on training data, as opposed to adopting a particular physics-based model. This approach is more adaptable and useful because it does not need creating a complicated physics-based model, and it has garnered considerable interest from researchers all over the world. Based on whether they are based on data-driven methodologies, three categories of battery RUL prediction have been identified as shown in Figure 3 below

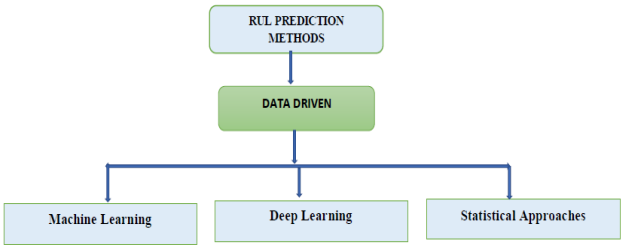


Fig 3: Data Driven RUL Method

Machine Learning Algorithms: Machine learning approaches can estimate battery RUL based on various measurements, such as current, voltage, and temperature, and, therefore, can be used at various operating conditions. The widespread use of data-driven residual life prediction in the field of equipment is encouraged by the continual improvement in the equipment's ability to continuously detect and monitor itself throughout its life cycle. Currently, the lithium-ion battery's data-driven prediction technique. RUL for batteries typically uses a solitary time-series forecasting model.[12] The prediction method's robustness and generalizability are insufficient. It needs more work to increase the prediction's robustness and accuracy. According to the predictions' outcomes, immediate preventive maintenance steps must be implemented to guarantee a reliable supply of electricity at all times. This study proposes an integrated learning method based on monitoring data to suit the lithium battery degradation model forecast their RUL. The relevance vector machine (RVM), the random forest (RF), the elastic net (EN), the autoregressive model (AR), and the long short-term memory (LSTM) Network are the five fundamental learners that make up the ensemble learning approach, which aims to improve prediction performance. In the ensemble learning approach, the final lithium battery prediction result is obtained by finding and determining the optimal weights of the basic learners using the genetic algorithm (GA). Battery cycle life study through relaxation and forecasting the lifetime via machine learning [13] GPR is a kernel-based probabilistic machine learning technique that has recently gained attention in battery lifetime prognosis. The Gaussian process is typically sensitive to inconsistent data. It is difficult to predict the state of charge (SoC) with battery management systems that are durable and reliable for electric vehicles. Predicting SoC estimation with significantly less degradation is exceedingly difficult because battery degradation is typically a non-linear process.[14] uses six machine learning algorithms to estimate the SoC of lithium-ion battery systems for use in electric car applications. The applied techniques are ensemble bagging (EBa), ensemble boosting, support vector machine (SVM), linear regression (LR), Gaussian process regression (GPR), and artificial neural network (ANN). To improve the battery's performance parameter, the model's error analysis is done.

Deep Learning Algorithms: One of the fields of machine learning known as "deep learning" developed from artificial neural networks and is characterised by several nonlinear processing layers (ANN). The deep network design of DL allows for the full collection of representative information from raw input data by stacking numerous layers on top of one another. In numerous domains, including image identification, audio recognition, and natural language processing, DL models have attracted significant attention and achieved notable successes. However, in the area of RUL prediction, it has not yet been completely utilised. Many studies using DL approaches for machine health monitoring have been conducted, but there are currently very few that concentrate on the use of DL for RUL prediction. Accurate RUL prediction can prevent fatal failures, lower maintenance costs, and dramatically increase the operational safety and reliability of industrial systems or components. In [15] research, RUL prediction is briefly introduced, and state-of-the-art DL techniques are reviewed in terms of four exemplary deep architectures: auto-encoder, deep belief network (DBN), convolutional neural network (CNN), and recurrent neural network. The deep learning approach increases remaining usable life forecast accuracy while decreasing the amount of time needed for characteristic testing, potentially increasing the power profitability of predictive energy management. In order to anticipate the remaining useful life, this article reviews, categorises, and compares various adaptive mathematical models on deep learning techniques. In [16] The modelling ability features are determined, and the adaptive prediction methods are categorised as a result. To evaluate various modelling accuracy in the deep learning calculation process, several criteria are provided. The most important characteristics of successful life prediction are employed to make pertinent deductions and recommendations, and the highly accurate deep convolutional neural network–extreme learning machine technique is chosen to be applied for the stable remaining life.[17] Although Multilayer Perceptron (MLP) has been used to forecast RUL, its network structure prevents it from automatically picking up salient features. This research proposes a unique deep convolutional neural network (CNN) based regression approach for estimating the RUL. Although CNN has been used for other tasks like speech recognition, computer vision, and natural language processing, this is the first attempt to use CNN for RUL estimate in prognostics.

Statistical model: Statistical model predicts the damage initiation and progression according to the previous inspection results on similar machines. This method does not need knowledge on the ageing mechanism, while it requires a large number of effective data set. Among them, autoregressive (AR), autoregressive and moving average (ARMA), autoregressive integrated moving average (ARIMA) models are widely used for the modelling and prediction of the time series data. In [18] a novel hybrid Elman-LSTM method for battery remaining useful life prediction by combining the empirical model decomposition algorithm and long short-

term memory and Elman neural networks. The empirical model decomposition algorithm is employed to decompose the recorded battery capacity verse cycle number data into several sub-layers. Comprehensive battery test datasets have been collected and used for model parameterization and performance evaluation.[19] SOC and SOH co-estimation scheme is proposed based on the fractional-order calculus. First, a fractional-order equivalent circuit model is established and parameterized using a Hybrid Genetic Algorithm/Particle Swarm Optimization method.

III. EXPOSITION OF MACHINE LEARNING ALGORITHMS

Machine Learning algorithms are the programs that can learn the hidden patterns from the data, predict the output, and improve the performance from experiences on their own. More complicated patterns of data can be learned and recognised by machine learning algorithms. Based on experience, various apps' system data. The most effective way for forecasting is machine learning, which gathers historical data throughout the life cycle. Additionally, by adaptively improving network parameters, they are appropriate for extremely nonlinear systems and approach the genuine state of the system. These techniques do, however, inevitably have their limitations. The main flow of machine learning is depicted in Figure 4.

Machine Learning Algorithm can be broadly classified into three types:

1. Supervised Learning Algorithms
2. Unsupervised Learning Algorithms
3. Reinforcement Learning algorithm

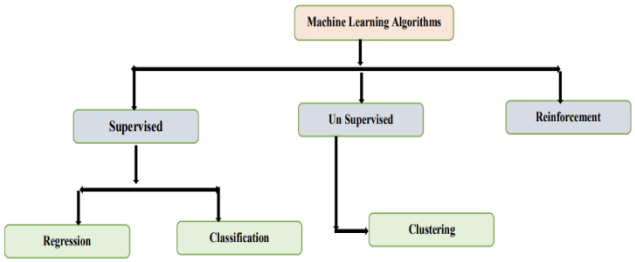


Fig 4: Flow of Machine Learning Algorithms

Supervised Learning Algorithms: In supervised learning, the machine is expected to deliver known outcomes. The training data is already supplied with predefined labels or outcomes. The algorithm has to identify matching characteristics or common features among training data that reference predefined labels/outcomes. Post-training, the same features/attributes are compared to label unknown data. The two most common learning problems are usually solved by supervised learning are classification and regression. Classification deals with labelling input data with predefined labels. Regression deals with deriving outcomes of unknown input data based on learned correlations between training data and known outcomes. The derived outcome is a numerical value or result.

Some of the common machine learning algorithms that fall under supervised learning include K Nearest Neighbor, Random Forest, Logistic Regression, Decision Trees, and Back Propagation Neural Network.

Unsupervised Learning: In unsupervised learning, the machine is expected to deliver unknown outcomes. The machine is exposed to unlabelled raw data samples and it must deduce structures present in the input data. This is usually done mathematically by either extracting similarities or removing redundancies. The outcome of machine learning is not a class/label or a numerical output; instead, the output is delivered by grouping similar data samples or identifying the odd ones.

Some of the common problems solved through unsupervised learning are clustering, association rule mining, and dimensionality reduction. Some of the common machine learning algorithms that fall under unsupervised learning include K-Means Clustering, Apriori Algorithm, KNN, Hierarchal Clustering, Singular

Value Decomposition, Anomaly Detection, Principal Component Analysis, Neural Networks, and Independent Component Analysis.

Reinforcement learning algorithms: In reinforcement learning, a system called an agent is developed to interact in a specific environment so that its performance for executing certain tasks improves from the interactions. The agent starts from a predefined initial set of policies, rules, or strategies and then is exposed to a specific environment in order to observe the environment and its current state. Based on its perception of the environment, it selects an optimal policy/strategy and performs actions. In response to every action, the agent gets feedback from the environment in the form of a reward or penalty. It uses the penalty/reward to update its policy/strategy and again interacts with the environment to repeat actions. Some of the common machine learning algorithms that fall under reinforcement learning include Q-Learning.

IV. RECOMMENDED ML ALGORITHMS

In the proposed work two supervised machine learning algorithms i.e, Gradient Boosting from Regression and Naïve Bayes from classification are compared for the RUL Prediction:

A. Gradient Boosting Regression:

In Machine Learning, we use gradient boosting to solve classification and regression problems. It is a sequential ensemble learning technique where the performance of the model improves over iterations. This method creates the model in a stage-wise fashion. It infers the model by enabling the optimization of an absolute differentiable loss function. As we add each weak learner, a new model is created that gives a more precise estimation of the response variable. The gradient boosting algorithm requires the below components to function as shown in Figure 5.

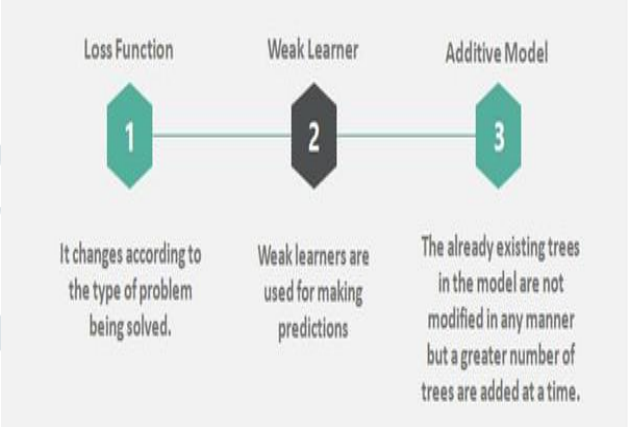


Fig 5: Gradient Boosting Functions

1. **Loss function**: To reduce errors in prediction, we need to optimize the loss function. Unlike in AdaBoost, the incorrect result is not given a higher weightage in gradient boosting. It tries to reduce the loss function by averaging the outputs from weak learners.

2. **Weak learner**: In gradient boosting, we require weak learners to make predictions. To get real values as output, we use regression trees. To get the most suitable split point, we create trees in a greedy manner, due to this the model overfits the dataset.

3. **Additive model**: In gradient boosting, we try to reduce the loss by adding decision trees. Also, we can minimize the error rate by cutting down the parameters. So, in this case, we design the model in such a way that the addition of a tree does not change the existing tree.

The state of charge estimation of lithium-ion battery systems by using an extreme gradient boosting algorithm for electric vehicles application, which acquires the nonlinear relationship model can with offline training. [20] The gradient boosting algorithm is the tree on based learning, which effectively performs and speeds. Voltage-time data used as an input of this system from the partial constant current phase; the proposed

algorithm improves the accuracy of predicting the relevant. Additionally, no initial state of charge is required in our proposed method; thus, estimating the state of charge can consider each battery state. Gradient Boosting Tree is a type of ensemble where additional trees are added at each stage to compensate the shortcoming of the existing model. These models are generally employed where features are too heterogeneous.[21] In this model of Gradient Boosting Regressor we have used Huber loss function in loss function parameter. X Consider a training set (x_i, y_i) (where i = 1, 2, 3.....N) and a differential loss function (i.e. 'deviance' in this case) L(y_i, z), where z is the predicted value. Initialize the model as

$$f_0(x) = argmin_z \sum_{i=1}^{i=n} L(y_i, z) \qquad (1)$$

For each observation in each tree calculate the gradient which is given by

$$\theta_{jm} = argmin_z \sum L(y, z + f(x_i)) \qquad (2)$$

Now, update the model of the succeeding tree with the gradient of the previous tree. This is given by

$$f_m(x) = f_{m-1}(x) + \sum_{j=1}^{j=Jm} l_{jm} * I \qquad (3)$$

for each x which belongs to the region of that tree (i.e. R_{jm}) The overall output is given by $f_m(x)$.

B. **Naïve Bayes**: The NB model assumes every predictor variable is independent. Thus, this means that it uses Bayes' Theorem in a naive way, which means it is a special case of a Bayesian Network. NB uses Bayesian statistics, which is based on Bayes' Theorem. It predicts the class of a test case with values T = a_1, a_2, a_3, . . . , a_n by choosing the class ci , which optimizes as shown in equation below by maximizing it . In Equation (4) P(c_i |T) denotes the conditional probability of class ci given test case T.

$$P(c_i|T) = \frac{P(T,c_i)}{P(T)} = \frac{P(c_i).P(T|c_i)}{P(T)} \qquad (4)$$

In this model, the probability estimation of each class is provided by the training set. As the model tries to maximize Equation (4), the denominator is reduced as much as possible so it can be removed from the equation as it does not have a direct contribution to the prediction process.

In addition, NB classifier is able to calculate the joint probability P(T|c_i) by assuming that all the attributes are conditionally independent given the class c_i. Therefore, Equation (5) shows how the model calculates the joint probability. This shows that the predictions made by the model depend only on the values of P(c_i) and P(a_j |c_i).

$$P(T|c_i) = P(a_1, a_2, \ldots\ldots a_n, c_i)$$

$$\approx P(c_i)P(a_1|c_i)P(a_2|c_i)P(a_n|c_i) \qquad (5)$$

$$= P(c_i).\prod_{j=1}^{n} P(a_j|c_i)$$

The main advantage of using NB is that it only needs small datasets for training. Moreover, training the model is fast and is not time-consuming. A naive Bayes (NB) model is proposed for RUL prediction of batteries under different operating conditions. [22] It is shown in this analysis that under constant discharge environments, the RUL of Li-ion batteries can be predicted with the NB method, irrespective of the exact values of the operating conditions. The case study shows that the NB generates stable and competitive prediction performance over that of the support vector machine (SVM). Robust Remaining Useful Life Prediction for Li-ion Batteries a Naïve Bayesian Classifier was shown in the figure 6 below. In [23] presents an empirical procedure for predicting robust remaining useful life (RUL) using a naïve Bayesian classifier (NBC) with time as the response.

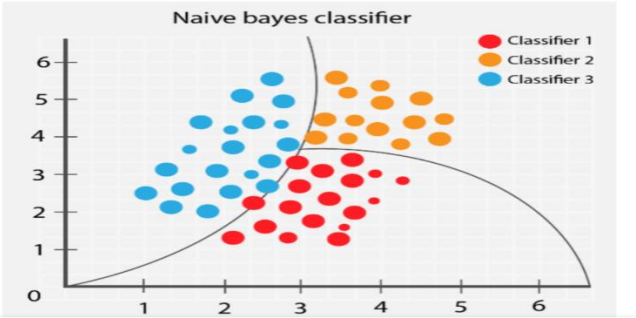


Fig 6: Naïve bayes classifier

The method is illustrated using public data for predicting Li-ion battery RUL to end-of-life (EOL). A battery life prediction is obtained using the capacity values up to the prediction time. The root mean squared error (RMSE) is used for performance evaluation. The prediction performance of the NBC is compared with that of a support vector machine (SVM). Thus, Naive Model assumes every predictor variable is independent. Thus, this means that it uses Bayes Theorem in a naive way, which means it is a special case of a Bayesian Network.

V. EXPERIMENTAL RESULTS

A. Lithium-ion battery Data set

In the early days of lithium-ion batteries, the lifetime of the battery was short. Consequently, accelerated aging tests are needed to obtain battery aging data in a short period of time, with different charge-discharge rates, and ambient temperature being the most commonly selected stress factors. However, conducting battery aging tests is time consuming, and extracting battery features from different aging cycles requires a complex and expensive signal acquisition system. Therefore, battery aging data are required to construct an RUL prediction algorithm and validate its stability and accuracy. Therefore, many researchers have utilized publicly available battery datasets to verify their RUL prediction algorithms. The Hawaii Natural Energy Institute examined 14 NMC-LCO 18650 batteries with a nominal capacity of 2.8 Ah, which were cycled over 1000 times at 25°C with a CC-CV charge rate of C/2 rate and discharge rate of 1.5C.

In [24] The publicly available databases for battery life cycles do not provide ready-to-use data for this project. Although they contain different variables such as voltage (V), current (A), time (S), discharge and charge capacity (Ah), and charge and discharge energy (Wh), not all of them can be used for this project. The objective is to use only voltage, current, and time as inputs. Nonetheless, employing these variables directly as inputs is not feasible since they provide meaningless information and are not sufficient to create a model. Therefore, they need to be treated and manipulated as a base to develop new features which the neural network will train with.

B. Performance Error Indices

Regression ML methods deal with predicting a target value using independent variables. [25] Most of the works conducted so far in the areas of engineering applications only utilized a few of the above Performance Fitness and Error Matrices.The bulk of here viewed works continue to incorporate traditional metrics such as MSE and RMSE as primary indicators of adequacy of the regression-based models.

Mean Absolute Error (MAE): Measures the Difference Between two Continuous variables. It also uses a similar scale to input data. It can also be used to compare series of different scales.

$$\text{MAE}=\frac{\sum_{i=1}^{n}|E_i|}{n} \qquad (6)$$

Mean Square Error (MSE): Measures the average of the squares of the errors. It is scale dependent and the values are closer to zero present adequate state.

$$\text{MSE} = \frac{\sum_{i=1}^{n} E_i^2}{n} \qquad (7)$$

Root Mean Square Error (RMSE): Root Square of average squared error. It is scale dependent, A lower value for RMSE is favourable. Highly dependent on fraction of data used.

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} E_i^2}{n}} \qquad (8)$$

C. RUL prediction frame work

There are three necessary steps that have to be followed to build an RUL prediction model, in particular, model selection, reconstruction, and prediction. Model Selection is an important step which involves dedicated experience in selecting the appropriate ML algorithm from a set of models based on data characteristics. model selection involves examining four main criteria, in particular, data availability, data complexity, data drift, and model complexity. Model reconstruction a set of well-defined steps of training to generalize the prediction model over both training and unseen samples. Predicting the Remaining Useful Life (RUL) one of the most important indicators to detect the component's failure before it effectively occurs.

D. **Effect of training set size on prediction performance**

In this paper, different observations are used for training the data and three separate observations are used for testing. It is well known that the size of training set used affects the test performance of a method accuracy on the training set increases. The testing prediction accuracy also increases, until the noises in the training set are also modelled (overfitting). After this point, the testing prediction accuracy decreases with increase in training set size, although the training prediction accuracy continues to increase. Table 1 shows Comparison of NB & GB performance error indices. The average RMSE of the NB is lower than that of the GB for training set sizes of three or more.

Table1: Comparison of NB & GB performance error indices

Machine Learning Algorithm	MAE	MSE	RMSE	TIME
NAÏVE BAYES	4.644	54.543	7.385	0.024
GRADIENT BOOSTING	4.984	57.447	7.579	2.564

Fig 7,8 & 9 shows the testing performance and Performance Error Indices of the Naive Bayes and Gradient Boosting Method when the data set is trained.

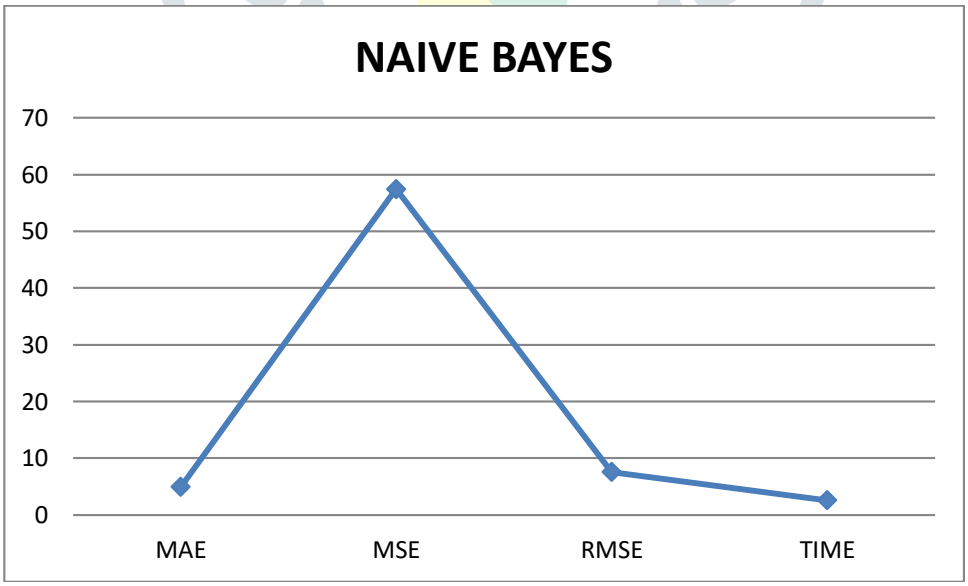


Fig 7: Plot of Naive Bayes

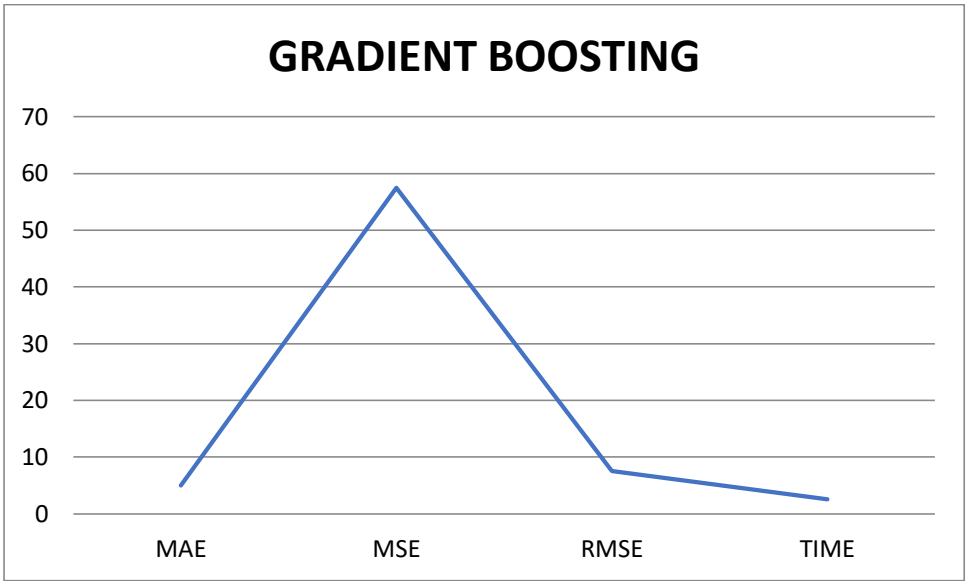


Fig 8: Plot of Gradient Boosting

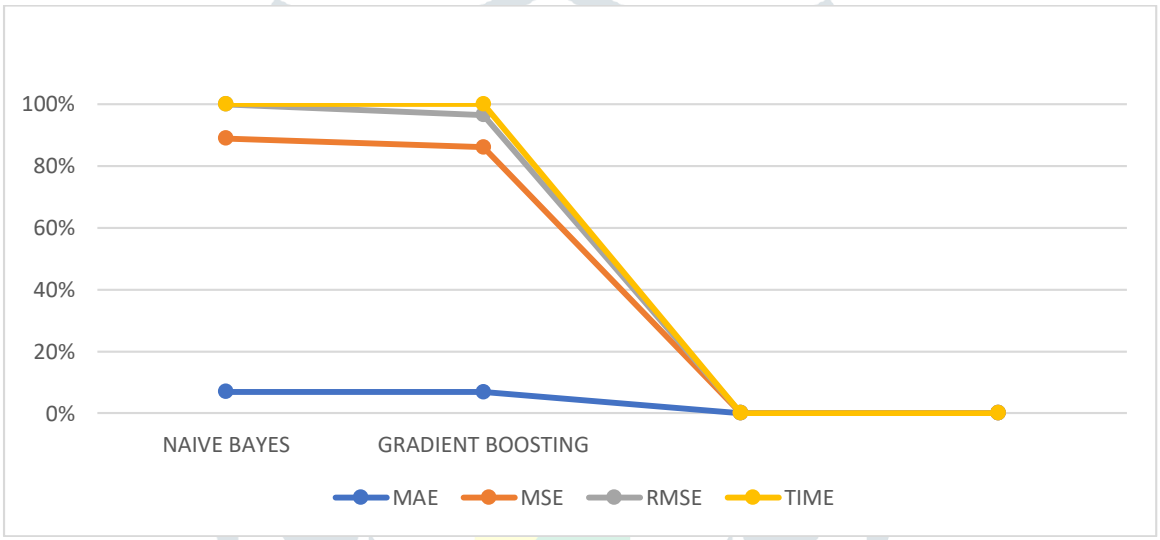
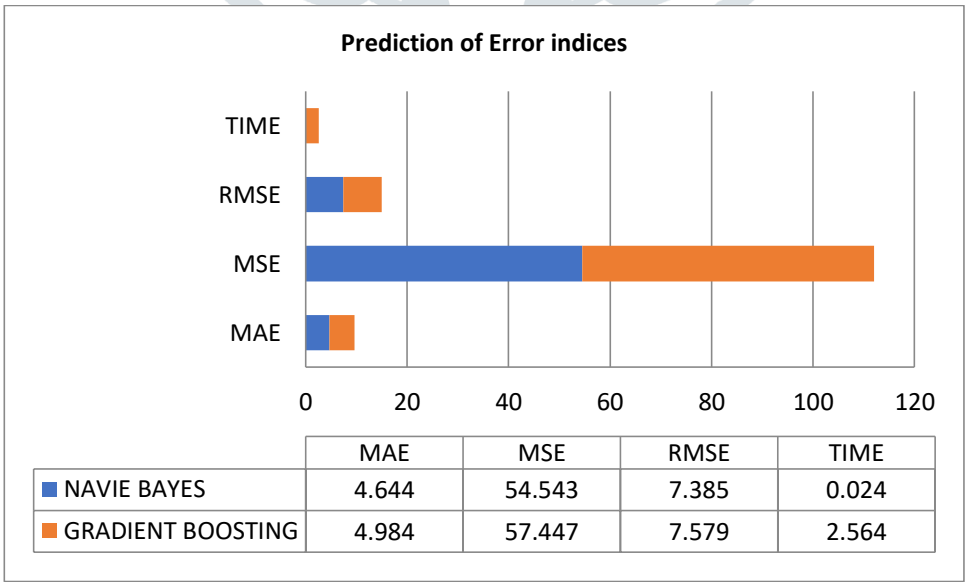


Fig 9: RUL prediction Analysis for performance error indices

Table 2: Prediction of Error indices



	MAE	MSE	RMSE	TIME
NAVIE BAYES	4.644	54.543	7.385	0.024
GRADIENT BOOSTING	4.984	57.447	7.579	2.564

However, the probability estimates of the NB are utilized in the RUL prediction so bias introduced by any deviations from the linked independence assumption is reflected in the accuracy of the final RUL predictions. These results show the robustness of the NB method at different times and with the batteries data set. Although

the NB produces close-to actual battery life predictions in less than of total battery life. Over all, the prediction performance of the NB is more stable and practical than that of the GB in this case study.

VI CONCLUSION

An empirical Procedure for Producing Robust and Practical RUL Predictions Using the Data Driven Machine Learning Algorithms. Using time as the Response, Stable and Accurate Predictions were Obtained with a simple and efficient method and the Transformation to RUL is Straight forward. The method was illustrated using Hawaii Natural Energy Institute data set to predict RUL For Lithium-ion Battery. In this Paper we have Proposed a new data driven methods of Machine Learning Algorithms for Prediction of RUL using Naive Bayes (NB) and Gradient Boosting (GB) method which is simple and efficient. Stable and accurate RUL Predictions over time are obtained for batteries under different operating conditions. A Comparison of Naive Bayes (NB) Algorithm and Gradient Boosting (GB) Algorithm is proposed for RUL prediction of batteries and the Error analysis of the model is carried out to optimize the battery's performance parameter. Thus, the statistical indicators like MAE, MSE and RMSE are Calculated and the results show that NB generates competitive prediction performance over the GB.

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Reactive Extraction of Gluconic Acid Using Tri-n-octylamine in 1- Hexanol

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Abstract-Gluconic acid is an important carboxylic acid widely used in chemical, pharmaceutical, food and other industries. The growing importance of biological production (fermentation) expressed with new routes and increasing production rates, leads to look for technologies of downstream processing for product separation.

Tertiary amines are effective extractants for separation of carboxylic acid from dilute solutions. The basic principle of recovery of acid by tertiary amines is through reaction with extraction. Generally, amines are used in diluents to improve their physical properties and to provide salvation of the complexes formed by them with the acids. The recovery of Gluconic acid with Trioctylamine and 1-hexanol is carried out for different Concentrations of acid, Trioctylamine (TOA) and 1-Hexanol

Key words: Reactive Extraction, Gluconic Acid, Tri-n-Octyl amine, 1-hexanol

1. INTRODUCTION

The carboxylic acids like tartaric acid, formic acid, pyruvic acid, acetic acid, succinic acid propionic acid, lactic acid, citric acid, gluconic acid, malic acid etc., are produced using aerobic fermentation process from past few decades. Separation of carboxylic acids from fermentation broth is anintriguing task. Since the downstream processing of carboxylic acids not only account for up to 50-60% of the manufacturing cost but also generates a large amount of solid wastes. With the burgeoningemphasis of production of carboxylic acidfrom fermentation technology. It is significant to originate an efficient, eco-friendly and economical method to separate carboxylic acids from fermentation broth. Several separation techniques have been researched for the separation of carboxylic acids like membrane separation, solvent extraction, liquid-liquid extraction, ultrafiltration, reverse osmosis, distillation, dialysis, electrodialysis, adsorption and ion exchange. These separation methods have certain drawbacks such as efficiency is less, expensive, the intricacy of operation and utilization of energy is huge. Reactive extraction with a desirable organic solvent has proved to be an efficient method to separate carboxylic acids from fermentation broth.

Reactive extraction is a separation technique used to enhance the extraction of solute from the AP to the OP. The extractant molecule reacts with the solute molecule to form a reaction complex, which will stabilize in OP due to the hydrogen bonding with 1-hexanol and hydrophobic nature of complex Reactive extraction has variousrewardslikeenhanced reactor productivity, amelioratecontrol over pH in the bioreactor, reduces the downstream processing load, minimizes the solvent recovery cost, phase equilibrium enhanced and higher efficiency. Therefore, it has fascinated several scientists to research the process and the effect of distinct parameters like the effect of pH, effect of temperature, kinetics of extraction and concentration of acid, extractant and diluents.

Gluconic acid is a carboxylic acid (pentahydroxycaproic acid, $C_6H_{12}O_7$) is the oxidation product of glucose, naturally occurring in plants, fruits, wine (up to 0.25%), honey (up to 1%), rice, meat, vinegarand other natural sources.Gluconic acid is the largest commercially produced of fungal organic acids, from glucose. Demand for metal gluconates is steadily increasing due to their multiple applications in different industries.

In the current work, an investigation on the recovery of gluconic acid from aqueous solution was aimed by employing TOA in 1-hexanol. The equilibrium parameters such as K_D, E %, Z are evaluated using experimental data.

2. THEORY

The extraction process was analyzed through the K_D.The distribution coefficient (K_D) is defined as the ratio of total concentration of acid in all forms (partition, dimers & as complexes) in the organic phase to total concentration of all existing forms (ionized & un-ionized) in the aqueous phase by assuming no change in volume at equilibrium.

$$K_D = \frac{[\overline{GA}]_{total}}{[GA]_{total}}$$

Where, $[\overline{GA}]_{total}$= Concentration of acid in organic phase.
$[GA]_{Total}$= Concentration of acid in aqueous phase.

The extraction efficiency (E %) is defined as the proportion of gluconic acid concentration in the OP to the sum of gluconic acid concentration in organic andAP

$$E\% = \frac{K_D}{1+K_D} \times 100$$

The value of Z depends on the extractability of the acid (strength of the acid base interaction) and its aqueous concentration. The stoichiometry of the overall extraction equilibrium depends on the loading ratio in organic phase (Z). If the organic phase is not highly concentrated by acid, i.e., at very low loading ratios (Z < 0.5), 1:1 complex of acid and extractant is formed.

The extent to which organic phase (TOA+Decanol) can be loaded with carboxylic acid is expressed as the loading ratio, Z;

$$Z = \frac{[GA]_{Org}}{[T]_{Org}}$$

Where, $[GA]_{org}$= Concentration of acid in organic phase after extraction.
$[T]_{org}$= Concentration of TOA in organic phase before extraction.

3. MATRIALS AND METHODS

Materials

Gluconic Acid ($C_6H_{12}O_7$)(49-53 wt % of H_2O), molar mass 116.11 kg/kmol, density 1.134 g/ml at 250C, 97 % purity was procured from Sigma-Aldrich (India). TOA (N,N-dioctyloctan-1-amine) ($C_{24}H_{51}N$)a tertiary amine is a colour less liquid with the molecular weight of 353.66 g/mol, density 0.81 g/cm3at 200C, 98 % purity, was procured from Sigma-Aldrich (India). 1-Hexanol (Hexyl alcohol, $C_6H_{14}O$), molar mass 102.17 kg/kmol, density 0.814 g/ml at 250C, 98 % purity was used as a diluent was obtained from Sigma-Aldrich (India). Sodium Hydroxide (0.1 N of NaOH) used for volumetric analysis is of laboratory gradeused for titration. Phenolphthalein solution with pH range 8.2 to 10 was used as an indicator was procured from Ranbaxy, India. Distilled water was used to prepare the solutions of various initial concentrations of Gluconic acid solutions. The initial concentration of TOA in 1-hexanol was varied from 10% to 50% on volume basis. The aqueous phase consists of Gluconic acid and water and the organic phase consists of TOA and 1-hexanol.

Methods

Equilibrium Studies:

Optimum time was calculated (12 hours) to attain liquid-liquid equilibrium for both physical extraction and chemical extraction by analyzing the samples at regular intervals of time. The initial concentrations of gluconic acid were 0.0634, 0.12653, 0.1897, 0.25306, 0.31632 mol/L respectively**.**

Physical equilibrium:

For physical equilibrium, 20 ml of gluconic acid (AP) of different concentrations were taken in different conical flasks and 20 ml of 1-hexanol (OP) was added in each conical flask. Mechanical shakers were used to thoroughly mix both the phases for 12hrs at room temperature. The organic and aqueous phases were permitted to steady down in a separating funnel for 2 hours. A sample fromAP was titrated with 0.1N NaOH using Phenolphthalein as an indicator to measure the concentration of gluconic acid in the AP. Mass balance was used to calculate the concentration of gluconic acid in the OP.

Chemical equilibrium:

For chemical equilibrium, 20 ml of gluconic acid and 20 ml of 10 % TOA (0.2264 mol/L) in 1-hexanol was added in a conical flask. The non-miscible solution was kept in shakers for 12 hours and then allowed to settle for 2 hours. The gluconic acid concentration was determined from the aqueous phase by titrating a sample solution with 0.1N NaOH using Phenolphthalein as an indicator. The same procedure was repeated for 20%, 30% and 40% TOA.

4. RESULTS AND DISCUSSION

Data obtained from the experiments are tabulated and compared to know the amount of the gluconic acid extracted from aqueous solution using the physical and chemical equilibrium methods with different concentration of the TOA. From the equilibrium data, the K_D, E %, Z, are calculated as shown in Table 1 and Table 2.

Physical equilibrium

The most effective diluents are alcohols since they enhance the extraction of carboxylic acids. Therefore, 1-hexanol which is intermediate molecular weight alcohol is used as a diluent. The physical equilibrium data values for gluconic acid using 1-hexanol are shown in Table 1. It is observed that an increase in the initial concentration of acid increases the concentration of acid in both aqueous and organic phase. It is observed that distribution coefficient K_D decreases with increase in initial concentration of gluconic acid because the increase in concentration of acid in aqueous phase is higher than the concentration of acid in organic phase.

[GA]In Mol/L	[GA]Aq	[GA]Org	K_D	E%
0.03	0.01	0.019	1.9	65.517
0.06	0.02	0.03	1.5	60

0.12	0.04	0.046	1.15	53.48
0.18	0.06	0.055	0.916	47.807
0.2	0.07	0.06	0.857	46.149
0.3	0.13	0.07	0.538	34.98

Table 1:Physical equilibrium of water – Gluconic acid – 1-Hexanol

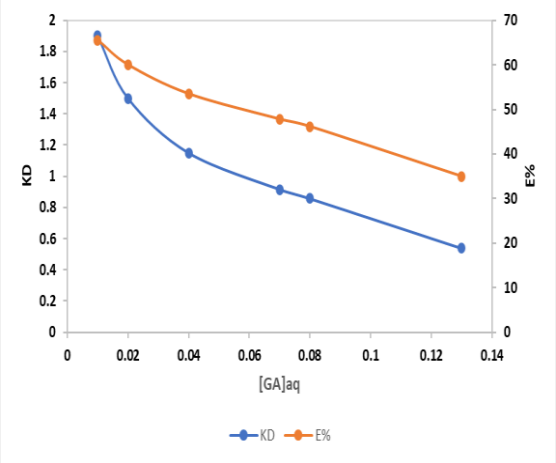


Fig 1: Equilibrium distribution of water – Gluconic acid – 1-Hexanol

Chemical equilibrium

The most effective diluents are alcohols since they enhance the extraction of carboxylic acids. Therefore, 1-hexanol which is intermediate molecular weight alcohol is used as a diluent. The chemical equilibrium data values for gluconic acid using 1-hexanol are shown in Table 2.

In this chemical equilibrium TOA is added 10-50%.It is observed that an increase in the initial concentration of gluconic acid increases the concentration of acid in both aqueous and organic phase. It is observed that distribution coefficient K_D decreases of Gluconic acid in aqueous phase $[HA]_{aq}$ because K_D is the ratio of concentration of acid in organic phase to the concentration of acid in aqueous phase. The chemical extraction distribution coefficient is found to be higher than physical extraction for all acid concentrations.
It is observed that extraction efficiency E% decreases, increases concentration of Gluconic acid in aqueous phase $[HA]_{aq}$ because E% is the ratio of concentration of acid in organic phase to the sum of acid concentration in aqueous and organic phase. It is observed that Loading Ratio Z increases with an increase in the concentration of acid in aqueous phase. The loading ratio decreases with an increase in the concentration of TOA because complexes involving more acid molecules are formed at lower concentrations of TOA.

10% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	2.11
0.02	0.0808	4.04	80.158	2.39
0.05	0.11514	2.3028	69.715	3.36
0.07	0.1313	1.8757	65.2258	3.76
0.11	0.15554	1.414	58.57	4.56
0.211	0.1818	0.8616	46.2827	4.83
20% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	1.95
0.02	0.0909	4.545	81.9657	2.26
0.05	0.1313	2.626	72.4214	3.25

0.07	0.14948	2.1354	68.106	3.58
0.11	0.1717	1.5609	60.951	4.32
0.211	0.19796	0.93819	48.405	4.64
30% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	1.83
0.02	0.10504	5.252	84.005	2.13
0.05	0.14746	2.9492	74.678	3.11
0.07	0.16968	2.424	70.79	3.39
0.11	0.18988	1.72618	63.318	4.14
0.211	0.21412	1.01478	50.36	4.49
40% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	1.74
0.02	0.1212	6.06	85.835	1.99
0.05	0.16564	3.3128	76.813	2.88
0.07	0.18584	2.6548	72.368	3.26
0.11	0.20604	1.87309	65.194	3.97
0.211	0.23028	1.09137	52.188	4.26
50% TOA				
[GA]aq	[GA]org	KD	E%	Z
0.01	0.064	6.4	86.486	1.65
0.02	0.13332	6.666	86.955	1.84
0.05	0.1818	3.636	78.429	2.68
0.07	0.19998	2.8568	74.07	3.11
0.11	0.22624	2.0567	67.284	3.63
0.211	0.25048	1.1871	54.277	4.12

Table 2: Equilibrium for reactive extraction of gluconic acid with various concentrations of TOA (10-50%) in 1- hexanol

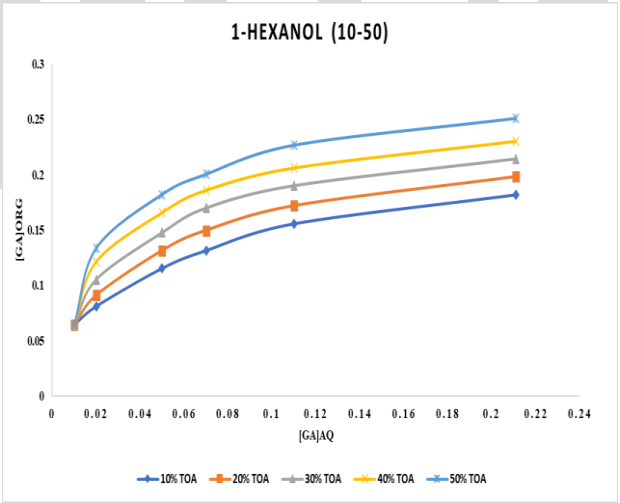


Fig 2: Equilibrium for reactive extraction of Gluconic acid with various concentrations of TOA in 1-Hexanol

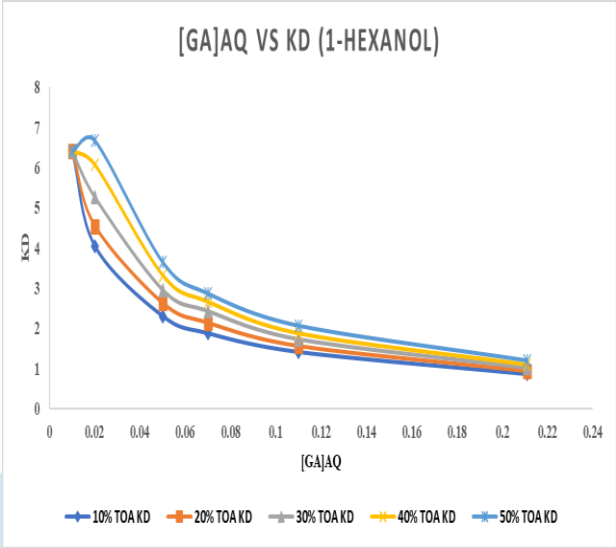


Fig 3: Effect of concentration of acid in aqueous phase on Distribution Coefficient with variable TOA Concentration in 1-Hexanol

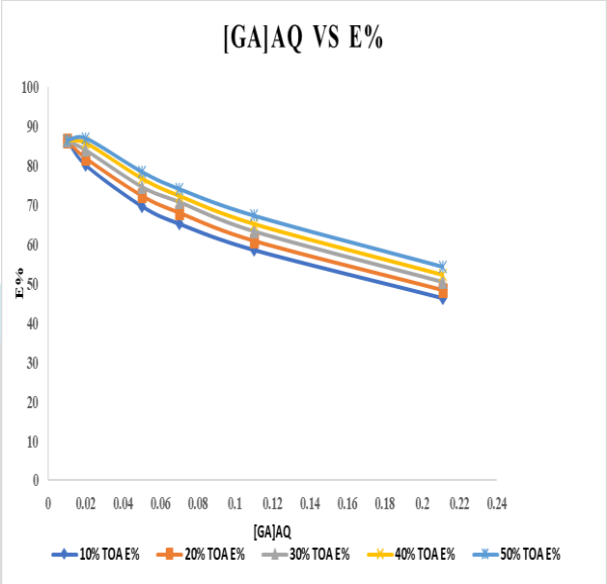


Fig 4: Effect of concentration of acid in aqueous phase on Extraction Efficiency with variable TOA Concentration in 1-Hexanol

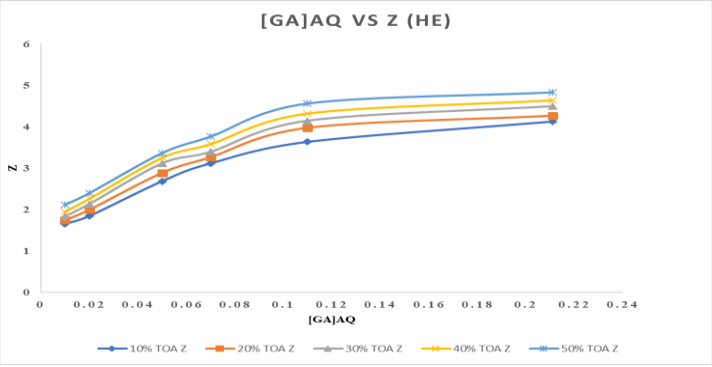


Fig 5: Effect of concentration of acid in aqueous phase on Loading Ratio (Z) with variable TOA concentration in 1-Hexanol

V. CONCLUSION

The experiments conducted for the reactive extraction of Gluconic acid with TOA in 1-hexanol were investigated. The key findings are as given below

- The physical and chemical equilibria for the extraction of gluconic acid by tri-n-octyl-amine in 1-hexanol are determined. The chemical extraction is found to be superior over to physical extraction.
- The optimum TOA concentration is found to be 50% at which K_D values for 1-hexanol is 6.66.
- The loading ratio Z decreases with an increase in TOA initial concentration in 1-hexanol is 4.83. It increases with an increase in concentration of acid in aqueous phase.
- The degree of extraction of acid increased with decreased in initial concentration of acid and increase in TOA concentration is 86.95%.

VI. NOMENCLATURE

K_DDistribution coefficient

E%Extraction efficiency or degree of extraction

ZLoading ratio

[GA] Concentration of Gluconic acid (mol/L)

[T] Concentration of Tri-n-octylamine (mol/L)

HEHexanol

Subscripts

aq aqueous phase

org organic phase

VII. ABBREVIATION

TOA Tri-n-octylamine

AP Aqueous phase

OP Organic phase

ICGA Initial concentration of Gluconic acid

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Production of biodiesel from Palmolein oil, Ricebrane oil, Neem oil and their yield comparison

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***Abstract*— Biofuel production from renewable sources is widely considered to be one of the most sustainable alternatives to petroleum sourced fuels and a viable means for environmental sustainability. Biodiesel is an alternative fuel similar to conventional or 'fossil' diesel. Biodiesel can be produced from vegetable oil, animal oil/fats and waste cooking oil. The process used to convert these oils to Biodiesel is called transesterification. The largest possible source of suitable oil comes from oil crops such as palm, rice, neem, ground nut etc. Biodiesel has many environmentally beneficial properties. The main benefit of Biodiesel is that it can be described as 'carbon neutral', this property of Biodiesel may helpful in the future carbon border adjustment tax. Biodiesel is biodegradable and completely non-toxic, meaning spillages represent far less of a risk than fossil diesel spillages. Biodiesel has a higher flash point than fossil diesel and so is safer in the event of a crash. Present study focuses on production of biodiesel from Palm olein oil, Rice brane oil, Neem oil and their yield comparison. All the experiments were carried out in batch mode. To produce Biodiesel, oils are heated to 60 ^{0}C and (1:4, 1:5, 1:6, 1:7, 1:8) oil to methanol molar ratio, containing 0.5g KOH catalyst, added to heated oil and stirred to 60 min. The fuel properties of produced biodiesel such as density, flash point, fire point, kinematic viscosity was analyzed and compared to conventional diesel, biodiesel and acid value, % free fatty acid, saponification value, ester values are founded.**

***Index Terms*—Biodiesel, Batch process, Palm olein oil, Rice brane oil, Neem oil, Catalyst.**

I. INTRODUCTION

Transesterification of vegetable oils was conducted as early as 1853 by Scientists, E. Duffy and J. Patrick, many years before the first diesel engine became functional. Rudolf Diesel (1858–1913) prime model, a single 3 m (10ft) iron cylinder with a fly wheel at its base, run on its power for the first time in Augsburg, Germany, on August 10, 1893. In remembrance of this event, August 10 has been declared ―International Biodiesel Day (Lin et al., 2011). Diesel later demonstrated his engine and received the Grand Prix (highest prize) at the World Fair in Paris, France in 1900.

This engine stood as an example of Diesel 's vision because it was powered by peanut oil a biofuel, though not biodiesel, since it was not trans-esterified. He believed that the utilization of biomass fuel was the real future of his engine. In a 1912 speech Diesel said, ―The use of vegetable oils for engine fuels may seem insignificant today but such oils may become, in the course of time, as important as petroleum and coal-tar product of the present time. During the 1920s, diesel engine manufacturers altered their engines to utilize the lower viscosity of petrol diesel (a fossil fuel) which was much cheaper to produce, rather than vegetable oil.

Scientists are currently researching ways to produce biodiesel using new feed stocks that are less limited by the availability of land. For example, some types of algae can produce oil. Energy crops could also be grown on land that is not suitable for food crops, such as soil that is too acidic or too salty, that has too many minerals or is too shallow, or that is in danger of eroding. In these cases, energy crops might help stabilize and restore this land.

Scientists are also experimenting with producing fuel from feed stocks such as inexpensive, non-edible biomass (agricultural residue, waste from the wood products industry, and switch grass and other grasses) that can be converted into a diesel replacement. While it is a fairly simple process to convert vegetable oil or animal fat into biodiesel, the conversion of cellulosic feed stocks to fuel is more complicated and more expensive. To produce a hydrocarbon fuel, the biomass is generally first converted into a synthetic gas using high heat. Then the gas can be converted into a liquid diesel fuel.

II. BENEFITS OF BIODIESEL

- It is a renewable fuel that can be derived from soybean oil, vegetable oils, animal fats and algal oils, used cooking oil can even be recycled to produce the bio fuels.
- At the tailpipe, biodiesel emits 4.7 % more CO2 than petroleum diesel. However, if biomass carbon is accounted for separately from fossil-derived carbon one can conclude that biodiesel reduces emissions of carbon monoxide (CO) by approximately 50 % emission and carbon dioxide by 78% on a net lifecycle basis because the carbon in biodiesel emissions is recycled from carbon that was in the atmosphere, rather than the carbon introduced from petroleum that was sequestered in the earth 's crust.
- Biodiesel contains fewer aromatic hydrocarbons: benzo fluoranthene: 56 % reduction; Benzopyrenes: 71 % reduction.
- It is a domestic product that lessens the dependence on foreign oil and produces jobs for the economy.
- Biodiesel can reduce by as much as 20 % the direct (tailpipe) emission of particulates, small particles of solid combustion products, on vehicles with particulate filters, compared with Low-Sulphur (<50 ppm) diesel. Particulate emissions as the result of production are reduced by around 50 %, compared with fossil-sourced diesel. (Beer et al, 2004).

- Biodiesel has a higher cetane rating than Petro-diesel, which can improve performance and clean up emissions compared to crude Petro-diesel (with cetane lower than 40).
- Since biodiesel is more often used in a blend with petroleum diesel, there are fewer formal studies about the effects on pure biodiesel in unmodified engines and vehicles in day-to-day use. Fuel meeting the standards and engine parts that can withstand the greater solvent properties of biodiesel is expected to—and in reported cases does—run without any additional problems than the use of petroleum diesel.
- The flash point of biodiesel (100-170 0C) is significantly higher than that of petroleum diesel (55-65 0C) or gasoline (-23 0C) which makes it safer to handle. The gel point of biodiesel varies depending on the proportion of different types of esters contained.

III. BIODIESEL PRODUCTION IN A BATCH REACTOR BY USING TRANSESTERIFICATION PROCESS

The transesterification process is a reaction between triglycerides in the vegetable and alcohol which produces the biodiesel (mono alkali ester) and glycerol. [A. Rajalingam et al J. Chem. Pharm. Res., 2016]

Biodiesel is obtained through transesterification reaction of palm olein oil, rice brane oil, neem oil by methanol, using potassium hydroxide as a catalyst. The reaction is taking place in a batch reactor.

THEORY

Biodiesel production is gaining increasing attention since in principle can reduce more CO2 emissions significantly. It has also many other environmental advantages. The most common way to obtain biodiesel is the transesterification reaction of vegetable oils in the presence of a low molecular weight alcohol and a catalyst. The transesterification reaction involves the exchange of organic groups R1, R2, R3 belonging to a glyceride with the organic group of an alcohol R'.

The transesterification reaction: R1, R2, R3 is a mixture of various fatty acid chains. The alcohol used for producing biodiesel is usually methanol (R′ = CH3). The overall process is normally a sequence of three consecutive steps, which are reversible reactions. In the first step, diglyceride is obtained from triglycerides, from diglyceride monoglyceride is produced and in the last step from monoglycerides glycerin is formed. In all these reactions fatty acid methyl esters (FAME) are produced. However, an excess of alcohol is usually more appropriate to improve the reaction towards the desired product [8].

Reaction Mechanism

The mechanism of the base-catalyzed transesterification of vegetable oils is shown below. The first step is the reaction of the base with the alcohol, producing an alkoxide and the protonated catalyst. The nucleophilic attack of the alkoxide at the carbonyl group of the triglyceride generates a tetrahedral intermediate, from which the alkyl ester and the corresponding anion of the diglyceride are formed. The latter deprotonates the catalyst and reacts with a second molecule of alcohol starting a new catalytic cycle. Diglycerides and monoglycerides are converted by the same mechanism to a mixture of alkyl esters and glycerin.

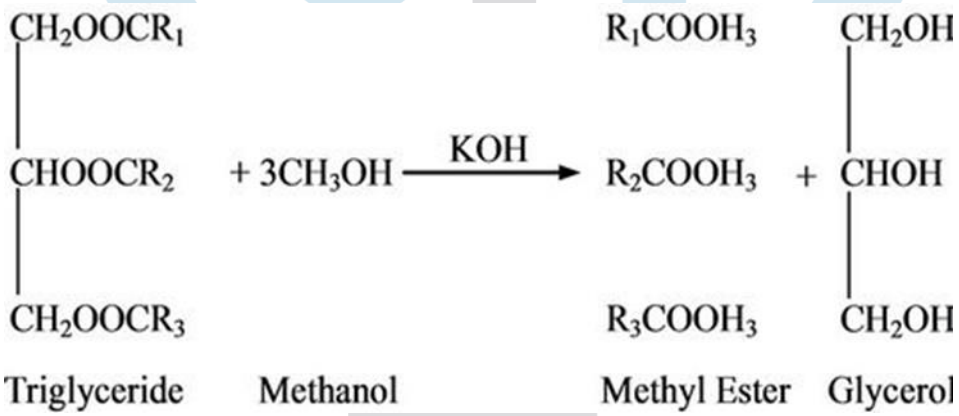


Figure : Mechanism of the alkali-catalyzed transesterification of vegetable oils [24].

Alkaline-catalyzed transesterifications proceed at considerably higher rates than acid catalyzed transesterifications. Due to this fact and also because alkaline catalysts are less corrosive to industrial equipment, most commercial transesterifications are conducted with alkaline catalysts [11].

Materials

Palm olein oil, Rice brane oil, Neem oil, Methanol, Potassium hydroxide (KOH) in pellets, Concentrated sulfuric acid, Phenolphthalein indictor, Ethanol, 0.1N KOH, 0.5N Hydrochloric Acid, 0.5N Alcoholic Potassium Hydroxide

Methods

The two steps procedure should be carried out for the production of biodiesel.

The following steps are involved

1. Acid pretreatment
2. Base catalyzed transesterification

Acid pretreatment (acid catalyzed esterification)

The 250 ml crude oil was measured and heated at 60 0C for about 10 minutes then mixed with methanol which is 60% w/w of oil. To the mixture 1.2 % w/w of concentrated H2SO4 was added. The resultant mixture was then stirred for 1hr then it was allowed to settle for 2h. The pretreated oil was separated from the methanol water phase at the top.

This step is not necessary for oils contain <1% free fatty acids.

Base catalyzed transesterification

The experiments were carried out in a batch wise manner in 500ml flask containing 250ml of the acid pretreated oil. Then oil heated to 60 0C on a heating plate. The oil to alcohol molar ratios was maintained 1:4, 1:5, 1:6, 1:7 1:8. The catalyst KOH taken 0.5g and kept constant for all runs. KOH pellets are dissolved in the methanol as that of the respective molar ratios. This solution is added to heated pretreated oil. The reaction time maintained was 1h. This procedure was repeated for above mentioned molar ratios.

Experimental conditions:

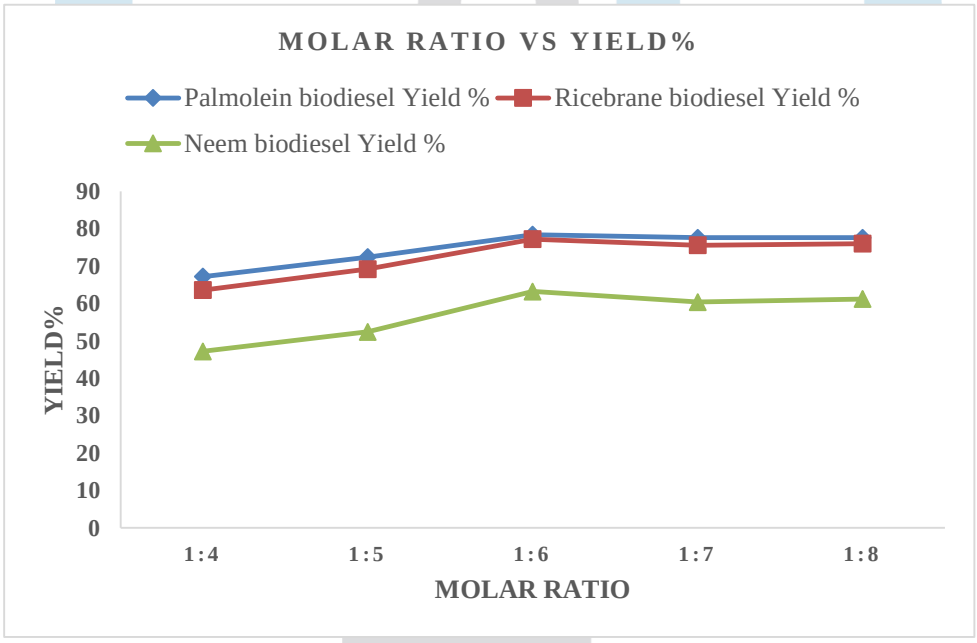
- 250ml of oil heated to 60 0C ,
- Oil to methanol molar ratios maintained 1:4, 1:5, 1:6, 1:7 1:8,
- Catalyst KOH 0.5g constant for all runs,
- Reaction time maintained was 1h.
- Separation time 24hrs.

Key parameters such as Density, Flash point, Fire point, Viscosity, Acid value, Saponification number, Ester value, and yield% of Biodiesel produced from Palm olein oil, Rice brane oil and neem oil are studied and compared with conventional diesel and biodiesel values of EN 14214 properties.

IV. RESULTS

Yield %:

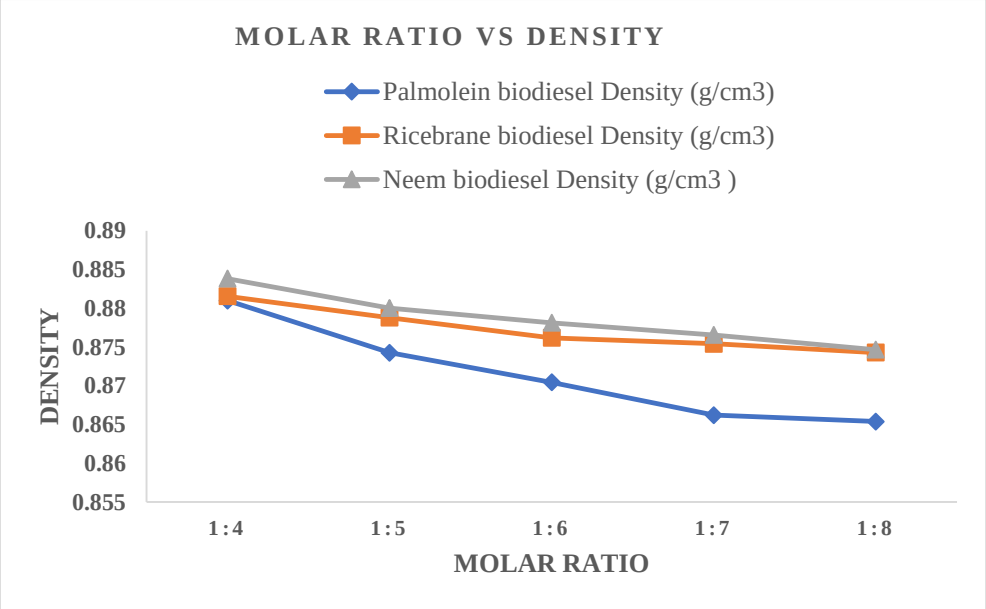
We got highest yield from Palm olein oil biodiesel compared to Rice brane, Neem biodiesel samples. In terms of yield % Palm olein oil is preferred for the biodiesel production. By increasing molar ratio yield % decreased, because of increasing glycerol formation at higher methanol ratio.



Graph : Effect of molar ratio on Yield %

Density

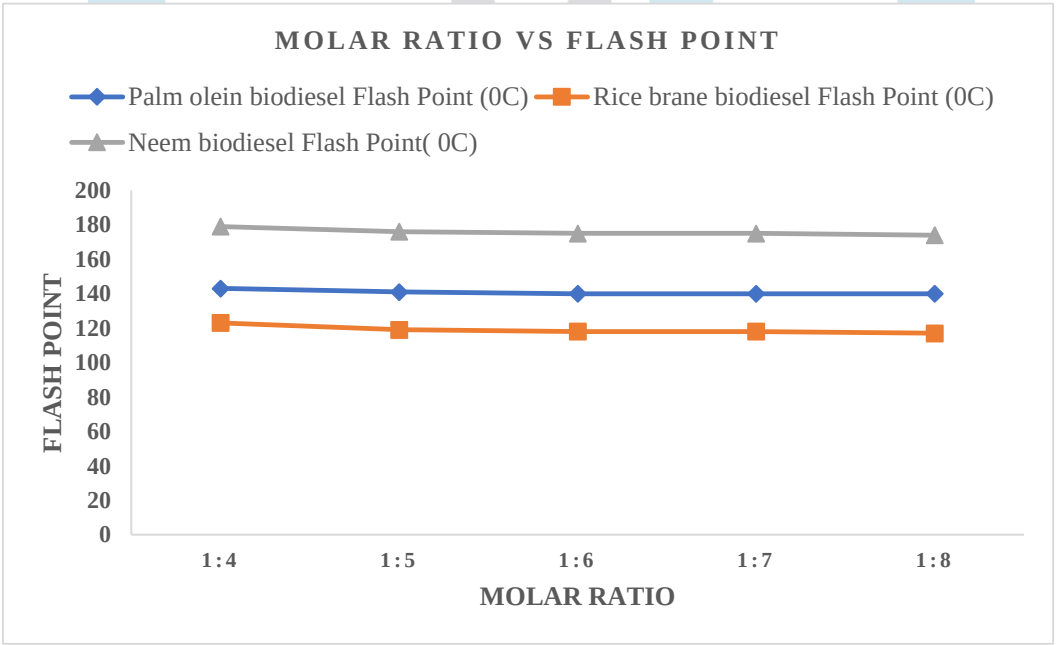
Density of diesel is 0.832 (g/cm3), biodiesel density is 0.88(g/cm3), here all biodiesel samples met the conventional values and biodiesel from neem oil denser than the remaining biodiesel samples, because neem oil that we used here have the high-density value compared to the palm olein oil and rice brane oil. When we consider density parameter, palm olein oil and rice brane oil are preferred compared to neem oil. At higher molar ratios the density of biodiesel samples are decreased because of higher alcohol presence.



Graph : Effect of molar ratio on density

Flash Point

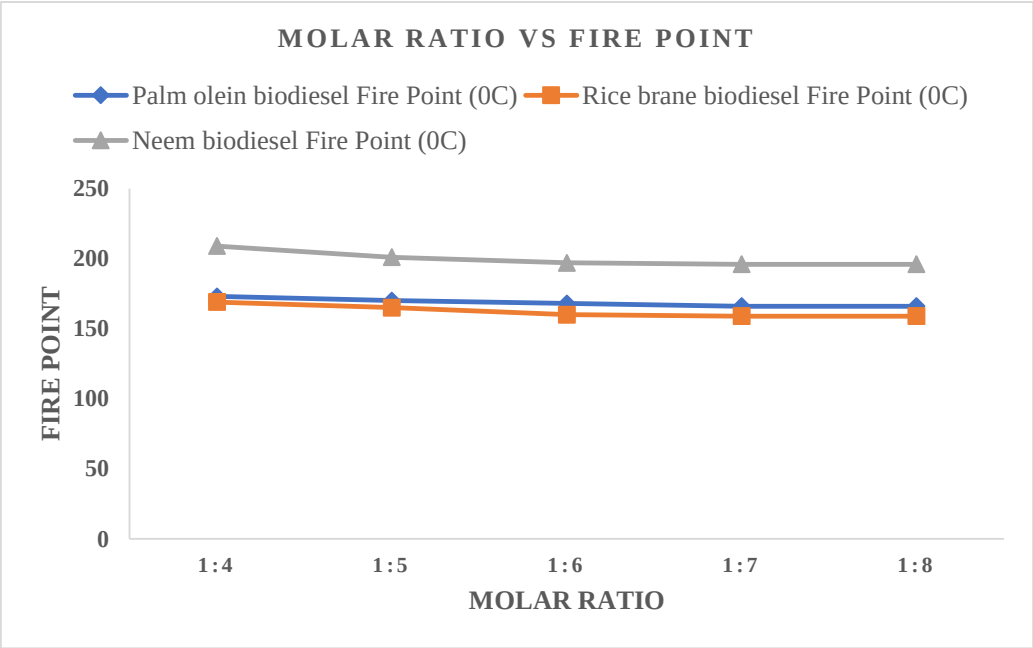
Diesel flash point range 55-65 0C, biodiesel flash point 100-170 0C. Rice brane biodiesel has the lower flash point temperature compared to the remaining two oils biodiesel samples. Rice brane oil preferred in terms of flash point.



Graph : Effect of molar ratio on flash point

Fire point

Diesel fire point is 90 0C, Biodiesel fire point is 164-175 0C, biodiesel from rice brane oil has the lowest fire point temperature compare to the remaining sample. when we consider the fire point rice brane oil is preferred for the biodiesel production.

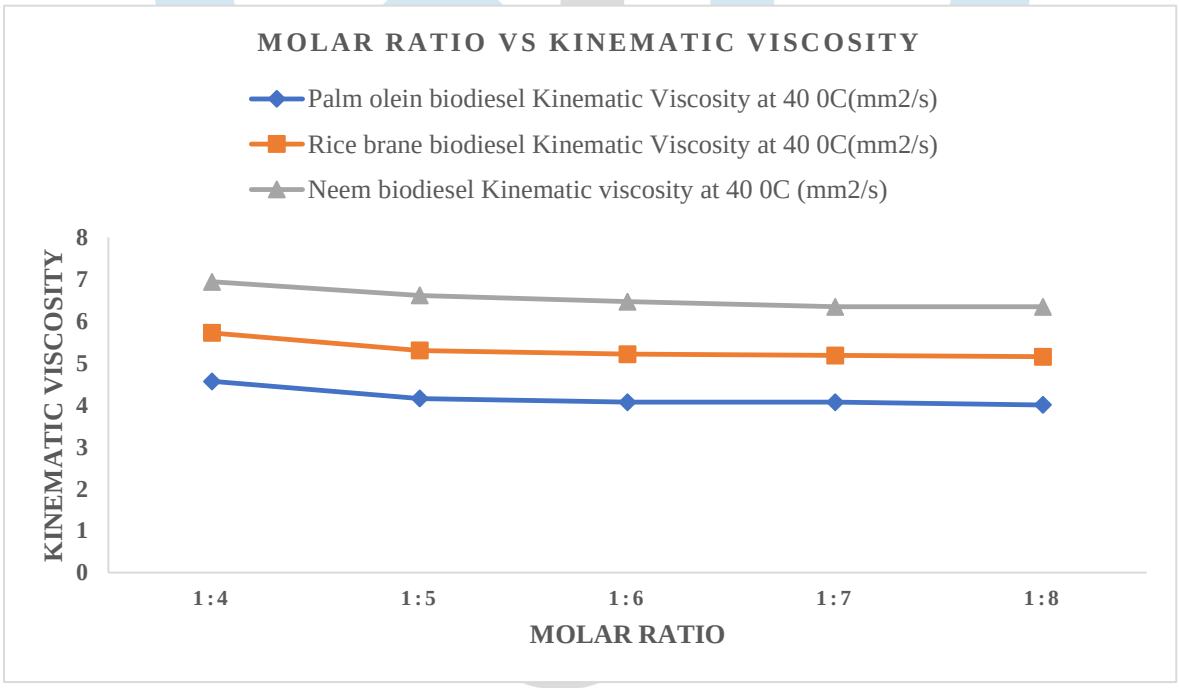


Graph : Effect of molar ratio on fire point

Kinematic Viscosity

Diesel viscosity at 40 0C is 2.2 (mm2/s), Biodiesel viscosity range 1.9 – 6.0 mm2/s.

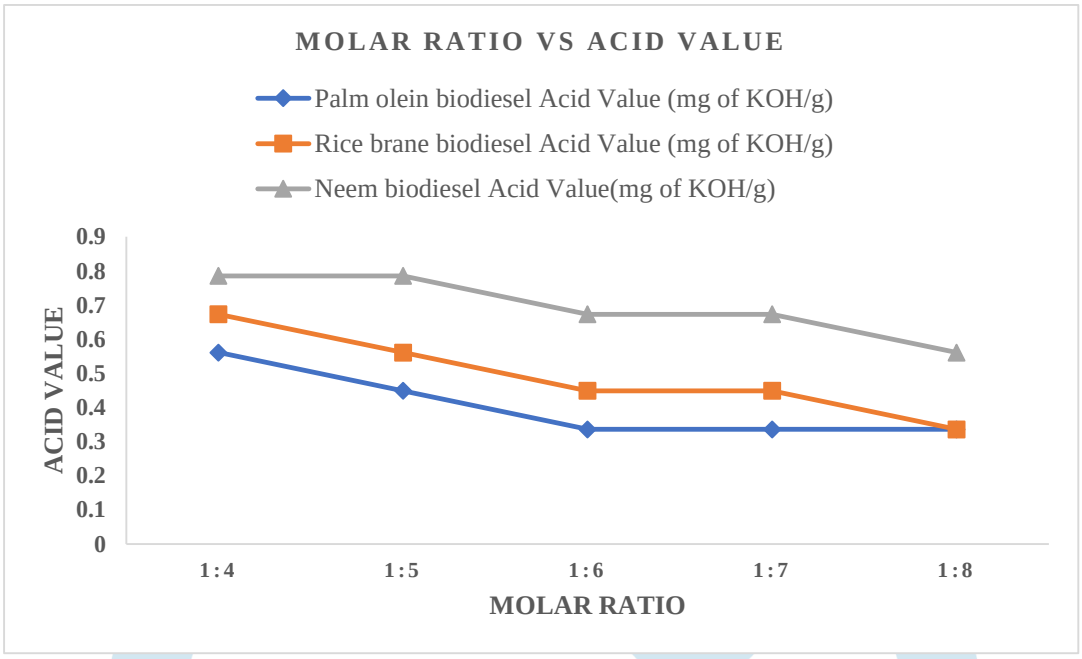
Palm olein biodiesel samples have the lowest kinematic viscosity compared to rice brane, neem biodiesel samples. In terms of kinematic viscosity palm olein oil is preferred for the biodiesel production.



Graph : Effect of molar ratio on Kinematic viscosity

Acid Value

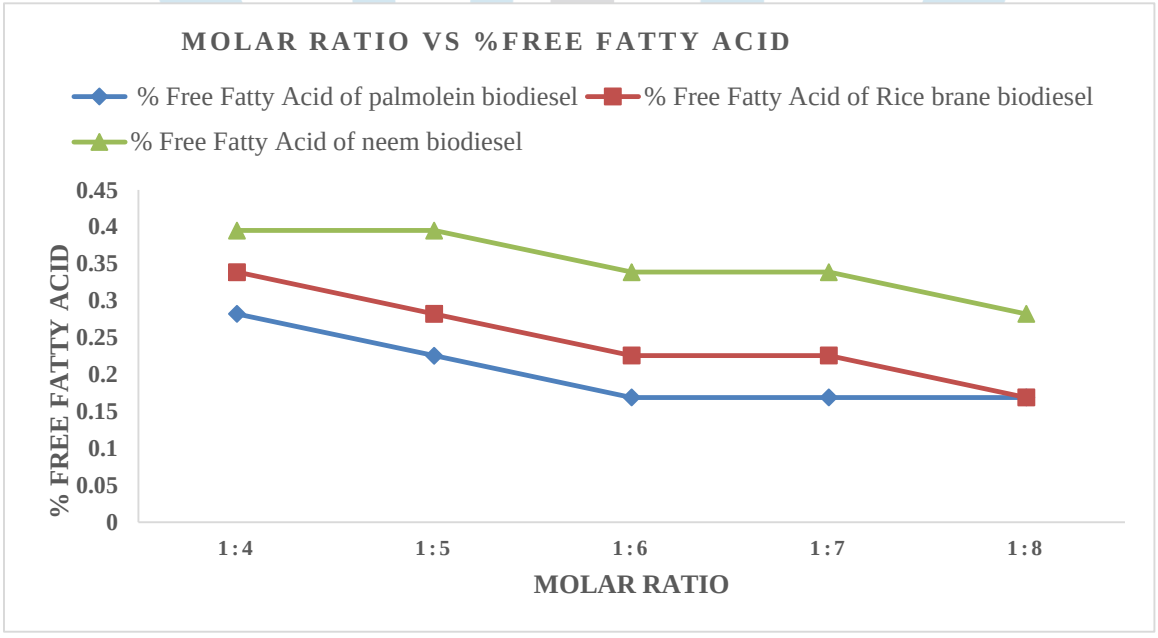
Acid values of produced biodiesel samples at various molar ratios. Acid values for palm olein, rice brain biodiesel samples are lower compared to neem biodiesel samples. In terms of acid value palm olein, rice brane oils are preferred.



Graph : Acid Value of Biodiesel samples

% Free Fatty Acid

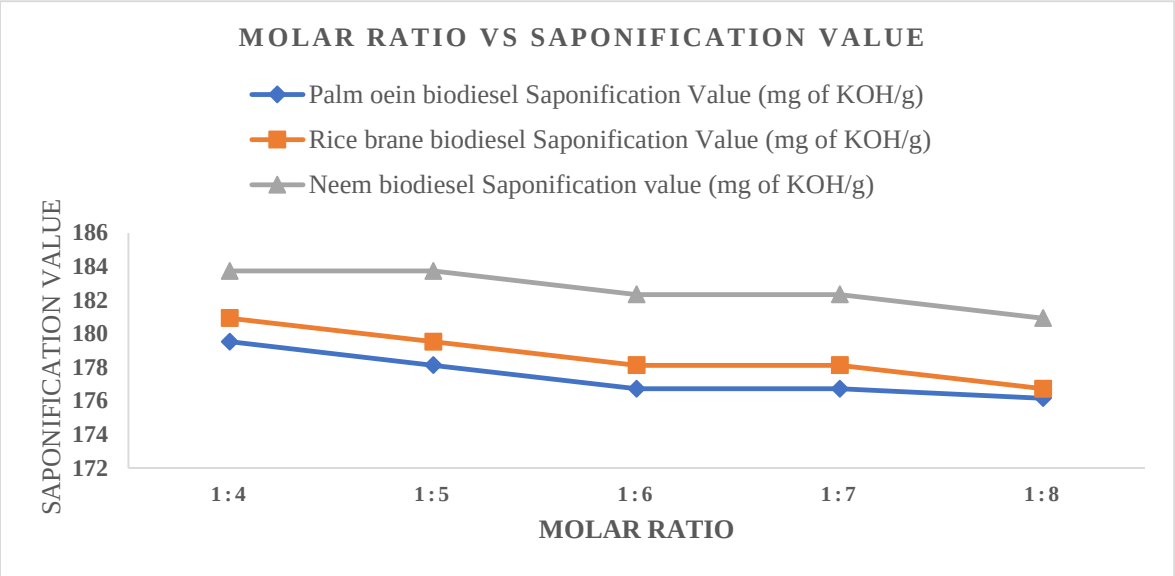
% Free Fatty Acid values of produced Biodiesel samples at various Molar Ratios. % free fatty acid of palm olein, rice brane biodiesel samples are lower than neem biodiesel samples. In terms of free fatty acid palm olein, rice brane oils are preferred for the biodiesel production.



Graph : % Free fatty acid values of Biodiesel samples

Saponification value

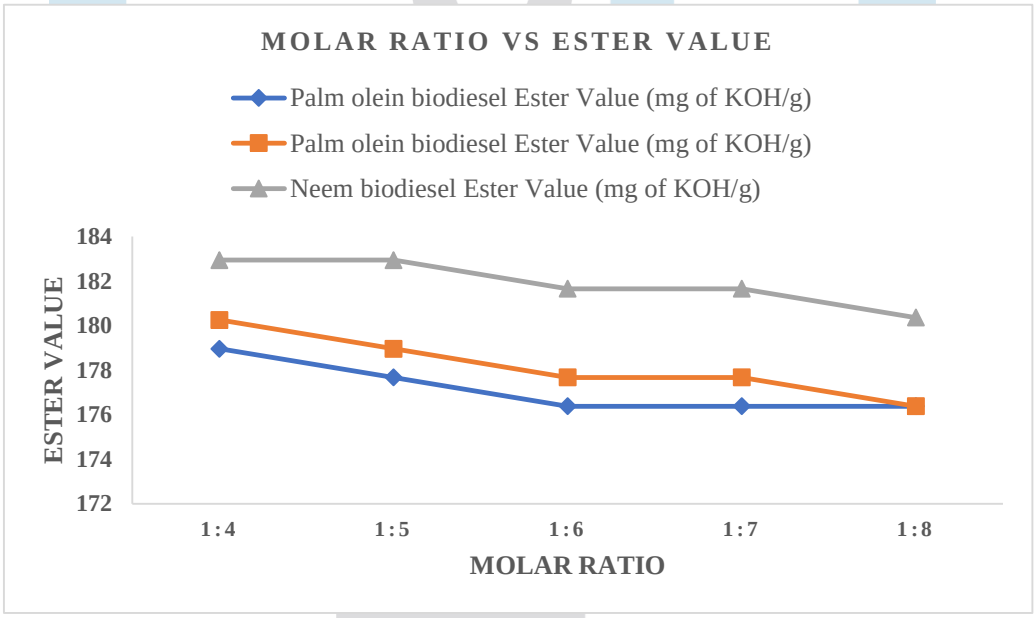
Saponification values of Biodiesel samples produced at different molar ratios. Saponification value of palm olein biodiesel is lower than the rice brane, neem biodiesel samples. In terms of saponification value palm olein oil is preferred for the biodiesel production



Graph : Saponification values of Biodiesel samples

Ester value

Ester value of biodiesel produced at different molar ratios. Ester values of palm olein, rice brane biodiesel samples are lower than neem biodiesel. In terms of ester value palm olein, rice brane oils are preferred for the production of biodiesel.



Graph : Ester Value of Biodiesel samples

V. CONCLUSION

The results obtained shows that palm olein oil is effective in Biodiesel production compared to rice brane oil and neem oil. Effect of molar ratio on Yield %, Density, Flash Point, Fire Point, Kinematic Viscosity were studied and the data was interpreted. Maximum Yield % was achieved at Palm olein oil 1:6 molar ratio. Acid Values, % Free Fatty Acid, Saponification values, Ester values are studied and the obtained values are tabulated. All the Biodiesel samples met the EN14214 Density, Flash Point, Fire Point, Kinematic Viscosity standards.

- By varying molar ratio maximum yield of Palm olein biodiesel 78.4%, Rice brane biodiesel 77.2%, Neem biodiesel 63.2% obtained at 1:6 molar ratio.
- Increasing in molar ratio results in decrease in biodiesel Density, Flash Point, Fire Point, Kinematic Viscosity properties.
- Minimum Acid Value 0.336 (mg of KOH/g) obtained at 1:8 molar ratio of Palm olein, Rice brane biodiesel.
- Minimum % Free Fatty Acid value 0.169 obtained at 1:6, 1:7, 1:8 molar ratios of Palm olein biodiesel
- Minimum Saponification Value 176.15 (mg of KOH/g), Ester value 176.378 (mg of KOH/g) obtained at 1:8 molar ratio of Palm olein oil, Rice brane oil.

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REMOVAL OF MALACHITE GREEN DYE FROM AQUEOUS SOLUTION USING LEMON LEAF POWDER AS AN ADSORBENT

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ABSTRACT

The majority of developing nations experience significant water contamination from textile sector wastewater. The use of low-cost, environmentally friendly adsorbents has been researched as a means of addressing problems of water contamination and high costs for waste - water treatment processes. Malachite green is an incredibly dangerous colour that not only damages mammalian cells but also has a key influence in the growth of liver cancers. The life cycle of aquatic creatures, plants, and people is hampered by dye released into bodies of water without sufficient treatment. In this study, the powdered lemon leaves are utilized for removal of the aniline green dye. By using batch-style setting and design of the experiment (the Box–Behnken technique) adsorbent has been investigated & have been developed to evaluate the process's critical factors, including agitation time, size of adsorbent, dosage of adsorbent, pH, initial concentration and temperature.

The acquired values were fitted with adsorption isotherms. Malachite green dye sequestration onto Lemon Leaf Powder was chosen using kinetic models. The results of the trials showed that employing powdered lemon leaves, malachite green could be removed to a maximum of 82.21%. Malachite green dye concentration of 50 mg/L, temp of solution 303 K, and dosage of adsorbent 20 g/L are the ideal parameters. Lemon leaf powders have a maximum sorption capacity (qmax) of 8.08 mg/g. The equilibrium was more accurately modelled using the Freundlich isotherm. When compared to other models, the data which fits the pseudo 2nd order kinetics model is better. Previously researchers had proved several low – cost materials such as wheat bran, marina alga, wood apple shell etc… In the current work, to remove malachite green dyes the efficacy of citrus lemon leaves is thoroughly done. The operating parameters that are optimized include dye solution concentration, initial solution pH, sorbent dose, and temperature. Studies on thermodynamics have demonstrated that the adsorption process was endothermic & spontaneous.

Keywords: Lemon leaves, Malachite Green dye, Concentration of dye solution, adsorbent dosage, agitation time, sorbent size.

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1. Introduction

In the modern world, one of the greatest environmental challenges is water contamination. Because of people and their activities, water resources, such as rivers, seas, and groundwater, have been contaminated (Dutta et al., 2011).There are many methods to pollute water, but spilling industrial waste water into water bodies is one of the most significant. Untreated sewage from households that is released into the environment is another significant source of pollution (Dizaj et al., 2015).Other sources include chemicals that are released from various operations and flow on the surface, as well

as fertilizers and pesticides that are released from agricultural activities. Industries release waste - water into water bodies without sufficient treatment, contaminating the water with heavy metals, chemicals, dyes, oils, and many other hazardous substances. The fact that contaminated drinking water has grown to be a serious worry for mankind today should give you a good idea of the terrible effects of water pollution. For the dye-contaminated wastewaters treatment, a number of different techniques have been tried, including adsorption, ion exchange, precipitation, coagulation and flocculation, and chemical oxidation. Due to its simplicity, cheap cost, high selectivity, and high efficiency, the adsorption approach has been shown to be a better separation & purification method. (Gupta et al., 2016)

Adsorption is a key step in the physiochemical treatment of wastewater, a procedure that may cheaply fulfil the increased effluent regulations and water reuse specifications of the present. The building of materials along the boundary between 2 phases is referred to as adsorption, which is a mass transfer technique. The substance that is being adsorbed is referred to as the "adsorbate," while the substance that is doing the adsorption is called "adsorbent". (Gupta et al., 2011; Santhi e t al., 2016); (Oyelude et al., 2018).The most important adsorption parameters are surface area for adsorption per unit volume, pH, chemical reactivity, and a decrease in surface tension. Previously researchers had proved several low – cost materials such as wheat bran, marina alga, wood apple shell etc… In this present study, lemon leaves have been used as adsorbent whose results showed good capacity of Malachite Green in a very short period of agitation, good and higher % removal adsorption compared to previous studies.

1.1 Malachite green:

It is an organic chemical which is used in aquaculture as an antibacterial and, controversially, as a colour. It may be dissolved in water, alcohol, ethanol, and methanol and is useful as a dye for materials including leather, silk, paper & wool (Hamdaoui et al., 2008). In 1992, Canadian officials concluded that consuming fish tainted with malachite green presented a serious health danger. A Class II health hazard designation was given to malachite green. Malachite green is still utilized for non-aquaculture activities in some nations with less stringent legal regulations due to its inexpensive manufacturing cost. (Rout & Jena, 2021) Malachite green was discovered in fish imported from China and Taiwan in 2005 by experts in Hong Kong and also by the US FDA in 2006 in seafood which was imported from countries like China, where the material is similarly forbidden for use in aquaculture. (Ismail et al., 2018; Khattri & Singh, 2009) Due to persistent malachite green contamination, the FDA prohibited the importation of numerous different seafood species in June 2007. Since 1983, the chemical has been prohibited in the US for use in foods. Malachite green is converted by animals to its leuco form (Zhang et al., 2008).

Malachite green is a harmful dye that not only has very poisonous qualities that harm mammalian cells but also has a significant role in the development of liver tumors. By preventing sunlight from penetrating into water bodies, dye spilled there impairs the life cycles of aquatic organisms and plants (Issa et al., 2014). They cause a shortage of dissolved oxygen as a result of an increase in the biological oxygen demand (BOD) to support aquatic life. Some colours can directly harm or hinder the chemical activity of certain substances because they are extremely cyanogenic. Dye has an impact on marine life and consequently the food cycle at low quantities (Kushwaha et al., 2014).

1.2 Lemon Leaf Powder (Adsorbent):

Nerve conditions including sleeplessness, jitters, and palpitations can be treated with lemon leaves. Valium and other artificial sedatives that have adverse effects can be replaced with lemon leaves as an excellent and superior option. Take the recipe every day for at least a month to receive the best results from lemon leaf. Blanched leaves can be useful to flavor drinks, wrap meat or shellfish, and roast, steam, or grill them. Thai cuisine frequently uses lemon leaves. They are used to wrap cheese in Italy. Lemon leaves are used in Greek roast pork dishes. Indians use lemon leaves to spice their curries. In their meat kabobs or sosatie, South Africans add lemon leaves. Many cultures use lemon leaves to flavour tea (Sarath Babu & Yamini, 2020; Shakoor & Nasar, 2016).

2. Experimental Method and Analysis

2.1 Method for preparing malachite Green stock solution

Malachite green stock solution containing 1000 mg/L (1000 ppm, w/v) of the dye is made by dissolving 1 g of the dye in 1 lt. of distilled water. For the tests, adequate dilution is used to create solutions with various dye concentrations. A 50 ml volumetric flask is filled to the mark with distilled water after 2.5 ml of a 1000 ppm Malachite green stock solution has been diluted. Similar to this, solutions with various dye conc's., including (50, 100, 150, 200, 250, and 300mg/L), are made. Aqueous solutions' pH can be changed to the required value by mixing 0.1N sulphuric acid and 0.1N NaOH solution. (Sartape et al., 2017; Shanthi & Mahalakshmi, n.d.).



Figure 1: Preparation of Malachite Green Stock Solution

2.2 Preparation of Lemon leaf powder

Dinnupativaripalli, in the Chittoor district, is where fresh lemon leaves from sweet lemon (local name: Mosambi; Scientific name: Limetta Lemon plant) were gathered. To get rid of any dust or other soluble materials, the gathered leaves are rinsed in tap water. After being divided into little pieces (between one and three centimeters), the leaves were dried in the sun. To get a particle size range of 80 (175m) to 200 (74m) of Lemon leaf powder, the dried pieces are ground and sieved using various B.S.S. standard sieves of mesh size. The powder is then packaged in a bottle. The powder is once again cleaned with distilled water to get rid of any contaminants that could have caused the color to be off, and it is then allowed to air dry. In a separate, airtight vial, the dried samples are kept for use in experiments (Kumar, 2007).

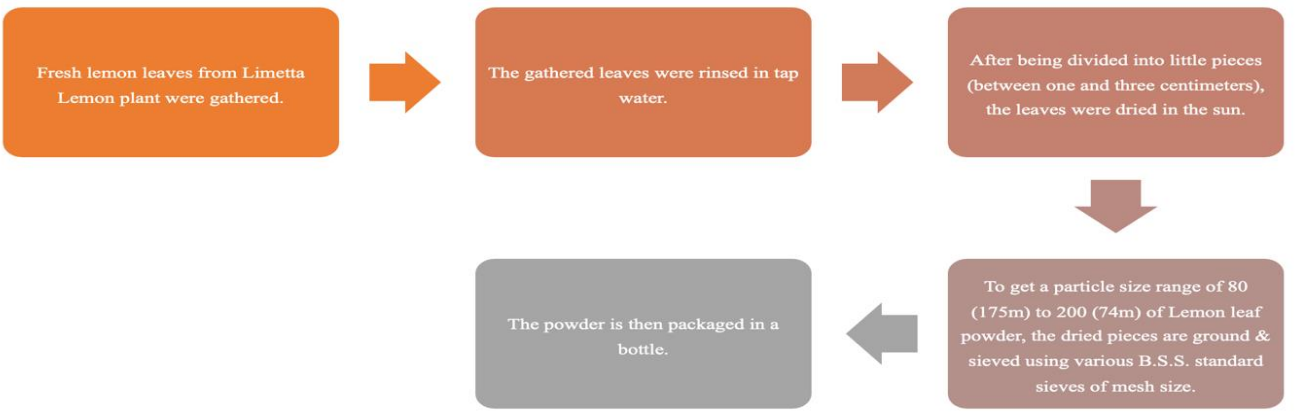


Figure 2: Preparation of lemon leaf powder

2.3 Adsorption study

The adsorption of color using powdered lemon leaves is researched utilizing the batch approach. The initial pH of the solution is set to the appropriate value by introducing solutions of 0.1N sodium hydroxide and 0.1N sulfuric acid to a series of labelled conical flasks containing 50 mg/L of dye solution. The flasks are shaken in an incubator shaker at a constant 120 rpm after being meticulously filled with 0.5 g of 74 mm-diameter adsorbent. Samples were collected, filtered, and the clean filtrate was analyzed using UV-Visible Spectroscopy over a period of time. (10, 20, 30,...140 and 150 min). Equation is used to determine the percentage of dye elimination (Ahmad & Kumar, 2010; Hameed et al., 2007).

$$\%Removal = \frac{C_O - C_f}{C_O} * 100$$

C_0 = Initial Dye solution concentration (mg/L); C_f = Final dye solution concentration (mg/L)

Initial concentration of dye in solution, dosage of adsorbent & temperature that is the effect of three factors, on dye removal is studied by using equation.

$$q_e = \frac{(C_0 - C_f) * V}{m}$$

q_e = The amount of dye adsorbed is calculated as per the amount of adsorbent (mg/g).

C_0 = Dye solution initial concentration (mg/L); C_f= Final concentration of dye solution (mg/L)

V= volume of dye solution (50 ml); m = adsorbent mass (g)

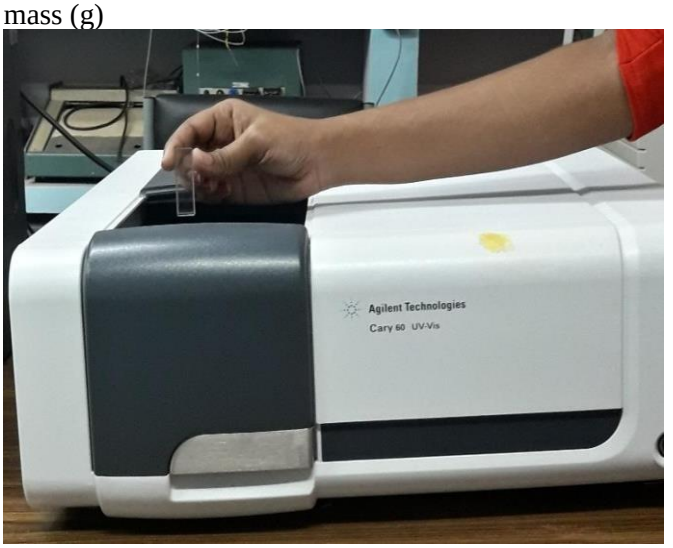


Figure: 3: UV Visible double beam



Figure 4: Incubator shaker

3. Results & discussion

Data collected from experimentation on the adsorption of aniline green using Lemon leaf powder is given section wise and discussed in this Chapter. The repeatability of the results is 3 – 4 times with $\pm$ 0.1 - $\pm$ 0.3.

3.1 Adsorption of Malachite green dye using Lemon leaf powder

Dye concentration in all the studies is obtained from UV-VIS spectrophotometer. Standard calibration curve – a plot of dye concentration Vs. absorbance, is as shown in figure 5.

3.2 Preliminary Studies – Particle Size, Contact time and pH:

Particle size influences adsorption significantly. Lower particle sizes are suitable for treatment as they offer more surface area and more binding sites. Therefore, the smallest particle size, limited by the ease of separation post-adsorption is to be used. In my study, a particle size of 74 µm (passing through 120 and retained by 200 mesh) is used in all experiments. For the identification of contact time to attain equilibrium, an experiment is conducted and the time course of adsorption is shown in figure 5.

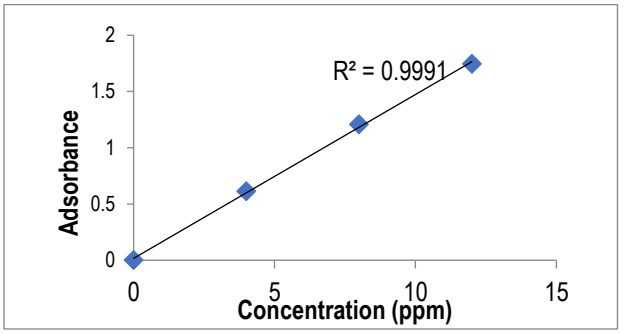


Figure 5: Malachite green calibration curve

Table 1: Experimental Conditions

V = 50 ml	C_o = 20 mg/L
d_p = 74µm	Rpm = 120
w = 10g/L	T = 303K

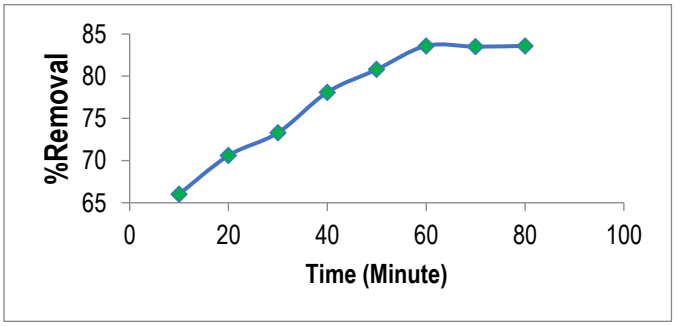


Figure 6: Agitation time vs % adsorption of Malachite green

Adsorption proceeds at a rapid rate and progressively slows increase as time passes. After some time, there is no change of removal is absorbed in graph so ultimately equilibrium is attained after a treatment period of 60 minutes. This is chosen as the optimum contact time. pH effect on adsorption is studied within a range of 2 to 10, and the results are plotted and shown as figure 6.

Table 2: Experimental Conditions

T=60min	Rpm=120
C_o= 20 mg/L	d_p = 74µm
w = 10g/L	T = 303K

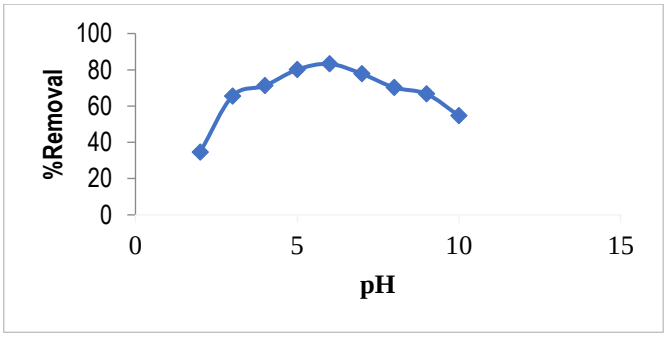


Figure 7: pH vs %Removal

From figure 7, the % of MG removal increased with increase in solution pH & subsequently decreased. This trend can be attributed to the favorable configuration of the active functional groups, resulting in a peak removal at a pH of 6.0. The following decrease is once again to distortion in the structure.

3.3 Optimization of Parameters and Model Development:

Thus, a particle size of 74 µm, a contact time of 60 minutes and pH of 6.0 are fixed for all the experiments. Three other major parameters, namely initial dye concentration, temperature and adsorbent dosage are optimized for the dye removal with leaf powder of Lemon, using a Box-Behnken design approach.

Dye concentration from 50 to 150 mg/L, dosage of adsorbent between 2 to 20 g/L and temperature from 293 to 313 K, are considered. Results of experiments conducted as per the said factorial design approach are tabulated as table 3.

Table 3: Box Behnken model results for Malachite green onto Lemon L

RUNS	Real(Coded) values			%Removal	
	Concentration mg/L (A)	Temperature K (B)	Dosage g/L(C)	Experiment	Predicted
1	100(0)	300(0)	11 (0)	79.8	79.2
2	100(0)	300(0)	11 (0)	79.8	79.2
3	100(0)	293 (-1)	2 (-1)	69.7	69.4
4	100(0)	313 (+1)	20 (+1)	80.3	79.84
5	100(0)	303 (0)	11 (0)	79.8	79.2
6	50(-1)	293 (-1)	11 (0)	67.6	67.6
7	50(-1)	313 (+1)	11(0)	73.8	73.6
8	150(+1)	313 (+1)	11 (0)	72.2	72.16
9	150(+1)	293 (-1)	11(0)	69.8	69.78
10	100(0)	313 (+1)	2 (-1)	73.4	73.4
11	150(+1)	303 (0)	2 (-1)	78.9	78.84
12	50(-1)	303 (0)	2 (-1)	60.97	60.97
13	100(0)	303 (0)	11 (0)	79.8	79.2
14	150(+1)	303 (0)	20 (+1)	66.02	66.15
15	**50(-1)**	**303 (0)**	**20 (+1)**	**82.2**	**82.14**
16	100(0)	293 (-1)	20 (+1)	69.7	69.54
17	100(0)	303 (0)	11 (0)	79.8	79.2

$$\% \text{ Removal} = 79.80 + 0.29*A + 2.68*B + 2.10*C - 0.95*AB - 8.53*AC + 1.36*BC - 5.29*A^2 - 3.66*B^2 - 2.48*C^2$$

A peak removal of 82.2% is realized experimentally. The data are fitted to yield a quadratic model, which is given as equation (27). The coefficients in the expression indicate the relative weight, each term carries and contributes to the total % removal. As per the model, the highest removal is 82.2%, which is very close to the experimental level.

A conclusion that a solution of 50 mg/L of Malachite green dye treated with 20 g/L *Lemon* leaf powder at a 6.0 pH and a temp of 303 K, yielded the highest removal of 82.2% and the corresponding model prediction is 82.14%. The results are further analyzed by variance analysis to understand the contribution of terms in the prediction. The outcome is shown in table. Table 3.

'F-statistics' value, with a low probability and high model F (198.6) value indicates the significance of the regression model. Based on (Prob>F) values, all terms are A, B, C, AB, AC, BC, A^2, B^2, and C^2 found to be significant. R^2 predicted is 0.9376, whereas R^2 adjusted is 0.9911; this represents a difference of 0.2 is both the signal and the permissible norm. Table 5 lists the three variables' optimal values from both the experiment and the model.

Table 4: ANOVA and regression coefficients

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	616.27	9	68.47	198.60	< 0.0001	significant
A-concentration	0.69	1	0.69	2.00	0.2000	
B-temperature	57.46	1	57.46	166.65	< 0.0001	
C-dosage	35.24	1	35.24	102.20	< 0.0001	
AB	3.61	1	3.61	10.47	0.0143	
AC	290.87	1	290.87	843.63	< 0.0001	
BC	7.40	1	7.40	21.46	0.0024	
A^2	117.99	1	117.99	342.22	< 0.0001	
B^2	56.29	1	56.29	163.25	< 0.0001	
C^2	25.97	1	25.97	75.34	< 0.0001	
Residual	2.41	7	0.34			
Lack of Fit	2.41	3	0.80			
Pure Error	0.000	4	0.000			
Cor Total	618.69	16				

R^2 (Adj) = 0.9911 and R^2 (Pred) = 0.9376

Table 5: Optimum Levels

Name of the variable	% Removal of Malachite green	
	Experimental	Calculated with optimum values
Concentration Of dye (C_o)mg/L	50	54.76
Sorbent Dosage (w), g/L	20	20.4
Temperature (T),K	303	301.5
% Removal	82.2	82.14

The experimentally determined values of the ideal operating conditions and those predicted by the model correspond very adequately.

3.3.1 Diagnostic model:

Figures 8 and 9 compare the actual percentage of malachite green removal to that predicted by the model, as well as the normal plots for residuals. Figures 5, 6, and 7 show surface contour plots of the interaction effects of three variables—malachite green concentration, adsorbent dosage, and temperature—to help viewers better comprehend the dependence.

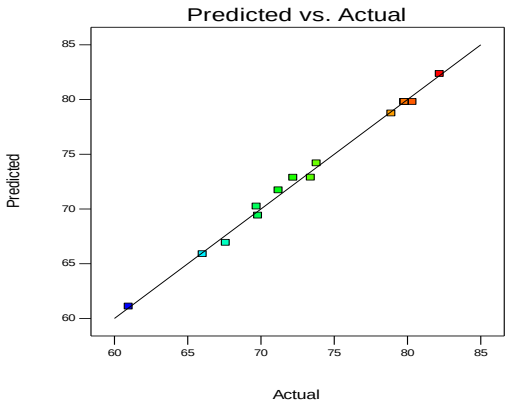


Figure 8

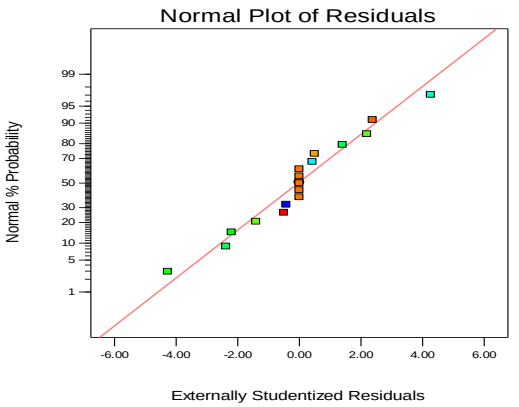


Figure 9

Actual (experimental values) values and the model predicted values are close, indicating a good fit of the experimental data to the mathematical model. The correlation coefficient between predicted $R^2$and adj R^2 (<0.2) are in reasonable agreement.

The residuals, the discrepancy between the experimental and observed responses, and the projected responses are all evaluated using the normal probability plots of the residuals. If the model is effective, the points on the normal probability plots of the residuals should form a straight line.

3.3.2 Three-dimensional (3D) response surfaces

Contour plots or response surface for the measured response are shown in figures 10, 11 & 12 these plots will provide better understanding of the interactive manner in which the independent variables would affect the dependent variable. Three independent variables make up the regression model in this study's work; two of these variables are kept at their current levels, yielding a total of three response 3D plots.

From figure 10 it is apparent that % removal increases as temperature increases (293-313K). Dependence on adsorbate concentration is showing the same trend as shown with temperature. With more adsorbent in the system, the number of binding sites also increases and hence a better removal is recorded. From figure 11 it is apparent that % removal increases as adsorbent dosage increases. Dependence on adsorbate concentration is showing the same trend as shown with temperature. With more adsorbent in the system, the number of binding sites also increases and hence a better removal is recorded. From figure 12 it is apparent that % removal increases as temperature increases (293-313K). Dependence on adsorbate dosage is showing the same trend as shown with temperature. With more adsorbent in the system, the binding sites number also increases and hence a better removal is recorded.

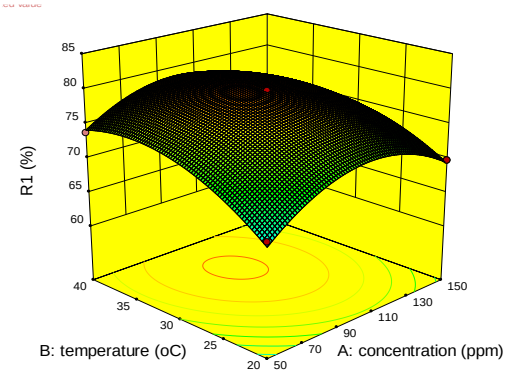


Figure 10: Surface contour plot of Temperature – Initial concentration –% Removal

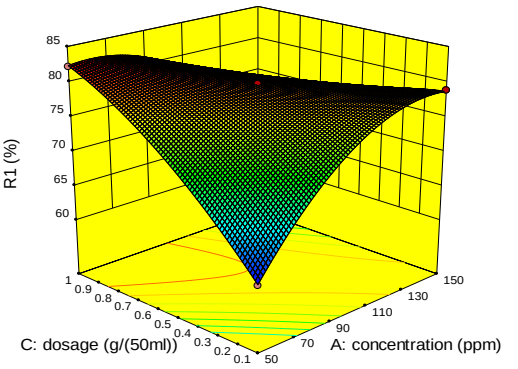


Figure 11: Surface contour plot of concentration– Dosage – % Removal

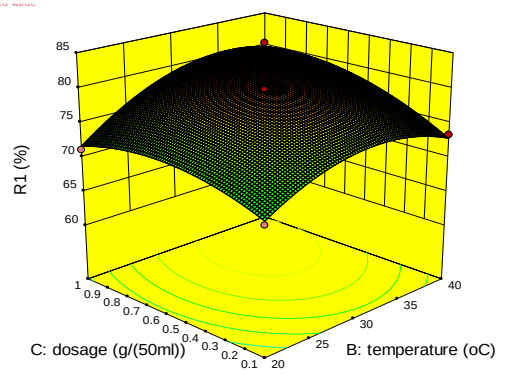


Figure 12: Surface contour plot of Temperature–Dosage –% Removal

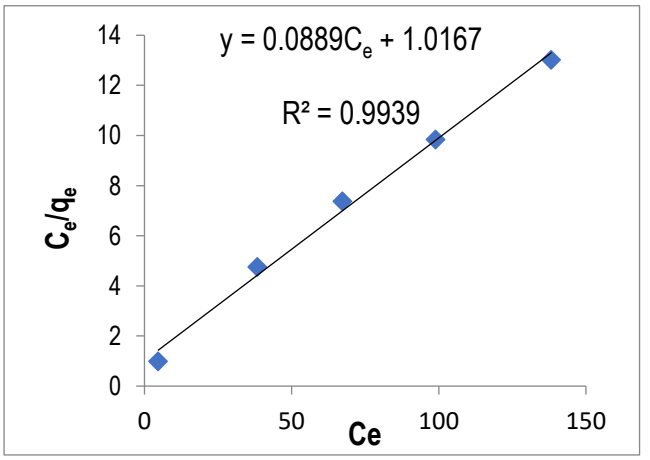
3.4 Adsorption isotherms

The equilibrium data are represented in four standard isotherm models -Langmuir isotherm model, Temp k in isotherm model, Freundlich isotherm model & D – R model obtained at the optimized conditions for adsorption of malachite green dye are Co of 50 mg/L, dosage of adsorbent: 20 g/L, pH of 6.0, time of 60 minutes and temperature of 303K for different Malachite green dye concentrations (50,100…. 300 mg/L). The resulting plots are shown in Figures 13 (i) – 13 (ii) & 14 (iii) – (iv). The graph depicts the equation for the straight line fit and the corresponding correlation coefficient. With a higher correlation coefficient of 0.9979, Freundlich isotherm is shown to be the best model for adsorption data, followed by Langmuir. Temkinand D-R model with correlation coefficients of 0.9939, 0.9954 and 0.9048respectively.

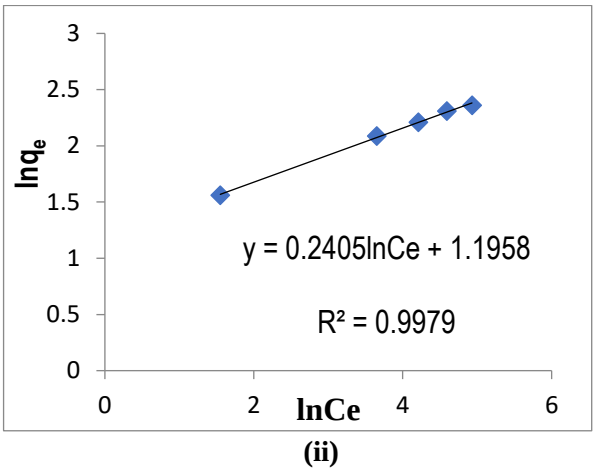
Table 6: Comparision of adsorption capacities with other low - cost adsorbents

Adsorbent	q_{max} (mg/g)	References
Thuya lignin	3.55	(Mohammed Saber et al., 2022)
Saw dust	7.84	(Chaimaa Bouyahia et al., 2023)
Algerian date stones	4.9	(KHELIFI O et al., 2016)

The amount of adsorption (q_{max}) of MB by was compared with other adsorbents reported in the literature, which are listed Table 6. The comparative study shows that the efficiency of the studied adsorbent can be used as an alternative to the usual adsorbents.



(i)



(ii)

Figure 13: Adsorption isotherm plots of MG (i) Langmuir (ii) Freundlich

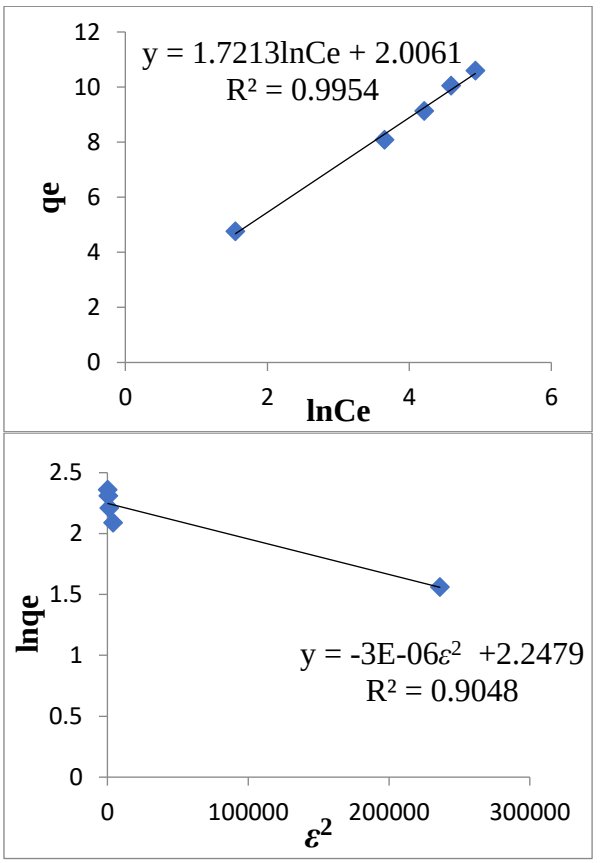
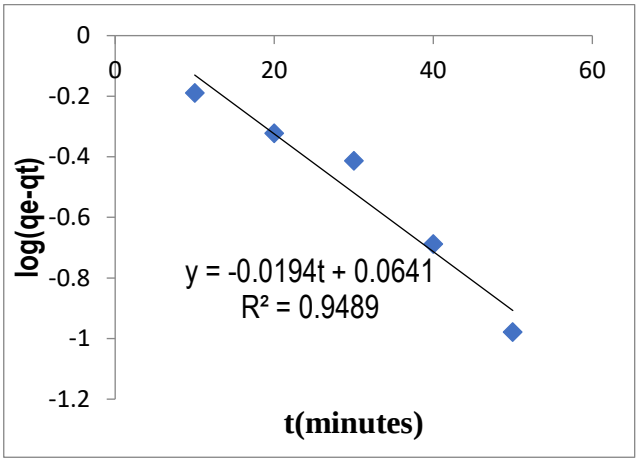


Figure 14: Adsorption isotherm plots of MG (i) Temkin (ii) D-R model

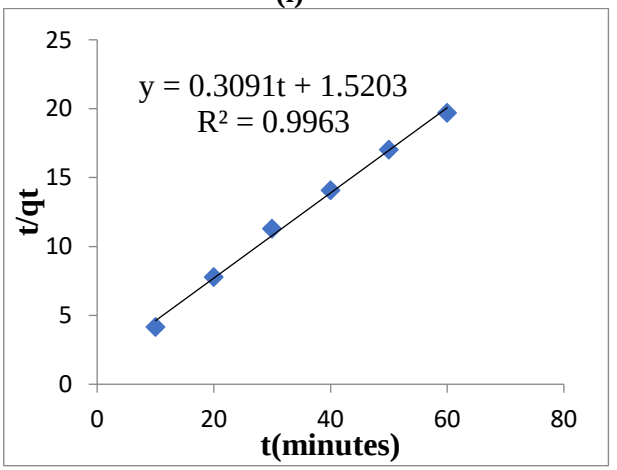
This suggests that single binding site, possibly formed by same functional groups are involved in the formation of the adsorption sites. The maximum dye uptake capacity (q_{max}) is 11.25mg/g as observed from the plots. A separation factor (R_L) of 0.709, (< 1) indicates favorable adsorption.

3.5 Adsorption Kinetics

The four kinetic models used are Pseudo 1st order, pseudo 2nd order, intra – particle diffusion, Elovich model. In the present study, kinetic evaluation is carried out with the data obtained at the following conditions: C_0= 50 mg/L, w = 20 g/L, T = 303 K, pH = 6 and t = 60 min. Necessary plots for analysis are as shown in figure 15 (i) – 15 (iv).

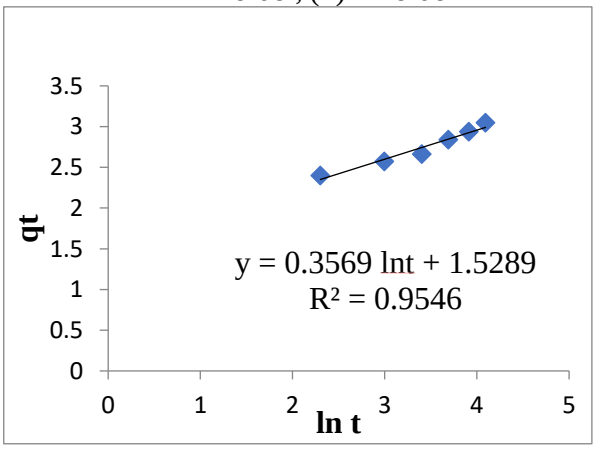


(i)

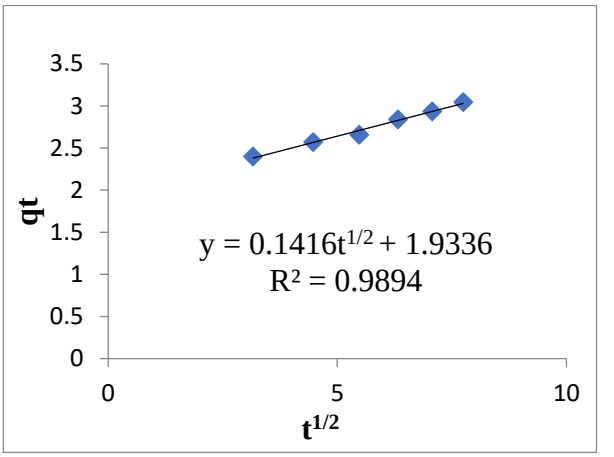


(ii)

Figure 15: MG adsorption kinetic graphs (i) Pseudo 1st order, (ii) 2nd order



(iii)



(iv)

Figure 15: MG adsorption kinetic graphs (iii) Elovich model, (iv) Intra-particle diffusion model

Pseudo second order model describes the adsorbate-adsorbent interactions better because regression coefficient is higher when compared to other kinetic model, suggesting that the bond formation is facilitated sharing of electrons.

3.6 Thermodynamics of adsorption process

It is of interest to estimate the energy implications of an operation. Three thermodynamic parameters - enthalpy change (ΔH), entropy change (ΔS) and Gibbs free energy change (ΔG) reveal the nature of the energy changes associated with a particular operation. These thermodynamic properties are obtained using the experimental data over the temperatures of 293-333 K., other conditions being time = 60 min, C_o= 50 mg/L, pH = 6.0, w = 20 g/L . The Van't Hoffs plot for the adsorption data is shown in Figure 16.

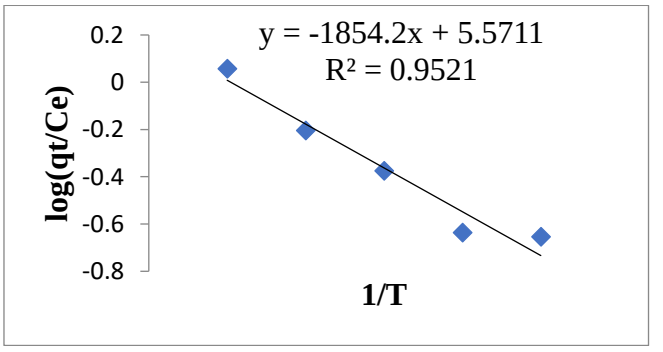


Figure 16: Van't Hoff's plot of adsorption of malachite green on Lemon L

$$lnK_d = \frac{-\Delta H^0}{RT} + \frac{\Delta S^0}{R}$$

Conditions

Co=50mg/L	t=60min
w=20g/L	pH=6

S.NO	TEMPERATURE (K)	ΔG (KJ/mol)	ΔH (KJ/mol)	ΔS (J/mol. K)
1	293	14.04	15.41	46.32

Enthalpy's positive value signifies that the process is endothermic. The adsorption benefits from a greater temperature. Even the experimental findings, which show that elimination rises as temperature rises, confirm this. Gibbs free energy change is negative, which suggests that the adsorption is spontaneous. Malachite green was absorbed onto Lemon L, and a positive entropy change (46.32 J/mol-K) revealed spontaneous dye binding and an rise in randomness at the solid/solution interface.

In future cost analysis studies can be done and different waste material like rice husk, sugarcane bagass etc. This lemon leaves powder adsorbent may be used by applying acid – base treatment to remove these dyes. Lemon leaves are also used to remove binary mixture which consists of malachite green. Lemon leaves are cost effective and easily available sorbent so we can use this in activated carbon form or ash powder to remove malachite green dye.

4. Conclusion

In the current work, to remove malachite green dyes the efficacy of citrus lemon leaves is thoroughly explored, and the results are promising. The operating parameters that are optimized include dye solution concentration, initial solution pH, sorbent dose, and temperature. The results of the trials showed that employing powdered lemon leaves, malachite green could be removed to a maximum of 82.21%. Malachite green dye concentration of 50 mg/L, temperature of solution 303 K, and dosage of adsorbent 20 g/L are the ideal parameters. Lemon leaf powders have a maximum sorption capacity (q_{max}) of 8.08 mg/g.

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Comparative Study Of Bioplastics Using Corn Starch, Rice Starch & Coconut Fibre

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Abstract

With the world's growing need for plastics and the resulting environmental damage, a suitable environmentally acceptable alternative, such as bioplastics/biodegradable plastics, is becoming highly significant. Corn and rice starch all contain lots of starch and can be used as bio polymers. Usage of bio polymers not only reduces pollution but also provides a new scope to the future generations. The project objective is to synthesise various bio polymers by altering their composition and conducting a comparative study using characterisation techniques suchas FTIR , and assessing physical and chemical parameters such as biodegradation, water absorption, and solubility & chemical reactivity, thickness, density & tensile strength.

Abbreviations: BP – Bioplastic; PVC - Polyvinyl chloride; BOD– Biochemical Oxygen Demand;

1. Introduction

Plastics are made by polymerization of complex organic materials and these can be made intothin films by the application of heat and pressure [1]. The usage of plastic is increasing day today in many fields like in packaging, school, office, pharmaceuticals, lamination due to the advantage of they being flexible, transparent, low weight, cost effective, insulation properties and resistant to microbial degradation. Today most of the plastic which is available has cross

– linkages which include wide variety of plastics like PVC, polyesters, propylene, polyethylene, polystyrene [2]. All the above specified plastics have great tensile strength but are causing the landfill deposition problems, toxicity, deposition in water bodies thereby increasing the BOD and adversely affects the biodiversity [3].

The raw resources such as vegetable fats and oils, straw, sawdust, wood chips, agricultural andfood waste, etc. are typically included in biomass. To generate bioplastics, biomass—which iscreated by photosynthesis from atmospheric carbon dioxide—is harvested to extract ingredients like cellulose, starch, hemicellulose, lignin, or plant oil. [4].

Plastics which are produced or prepared from renewable resources like potatoes, bana, sugar, corn algae and which are partially biodegradable or compostable are known as bioplastics.

Bioplastics are basically classified into 2 different categories. They are biodegradable and bio

– based plastics.

- Bio based plastics: Bio means the materials which are partly derived from biomass i.e.,plants. Biomass used for bioplastics from plants are sugarcane, cellulose, rice, corn starch etc…
- Biodegradable plastics: These are the plastics which decompose into organic matter andgases like CO_2 in a particular time and decompose. However the decomposition doesn't depend on the resource but instead it depends on the chemical structure linkages [5,6].

The bioplastics are basically prepared by using cellulose and starch. Cellulose and starch are not plastics but we can turn them into sheets and plastics by using various different techniqueslike casting, mixing, injection, extrusion, moulding etc. [7,8] Starch and its additives are produced from various different potato & its peel, corn, rice etc… Due to its neutral & non – reactive property these are not just food industry but are also used

in various applications likein pharmaceuticals [9].

Pure starch is white in colour. There is no distinct flavor or smell to the starch powder. Moreover, alcohol or cold water cannot dissolve pure starch. It is semi-permeable to carbon dioxide, biologically absorbable, and non-toxic. Starch contains two different types of molecules: branching amylopectin and linear and helical amylose [10]. Pliability, user- friendliness, and most crucially, degradation tractability are the qualities of the materials that are made utilizing banana peels. These days, having a viable bioplastic material as a substitutefor traditional plastics is essential [11].

The goal of this research is to use starch that has been separated from rice and corn starch to create bioplastics [12]. This would be extremely helpful for developing nations where the economy is significantly impacted by environmental issues. It was discovered that the bioplastics made from leftover coconut oil, corn, and rice starch had qualities similar to those of commercial packaging materials already on the market [13].

2. Methodology

2.1 Extraction Of Starch From Rice And Corn Starch SolutionChemicals required: Corn powder, distilled water, rice Apparatus: Beaker (200ml), motar and pestle

Procedure: Corn starch solution can be obtained by dissolving 20grams of corn powder inrequired amount of distilled water. We add distilled water till it reaches 100ml.

We obtain rice starch solution by boiling rice in water for 30min, filtering the starchy waterand then we boil it to reduce its volume to 50% [14].



Figure 1: Procedure for Extraction of Starch from Rice & Corn Powder

2.2 Extraction Of Fibre From Coconut Oil Cake

Chemicals/materials required: Coconut oil cake, distilled water, Whitman filter paper, motar and pestle

Procedure: 300gm of coconut oil waste should be kept in 800ml of distilled water. The waste kept should be boiled for 30min. The water is then decanted off and the sludge is left out on filter paper for drying for 30min at room temperature. After drying for 30min, peels were pureed using motar and pestle to form a fine paste. [15]



Figure 2: Procedure for Extraction of fibre from Coconut Oil Waste

2.3 Preparation Of Bioplastic Film

Chemicals required/Materials required: coconut oil cake, rice and corn starch obtained from above, aq. acetic acid.

Apparatus: Beaker, magnetic stirrer, petri dish, aluminium foil, hot plate

Procedure: The composition of coconut oil waste, rice and corn starch composition are variedaccordingly as shown in table 2. The necessary amount of composite starch solution can be obtained by adding 5 ml of aqueous acetic acid to a beaker and stirring it for 10 minutes at 180rpm. After that, the mixture is cooked for 15 minutes at 220^0C while being constantly stirred. The cooked mixture should then be transferred to a petri dish coated with aluminium foil, let to dry at room temperature for 24 hours, and then heated once again for two hours at 85^0C in the oven. Before taking the bioplastic out of the foil, it should be given enough time to cool. [14].

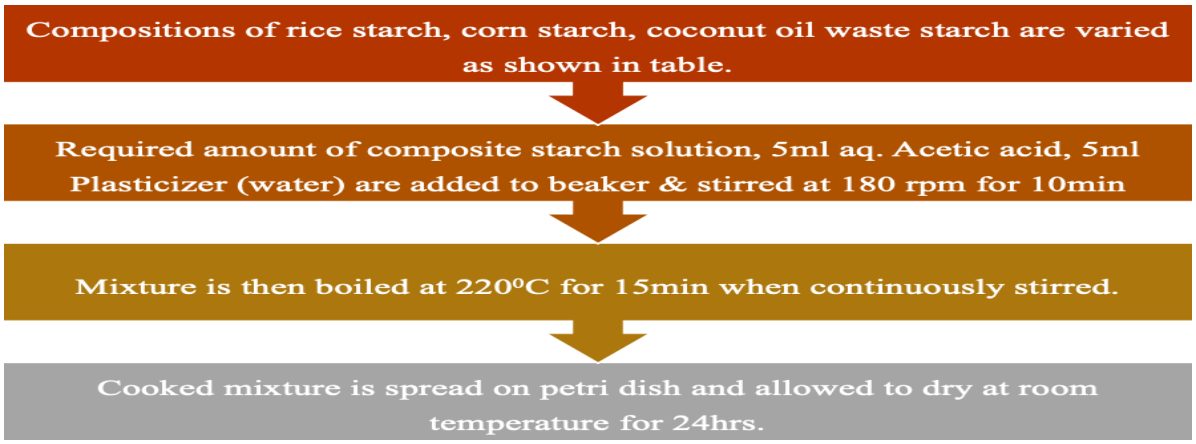


Figure 3: Preparation Of Bioplastic FilmTable 2: Varying Concentrations

	Coconut oil waste (ml)	Corn Starch(ml)	Rice Starch(ml)
BP 1	0	40	0
BP 2	0	0	40
BP 3	40	0	0
BP 4	16	12	12

3 Results

3.1 Biodegradability Test

Initial weight (W_O) of bioplastic was taken and then buried in soil for 5 days withoutdisturbing. After 5 days again the weight of bioplastic (W) was taken.

$$Biodegradability\% = \frac{W - Wo}{Wo} * 100$$

From the Table 3 it is clear that biodegradability of bioplastics prepared using corn starch & coconut oil cake had good degradability percentage compared to the one's prepared using rice starch. We can also observe that percentage of BP 1 & BP 4 are almost the same with a little difference. Films got completely degraded after 30 days.

Table 3: Percentage Of Bioplastic Sheet Degradation In Soil

Sample	Biodegradability%
BP 1	83.3%
BP 2	56.89%
BP 3	70%
BP 4	89.23%

3.2 Water Absorption Test

Initial weigh the sample (W_O) and immerse it in 50ml distilled water. After 24hrs filter the water and weigh the sample (W).

$$Absorption\% = \frac{W - Wo}{Wo} * 100$$

The presence of hydrophilic compounds in the films may be determined by looking at their solubility. Moreover, the bioplastic films made from rice and corn starch were better at absorbing water. This is because water molecules are drawn to the hydroxyl group in starch, and starch granules are broken apart during the gelatinization process, allowing water to permeate.

Table 4: Water Absorption % Capacity Of Bioplastic Sheets

Sample	Water Absorption%
BP 1	668.63%
BP 2	449.514%
BP 3	323.44%
BP 4	100.652%

3.3 Film Thickness

The bioplastic film thickness was measured using a screw micro meter with an accuracy of 0.001mm. 5 x 2.5 cm bioplastic sheet was taken and then thickness was measured in 5 places which includes 4 corners and middle of the film. Finally average thickness was taken.

Table 5: Thickness Of Bioplastic Sheets

Sample	Average Thickness
BP 1	0.527
BP 2	1.032
BP 3	1.058
BP 4	0.984

3.4 Density

Prepared samples were weighed on electronic weighing balance machine and respectivedensities were determined. Each sheet was cut into 5 x 2.5cm.

$$Density = \frac{Mass}{Volume} = \frac{Mass}{Area * Thickness}$$

Table 6: Density Of Bioplastic Sheets

Sample	Mass (g)	Average Thickness (cm)	Volume (cm^3)	Density (g/cm^3)
BP 1	0.0733	0.0527	0.6587	0.1112
BP 2	0.1508	0.1032	1.2900	0.1168
BP 3	0.1532	0.1058	1.3225	0.1158
BP 4	0.1366	0.0984	1.2300	0.1110

We can also observe that rice starch bioplastic has high density compared to any other sheets.The higher density indicates compact arrangement of polymer chains.

3.5 Tensile Strength

Tensile strength was measured using a RT-201A Plastic Thin Film Tensile Test (ASTM D882).Each sheet was cut into 5 x 2.5cm. The results from the table tells us that tensile strength decreases due to which there would be a increase in flexibility of bioplastics sheets. Increase in flexibility tell us the reducing intermolecular forces. Apart from intermolecular forces, reduction in tensile strength can be due to composition, heating & stirring.

Table 7: Tensile Strength Of Bioplastic Sheets

Sample	Tensile Strength (MPa)
BP 1	10.698
BP 2	11.216
BP 3	19.865
BP 4	13.130

3.6 Solubility Test & Chemical Resistance

Immerse bioplastic in different solvents for 48hrs. High acidity has an impact on every film that was created which can be seen in tables 8–11 . They may have absorbed the solvent and become softer in the alkali as a result of the acid in the film reacting and neutralising. Any bioplastic film didn't show its affect when placed in ketone. Only coconut oil cake has shownit's effect when placed in ethyl alcohol & acetic acid. It's observed that plastic film got softened

Table 8: Solubility Test Of BP 1

Solvents Used	Completely Soluble	Partially Soluble	Incompletely Soluble
Ammonia		+	
Sulphuric Acid	+		
Acetone			+
Acetic Acid			+
Ethyl Alcohol			+

Table 9: Solubility Test Of BP 2

Solvents Used	Completely Soluble	Partially Soluble	Incompletely Soluble
Ammonia		+	
Sulphuric Acid	+		
Acetone			+
Acetic Acid			+
Ethyl Alcohol			+

Table 10: Solubility Test Of BP 3

Solvents Used	Completely Soluble	Partially Soluble	Incompletely Soluble
Ammonia		+	
Sulphuric Acid	+		
Acetone			+
Acetic Acid			+
Ethyl Alcohol			+

Table 11: Solubility Test Of BP 4

Solvents Used	Completely Soluble	Partially Soluble	Incompletely Soluble
Ammonia			+
Sulphuric Acid	+		
Acetone			+
Acetic Acid		+	
Ethyl Alcohol		+	

3.7 FTIR Spectra

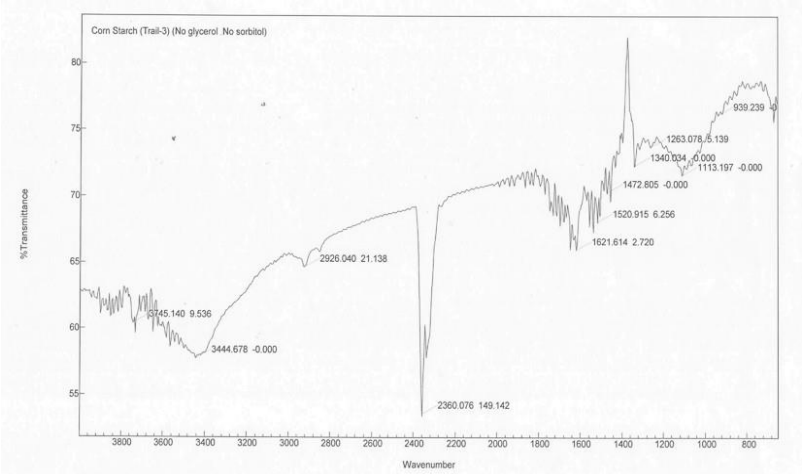


Figure 4: FTIR Spectra Of BP 1

FTIR spectroscopy was used to ascertain the possible chemical interactions in the films. From figure 20 we can observe that the sharp peak at 3745.140 cm^{-1} indicates the single bond region. The broad peak at 3444.678 cm^{-1} indicated the presence of carboxylic acid O–H stretch, confirming the interaction of different –OH groups in the starch and polylactic acid blends. C
– H stretching in alkene groups is confirmed by the broad peak 2926 cm^{-1} and sharp peak at 2360.076 cm^{-1}. The peak at 1621.614 cm^{-1} shows us the C = C stretching in conjugated alkenes.

The narrow peak at 1263cm^{-1} indicates the presence of amines and amides. The peak at 939.239cm^{-1} tells us about the presence of vinyl terminals (-CH = CH2).

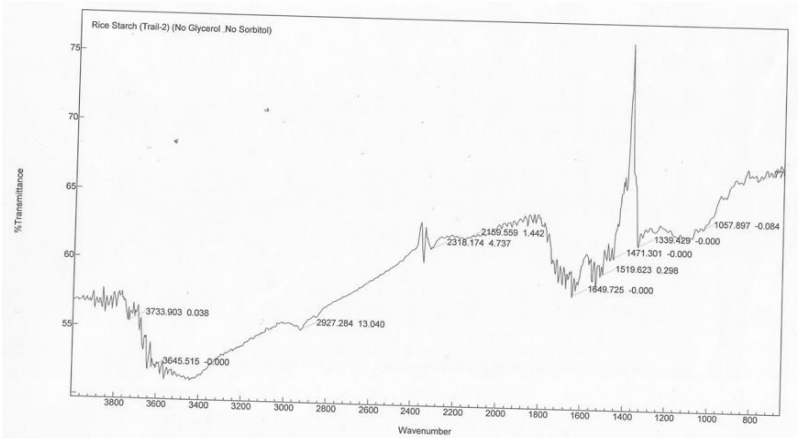


Figure 5: FTIR Spectra Of BP 2

From figure 21 we can observe that the sharp peak at 3733.903 cm^{-1} indicates the single bond region. The broad peak at 3645.515 cm^{-1} indicated the presence of carboxylic acid O–H stretch,confirming the interaction of different –OH groups in the starch and polylactic acid blends. C
– H stretching in alkene groups is confirmed by the broad peak 2927.264 cm^{-1} and sharp peak at 2318.174.076 cm^{-1}. The peak at 1649.725 cm^{-1} shows us the C = C stretching in conjugated alkenes. The peak at 1057.897 cm^{-1} tells us about the C – O stretching in ethers & esters.

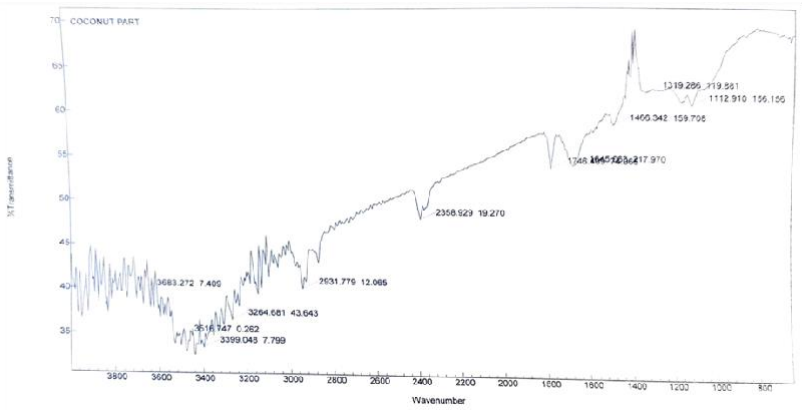


Figure 6: FTIR Spectra Of BP 3

From figure 22 we can observe that the sharp peak at 3683.273cm^{-1}, 3516.747cm^{-1},3399.799cm^{-1} indicates the single bond region. The broad peak at 2931.779 cm^{-1} and narrow peak at 1319.285cm^{-1} indicated the presence of absorption band for long chain liner aliphatic compounds. C – H stretching in alkene groups is confirmed by sharp peak at 2358.929 cm^{-1}. The peak at 1645.063 cm^{-1} shows us the C = C stretching in conjugated alkenes. The peak at 1112.910 cm^{-1} tells us about the presence of hydroxyl group.

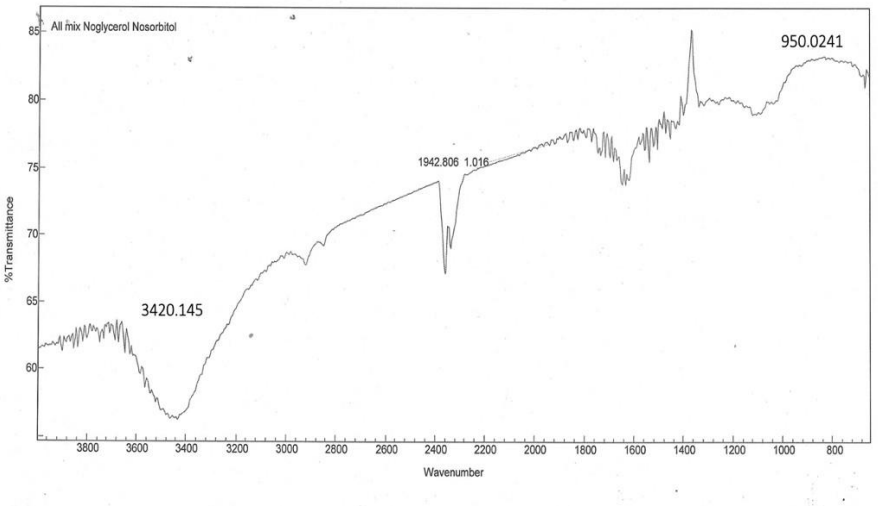


Figure 7: FTIR Spectra Of BP 4

From figure 7 we can observe that the broad peak at 3420.145 cm^{-1} indicated the presence of carboxylic acid O–H stretch, confirming the interaction of different –OH groups in the starch and polylactic acid blends. The peak at 1942.806 cm^{-1} shows us the C = C stretching in conjugated alkenes. The broad peak at 950.0241 cm^{-1} tells us about the presence of vinyl terminals (-CH = CH2).

3.8 pH

Bioplastics were kept in 50ml distilled water & continuously stirred in magnetic stirrer for about 24hrs and then pH was measured using pH meter. It was observed that all the bioplasticsheets pH ranged between 6 – 8.

4 Conclusion

Bioplastic sheets are obtained by varying the concentrations of plasticizers and also by usage of various different starch & fibre based products Soil degradability of rice – corn – coconut oil waste is highest ie., 89.23%. pH calculated after addition of bioplastic in 50ml of water is ranging b/w 6 – 8 this tells us that bioplastic doesn't harm any aquatic life or cannot cause any water pollution. FTIR spectra tells us the presence of organic & inorganic compounds. Tensilestrength of coconut oil waste cake is highest which is about 19.865MPa. As an excellent alternative to plastics derived from petroleum and an effective means of reducing the issue of plastic pollution, all of the bioplastics that were generated were environmentally benign and biodegradable.

5 Future Scope

Biodegradable biopolymers can be synthesised from a wide range of renewable organic raw materials found in flora, fauna, algae, and microorganisms. These materials are abundant, low-cost, and do not interfere with the production of food and feed. Therefore, more research is needed to determine the best raw materials for the synthesis of biodegradable biopolymers. Bioplastics' low moisture resistance hinders their growth and wider use; therefore, further study is needed to find agents that can give bioplastics hydrophobic qualities, which will increase their moisture resistance. It is necessary to do research on various waste materials to ascertain their effectiveness as reinforcing filler in bioplastics. Bioplastics may potentially be commercially viable if they are made from cheap basic substances.

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Recovery of Propionic Acid from Aqueous Phase using Alamine 336 in 1 - Octanol by Reactive Extraction

B. Sarath Babu, Priyanka Seerla Venkata

Abstract: ***The by-products of carboxylic acids are useful in chemical industry, pharmaceutical industry, preservations, drug delivery towards a more economical energy efficient technology. Physical and chemical equilibria results are presented as equilibrium distribution, distribution co -efficient, extraction efficiency, loading ratio and volume percentage by varying concentrations. The distribution of propionic acid between aqueous phase and organic phase reaches equilibrium over a concentration range of 0.009 kmol/m^3 – 0.055 kmol/m^3. The optimum TOA concentration is found to be 40% at which K_D value for 1 - octanol is 16.7. The modified separation increases with decrease in TOA & acid concentration and alamine loading with acid Z decreases with increase in alamine concentration in 1 – octanol. Optimum extraction efficiency is 43.82% for a conc. of 40% TOA at 0.2 kmol/m^3***

Keywords: Carboxylic Acids, Propionic Acid, 1 – Octanol, Alamine – 336, Reactive Extraction, Loading Ratio, Equilibrium Distribution, Efficiency, Modified Separation.

Abbreviations: TOA, (T) – Tri - n - Octyl Amine; [PA] – Propionic Acid; K_D – Distribution Co – efficient; Z – Loading Ratio; S – Separation Factor;

Units: [PA] – Kmol/m^3

I. INTRODUCTION

Carboxylic acids which include propionic acid, succinic acid, lactic acid can be recovered or extracted by traditional methods which involves processes like acidification, crystallization and acidification by ion-exchange resins. However, the rapid industrialization of recent decades has resulted in a reduction or depletion of natural resources, and the growing concern for the environment has prompted a search for clean and environmentally friendly technologies [1]. The recovery of carboxylic acids, which provide a complex functional group of a solute from aqueous solution, using the reactive extraction method has become popular in recent years [2].

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Propionic acid is obtained mainly by three chemical routes [3][17]: Oxidation of propanol:

$$\text{Propanol} + O_2 \longrightarrow \text{Propionic acid}$$

$$CH_3CH_2CH_2OH + O_2 \longrightarrow CH_3CH_2COOH$$

Oxidation of propanol

$$\text{Propanol} + [\,O\,]\ (H_2SO_4/\ KMnO_4) \longrightarrow CH_3CH_2COOH$$

Hydrolysis of esters:

$$X\ \text{Propionate} + H_2O \longrightarrow \text{propionic acid} + \text{alcohol}$$

$$CH_3CH_2COO - X + H_2O \longrightarrow CH_3CH_2COOH + X - OH$$

Propionic acid can also be commercially produced by oxidation of liquid phase propane or propionaldehyde. Propionic acid production by fermentative and chemical processes has not been economically competitive. Therefore it has not been used commercially [4]. Reactive extraction uses extractants from three different groups. There are several of them, such as solvation with carbon- and phosphorus-bonded oxygen-bearing extractants, proton transfer or ion-pairing creation with large molecular weight aliphatic amines and their salts, as well as others [5]. Tertiary amines have good extractabilities for carboxylic acids due to their higher molecular weight, high viscous and corrosive property [6]. Active & inactive diluents are two different categories of diluents. The extraction is improved by a variety of polar, active, proton- or electron-donating solvents [7]. Tertiary aliphatic amines are one of the several extractants for reactive extraction that are frequently utilised in the reactive extraction of carboxylic acids. Chain length aliphatic amines are rather poorly soluble in water without losing any extractant [8][13][14][15][16]. They are also thermostable, making distillation a viable method for regeneration. In general, tertiary amines are preferred to primary or secondary amines. With carboxylic acid, secondary amines may possibly form amides, losing both the product and the extractant [9 – 10].

Selecting the appropriate extractant is crucial for a reactive extraction procedure. he selectivity for the product in comparison to water and a high capacity for the product are its two most crucial properties. The separation factor and distribution coefficient serve as representations of these two needs. In order to overcome the solute's low activity in the aqueous phase, the binding between the extractant and the solute should also be robust, but not so strong as to make regeneration difficult or impossible [11]. This paper includes reactive extraction of propionic acid using alamine – 336 in 1 – octanol.

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II. EXPERIMENTAL PROCEDURE

A. Materials

Alamine 336 (TOA) (98%), Propionic acid (99%), diluent 1-octanol (ACS Reagent (99%)). The solutions of various propionic acid concentrations were made using distilled water. Titration is done using NaOH and phenolphthalein indicator.

B. Apparatus

100 ml standard flask ,25 ml standard flask ,125 ml separating funnel, pH meter, rotating shakers, beakers, pipette, measuring jar.

C. Procedure

Initially 25 ml aqueous solution of required acid concentration was prepared in a conical flask. To this 25 ml of 1-octanol (organic phase) without tertiary amine was added for physical equilibrium. For chemical equilibrium the required quantity of tertiary amine ie., 10% (0.2066kmol/m^3), 20% (0.4132 kmol/m^3), 30% (0.6198 kmol/m^3), 40% was taken in the 1-octanol. Experiments on physical and chemical equilibria were performed at 30°C, or normal temperature. Propionic acid's starting concentration was adjusted from 0.05 to 0.4 kmol/m3. Tri-octyl-amine concentrations of 10% (0.2066 kmol/m^3), 20% (0.4132 kmol/m^3), 30% (0.6198 kmol/m^3), and 40% in 1-octanol were studied at concentrations of 0.05, 0.1, 0.2, 0.3, and 0.4 kmol/m^3 of propionic acid.

Equal amounts (25 ml) of both aqueous and organic solutions are used in extraction experiments, which are run for 12 hours at a constant room temperature. At least two hours were given for the mixture to settle at the same temperature. pH of the aqueous phase was determined using a pH metre. Propionic acid aqueous solutions range in pH from 2.65 to 3.13. Based on the variations in densities, the organic and aqueous phases were separated after settling. A sample of 2 ml is used to estimate the quantity of acid in the aqueous phase using potentiometric titration with 0.05 N NaOH solutions & phenolphthalein as an indicator. The organic phase's acid concentration was estimated using mass balance. Different pH values from 3 to 7 were used in the chemical equilibrium studies [12].

III. RESULTS & DISCUSSION

A. Physical Equilibria

Equilibrium data are produced utilising 1-octanol as a diluent for the propionic acid physical extraction from the aqueous phase. Figure 1, 2 show the distribution of propionic acid between aqueous phase and the organic phase, at equilibrium, over the concentration range of 0.05 kmol/m^3 - 0.4 kmol/m^3. 1 – Octanol is polar in nature. $[PA]_{aq}$ increases with increase in $[PA]_{org}$.

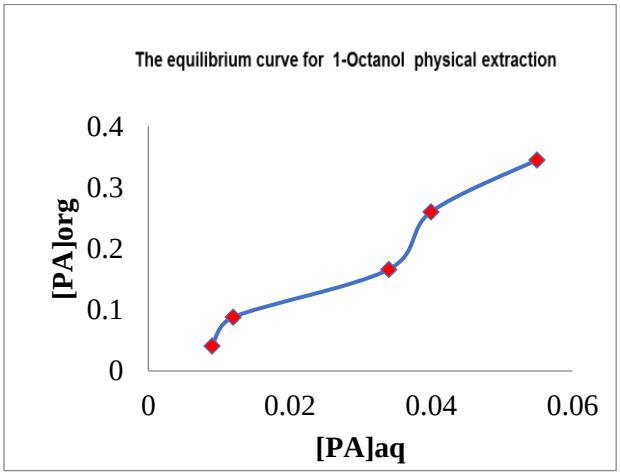


Fig. 1: Physical Equilibrium of (Water – Propionic Acid –1-Octanol)

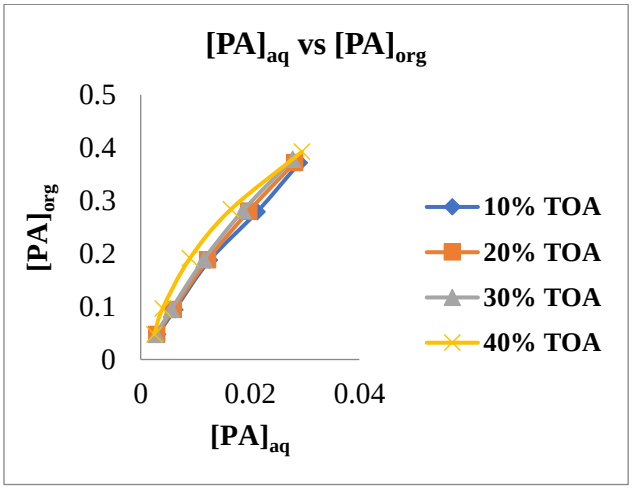


Fig. 2: Equilibrium for Reactive Extraction

Figure 1 shows in organic phase the variation of acid with aqueous phase for different concentrations of propionic acid from 0.05 kmol/$m^3$to 0.4 kmol/m^3in 1-octanol. It is observed that the increase in initial concentration of propionic acid increases the acid concentration in both aqueous phase and organic phase. This indicates that the extraction was clearly impacted by the tri-n-octyl amine in 1-octanol. At any acid concentration, with increasing tri-n-octyl amine concentration, more acid was extracted from aqueous solutions.

The physical extraction figure 1 show that the acid in organic phase for 0.05. 0.1, 0.2, 0.3, and 0.4 kmol/m^3initial concentration of propionic acid are 0.04, 0.088, 0.166, 0.26 and 0.345kmol/m^3 respectively.

The chemical extraction figure 2 show that the acid in organic phase for the same initial concentrations of propionic acid and 10% TOA are 0.0469, 0.0937, 0.1874, 0.2789, and 0.372 kmol/m^3respectively.

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B. Chemical Equilibria

a. Distribution Coefficient

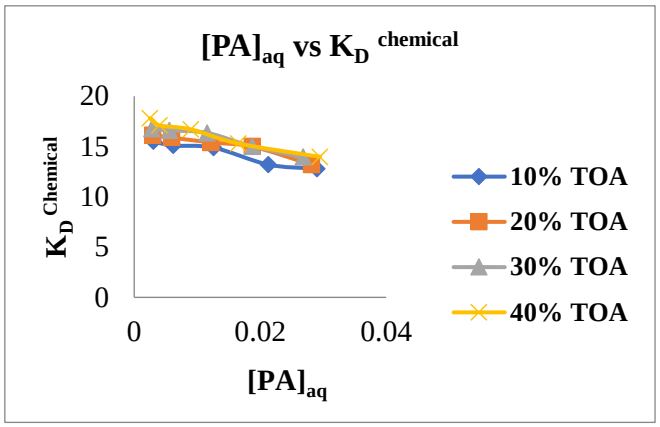


Fig. 3: Effect of Aqueous Concentration $[PA]_{aq}$ on $K_D^{Chemical}$

Alcohols are active diluents by inter molecular hydrogen bonding and also is 1-octanol is insoluble in water due to which the amount of acid extracted at any initial acid concentration from aqueous solution increases with increasing amine concentration and decreasing acid concentration. This can be clearly seen in figure 3.

b. Extraction efficiency

Propionic acid concentration in aqueous medium has an impact on extraction effectiveness, as shown in Figure 4. When the propionic acid concentration is reduced, the level of extraction dramatically increases. The influence of aqueous concentration on extraction efficiency has been studied using various TOA concentrations, and it has been shown that the extraction efficiency improved as tri-n-octyl amine concentrations rose. This is brought on by the fact that when TOA concentration rises, the acid concentration in the aqueous phase decreases.

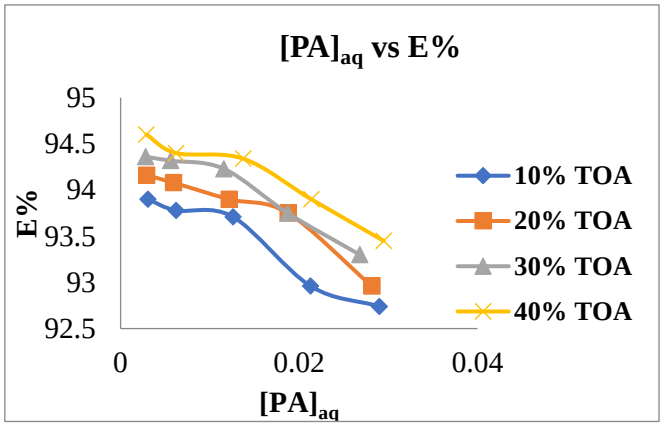


Fig. 4: Effect of Aqueous Concentration on Extraction Efficiency

c. Loading ratio

The stoichiometry of the entire extraction method is determined by the loading ratio, Z, in the organic phase.

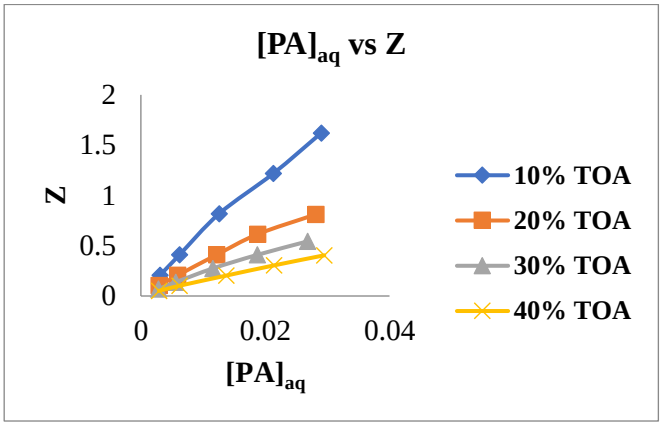


Fig. 5: Effect of Aqueous Concentration on Loading Ratio

It can be seen in Figure 5 that the loading ratio (Z) declined as tri-n-octyl amine concentrations increased. Only when complexes comprising more acid molecules form at lower tri-n-octyl amine concentrations does this occur. It is obvious that complexes containing a single amine develop since loading decreases as tri-n-octyl amine concentration increases.

d. Effect of volume percentage of TOA

The distribution coefficient first increased then decreased, It has increased for chemical extraction ($K_D^{Chemical}$) from 10 – 40% and decreased from 40 - 60% TOA in 1-octanol. The 40 volume % of TOA is considered to be the optimum because high K_D is obtained. Propionic acid is one of the by products from fermentation and effluent industries. The acid amine complex involve with a few acid molecules at higher concentrations of tri-n-octyl amine.

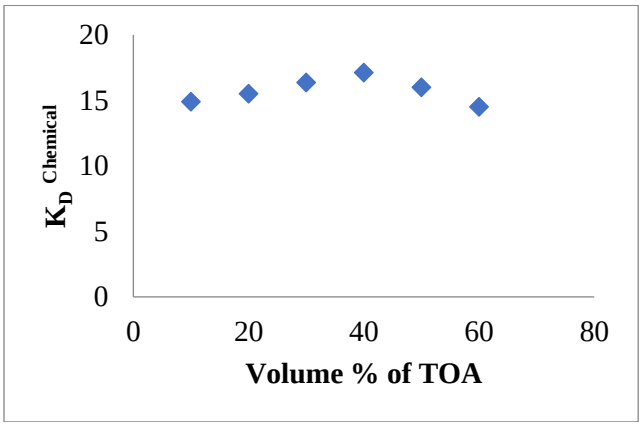


Fig. 6: Effect of Volume % for Extraction of 0.2 kmol/m3 Propionic Acid

e. Effect of pH

pH was calculated using pH meter. Propionic acid extraction employing 40% TOA in 1-octanol is shown in figure 7. Since the pH of the fermentation broth changes as acid is created, it is crucial to research how pH affects the extraction of propionic acid at varied pH values. It is discovered that extraction is relatively low at pH 5 of acid when pH is changed from 3.0 to 7.

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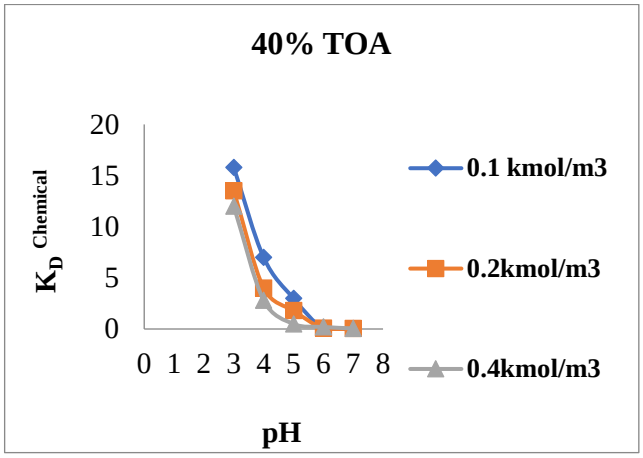


Fig. 7: Effect of pH

The cause is greater pH levels. Acid is mostly present in its dissociated state, while TOA only removes acid in its undissociated form. As a result, K_D Chemical is quite low. For a 30% TOA in 1-octanol, it can be shown that a rise in pH causes a progressive reduction in K_D Chemical with almost no extraction at pH 6. For 40% TOA in 1-octanol, however, K_DChemical decreases sharply when pH is raised above natural pH; beyond that, the reduction is more gradual and slower. The most likely explanation for this is that when pH rises, the proportion of undissociated acid decreases. The excessive amount of TOA present caused the existing bonding sites to become cluttered, which resulted in a very low acid partition from the aqueous phase.

f. Modified Separation Factor

From figure 9 the S_f observed is 0.5172 at initial concentration of acid 0.1 kmol/m^3 and TOA concentration of 30% in 1-octanol. From figure 10 for same concentration of acid and 40% TOA in 1-octanol, the S_f is found 0.5157 which is lower that 30% TOA concentration.

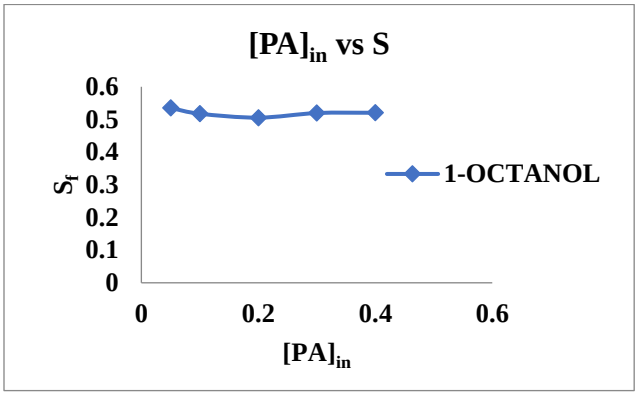


Fig. 8: Effect of acid concentration ([PA]in) on Sf using 30% Alamine

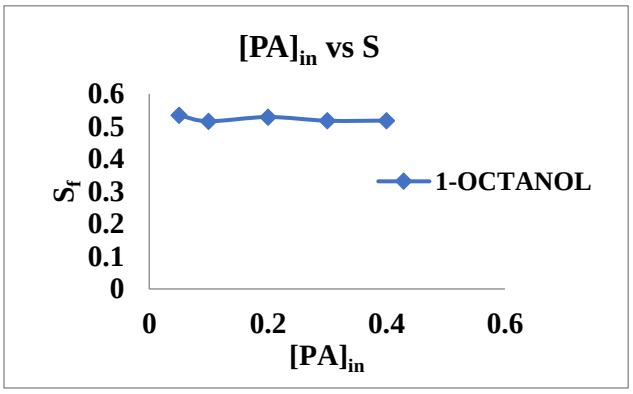


Fig. 9: Effect of acid conc. ([PA]in) on Sf using 40% alamine

Figures 8 & 9 depict how the modified separation factor affects the initial acid concentration. With increasing acid content, a reduction in the relative proportion between physical interaction and chemical reaction, indicated by S, was seen. While loading was observed to decrease with higher TOA concentrations in 1-octanol.

Table 1: Physical Equilibrium of (Water – Propionic Acid –1-Octanol)

$[PA]_{aq}$	$[PA]_{org}$
0.009	0.041
0.012	0.088
0.034	0.166
0.04	0.26
0.055	0.345

Table 2: Equilibrium for Reactive Extraction of Propionic Acid

10% (T)		20% (T)		30% (T)		40% (T)	
$[PA]_{aq}$	$[PA]_{org}$	$[PA]_{aq}$	$[PA]_{org}$	$[PA]_{aq}$	$[PA]_{org}$	$[PA]_{aq}$	$[PA]_{org}$
0.00305	0.04695	0.00292	0.04708	0.0028	0.0472	0.0025	0.0475
0.00621	0.09378	0.00592	0.09408	0.0056	0.0944	0.004	0.096
0.01259	0.1874	0.01219	0.1878	0.01158	0.18884	0.009	0.191
0.0213	0.2789	0.01876	0.28124	0.01874	0.28126	0.0165	0.2835
0.029	0.3710	0.02816	0.37184	0.0268	0.3732	0.02949	0.3705

Table 3: Effect of Aqueous Concentration on KD With Varying TOA Concentration In 1-Octanol

10% (T)		20% (T)		30% (T)		40% (T)	
$[PA]_{aq}$	$K_D$chemical	$[PA]_{aq}$	$K_D$chemical	$[PA]_{aq}$	$K_D$chemical	$[PA]_{aq}$	$K_D$chemical
0.00305	15.5	0.00292	16.12	0.0028	16.75	0.0025	17.8
0.00621	15.09	0.00592	15.89	0.0056	16.6	0.004	17.1
0.01259	14.89	0.01219	15.4	0.01158	16.35	0.009	16.7
0.0213	13.2	0.01876	14.99	0.01874	15.01	0.0165	15.3
0.029	12.78	0.02816	13.2	0.0268	13.94	0.02949	13.97

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Table 4: Effect of Aqueous Concentration on Extraction Efficiency

10% (T)		20% (T)		30% (T)		40% (T)	
$[PA]_{aq}$	E%	$[PA]_{aq}$	E%	$[PA]_{aq}$	E%	$[PA]_{aq}$	E%
0.00305	93.90	0.00292	94.16	0.0028	94.36	0.0025	94.6
0.00621	93.78	0.00592	94.08	0.0056	94.318	0.004	94.4
0.01259	93.71	0.01219	93.9	0.01158	94.23	0.009	94.34
0.0213	92.96	0.01876	93.75	0.01874	93.75	0.0165	93.9
0.029	92.74	0.02816	92.96	0.0268	93.3	0.02949	93.45

Table 5: Effect of Aqueous Concentration on Loading Ratio

10% (T)		20% (T)		30% (T)		40% (T)	
$[PA]_{aq}$ Kmol/m^3	Z	$[PA]_{aq}$ Kmol/m^3	Z	$[PA]_{aq}$ Kmol/m^3	Z	$[PA]_{aq}$ Kmol/m^3	Z
0.00305	0.2050	0.00292	0.1028	0.0028	0.0687	0.0025	0.051
0.00621	0.4095	0.00592	0.2054	0.0056	0.1374	0.004	0.1023
0.01259	0.8184	0.01219	0.4099	0.01158	0.2743	0.009	0.2033
0.0213	1.2179	0.01876	0.6139	0.01874	0.4094	0.0165	0.3041
0.029	1.6200	0.02816	0.8120	0.0268	0.543	0.02949	0.4045

Table 6: Effect of pH on KDChemical for different acid Conc. of Propionic Acid using 40% TOA

$[PA]_{in}$	pH	$[PA]_{aq}$	$[PA]_{org}$	$K_D^{chemical}$
0.1	3	0.00489	0.0951	19.45
	4	0.00943	0.09057	8.8
	5	0.0227	0.07727	2.9
	6	0.053	0.0474	0.09
	7	0.095	0.00476	0.05

$[PA]_{in}$	pH	$[PA]_{aq}$	$[PA]_{org}$	$K_D^{chemical}$
0.2	3	0.0133	0.1867	14
	4	0.02597	0.17402	6.6
	5	0.04762	0.15238	3.2
	6	0.18349	0.01651	0.09
	7	0.19048	0.009524	0.05

$[PA]_{in}$	pH	$[PA]_{aq}$	$[PA]_{org}$	$K_D^{chemical}$
0.4	3	0.0308	0.3692	12
	4	0.05479	0.3452	6.3
	5	0.08333	0.3167	3.8
	6	0.36697	0.03303	0.0-9
	7	0.3809	0.01905	0.05

IV. CONCLUSION

Propionic acid is obtained by reactive extraction using alamine 336 in 1 – Octanol. Physical and chemical equilibria for propionic acid by Tri – n octyl amine in 1 - Octanol as a diluent have been determined. . The optimum TOA concentration is found to be 40% at which K_D value for 1 - octanol is 16.7. The modified separation increases with decrease in TOA & acid concentration and loading of TOA with acid Z decreases with increase in TOA concentration in 1 – octanol. Optimum extraction efficiency is 43.82% for a conc. of 40% TOA at 0.2 kmol/m^3. In future different carboxylic acids can be extracted using alamine 336 or aliquat in different diluents due to the high applications of carboxylic acids in various different fields.

DECLARATION STATEMENT

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Conflicts of Interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	Not relevant
Authors Contributions	All authors have equal participation in this article.

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Reactive Extraction of Gluconic Acid Using Tri-n-Octylamine in 1- Octanol

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Abstract- ***Reactive extraction is a separation method which is used for the recovery of carboxylic acids from fermentation broth. Gluconic acid is a carboxylic acid which is used in chemical, pharmaceutical and food industries. Tertiary amines are effective extractants for separation of carboxylic acid from dilute solutions. An Adequate combination of extractant and diluent will provide a high yield. The reactive extraction of Gluconic acid with Trioctylamine and 1-octanol is carried out for different Concentrations of acid, Trioctylamine (TOA) and 1-octanol at room temperature. From the physical and chemical equilibrium experimental results, the distribution coefficient (K_D), extraction efficiency (E %), loading ratio (Z) are calculated. It was found that physical extraction provided less yield compared to chemical extraction. A maximum K_D was obtained as 3.57 using 40% TOA (0.02 mol/L) while 78.13 % of the gluconic acid was extracted. By increasing the initial concentration of gluconic acid increased the concentration of gluconic acid in both phases. As the concentration of TOA increases from* **10 to 40 % (0.0229mol/L to 0.02 mol/L),** ***the distribution coefficient and extraction efficiency also increases.***

Key words: Reactive Extraction, Gluconic Acid, Tri-n-Octyl amine, 1-octanol

I. INTRODUCTION

Gluconic acid is a carboxylic acid. Gluconic acid (pentahydroxycaproic acid, $C_6H_{12}O_7$) is the oxidation product of glucose, naturally occurring in plants, fruits, wine (up to 0.25%), honey (up to 1%), rice, meat, vinegar and other natural sources. Gluconic acid is the largest commercially produced of fungal organic acids, from glucose. Demand for metal gluconates is steadily increasing due to their multiple applications in different industries.

The separation and purification of Gluconic acid from fermentation broth is inefficient by conventional methods like adsorption, distillation, solvent extraction, reverse osmosis, ion exchange, ultra filtration etc. Reactive extraction is a separation method which is used to enhance the extraction of solute from the Aqueous Phase to the Organic Phase. The extractant molecule reacts with the solute molecule to form a reaction complex, which will stabilize in Organic Phase due to the hydrogen bonding with 1-Octanol and hydrophobic nature of complex. Reactive extraction has various rewards like enhanced reactor productivity, control over pH in the bioreactor, reduces the downstream processing load, and minimizes the solvent recovery cost and higher efficiency. In the current work, an investigation on the recovery of Gluconic acid from aqueous solution was conducted by using TOA in 1-Octanol. The equilibrium parameters are studied such as K_D, E %, Z using experimental data.

II. THEORY

The extraction process was analyzed by using the Distribution Coefficient K_D. The distribution coefficient (K_D) is defined as the ratio of total concentration of acid in all forms in the organic phase to total concentration of all existing forms in the aqueous phase. Consider that no change in volume at equilibrium.

$$K_D = \frac{[\overline{GA}]_{total}}{[GA]_{total}}$$

Where, $[\overline{GA}]_{total}$= Concentration of acid in organic phase. $[GA]_{total}$= Concentration of acid in aqueous phase.

The extraction efficiency (E %) is defined as the proportion of Gluconic acid concentration in the

Organic Phase to the sum of Gluconic acid concentration in organic phase and Aqueous Phase.

$$E\% = \frac{K_D}{1+K_D} \times 100$$

The value of Z depends on the extractability of the acid i.e. strength of the acid base interaction and its aqueous concentration. The stoichiometry of the overall extraction equilibrium depends on the loading ratio in organic phase (Z). If the organic phase is not highly concentrated by acid, i.e., at very low loading ratios (Z < 0.5), 1:1 complex of acid and extractant is formed.

The extent to which organic phase (TOA+Octanol) can be loaded with carboxylic acid is expressed as the loading ratio, Z;

$$Z = \frac{[GA]_{org}}{[T]_{org}}$$

Where, $[GA]_{org}$= Concentration of acid in organic phase after extraction.

$[T]_{org}$= Concentration of TOA in organic phase before extraction.

III. MATERIALS AND METHODS

Materials

Gluconic Acid (pentahydroxycaproic acid ,$C_6H_{12}O_7$) (49-53 wt % of H_2O), molar mass 196.16 kg/kmol, density 1.134 g/ml at 25^0C, 97 % purity was procured from Sigma-Aldrich (India). TOA (N,N-dioctyloctan-1-amine) ($C_{24}H_{51}N$) a tertiary amine is a colour less liquid with the molar mass 353.66 g/mol , density 0.81 g/cm3 at 20^0C, 98 % purity, was procured from Sigma-Aldrich (India). 1-octanol, molar mass 130.23 g/mol, density 0.827 g/ml at 250C, 98 % purity was used as a diluent was obtained from Sigma-Aldrich (India). Phenolphthalein solution with pH range 8.2 to 10 was used as an indicator was procured from Ranbaxy, India. Distilled water was used to prepare the solutions of various initial concentrations of Gluconic acid solutions. 0.1 N of NaOH and phenolphthalein indicator used for titration. The initial concentration of TOA in 1-octanol was varied from 10% to 50% on volume basis. The aqueous phase consists of Gluconic acid and water and the organic phase consists of TOA and 1-Octanol.

Methods

Equilibrium Studies:

Optimum time was calculated (12 hours) to attain liquid-liquid equilibrium for both physical extraction and chemical extraction by analyzing the samples at regular intervals of time. The initial concentrations of Gluconic acid were 0.03, 0.0634, 0.12653, 0.1897, 0.25306, 0.31632 mol/L respectively.

Physical equilibrium:

For physical equilibrium, 20 ml of Gluconic acid (AP) of different concentrations were taken in different conical flasks and 20 ml of 1-octanol (OP) was added in each conical flask. Mechanical shakers were used to mix both the phases for 12hrs at room temperature. The organic and aquennnous phases were allowed to steady down in a separating funnel for 2 hours. A sample from aqueous phase was titrated with 0.1N NaOH using Phenolphthalein as an indicator to measure the concentration of Gluconic acid in the Aqueous Phase. By using Mass balance calculated the concentration of Gluconic acid in the Organic Phase.

Chemical equilibrium:

For chemical equilibrium, 20 ml of gluconic acid and 20 ml of 10 % TOA (0.2264 mol/L) in 1-octanol was added in a conical flask. The immiscible solution was kept in shakers for 12 hours and then kept under separation for 2hours. The Gluconic acid concentration was determined from the aqueous phase by titrating a sample solution with 0.1N NaOH using Phenolphthalein as an indicator. The same procedure was repeated for 10%, 20%, 30% and 40% TOA.

IV. RESULTS AND DISCUSSION

Data obtained from the experiments are tabulated and compared to know the amount of the Gluconic acid extracted from aqueous solution using the physical and chemical equilibrium methods with different concentration of the TOA. From the equilibrium data, the K_D, E %, Z, are calculated as shown in Table 1 and Table 2.

Physical equilibrium

The most effective diluents are alcohols since they enhance the extraction of carboxylic acids. Among those 1-octanol is the one alcohol which is used as a diluent here for extraction of Gluconic acid. The physical equilibrium data values for Gluconic acid using 1-octanol are shown in Table 1.

$[GA]_{in}$ mol/L	$[GA]_{aq}$ mol/L	$[GA]_{org}$ mol/L	K_D	E%
0.03	0.01	0.018	1.80	64.29
0.06	0.02	0.023	1.15	53.49
0.12	0.04	0.039	0.98	49.37
0.18	0.07	0.049	0.70	41.18
0.2	0.08	0.054	0.68	40.30
0.3	0.13	0.056	0.43	30.11

Table 1: Physical equilibrium of Gluconic acid & 1-octanol

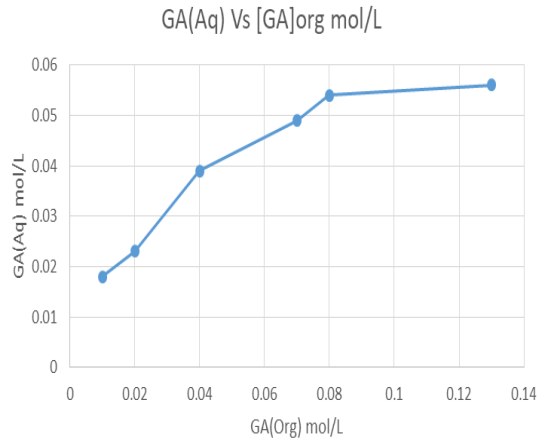


Figure 1 physical extraction equilibrium curves for extraction of Gluconic acid using 1-octanol

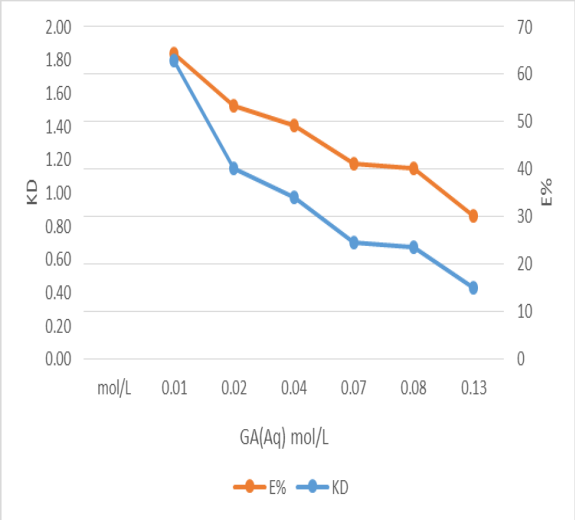


Fig 1: Equilibrium distribution of water -Gluconic acid &1-octanol

Chemical equilibrium

The Chemical Extraction of Gluconic Acid was studied with 1-Octanol in the presence of Tri-octylamine solution. Reaction extraction of Gluconic acid with five different concentrations of TOA in 1-octanol revealed that the amount of Gluconic acid extracted in both Aqueous Phase and Organic Phase is directly proportional to the ICLA The phase equilibrium data of octanol was measured by varying the Gluconic Acid concentration in feed phase in the range of 0.03-0.3 mol L^{-1}.The maximum K_D was obtained is using 40% TOA (mol/L). As the concentration of TOA increased from 10%-40%, K_D and E% Increased.

10% TOA				
[GA]aq	[GA]org	K_D	E%	Z
0.012	0.013	1.08	52.00	0.5677
0.03	0.03	1.00	50.00	1.3100
0.06	0.05	0.83	45.45	2.1834
0.09	0.07	0.78	43.75	3.0568
0.12	0.08	0.67	40.00	3.4934
0.16	0.09	0.56	36.00	3.9301
20% TOA				
[GA]aq	[GA]org	K_D	E%	Z
0.01	0.02	2.00	66.67	0.8811
0.025	0.04	1.60	61.54	1.7621
0.055	0.06	1.09	52.17	2.6432
0.085	0.08	0.94	48.48	3.5242
0.1	0.09	0.90	47.37	3.9648
0.15	0.1	0.67	40.00	4.4053
30% TOA				
[GA]aq	[GA]org	K_D	E%	Z
0.005	0.015	3.00	75.00	0.7009
0.02	0.04	2.00	66.67	1.8692
0.05	0.065	1.30	56.52	3.0374
0.08	0.085	1.06	51.52	3.9720
0.09	0.09	1.00	50.00	4.2056
0.15	0.11	0.73	42.31	5.1402
40% TOA				
[GA]aq	[GA]org	K_D	E%	Z
0.007	0.025	3.57	78.13	1.2500
0.01	0.035	3.50	77.78	1.7500
0.04	0.07	1.75	63.64	3.5000
0.08	0.09	1.13	52.94	4.5000
0.095	0.1	1.05	51.28	5.0000
0.15	0.12	0.80	44.44	6.0000

Table 2: Equilibrium for reactive extraction of Gluconic acid with various concentrations of TOA in 1- octanol

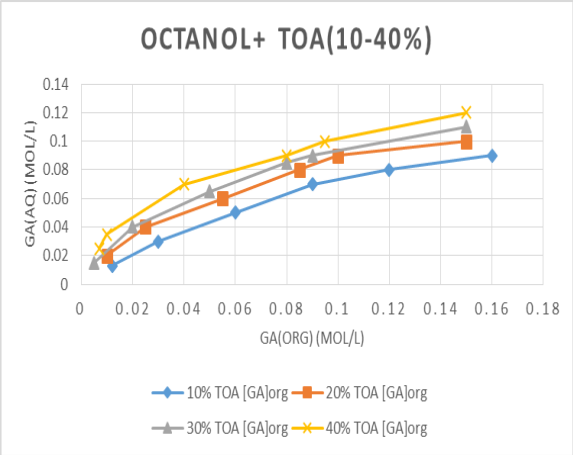


Fig 2: Equilibrium for reactive extraction of Gluconic acid with various concentrations of TOA in 1-octanol

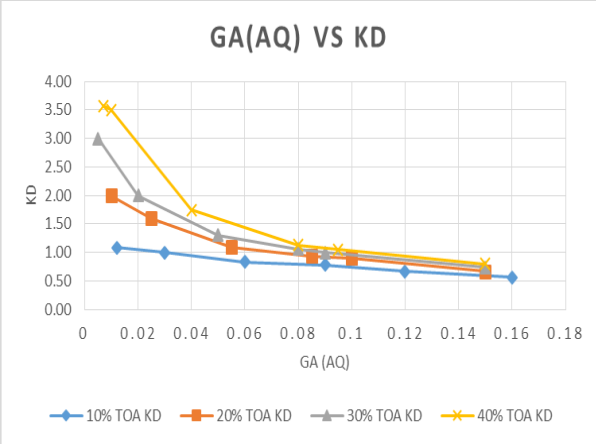


Fig 3: Effect of concentration of acid in aqueous phase on Distribution Coefficient with variable TOA Concentration in 1-octanol

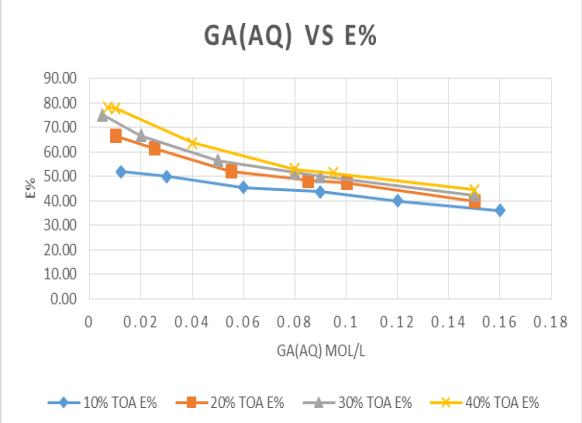


Fig 4: Effect of concentration of acid in aqueous phase on Extraction Efficiency with variable TOA Concentration in 1-octanol

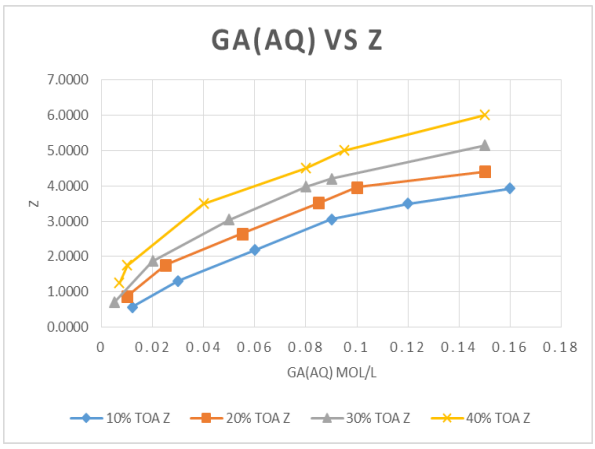


Fig 5: Effect of concentration of acid in aqueous phase on Loading Ratio (Z) with variable TOA concentration in 1-octanol

V. CONCLUSION

The Reactive extraction of Gluconic acid using TOA in 1-octanol experiment was conducted. The key findings are as given below Chemical extraction was found to have high distribution coefficient and extraction efficiency than Physical extraction. The distribution coefficient and extraction efficiency decrease with increase in acid concentration. The loading ratio of TOA with acid Z increases with increasing in Gluconic acid concentration. The optimum TOA concentration is found to be 40% at K_D values for 1-octanol is 3.57

VI. NOMENCLATURE

K_D distribution coefficient
E% extraction efficiency
Z loading ratio
[GA] Concentration of Gluconic acid (mol/L)
[T] Concentration of Tri-n-octylamine (mol/L)
Subscripts
aq aqueous phase
org organic phase

VII. ABBREVIATION

TOA Tri-n-octylamine
AP Aqueous phase
OP Organic phase
ICGA Initial concentration of Gluconic acid

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PSO Trained Feed Forward Neural Network Based SAPF for Power Quality Enhancement in Distribution Networks

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***Abstract*—Power distribution infrastructure is being harmed by the advent of nonlinear devices, which cause harmonics to enter into the power system networks and distort the voltage and current signals. Shunt Active Power Filter (SAPF) is a new power electronics-based technology that can reduce harmonics and improve the power quality in distribution networks. This research provides an efficient and inexpensive strategy to minimizing harmonics and improving the power quality in power distribution networks by employing Shunt Active Power Filter's (SAPF), which uses the Particle Swarm Optimized Artificial Neural Network Controller (PSO-ANN). The goal of the PSO-ANN algorithms have been developed for SAPF is to improve system performance by lowering the amount of Total Harmonic Distortion (THD). In this work, the standard PI controller is initially tuned using the PSO algorithm to obtain the optimal gain values (K_i, K_p) for the PI controller. After that, these values of the PSO-PI controller's input and output will serve as a dataset for the ANN controller. Now, the PSO algorithm is being used to tune this ANN controller in order to acquire the optimal values for the weight and bias. Using the MATLAB/SIMULINK tool, the proposed algorithm's performance is evaluated and compared to that of a PSO-PI based SAPF and the conventional PI based SAPF. The results of the simulation demonstrate that a SAPF which is based on a PSO-ANN controller is capable of achieving superior THD in the drawing source current while maintaining minimum levels and which are acceptable in accordance with the IEEE-519 standard for harmonics.**

***Index Terms*—ANN-controller tuning, particle swarm optimization algorithm, PI-controller tuning, power quality, shunt active power filter, total harmonic distortion**

I. Introduction

Harmful harmonic currents are produced at the Point of Common Coupling (PCC) due to the usage power electronics devices and non-linear load in huge quantities [1]. Because of the many issues that can arise from distribution system current harmonics, loss, instability, noises, heating appliances, etc. It would be preferable to reduce their risk and bring them down to an acceptable level, as specified by the IEEE-519 standards for Total Harmonic Distortion (THD) [2].

To reduce current harmonics, compensate for reactive power, and improve power factor, a Shunt Active Power Filter (SAPF) could be the solution. Fig. 1 (next page) depicts the SAPF setup, this consists of the active filter controller as well as the Voltage Source Inverter (VSI). In order to achieve the desired result of injecting a controlled compensating current into the power system, the VSI requires instantaneous adequate firing signals from the control unit [3, 4]. The reactive power control to the grid is supplied by the DC-link capacitor employed on the front side of the VSI [5]. In order to connect the DC component to the three-phase power distribution system, a VSI is necessary. To reduce the amount of distortion in the source current, VSI injects a compensating current in response to the firing signals [6].

To analyze the VSI switching operation, either reference generating methods or control techniques are used. The SAPF control techniques are able to be implemented in two steps, which are as follows: first, by using reference current generation theories to extract compensating signals from distorted signals, and then, by using signal estimated reference methods to produce appropriate firing signals for the purpose of controlling the SAPF switching devices [7]. Several writers have compared SAPF control techniques ([8, 9]).

The PI-controller, which is an integral aspect of reference current theory, is responsible for minimizing the impact of harmonics. K_i and K_p gain settings of the PI-controller need to be properly tuned in order to obtain the best possible results. The traditional approach for tuning the gains of the PI-controller utilizes linear modeling, which ultimately results in a less-than-optimal setting for the gains [10, 11]. Consequently, PI-controller tuning makes use of a variety of different metaheuristic optimization strategies. There are a variety of control methods that can lower current harmonics and introduce the converter to brand new opportunities [12]. Consider, for example, the Particle Swarm Optimization (PSO) [13−17] method and Genetic algorithm (GA) [18].

Artificial Neural Network (ANN) is a network that is set up and works in a way that is similar to how the human brain works. To simply stated, the brain is a network of cells called neurons. The behavior of the

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whole network depends on how strong the connections between interneuron's are and how they are set up. During the training of the network, the weights are changed and tweaked [19]. At the moment, Artificial Neural Network (ANN) techniques are only used on SAPF for producing reference compensation current, which is used to control the compensation that SAPF gives [20, 21]. Learning weights can be accomplished in a variety of techniques [22]. Some examples include the Widrow-Hoff (W-H) approach, the Steepest Descent method of variable learning, the Levenberg-Marquardt method, and others.

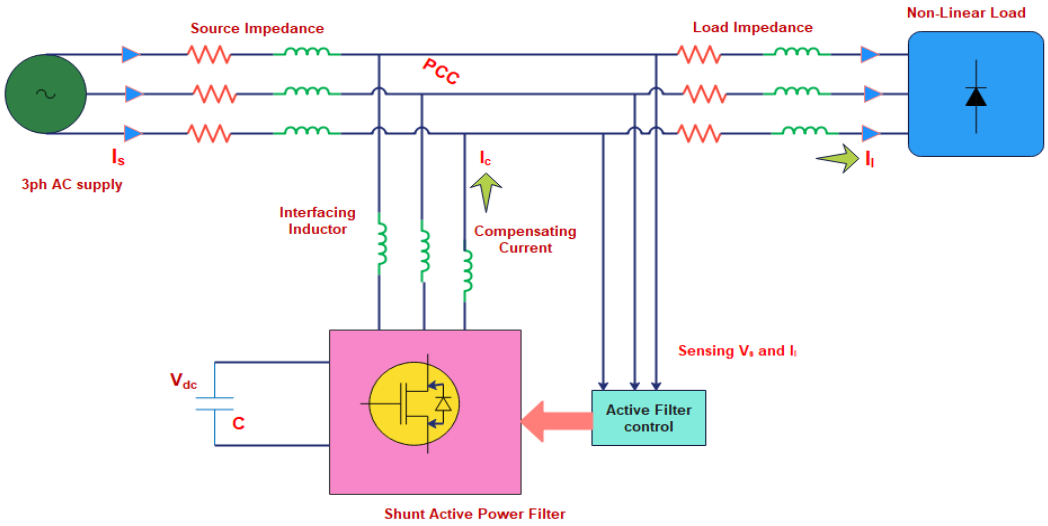


Fig. 1. Basic elements of the shunt active power filter.

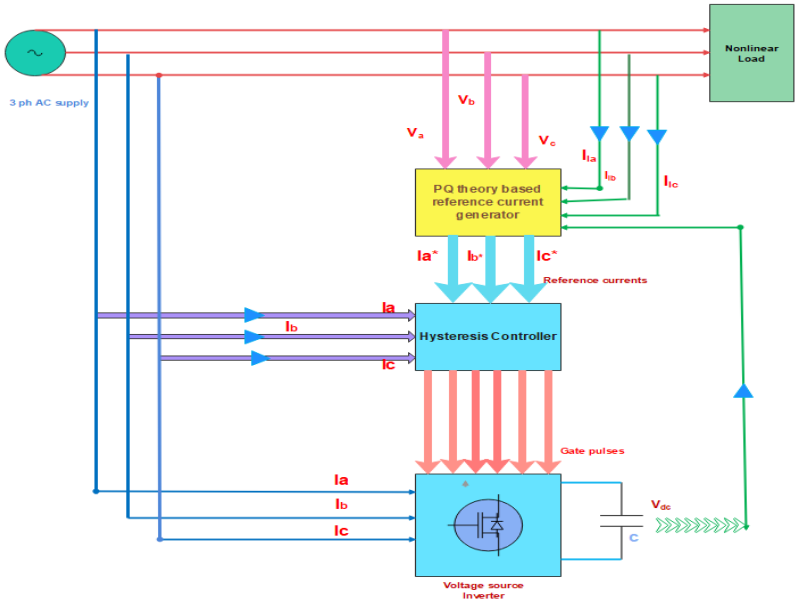


Fig. 2. SAPF controller configuration.

This work uses the concepts of instantaneous active and reactive power to derive the reference current (PQ-theory). Hysteresis current controller technique, as shown in Fig. 2 [23], estimates reference currents to provide necessary gating pulses. For optimum performance of a PQ-theory based ANN-controller for a dc-link voltage requires fine-tuning of weight and bias values. For the optimum ANN-controller weight and bias particle swarm optimization algorithm is implemented in order to identify its optimal state.

II. PQ Theory

In the case of three-phase, three-wire systems that have sinusoidal and balanced source voltages, a PQ-theory-based constant instantaneous power control approach has been developed. The instantaneous power is calculated by sensing the source voltage (V_a, V_b, V_c) and load current (I_{la}, I_{lb}, I_{lc}) and transforming them using Clarke transformation into (α, β) components. Error signal is derived from reference and measured dc-link voltages, then introduced to PI or ANN controller to obtain power losses component of dc-link voltage (P_{loss}). As illustrated in Fig. 3 (next page) [24], the reference current signals are obtained by inverting the components (α, β) with the real and reactive power by use of the inverse Clarke transformation (α, β to three phase values (V_a, V_b, V_c, I_{la}, I_{lb}, I_{lc}).

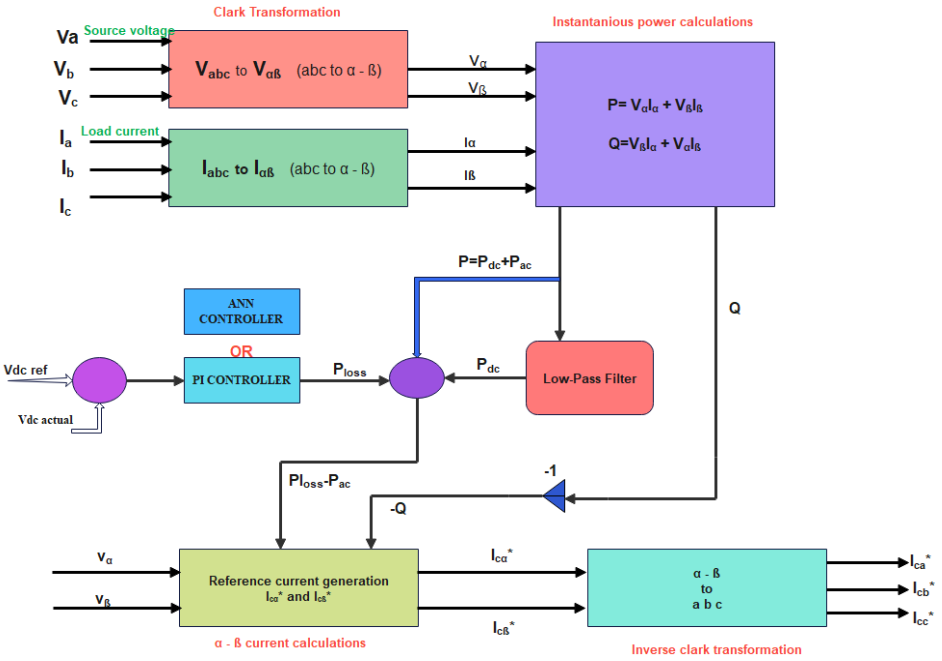


Fig. 3. Work flow of PQ theory based reference current generation.

III. Artificial Neural Network (ANN)

The human brain's structure is built on neural networks, hence the terminology "Artificial Neural Network" is adopted from the neuroscience area. Multiple layers of interactions are present between neurons in artificial neural networks, just like the neurons in the human brain are connected to each other. These nerve cells are called nodes as shown in Fig. 4. A nominal neuron is a processing element that, in general, possesses one or more outputs and n inputs (x_1, x_2,⋯, x_n) which are the independent inputs or outcomes of the different neurons. Fig. 5 provides a visual representation of these inputs and outputs. The neuron begins by computing the sum of its inputs, and then it transfers this value through its activation function in order to form its output, which is indicated by the value Y_i [25].

$$Y_i = f_i\left(\sum_{j=1}^{n} w_{i,j}x_j + b_i\right) \quad (1)$$

where $w_{i,j}$ are the weight of the connection between the input neuron and the output neuron, b_i is the bias of the neuron, x_j represents the neuronal input, and f is activation function that controls the characteristics of the neural network.

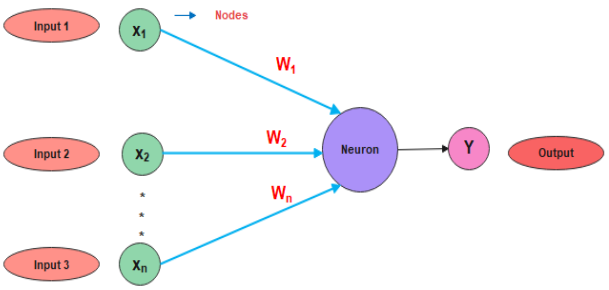


Fig. 4. Basic structure of artificial neural network.

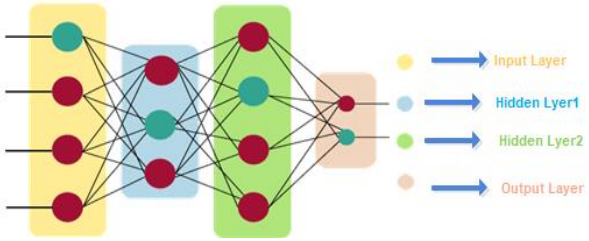


Fig. 5. Architecture of the artificial neural network.

Neural networks adjust to input data by changing connection weights (including biases) and sometimes layer number and neurons number.

IV. Introduction to PSO

The comprehensive implementation of PSO algorithm starts with the movement of a group of possible random solutions, which are represented in the form of moving particles in inside target region. This movement is done in order to find the optimal solution. Every one of the nearby particles that are being assumed has some a speed as well as a selective memory, which enables each other to recall the position and value that corresponds to their optimal level of performance. This is being done by taking into account all of the information that is currently being taken into account. A predetermined objective function that is tied to the problem that needs to be resolved [26] is used to evaluate the efficacy of each individual particle. The velocity of each particle at iteration is determined by linearly combining the velocity and position at iteration, as well as the intervals that separate the existing position of the particle from its preceding best position and finest position, respectively. This information is then used to calculate the velocity of each particle. This leads to the development of a formula for determining the velocity of the particle at the next iteration, which is denoted by t+1. The motion of the

particles is formalized for us by Eqs. (2) and (3), which provide us a representation of the movement of the particles.

$$v_i(t) = wv(t-1) + \left[P_{\text{best}}(t-1) - x_i(t-1)c_1r_1\right] + \left[G_{\text{best}} - x_i(t-1)\right]c_2r_2 \quad (2)$$

$$x_i(t) = x(t-1) + v_i(t) \quad (3)$$

where x_i is the ith particle position, v_i is the ith particle velocity, P_{best} is particle best position, G_{best} is target position, w is coefficient of inertia, c_1 and c_2 are coefficients of acceleration, and r_1 and r_2 are values at random between 0 and 1.

Iterate (2) and (3) until convergence is achieved [27].

V. Proposed Implementation

A. PSO Tuned PI Controller

The primary function of SAPF is dependent on DC link voltage regulation, which is controlled by standard PI controller. This controller requires a great deal of mathematical calculation, and it is possible that it will not produce optimal gain values for k_p and k_i. With the help of the PSO algorithm, we can determine the optimal values for k_p and k_i.

The actual dc voltage as compared to the reference dc voltage and the error that will be fed to the PSO-PI controller can be seen in the Fig. 6. The Integral Absolute Error (IAE) is the objective function that needs to be minimized with the help of the PSO algorithm in order to obtain the optimal gain values. The parameters for the PSO are specified in the Table I.

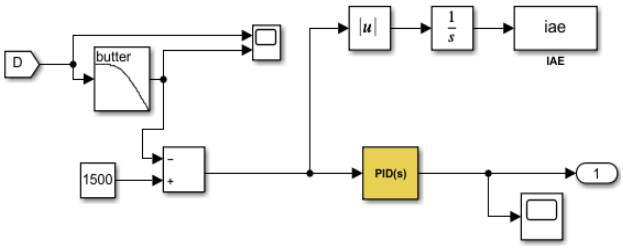


Fig. 6. DC voltage regulation of SAPF with PSO-PI controller.

TABLE I: PSO Parameters

Maximum iterations	1000
Total Population	50
Weight of Inertia	0.89
Constant of Acceleration (C_1)	2
Constant of Acceleration (C_2)	2
Total Variables	2
Higher Limit of K_i, K_p	200
Lower limit of K_i, K_p	0
Optimum value of K_p	5.65119
Optimum value of K_i	7.93019

B. PSO Tuned ANN Controller

The objective of ANN training is to arrive at the most accurate possible values for the network's weights and biases. The right values of the ANN's weights and biases are determined by the application of a variety of methodological approaches. The PSO method was utilized in this paper. According to the Fig. 7, the input (e) and output of the PSO-PI controller will serve as the dataset for the neural network feed forward controller.

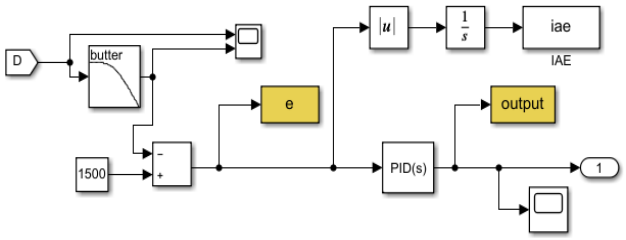


Fig. 7. The workspace representation of the PSO-PI controller's input (e) and output.

The Initialization of the neural network code shown in below says to get the input and target values from the PSO-PI controller, then initialize the hidden neurons are 10, configure the neural network based on the input and output, get the weights and bias of the configured neural network, create the objective function as root mean squire error, and use the PSO algorithm to fine-tune the weights and bias of the pre-trained neural network.

Initialize the neural network problem

- inputs = e';
- expects = output';
- hn = 10; (number of hidden neurons)
- Nn = feedforwardnet (hn);
- Nn = configure (Nn, inputs, expects);
- getwb(Nn) (Getting initial weight and biases)
- Based on weights and bias(y), Nn, inputs, and expects, calculate the objective function which is root mean square error denoted by (g).
- Train the neural network by applying the PSO algorithm .From that we can obtain the updated weights, bias (y), and error (e).
- Nn = setwb(Nn, y');
- getwb(Nn)
- e = expects - Nn (inputs);
- def = mean(e.^2)/mean(var(expects',1));
- gensim(Nn)

The algorithm's operation can be summed up using the steps as follows:

- Initialization at random of all of the local positions X_i (weights and biases).
- Evaluate the fitness function for each initialized particle, which is provided by (4), then establish the local locations $P_{i\text{-best}}$ and the global positions G_{best}.

$$f = \sum\sqrt{(\text{target} - \text{actual output})^2} \quad (4)$$

- Update all $P_{i\text{-best}}$ local positions
- Assess the current best in the area and the fitness function. If $(fP_{\text{best}}) < f(G_{\text{best}})$ then $G_{\text{best}} = P_{\text{best}}$.
- Using (2) and (3), modify the neural networks' weights and biases.
- The process should end if the stop condition holds true. If not, proceed to Step 2 to display the updated weights and biases.

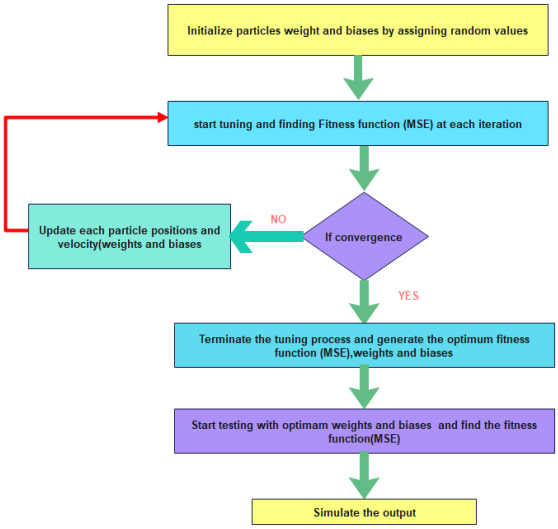


Fig. 8. Flow chart representation of PSO trained ANN controller.

Convergence is reached when the synaptic coefficients settle on a final value and the network's Mean square error (NMSE) drops below a specified threshold. Limiting the number of possible iterations is another way to interrupt the learning process. Fig. 8 depicts the training algorithm's flowchart.

Finally for a given input and an output, we will get the feed-forward neural network as shown in Fig. 9, which will be replaced by the PSO-PI controller.

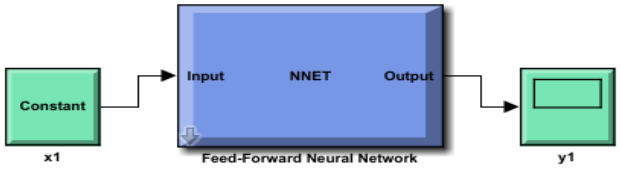


Fig. 9. Simulink block of PSO-ANN algorithm.

TABLE II: SIMULINK MODEL FRAMEWORK

Specification	Values
Source Voltage	415V
Source Frequency	50 Hz
Source Impedance	0.1 ohm, 15mH
Interfacing impedance	15mH
Load Real Power	4472 W
Load Reactive Power	1718 VAR
DC link Capacitance	100μF

VI. MODEL CONFIGURATION

The configuration of the suggested model is shown in Fig. 10, which consists of a three-phase power grid coupled to a three-phase un-controlled diode rectifier coupled to a non-linear load represented by an inductive load on the DC side. SAPF with a VSI design and a capacitor on the DC link are incorporated into the system at the PCC.

The simulation diagram of a PQ theory-based reference control method for SAPF is represented in the Fig. 11. Table II contains a listing of the suggested model's parameters.

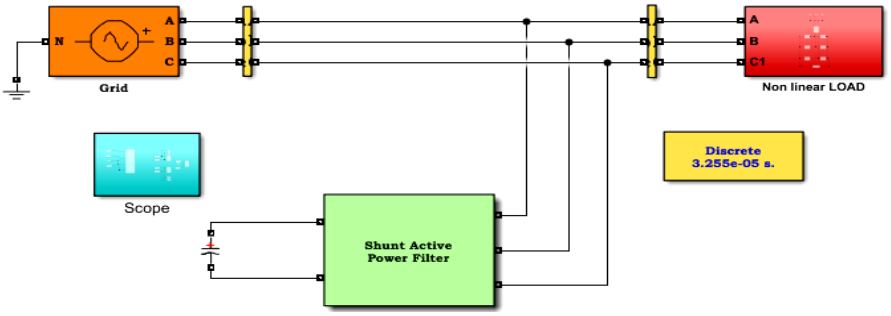


Fig. 10. Simulink model of Grid connected nonlinear load with SAPF.

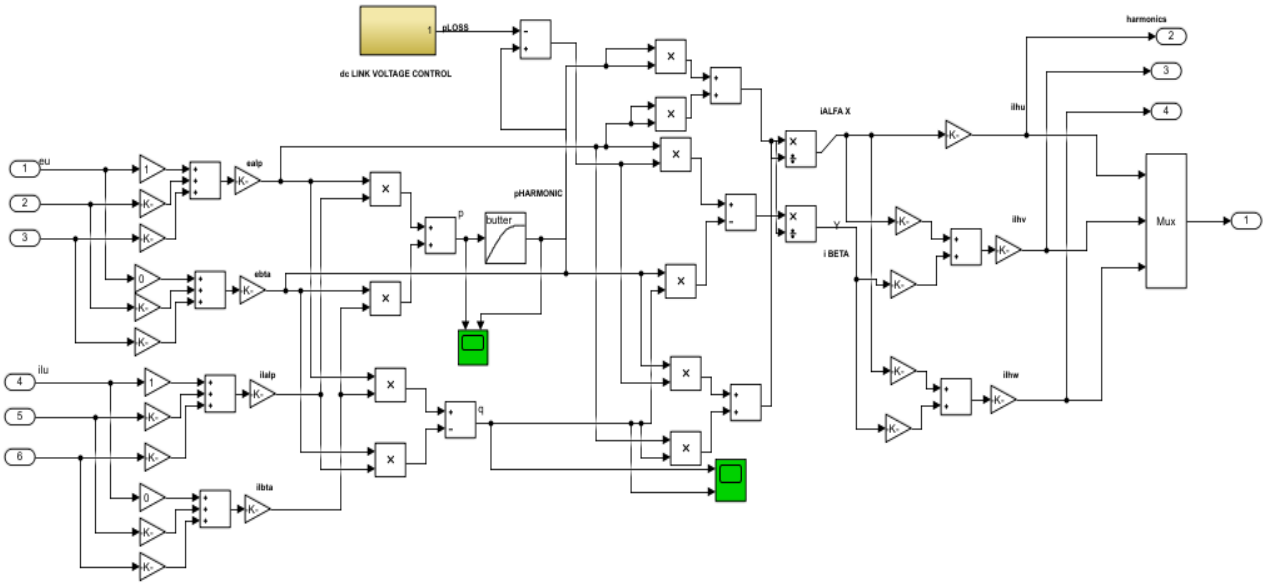


Fig. 11. Simulink model of PQ theory based SAPF.

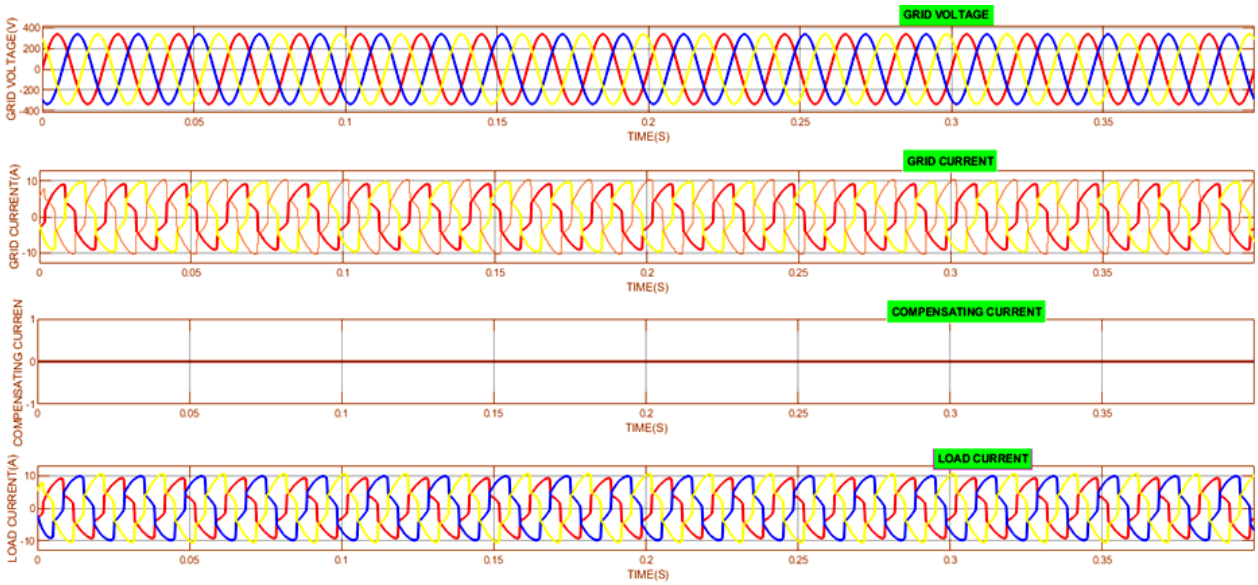


Fig. 12. The source voltage, source current, compensation current, and load current waveforms without SAPF.

VII. Simulation Results

The MATLAB simulative environment was used for the implementation of the proposed reference generation and current control techniques for a SAPF. This research was performed in accordance with the following scenarios.

- Without SAPF
- SAPF with conventional PI controller
- SAPF with PSO-PI controller
- SAPF with PSO-ANN controller

A. Without SAPF

In this scenario, SAPF is switched off, and a distortion in source current induced by a nonlinear load is evaluated using Fast Fourier Transform (FFT) analysis, which came out to be about 18.42%. Fig. 12 shows the source and load current waveforms from the three-phase simulation. Fig. 13 shows the source current FFT harmonic spectrum.

B. SAPF with Conventional PI Controller

In this scenario, SAPF is linked to the PCC, and the results of the simulation are obtained without any adjustment to the PI-controller gains. After SAPF connection, the supply current distortion is brought down to 3.76% of its original value as shown in Fig. 14.

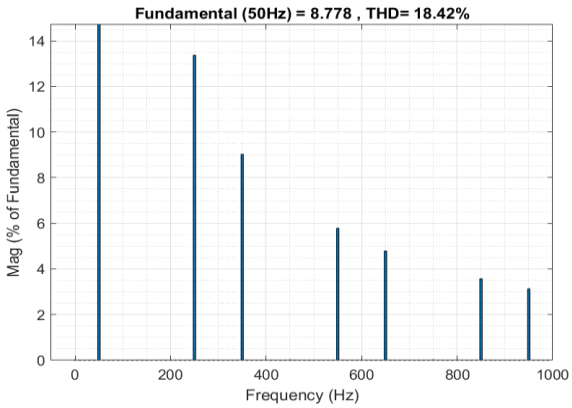


Fig. 13. Grid current THD value of distribution system without SAPF.

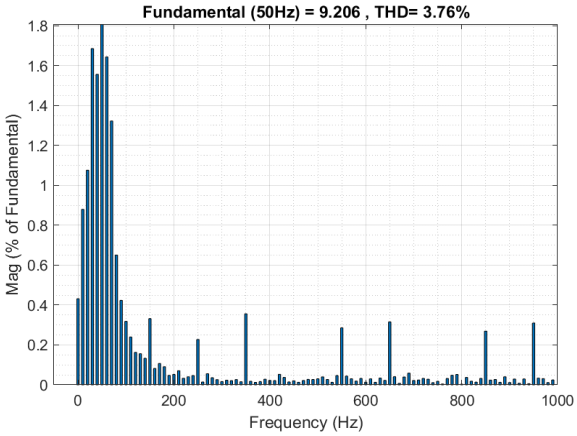


Fig. 14. Grid current THD value of distribution system with PI controller based SAPF.

C. SAPF with PSO-PI Controller

In this particular instance, the simulation was run using the SAPF compensation action, and the PSO Algorithm was utilized to modify the PI-controller gains. The findings that were collected suggest that the THD of the source current has been drastically reduced to 0.93%, as shown in Fig. 15.

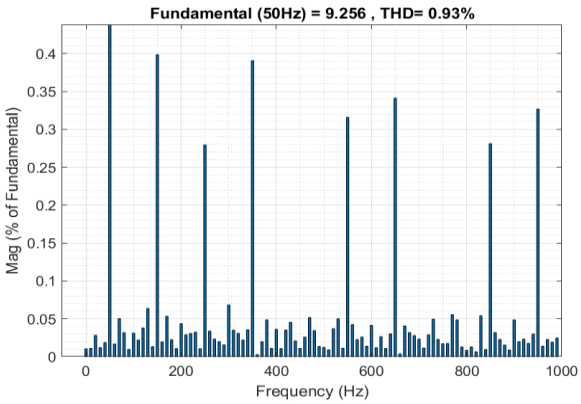


Fig. 15. Grid current THD value of distribution system with PSO-PI controller based SAPF.

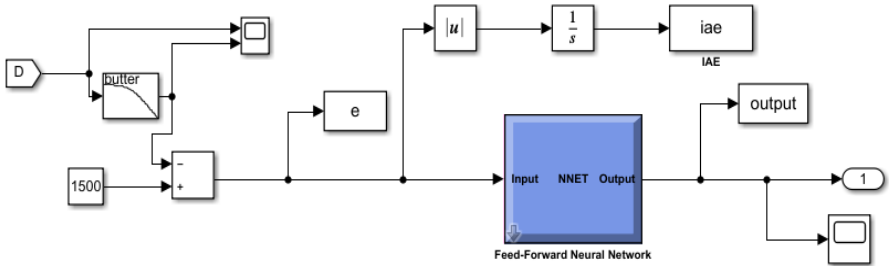


Fig. 16. DC voltage regulation of SAPF by using PSO-ANN controller.

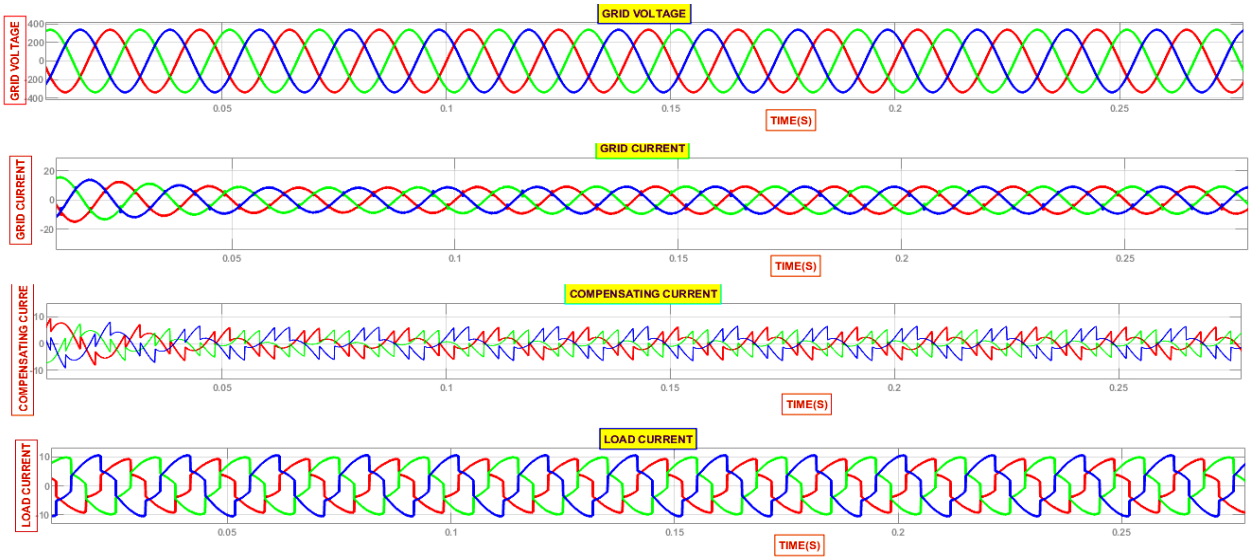


Fig. 17. The source voltage, source current, compensation current, and load current wave forms of PSO-ANN controller based SAPF.

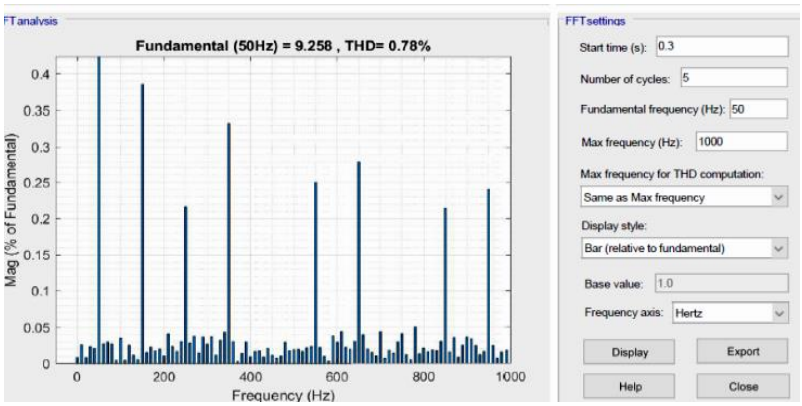


Fig. 18. Grid current THD of distribution system with PSO-ANN controller based SAPF.

D. SAPF with PSO-ANN Controller

In this particular instance, The PSO-PI controller is replaced by PSO-ANN controller Simulink block which was obtained from Fig. 9 Simulink representation with feed forward neural network block as shown in Fig 16. The findings that were collected suggest that the THD of the source current has been drastically reduced to 0.78%.

The source current, load current, and SAPF compensatory current waveforms are depicted in Fig. 17. Fig. 18 depicts the source current's harmonic spectrum. Fig. 19 depicts the converging spectrum for PSO-ANN controller.

PSO-ANN parameters are listed in Table III (next page). The SAPF performances of all four cases are given in Table IV (next page).

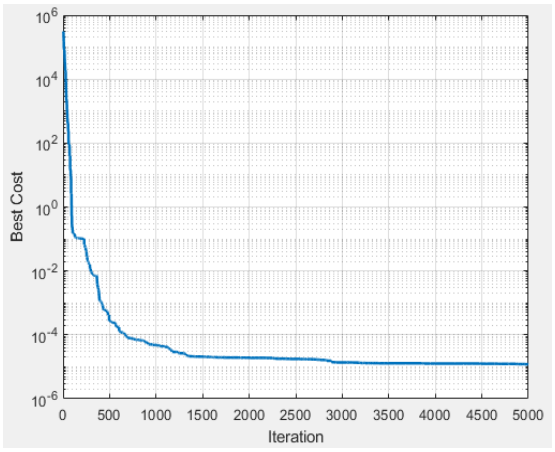


Fig. 19. Converges graph for the PSO-ANN controller.

TABLE III: PSO-ANN PARAMETERS

Maximum iterations	5000
Total Population	50
Weight of Inertia	0.89
Constant of Acceleration(C_1), (C_2)	2
Hidden Neurons	10
Total Variables	1
Higher Limit of weights	200
Lower limit of weights	0

TABLE IV: COMPARISON TABLE

Case studies	FFT -Analysis	Parameters	THD in %
1	Without SAPF	Grid current	18.42
2	SAPF with PI controller	Grid current	3.76
3	SAPF with PSO-PI controller	Grid current	0.93
4	SAPF with PSO-ANN controller	Grid current	0.78

The SAPF performance interns of power factor for all four scenarios as follows: Without SAPF, the power factor is 0.81, with conventional PI being 0.89, with PSO-PI being 0.94, and with proposed PSO-ANN being 0.96.

VIII. CONCLUSION AND FUTURE WORK

The power quality issues, such as harmonics and reactive power, are always expanding and becoming more complex. It has been discovered that implementing strategies derived from artificial intelligence on active filters can produce excellent results in the reduction of harmonics and the correction of reactive power. In this article, the PSO-ANN control method is proposed for use with the SAPF in order to lower the amount of total harmonic distortion occurring on the source side of the distribution system. The SAPF's effectiveness in a wide range of situations is studied and contrasted. The tool MATLAB/SIMULINK is used to perform simulations of four distinct scenarios, and the findings are reported. According to the results of simulations, both the PSO-PI-based SAPF and the traditional PI-based SAPF perform effective in terms of minimizing THD. It has been found that the proposed ANN-PSO-based SAPF is more effective in simulation in terms of achieving a lower THD value. This improved performance has been determined to be acceptable (within 5% of the IEEE standard), according to the findings of the investigation.

In future work, a hardware-in-loop implementation will be added to the proposed shunt active filter. Also, an ANFIS controller with PSO and other optimization methods will be used to make the SAPF's response even better.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Venkata Anjani Kumar G. was responsible for the development of the theoretical formalism, the working out of analytical calculations, and the performance of numerical simulations. Venkata Anjani Kumar G. is responsible for the final draught of the manuscript and M. Damodar Reddy acted as the project's supervisor throughout its entirety.

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TLBO-trained ANN-based Shunt Active Power Filter for Mitigation of Current Harmonics

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Abstract: The increased utilization of nonlinear devices is resulting in damage to power distribution infrastructure by introducing harmonics into power system networks, which in turn causes distortion in voltage and current signals. A novel solution called Shunt Active Power Filter (SAPF) has been developed to address this issue using power electronics. This study aims to provide a method that is efficient and cost-effective for lowering harmonics and improving power quality in distribution infrastructure. The proposed method combines the Teaching learning-based optimization (TLBO) technique with an Artificial Neural Network Controller (TLBO-ANN) in conjunction with SAPF. The primary objective of the TLBO-ANN algorithms in SAPF is to minimise total harmonic distortion (THD) for maximum system efficiency. Initially, Gain values (K_i, K_p) for a regular Proportional-Integral controller are optimised with the Particle Swarm Optimisation (PSO) technique. Those optimized parameters obtained from the PSO-tuned PI controller serve as input and target datasets for training the ANN controller. Subsequently, the TLBO algorithm is utilized to further refine the ANN controller by finding the optimal weight and bias values. Using MATLAB/SIMULINK software, we compare the performance of the proposed algorithm to that of the PSO-tuned PI controller and traditional PI controller. The findings from the simulation suggest that a SAPF utilizing a TLBO-trained ANN controller could improve THD in the supplying current while maintaining harmonics within IEEE-519 accepting levels.

Introduction

Bonding An imbalance between the quality of power available and the power needed by the load apparatus indicates a power quality issue. In order to protect electronic components from power outages, many power enhancement devices have been developed over time (Vishwakarma, 2020). These can be anything from specifically designed power sources to power conditioning devices. Isolation transformers and power conditioning equipment include capacitors, filters, voltage regulators, and uninterruptible sources of power (UPS) to prevent power outages caused by lightning and power surges. Surge capacitors for transient voltage are another type of power conditioning equipment. The Shunt Active Power Filter (SAPF) (Rajeshwari et al., 2017) is an example of a device that enhances power quality. There are many potential sources of damage in alternating current (AC) supply systems. Natural causes include lightning strikes, flashovers, equipment breakdowns and faults, whereas voltage distortions and notches are examples of human-made factors. Because it acts as a nonlinear load and develops non-sinusoidal current, much of the customer's equipment contributes to pollution in the supply system. Power quality is measured in terms of these factors because of the potential for damage to electronic devices due to fluctuations in

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voltage, current, or frequency. Power quality problems can often be traced back to the voltage at the point of common coupling (PCC), where numerous loads are connected (Gowtham et al., 2016; Dorigo et al., 1999; Janga et al., 2020; Huaisheng et al., 2012) Some examples of such problems are harmonics in the voltage, surges of electricity spikes, notches, and sag/dip/swell/imbalance/fluctuations/glitches/flickers/outages.

Non-linear loads, such as heaters, UPSs and variable-speed motors, can place a burden on the power grid and cause outages and other problems in the supply system. Some nonlinear loads can cause power quality concerns by drawing excessive current from the AC mains, creating the low power factor, harmonic currents, reactive power stress, imbalanced currents, and an excess neutral current in three-phase systems are all caused by the unbalancing and harmonic currents that come from using certain non-linear loads. Problems with dielectric breakdown, communication system interference, breaker issues, incorrect measurement, negative sequence currents in rotating electrical machines (especially rotors overheating) and disturbances affecting motor control units and technological control devices., and many others can all contribute to poor power quality (Sabarimuthu et al., 2021).

In some loads, however, the current changes in a way that is out of proportion with the voltage changes that occur at each half-cycle. Non-linear loads refer to this category of conditions. These non-linear loads produce the current and voltage harmonics. Many issues that utilities and power supply organizations face, such as low power factor, inefficient consumption of energy, and voltage fluctuations in the power system, can be traced back to non-sinusoidal current. A perfect compensator is necessary to prevent the harm caused by harmonics (Soliman et al., 2022). Over time, many different types of power enhancement devices have been developed to shield electronics from the consequences of grid failures. Methods that are both effective and efficient include those that are listed below. Implementing power conditioners and substitute energy sources. Power conditioning equipment includes isolation transformers, lightning arrestors, surge capacitors, filters, voltage regulators and an uninterruptible power supply. (Mikkili S et al., 2012; Om P et al., 2016). A Shunt Active Power Filter (SAPF) is one power conditioning device that enhances the supplied electricity's quality. By synchronizing the source current and voltage, current harmonics on the alternating current (Grid) side are cancelled out, and the DC link voltage is maintained at a constant level (Chelli et al., 2015). In order to achieve this goal, the real power flow in the system as well as the there must be no fluctuation in the amount of reactive power flowing into or out of the source.

The SAPF can be controlled by a single controller or multiple controllers working together to maintain a constant DC voltage. This is accomplished by balancing the real power flow in the system with the reactive power flow that comes from or towards the source, which brings the source current in phase with the source voltage (Babu et al., 2020). This cancels out current harmonics on the AC side. SAPF is necessary to eliminate current harmonics. The fundamental compensation principle of the active power filter is depicted in Figure 1. This principle serves as a form of energy storage to provide the real power difference between the load and the source throughout the transient period. When the load state changes, it affects the system's actual power; when that happens, the system will automatically. When compared to the reference voltage, the value of the voltage that is measured across the DC link capacitor is found to be different (Diab et al., 2019; Diab et al., 2018; Wen-guan Wang et al., 2012; Vadi et al., 2021) which leads to the dysfunction of the system. The reduction of the real power disturbance by using different controllers including chicken swarm optimization (Ramesh et al., 2023; Venkata and Reddy, 2023) at the DC link capacitor.

In this study, the utilization of IRP principles is employed to establish the desired current reference (referred to as PQ-theory). The hysteresis current controller technique estimates the reference currents to generate the required gating pulses (Kazemzadeh et al., 2014). Achieving optimal performance of an artificial neural network (ANN)-controller (Tekwani et al., 2020) based on PQ theory for a direct current (dc) link voltage necessitates precise adjustment of weight and bias values (Wilamowski et al., 2010). To determine the optimal state of the ANN controller, a Teaching learning-based optimization (TLBO) (Satapathy et al., 2013) algorithm is implemented, enabling the fine-tuning of weight and bias values.

PQ-Theory-based Reference Current Generation

PQ theory-based constant instantaneous power control is for 3-phase, 3-wire power distribution systems with sinusoidal and symmetrical source voltages. To apply this theory, the three-phase source voltage (V_a, V_b, V_c) and load current (I_{la}, I_{lb}, I_{lc}) must be sensed and transformed by the Clarke transformation into the (α, β) components.

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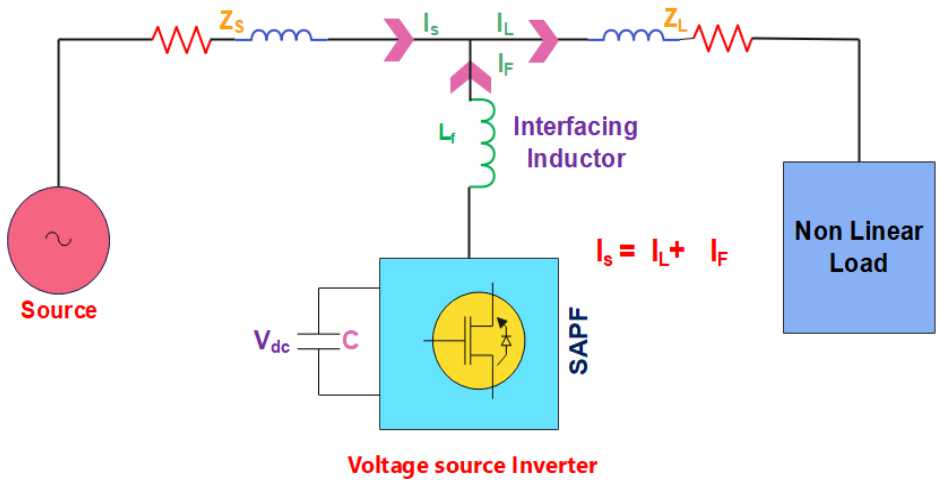


Figure 1. Schematic diagram of a Shunt Active Power Filter (SAPF).

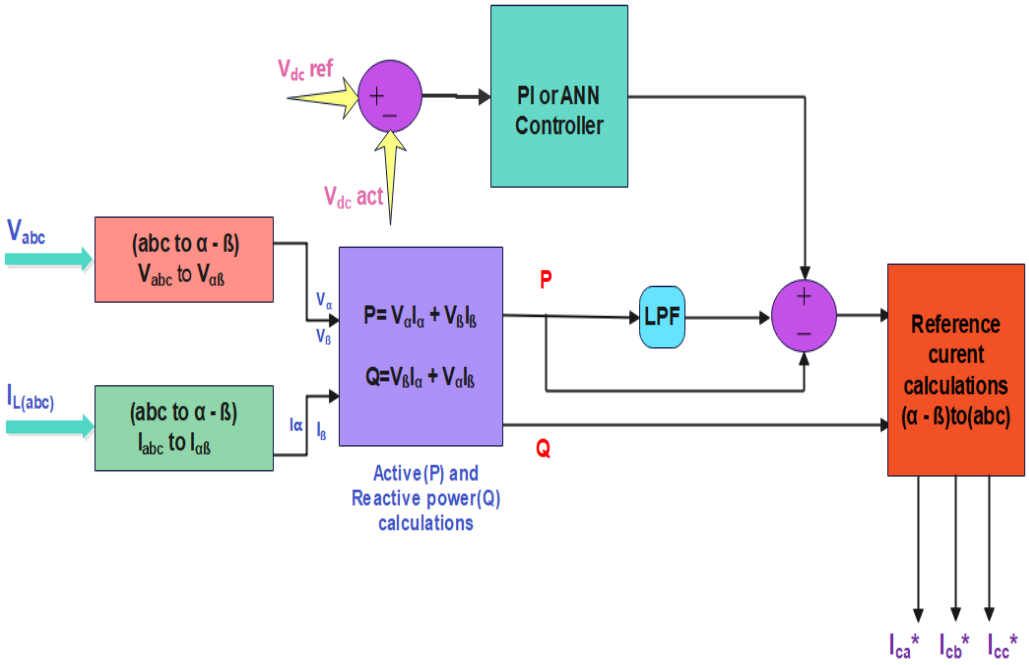


Figure 2. Reference generation diagram with PQ theory.

These components are input for instantaneous power calculations (Akagi et al., 2017). An error signal from the reference and measured dc-link voltages determines the power losses component. A PI controller receives this error signal to calculate power losses (Ploss). The (α, β) components, active and reactive powers, and current calculation are used to estimate the reference (α, β) components. An inverted Clarke transformation transforms these components to 3 phase abc values ($I_{abc,}V_{abc}$) as shown in Figure 2, to obtain the desired reference current signals.

Artificial Neural Network

An "Artificial Neural Network" is a system inspired by the way the human brain works, which is composed of interconnected neural networks Similar to the human brain. Multiple layers of neurons that are coupled to one another constitute artificial neural networks. These neurons, represented as nodes in Figure 3, are responsible for processing information. Typically, a neuron will have a single or multiple outputs and n inputs (x1, x2,... xn) that will receive or send information to other neurons in the network. In equation 1, the neuron's output, denoted by Yi (Asadi et al., 2022), is the result of multiplying the sum of its inputs by the activation function.

$$Y_i = f_i\left(\sum_{j=1}^{n} w_{i,j}x_j + b_i\right) \quad (1)$$

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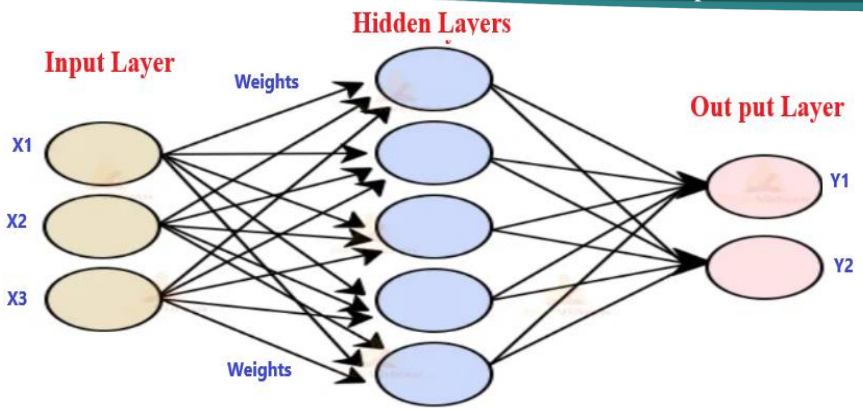


Figure 3. The fundamental structure of an artificial neural network

The $w_{i,j}$ notation represents the connection weight between a neuron on the input and a neuron at target. while b_i represents the neuron's bias. The input to the neuron is represented by x_j and the activation function f determines the neural network's actions. By changing the weights and biases and, in some cases, the number of layers and neurons, neural networks can adapt to new data.

Introduction to TLBO algorithm

Teaching-learning-based optimization, frequently referred to as TLBO, is an acronym given to one of the population-based algorithms that was recently proposed. In the year 2011, Rao et al. presented the teaching learning-based optimization (TLBO) method (Rao et al., 2011). It was inspired by the teaching and learning phenomenon that takes place in a classroom (Rao et al., 2012). In the context of the population-based algorithm TLBO, the class is considered as a population, and each individual learner within the class is considered as an individual member of this population. It is intended that the students in the class will have a greater level of knowledge by the end of the lesson to fulfill this objective. The process has two stages, known as the "teacher phase" and the "learner phase," respectively. This serves as the foundation for achieving this goal.

A. Teacher phase

The student who presents the most outstanding solution in the class is chosen as the teacher. The teacher is regarded as the most proficient learner among the entire population, possessing extensive knowledge and experience in a particular subject. As a result, other students enhance their understanding by leveraging the expertise of the teacher. If a student provides a superior solution compared to the teacher, they will replace the teacher's role. In the k^{th} iteration, the knowledge of the ith learner is updated using the following equation 2.

$$X_i^{new} = X_i + r_I(X_T - T_F{}^i . X_{mean}) \quad (2)$$

In the above scenario, knowledge of the teacher refers to "X_T,","r_I "is a random two-digit number between zero and one, mean results of the learners refers to "X_{mean}," and teaching factor refers to $T_F{}^i$ which can be obtained by the following equation 3.

$$T_F{}^i = round\,[1 + rannd(0,1)] \quad (3)$$

At the end of the teacher phase, all of the learners' knowledge is updated, and these values are now ready to be used as input values in the learner phase.

B. Learner phase

When students are in a real classroom, they can learn more by talking to the other students. This is what the TLBO learner phase is built on. During this step, the knowledge of the i^{th} student is compared to that of a randomly chosen j^{th} student as given in equation 4. When students are in a real classroom, they can learn more by talking to the other students. This is what the TLBO learner phase is built on. During this step, the knowledge of the i^{th} student is compared to that of a randomly chosen j^{th} student as given in equation 5.

If $f(X_i) < f(X_j)$ $then,$ $X_i^{new} = X_i + r_I(X_i - X_j)$ (4)

If $f(X_i) > f(X_j)$ $then,$ $X_i^{new} = X_i + r_I(X_j - X_i)$ (5)

If the knowledge of the **j^{th}** student is better at the end of the learner phase, the knowledge of the **i^{th}** student can be improved as given in equation 6.

If $f(X_i^{new}) < f(X_i)$ $than,$ $X_i = X_i^{new}$ (6)

The TLBO algorithm, consisting of the teacher and learner phases, will continue until either the termination condition or the maximum number of iterations has been reached.

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Proposed Methodology

PI controller tuned by PSO

For SAPF, a particularly important role depends on the abilities of a standard PI controller to regulate the DC link voltage. This controller probably produces for kp and ki will not be optimal values. Because it needs a great degree of mathematical calculation, The PSO method can be used to determine the best possible values for both kp and ki.

As shown in Figure 4, the PSO-PI controller will be given an error signal based on the difference between the actual and reference DC voltages. The PSO method must minimize the Integral Absolute Error (IAE) objective function to acquire the ideal gain values. With 1000 maximum number of iterations and 50 Populations, the Optimum values of gains (K_i, K_p) are 5.65119 and 7.93019 (Venkata et al., 2023).

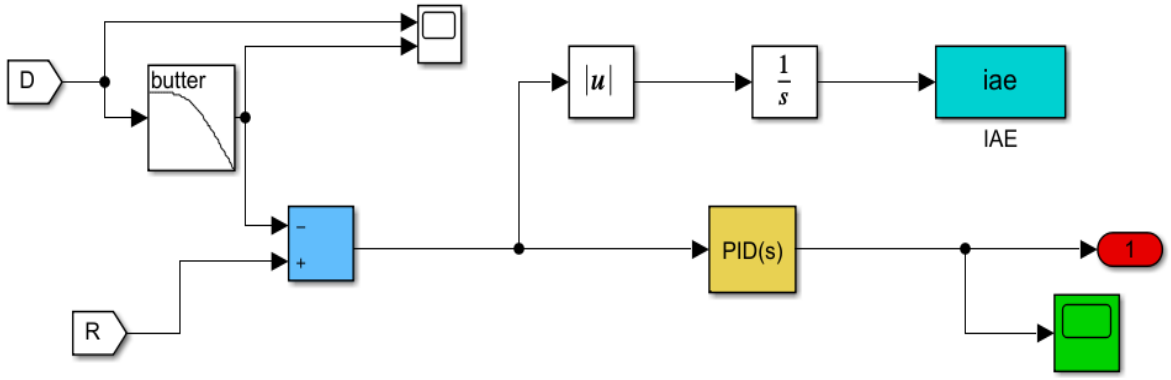


Figure 4. DC link voltage regulation by PSO trained PI based SAPF

TLBO trained ANN Controller

The main objective of a Neural Network algorithm is to obtain the appropriate weights and biases of the network to be as accurate as possible. ANN's weights and biases are given the right values using various methodological approaches. This paper used a method called TLBO. Figure 5 shows that the inputs (e) and outputs (out) of the PSO-PI controller are going to be used as a source of data for the neural network controller.

The necessary code to set up the neural network is provided below. The PSO-PI controller's input and target values are retrieved, hidden neurons are initialised. This data is used to configure the ANN, and finally, the network's weights and biases are extracted. Then, we'll define a pre-trained neural network's weights and bias using the TLBO algorithm, with the objective function defined as the root mean square error.

Step by Step approach of TLBO trained ANN

Step1: Take the input (e) from the workspace of PSO-PI controller.

Step 2: Take the Target (output) from the workspace of PSO-PI controller.

Step 3: Assign the number of Hidden Neurons.

Step 4: Define the Feed Forward Neural network based on hidden Neurons.

Step 5: Set up the Neural Network with the specified input and output values..

Step 6: Generate the initial weight and biases

Step 7: Use the root-mean-square-error as the objective function, by utilizing the weights and bias, Feed Forward Neural network, inputs and target values.

Step 8: The neural network is trained using the TLBO algorithm, resulting in the updated weights, biases and error.

Step 9: With this updated weights and biases again

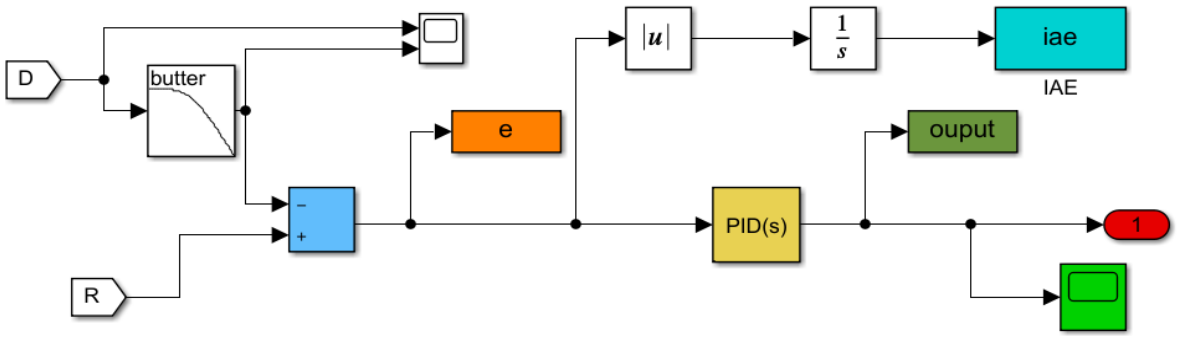


Figure 5. Output (o) and input (e) representation in the workspace for the PSO-PI controller.

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configure the Feed Forward Neural network.

Step 10: Repeat steps 7 to 9 until objective function is at a minimum.

Synaptic coefficients converge when they have settled on steady-state value and the network's Root Mean Square Error (NMSE) decreases below a predetermined threshold. Another approach to stop the learning process is to set a limit on the maximum number of iterations. The flowchart of the training algorithm is illustrated in Figure 6.

We will ultimately obtain the feed-forward neural network block and inside layering structure shown in Figure 7 response to a given input and output. The PSO-PI controller will substitute this feed-forward neural network block.

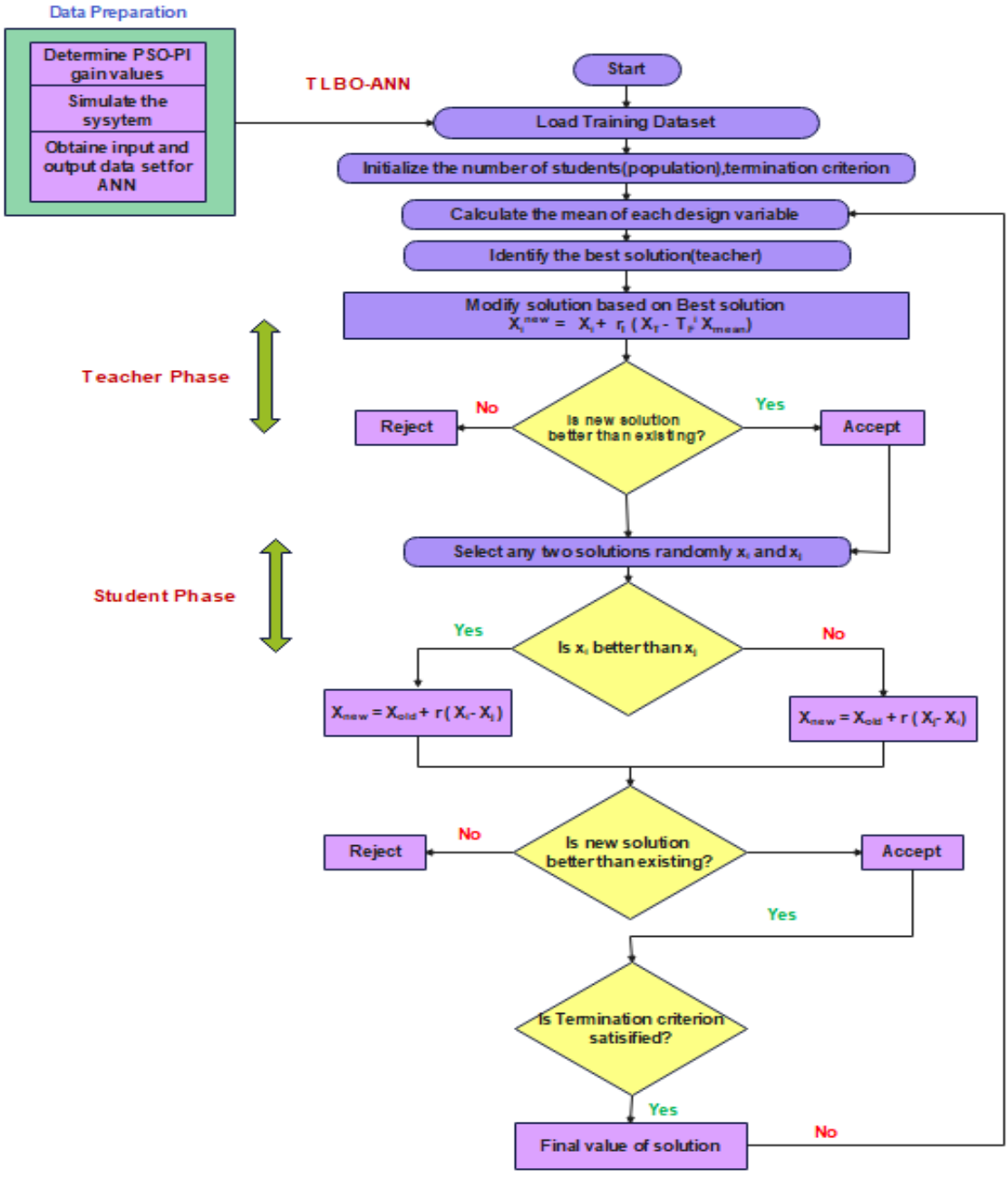


Figure 6. Flow chart of TLBO-ANN.

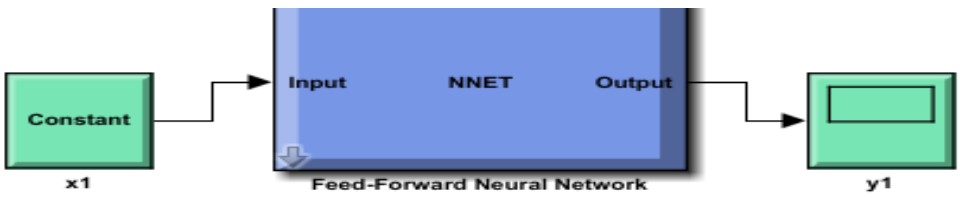


Figure 7. Simulink block of TLBO-ANN algorithm.

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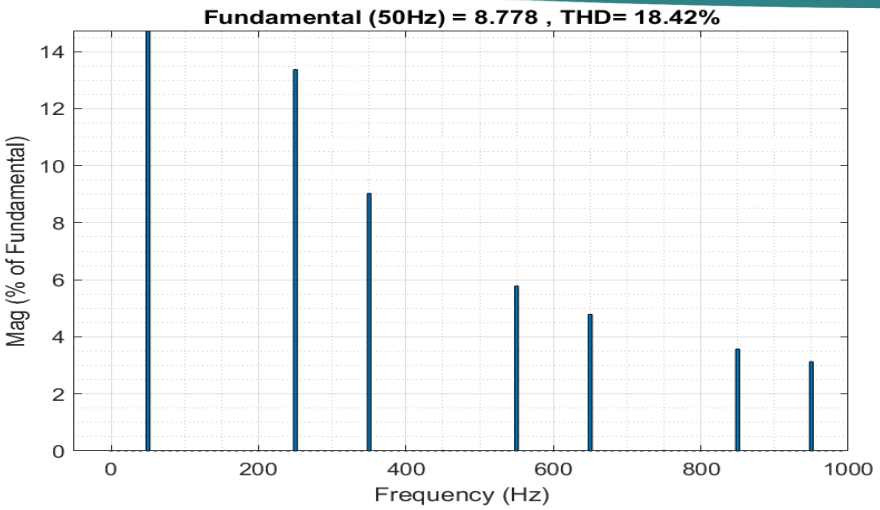


Figure 8. THD result of source current without using SAPF.

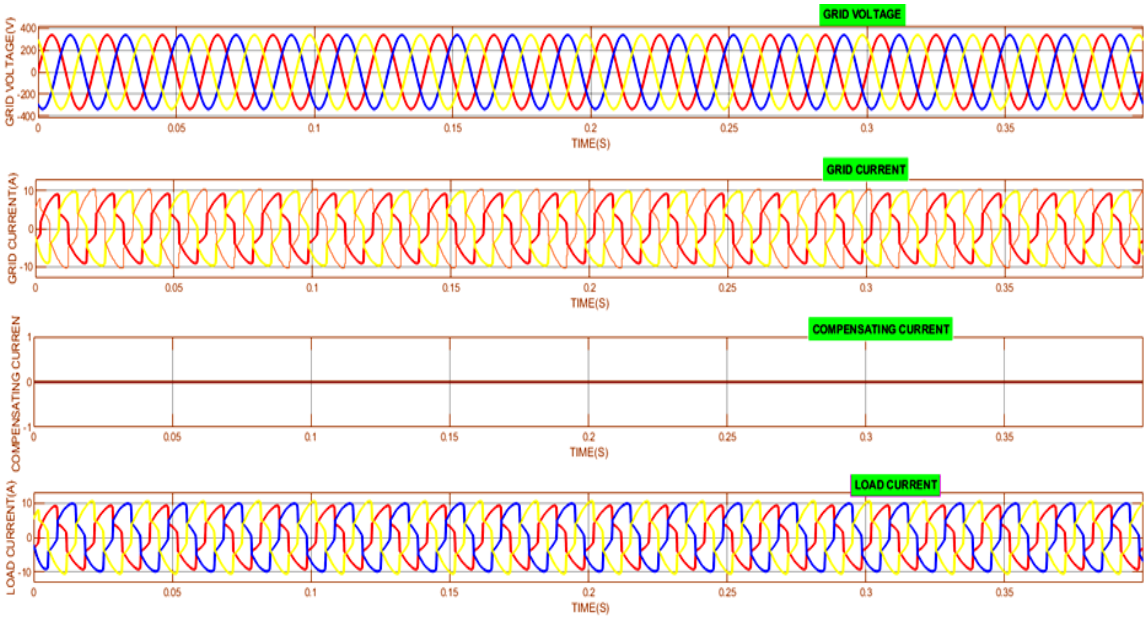


Figure 9. The waveforms of the IL, IS, IC and IS, without using SAPF.

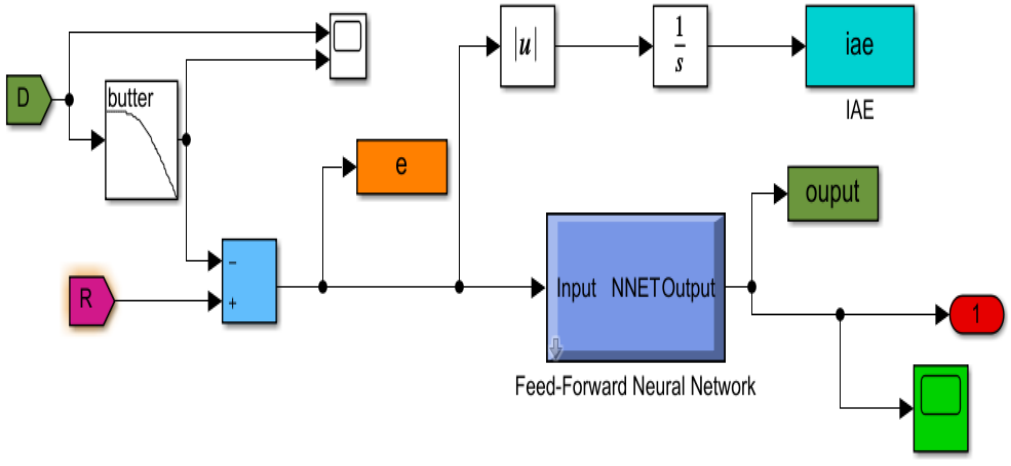


Figure 10. Controlling the DC voltage in a SAPF with a TLBO-ANN regulator.

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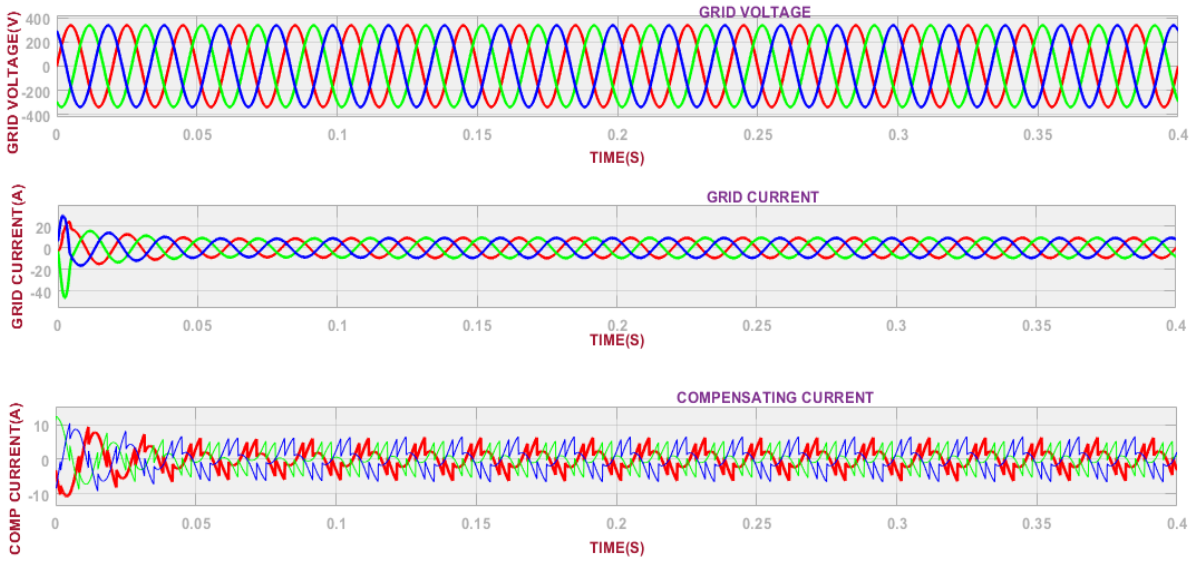


Figure 11. The waveforms of the IL, IS, IC and IS, by using TLBO trained ANN based SAPF

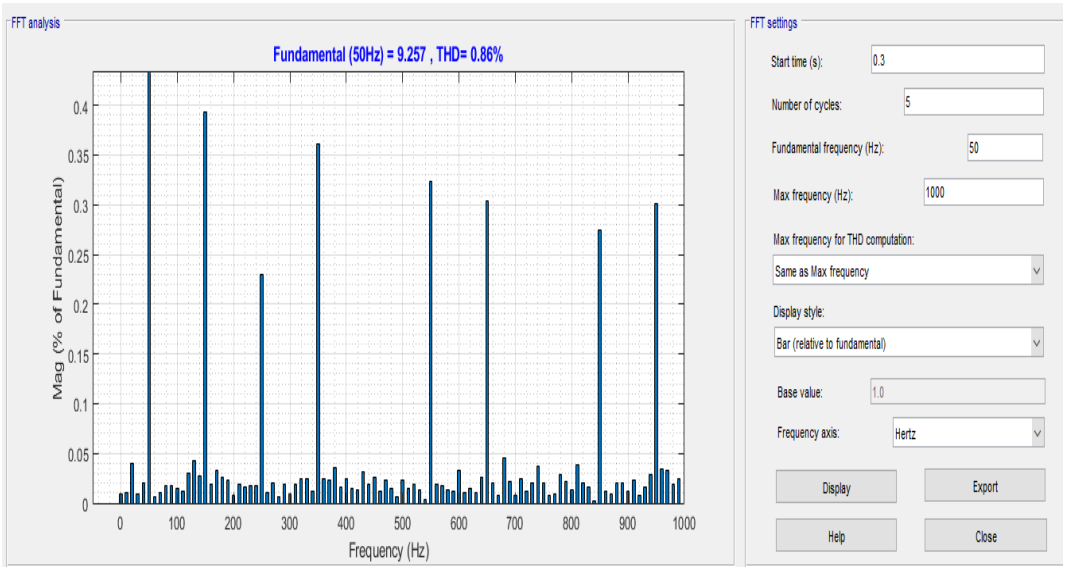


Figure 12. THD result of IS (Grid current) by TLBO tuned ANN-based SAPF.

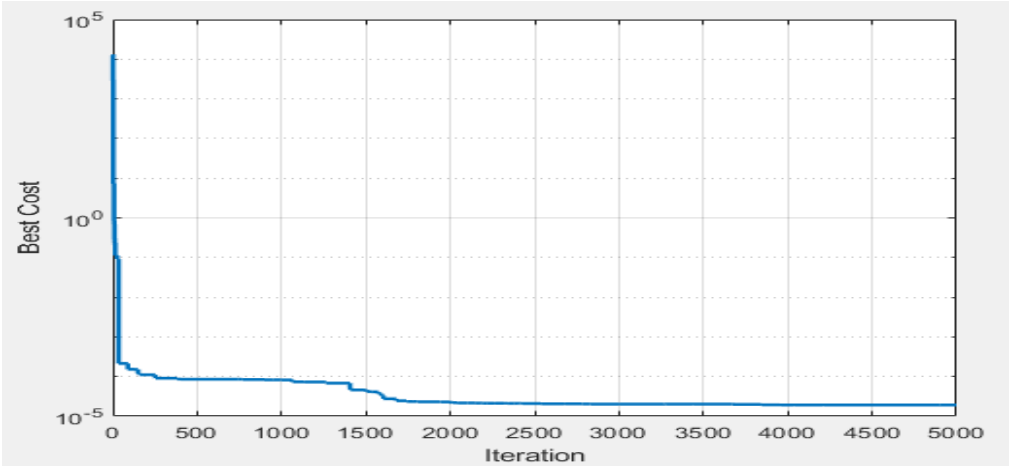


Figure 13. Converges graph for the TLBO-ANN based SAPF.

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Results and discussions

The proposed methods for a SAPF's current control and reference generation were implemented with the help of the MATLAB simulative environment. This study was carried out taking into account the various possibilities that were presented below. A tabulation of the simulation's parameters that were used for the simulation's purposes can be found in Table 1.

Table 1. Modeling framework in Simulink

Particulars	Values
Voltage at the Grid	415V
Frequency at the Grid	50 Hz
Impedance at the Source	0.15 ohm,15mH
Coupling inductance	15mH
Active Power at the Load	4472 W
Reactive Power at the Load	1718 VAR
Connected DC Capacitance	100µF

Without SAPF

In this case, we turn off SAPF and use Fast Fourier Transform (FFT) analysis to look at how the nonlinear load distorts the source current. This analysis showed that the distortion was close to 18.42%. The harmonic spectrum of the source current, as calculated by the fast Fourier transform, is shown in Figure 8. Figure 9 shows the waveforms of the I_S (Grid current), I_L (load current) that resulted from the simulation. The SAPF converter is not injecting a compensating current to reduce grid-side harmonics, as shown in Figure 9.

TLBO-trained ANN-based SAPF

Here, the TLBO-ANN controller Simulink block has taken the place of the PSO-PI controller. This Simulink block was taken from Figure 7 and is shown interacting with a feed-forward neural network in Figure 10. According to the results, the source current's total harmonic distortion (THD) appears to have dropped to 0.86%.

Table 2. Parameters of TLBO-trained ANN

Maximum iterations	5000
Total no of Students	25
Teaching Factor	0.5
Hidden Neurons	10
No of Variables	1
Weight Scale Upper Limits	200
Weight Scale Lower Limits	0

Figure 11 illustrates the waveforms of the currents flowing from the source, the load, and the SAPF compensating current. The harmonic spectrum of the source current is depicted in Figure 12. The TLBO-ANN controller's converging spectrum can be seen as depicted in Figure 13. This indicates that the MSE is steadily reducing and eventually reaching a constant value.

The parameters for the TLBO-ANN are detailed in Table II (on the following page). Table III (on the following page) provides an overview of how the SAPF performed in each of the four scenarios.

Table 3. Table of Comparison

Slno	Type of Controller	Component	THD value(%)
1	Without using SAPF	I_S (Source Current)	18.42
2	PI based SAPF	I_S (Source Current	3.76
3	PSO tuned PI Based SAPF	I_S (Source Current	0.93
4	TLBO tuned ANN based SAPF	I_S (Source Current	0.86

Conclusion

Harmonics and reactive power are just two examples of the increasing complexities of power quality issues.Active filters that employ strategies developed through artificial intelligence are particularly effective at mitigating harmonics and resolving reactive power. Within the scope of this article, we propose the TLBO-trained ANN control technique. as an alternative solution to be used in conjunction with the SAPF. The SAPF's effectiveness is measured and compared in a variety of settings. Matlab-Simulink runs simulations of four different scenarios and presents the findings. According to simulation findings, the proposed ANN-TLBO-based SAPF outperforms alternative scenarios in reducing THD in the source current. The PSO-tuned PI-based SAPF and SAPF with PI controller are also effective. According to the results, this performance improvement is satisfactory (within 5% of the recommended IEEE standard).

A hardware-in-the-loop version of the proposed shunt active filter will be developed for further research. In addition, we plan to improve the SAPF's flexibility by using an ANFIS controller that includes TLBO and other optimization techniques.

Conflict of interest

The authors have no competing interests to disclose.

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Mitigation of Grid Current Harmonics by ABC- ANN based Shunt Active Power Filter

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ABSTRACT

Harmonics are being introduced into power system networks as a result of the increasing use of nonlinear devices. These harmonics cause distortion of current and voltage signals, which in turn causes damage to power distribution systems. As a result, the suppression of harmonics is of extreme significance in power systems. This paper proposes Shunt Active Power Filters (SAPF) based on neural network algorithms like Artificial Neural Network (ANN) as a feasible approach to mitigating harmonic distortion and raising power quality in electrical distribution systems. This research shows that using shunt active power filters (SAPF), which use the Artificial Bee Colony Optimized Artificial Neural Network Controller (ABC-ANN), is an efficient method for enhancing power quality and minimizing harmonic distortion in distribution systems. The ABC-ANN algorithms have been produced for SAPF with the goal of improving system performance by reducing Grid current Harmonics. In the first stage of this work, PSO Technique is used to tune a standard PI controller to its optimum gain values (K_i ,K_p). Then, these target and input data of PSO tuned PI controller will be supplying inputs to the ANN controller. To find the optimal weight and bias values, this ANN controller has been tuned with the help of the ABC algorithm. Using MATLAB/SIMULINK software, we compare the performance of the proposed algorithm to that of other optimization algorithm like Differential Evaluation (DE) algorithm, as well as the PSO tuned PI controller and traditional PI controller. The findings from the simulation suggest that a SAPF utilizing an ABC trained ANN controller could improve THD in the supplying current while maintaining harmonics within IEEE-519 accepting levels.

1. Introduction

Power electronics components and large quantities of non-linear load bring about destructive harmonics in Grid current at the Point of Common Coupling or P.C.C [1]. Because harmonics in distribution system current can trigger an extensive range of problems, including loss, instability, noise, heating appliances, and so on, In order to reduce potential harm, it is essential to reduce them to an acceptable level of Total Harmonic Distortion [2] as defined by the IEEE-519 guidelines.

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In the 1970s, Gyugyi [3] was the first to discuss the power quality problems that arise when the current changes. Power quality analyzers and synthesizers, also known as shunt active power filters, can be used to fix the problem of current variation. Active filters dealing with power quality variations and their measurement in processed control and power utility systems were also stressed by Akagi [4], another notable researcher. Power engineers and researchers are on the lookout for transit solutions to maintain the distributed side of the system in light of the development of flexible AC transmission devices in the transmission line, which lower the operational cost without raising the installation cost. Typically, these are referred to as "custom power devices" (CPDs). Shunt active power filters are one low-cost method for lowering current fluctuations. Topological structures, sizes, optimal placement, and control factors for SAPF have all been investigated. These have left a few gaps, including issues with improper compensation and switching. Researchers looked into improved filter architecture as a solution.

One possible way to deal with current harmonics, reactive power, and poor power factor is to install a shunt active power filter (SAPF). The SAPF configuration shown in Figure 1 consists of a voltage source inverter (VSI) and an active filter controller. For the VSI to inject compensating reverse current at PCC, the control unit must provide timely and accurate firing signals [5,6].This will make it possible for the VSI to accomplish its goal. Reactive power control is provided to the grid via a DC-link capacitor installed on the VSI's input side [7].

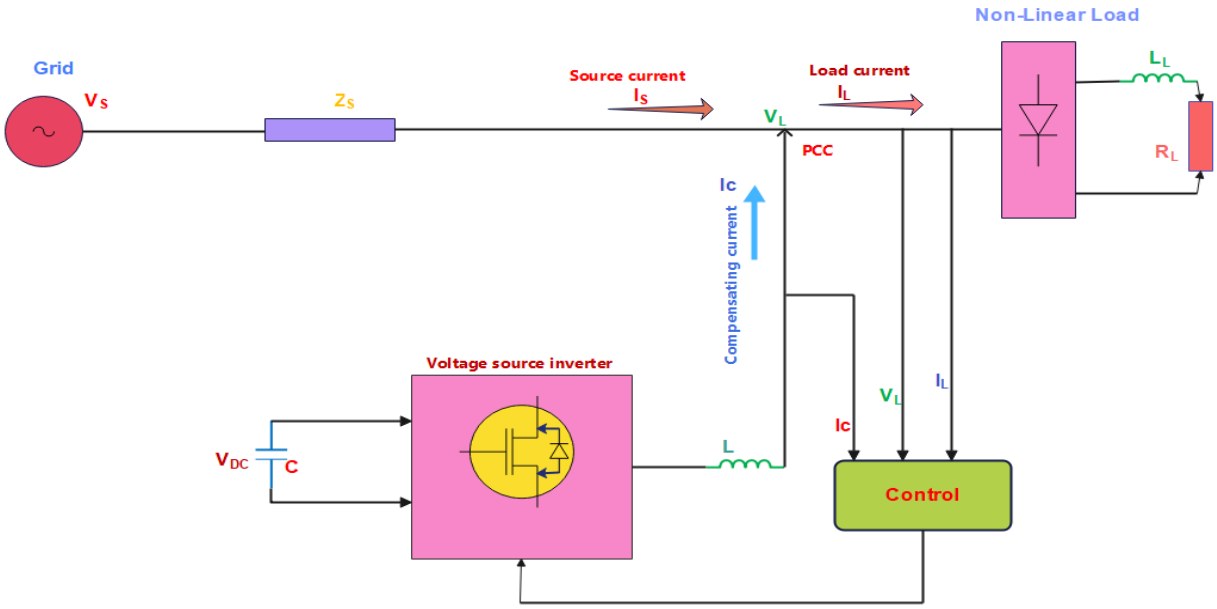


Fig. 1. Circuit diagram of the shunt active power filter

Either reference generating methods or control strategies can be utilized in the process of analyzing the VSI switching operation. Compensating signals are extracted from distorted signals using reference current generation theories, and then appropriate firing signals are generated using signal determined reference techniques to control the SAPF switching devices [8]. These two steps together constitute the SAPF control techniques. These are the two steps that are able to be implemented. Numerous authors have made comparisons between the various SAPF control strategies [9,10].

The harmonic content mitigation is performed by the PI controller that is a part of the control strategy. The PI proportional and integral gain values must be calculated for the controller. Methods such as Ziegler–Nichols and Cohen–Coon, for example, are helpful in determining the K_i and K_p values

explicitly for power systems that have linear loads. These linear control strategies will not function for a system that is subjected to nonlinear loads. In the present day, intelligent and optimal tuning algorithms such as Evolutionary Programming (EP) like Genetic Algorithm (GA) , Particle Swarm optimization (PSO), Simulated Annealing (SA), Differential Evolution (DE) [11-15] .Algorithm have been developed to solve the problems of dynamic electric system problems with enhanced optimal tuning SAPF devices.

The word Artificial Neural Network shortly ANN is used to describe a system which is designed and operates similarly to the human brain. Neurons form a network all over the brain. The overall network's behavior is determined by the strength of the connections between interneuron as well as the configuration of those connections. During network training, the weights are able to and will be adjusted and changed [15]. Only for the purpose of supplying reference compensation current is SAPF currently using Artificial Neural Network (ANN) techniques [16]. This current is then utilized to manage the compensation that SAPF provides. There are a number of approaches that can be used to learn weights. Methods include the Steepest Descent strategy to learning variables, the Levenberg-Marquardt [17] method, and the Widrow-Hoff (W-H) method are just a few examples.

In this work the reference current is calculated using instantaneous active and reactive power (PQ-theory) and hysteresis current controllers estimate reference currents to generate gating pulses [18]. Regulating dc link voltage using an ANN-controller [19] based on IRP theory requires tuning of weight and bias parameters. In addition, the Artificial Bee Colony Optimization Algorithm (ABC), which was proposed and tested against other Optimization algorithm such as Differential Evaluation (DE) algorithm, was used as the motivation for this article in order to find the ideal ANN-controller weight and bias and acquire the objective function while minimizing Total Harmonic Distortion(THD).

2. PQ Theory

PQ theory-based constant instantaneous power control is for 3-phase, 3-wire power distribution systems with sinusoidal and symmetrical source voltages. To apply this theory, the three-phase source voltage (V_a, V_b, V_c) and load current (I_{la}, I_{lb}, I_{lc}) must be sensed and transformed by the Clarke transformation into the (α,β) components. These components are input for instantaneous power calculations [20]. An error signal from the reference and measured dc-link voltages determines the power losses component. To calculate power losses (Ploss), a PI-controller receives this error signal. The (α, β) components, active and reactive powers, and current calculation are used to estimate the reference (α, β) components. An inverted Clarke transformation (α, β) transforming these components to three phase abc values ($I_{abc,}V_{abc}$) as shown in Figure 2 to obtain the desired reference current signals.

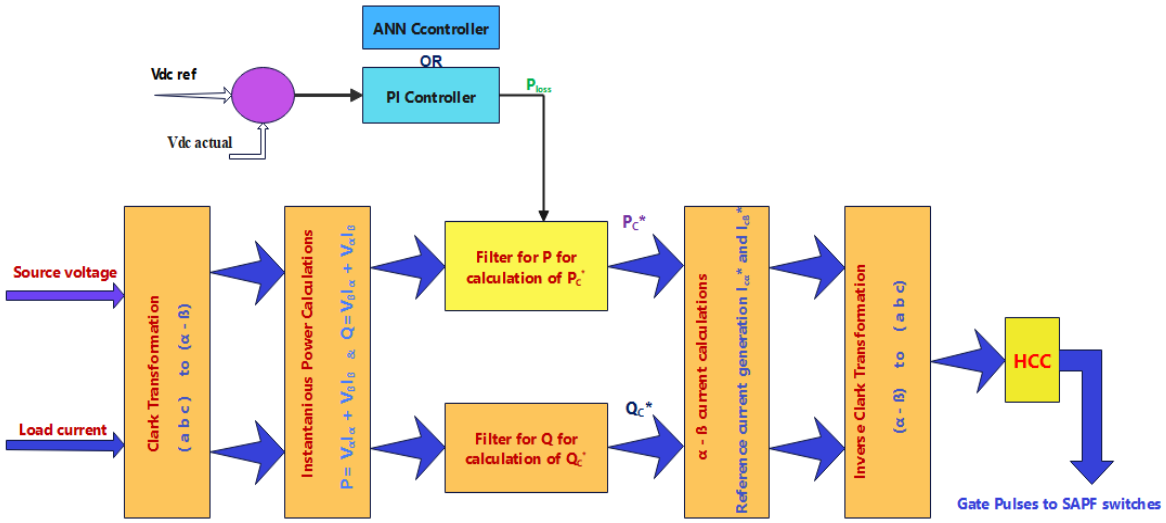


Fig. 2. Reference current generation with IRP (PQ) Technique

3. Structure of Artificial Neural Network (ANN)

The term artificial neural networks or ANN refers to a type of algorithm that is modeled after the way the brain operates and is used to model complicated patterns and predict future events. The concept of the Biological Neural Networks found in the human brain was the inspiration for the development of a technique known as the Artificial Neural Network, or ANN. An attempt was made to model the behavior of the human brain, which led to the development of artificial neural networks (ANN). The functioning of ANN is strikingly comparable to that of biological neural networks, despite the fact that the two systems are not identical. The ANN algorithm will only take in data that is numeric or structured.

- The architecture of the network is composed of three levels: the input layer, the hidden layer and the output layer as shown in Figure 3. As a result of the many layers, they are often referred to as the MLP (Multi-Layer Perceptron).
- The hidden layer can be thought of as a "distillation layer" that takes the most important patterns from the inputs and sends them to the next layer for more analysis. It speeds up the network and makes it more efficient by picking out the most important information from the inputs and getting rid of the rest.
- The activation function is useful for two reasons. First, it enables you to turn on your computer.
  - The presence of non-linear interactions between the inputs is captured by this model.
  - It aids in the transformation of the input into a more useable output.
- To construct an effective model, it's important to find the "optimal values of W—weights" that minimize Mean Square Error. This is done by the "back propagation algorithm," which turns ANN into an algorithm that learns from mistakes.
- The "gradient descent" method is used to measure prediction errors in the "optimization" approach. To find the best value for W, small changes are made and the effects on prediction errors are looked at. Lastly, those W values are chosen as the best because changing W any more doesn't make mistakes less likely.

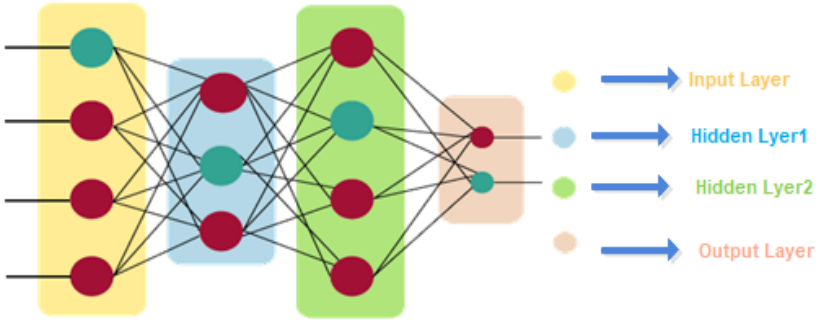


Fig. 3. Architecture of the artificial neural network.

To extract a fundamental component from SAPF while avoiding harmonic pollution, ANN architecture was utilized. For a given source voltage, it can be ensured by accurately predicting the reference current in ideal and real-time load applications. In the context of increasing reliance on nonlinear loads in residential and industrial applications, the mitigation of harmonic pollution has been a significant problem. ANN has been proven to be more applicable than p-q theory in circumstances of inaccurate voltage involving harmonic contamination in the source current and additional harmonic contamination due to the load current.

4. Artificial Bee Colony (ABC)

The ABC optimization method is an example of a meta-heuristic approach. Karaboga [21] came up with this idea first. The main idea behind ABC is how honey bees get food. In the ABC algorithm, there are three groups: worker bees, watcher bees, and scout bees. Bees were sent around the hive at random to find out where food was coming from. This information is shared with onlookers, who then decide which food source to choose. The random search is being done by Scout.

Figure 4 shows how honey bees act in general. Let's say that A and B are food. One of the possible bee starts out as a jobless bee. It has two options: it could be looking for food (S) or it could be doing the waggle dance (R). After it finds a food source, it will remember where it is and start taking advantage of it. Now, the Bee is a working bee. Once the food is turned into nectar, the same bee has three choices. may it lose its job, find new nest mates, and go back to the food source or keep looking for food in the same place.

The probability of a food source is given by the equation (1).

$$P_i = \frac{fit_i}{\sum_{n=1}^{SN} fit_i} \tag{1}$$

where, fit_i fitness value and SN is number of food sources.

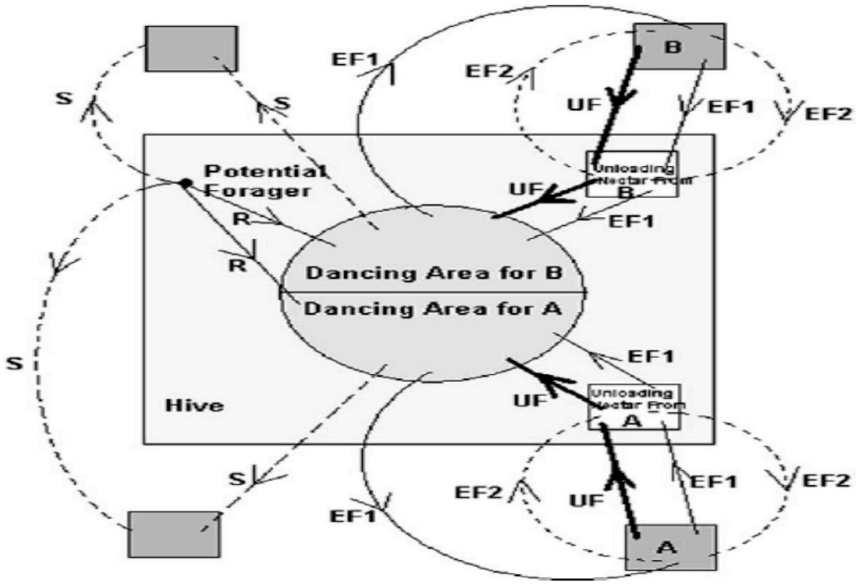


Fig. 4. ABC architecture

The candidate's food position from memory is given by equation (2).

$$v_{ij} = x_{ij} + {}^{\Phi}{}_{ij}(x_{ij} - x_{kj}) \quad (2)$$

$k\boldsymbol{\varepsilon}\{1,2,\ldots..SN\}andj\boldsymbol{\varepsilon}\{1,2,\ldots..D\}$, ϕ_{ij} random [0,1]
The following is a list of the stages that constitute the algorithm's procedure:

1. Read data
2. Read data
3. The distribution of working bees across various food sources
4. Distribute onlooker bees to the food sources in proportion to the amount of nectar they collect.
5. To find fresh sources of food, you should send the scouts to the area that is being searched.
6. In the meantime, keep the knowledge you've acquired regarding the greatest food source in storage.
7. Determine whether or not the requirements have been fulfilled.

5. Proposed Implementation

5.1 PI tuning with PSO Algorithm

The key function of SAPF is dependent on the abilities of a standard PI controller‘s regulation of the DC link voltage. It is probable that this controller produces for K_p and K_i will not be optimal values. Because it needs a great degree of mathematical calculation The PSO method can be used to determine the best possible values for both K_p and K_i.

As shown in Figure 5, the PSO-PI controller will be given an error signal based on the difference between the actual and reference dc voltages. To acquire the ideal gain values, the PSO method must minimize the Integral Absolute Error (IAE) objective function. With 1000 maximum number of iterations and 50 Populations, the Optimum values of gains (K_i, K_p) are 5.65119 and 7.93019. We set the bare minimum and highest possible values for K_p and K_i respectively at 0 and 200.

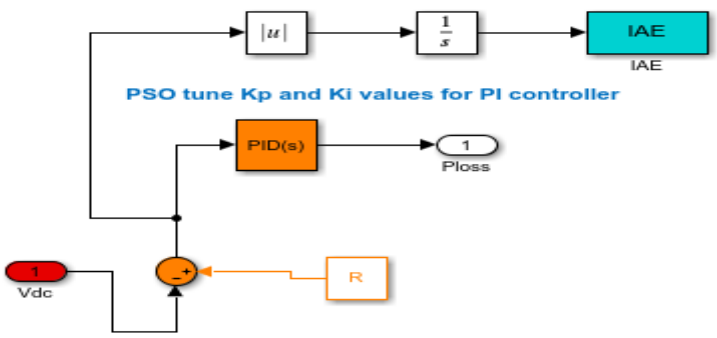


Fig. 5. DC link voltage regulation by PSO trained PI based SAPF

5.2 ABC Trained ANN Algorithm

The goal of ANN algorithm is to get the weights and biases of the network to be as accurate as possible. ANN's weights and biases are given the right values by using a variety of methodological approaches. This paper used a method called ABC. Figure 6 shows that The inputs (e) and outputs (out) of the PSO-PI controller are going to be used as a source of data for the neural network controller.

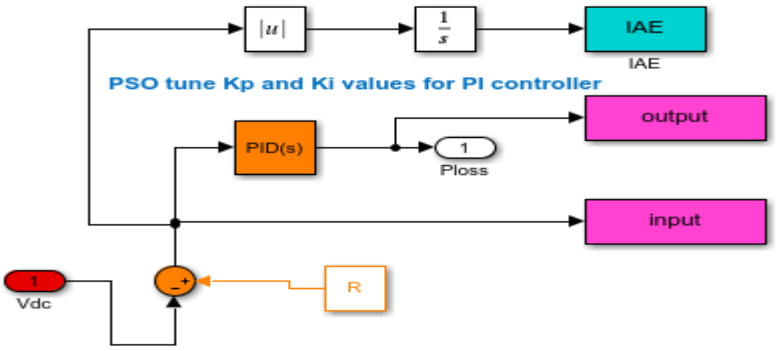


Fig. 6. PSO tuned PI controller's input and target extraction

The necessary code to set up the neural network is provided below. The PSO-PI controller's input and target values are retrieved, hidden neurons are initialised.This data is used to configure the ANN, and finally, the network's weights and biases are extracted. Then, we'll define a pre-trained neural network's weights and bias using the ABC algorithm, with the objective function defined as the root mean square error.

Initialization of ANN

- I = input(e)';
- T = output(out)';
- N = 12;
- Nnet = Feedforwardneuralnet (N);
- Nnet = configurate (Nnet, I, T);
- getingwb(Nnet) (W- weight and B- biases)
- Root-mean-squared error in expressing (g) is the objective function. and it is determined by the weights, bias(y), Nnet, I, and T.
- The ABC algorithm should be used to train the neural network.Weights, bias, and error (y, e), all updated, can be calculated from this.
- Nnet = setingwb(Nnet, y');

- getingwb(Nnet)
- error= T - Nnet (I);
- difference = mean(error.^2)/mean(var(T',1));
- generatesim(Nnet)

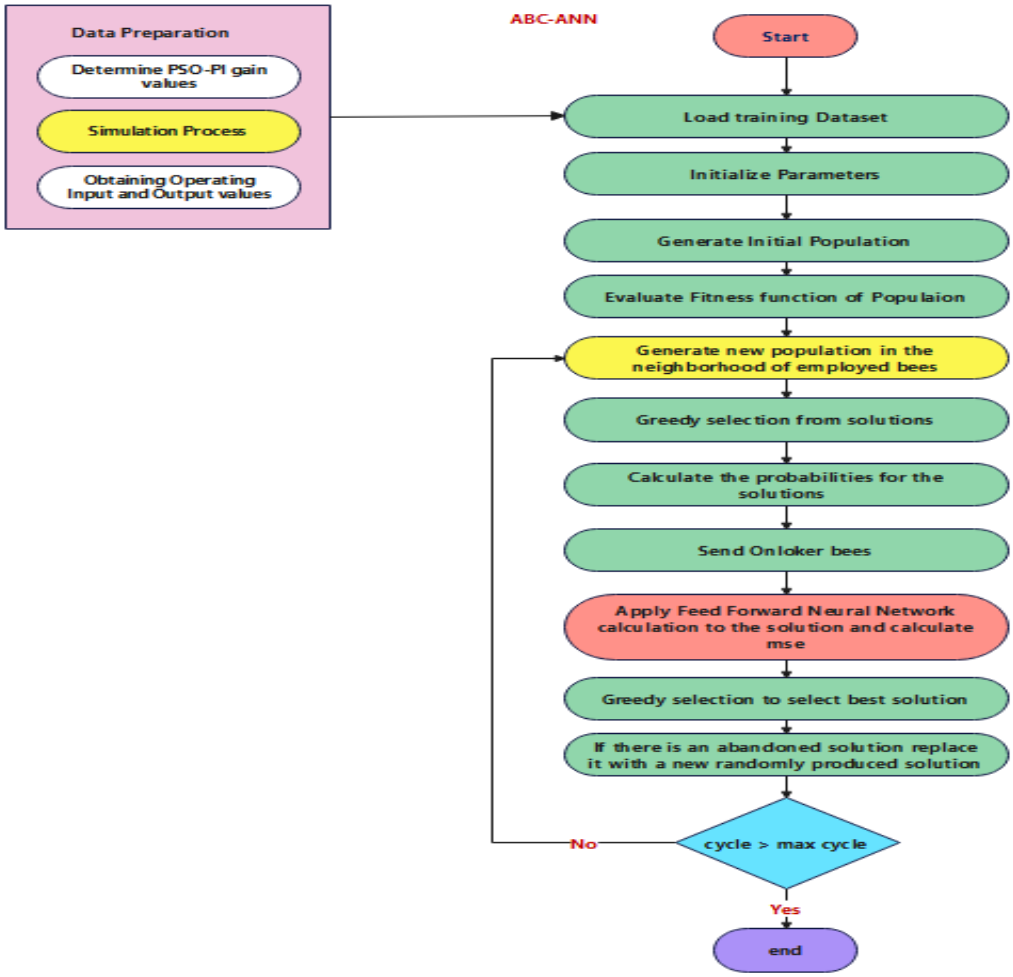


Fig. 7. Flowchart representation of ABC-ANN algorithm

Once the converges reaches steady state and the Mean Square Error (MSE) of the network decreases below a specific threshold, the network has reached convergence. Another way to stop learning is to limit the number of times something can be tried. The flowchart for the training algorithm is shown in Figure 7. Therefore, The PSO-PI controller will replace the feed-forward neural network shown in Figure 8 when input and output data are provided.

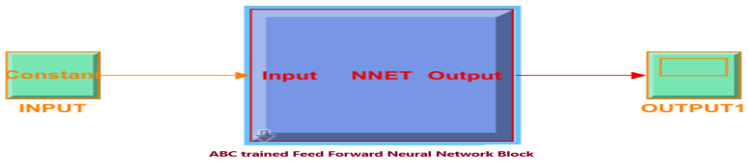


Fig. 8. Simulink block of ABC-ANN algorithm

6. Results and discussions

This section contains a discussion of the simulation results that were obtained using MATLAB. It is simulated both for the proposed ABC-ANN based controller as well as for the TLBO-ANN and DE-ANN controller based SAPF, and then comparing all of the obtained results.

The ANN- controller's weights and bias are adjusted to improve the source current THD value. Then, the controller's performance is measured with a static non-linear load connected to the PCC. The following situations were used to carry out this evaluation.

I. Without SAPF

In this case, SAPF is turned off, and a Fast Fourier Transform (FFT) analysis was used to figure out that the nonlinear load caused a 18.42% of THD change in the source current as shown in Figure 10 and Figure 9 shows how the source and load currents look in a three-phase simulation.

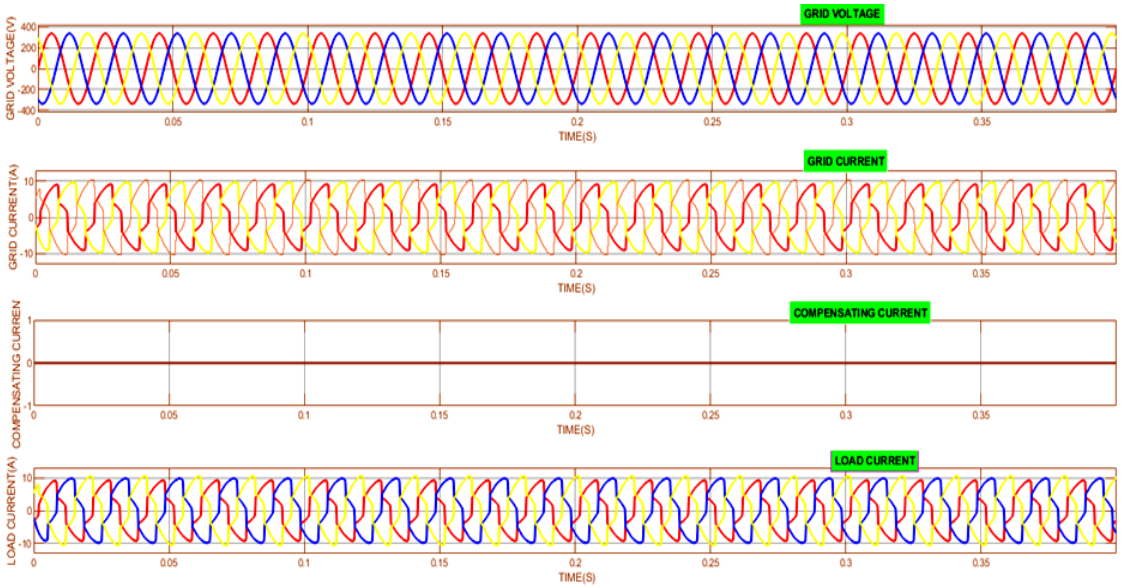


Fig. 9. The waveforms of the I_L, I_S, I_C, I_S, without using SAPF

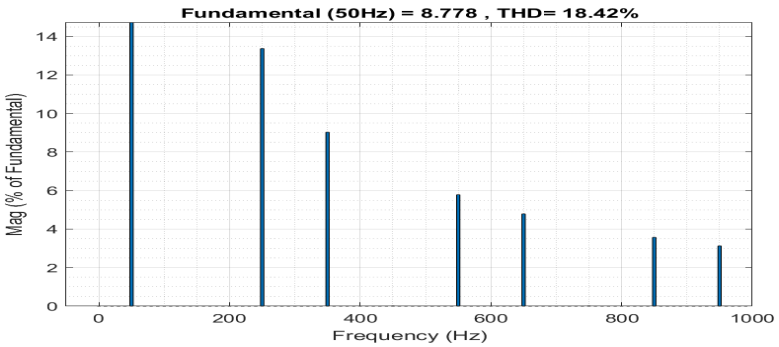


Fig. 10. THD result of source current without using SAPF

II. PI Controller based SAPF

Here, SAPF is attached to PCC, and conventional PI controller gains were used to obtain simulated results. Following the use of SAPF compensation, the distortion in the supply current was cut down

to 3.76 percent from its initial value. Moreover, the harmonic spectrum of the source current may be seen in Figure 11, as depicted correspondingly.

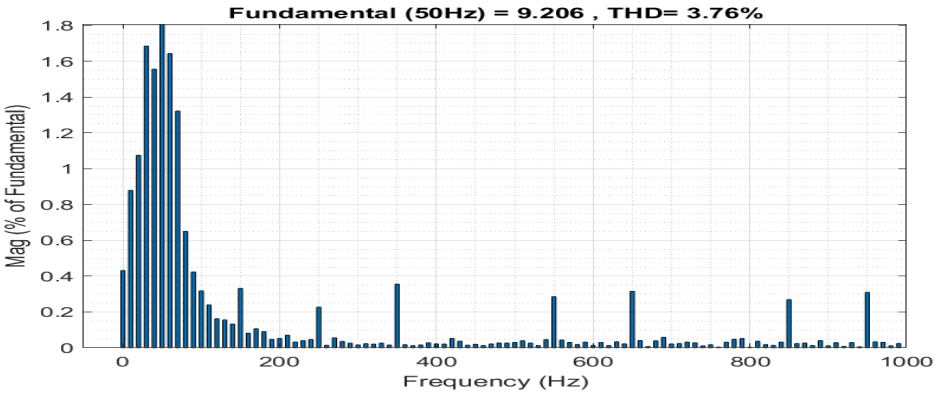


Fig. 11. THD result of I_S (Grid current) by PI based SAPF

III. PSO-PI based SAPF

In this present scenario, the SAPF compensation action was used to run the simulation, and the PI-controller gains were adjusted with the help of the PSO Algorithm. Both of these procedures were carried out in order to achieve the best possible results. According to Figure 12, the findings that were collected point to the possibility that there has been a significant decrease in the THD of the source current to an extremely manageable level of 0.93%.

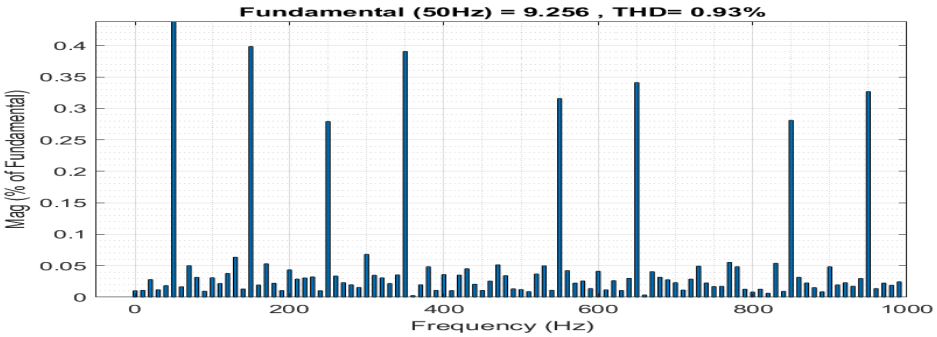


Fig. 12. THD result of I_S (Grid current) by PSO tuned PI based SAPF

IV. DE tuned ANN based SAPF

Here, instead of using a PSO-PI controller, a DE-ANN controller Simulink block was used. THD in the source current was mitigated to 0.90%, as displayed in Figure 13.

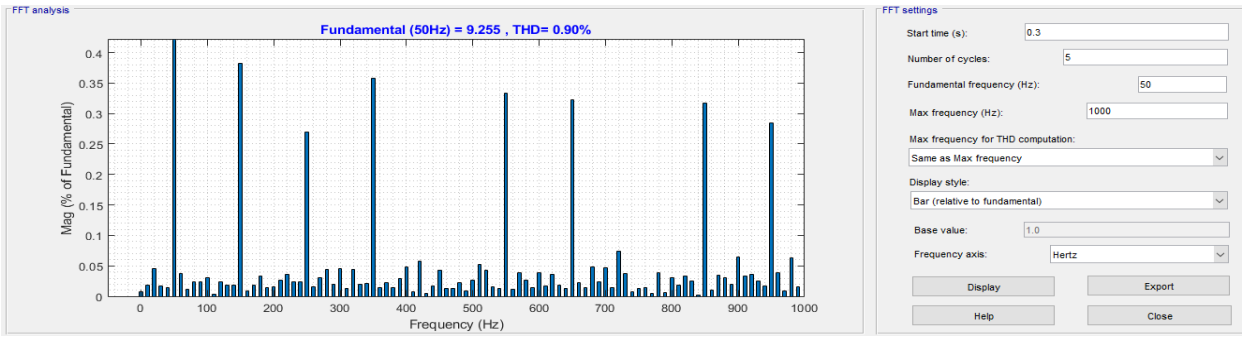


Fig. 13. THD result of I_S (Grid current) by DE tuned ANN based SAPF

V. ABC tuned ANN based SAPF

Here, the PSO-PI controller has been swapped out for the ABC-ANN controller Simulink part. Utilizing block of a feed-forward neural network, depicted in Figure 14. That is acquired from the Figure 9. Based on the results of the measurements, the total harmonic distortion (THD) of the source current appears to have diminished to 0.84%.

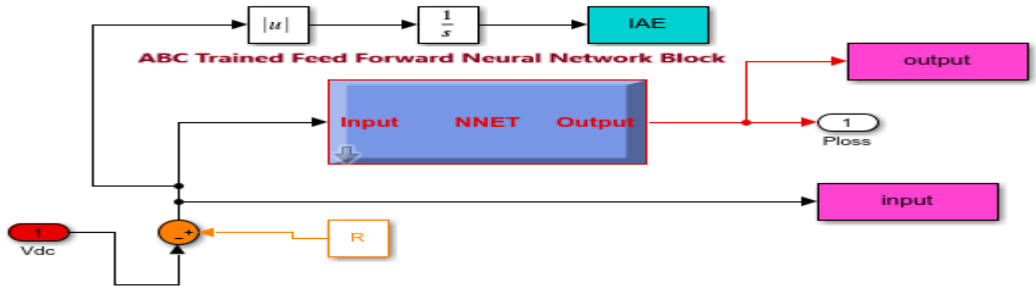


Fig. 14. Controlling the DC voltage in a SAPF with an ABC-ANN regulator

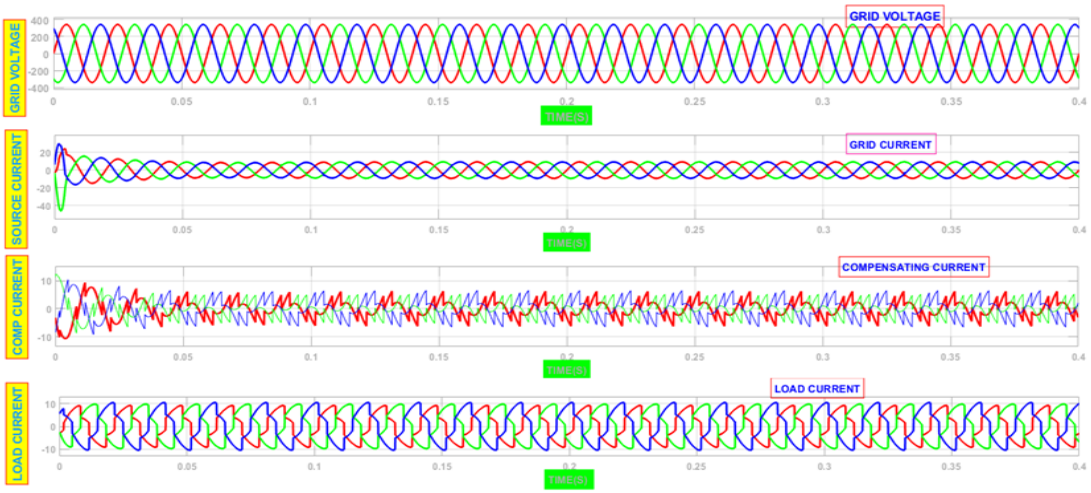


Fig. 15. The waveforms of the I_L, I_S, I_C, I_S, by using ABC trained ANN based SAPF

Figure 15 illustrates the waveforms of the currents flowing from the source, the load, and the SAPF compensating current. In order to maintain a sinusoidal source current, SAPF injects compensating current at the PCC using an ANN controller that was trained using the ABC algorithm. The harmonic spectrum of the source current is depicted in figure 16. The ABC-ANN controller's converging spectrum can be seen depicted in Figure 17. The error measured by the ABC ANN controller is shown to be smaller than that measured by the DE -ANN controller.

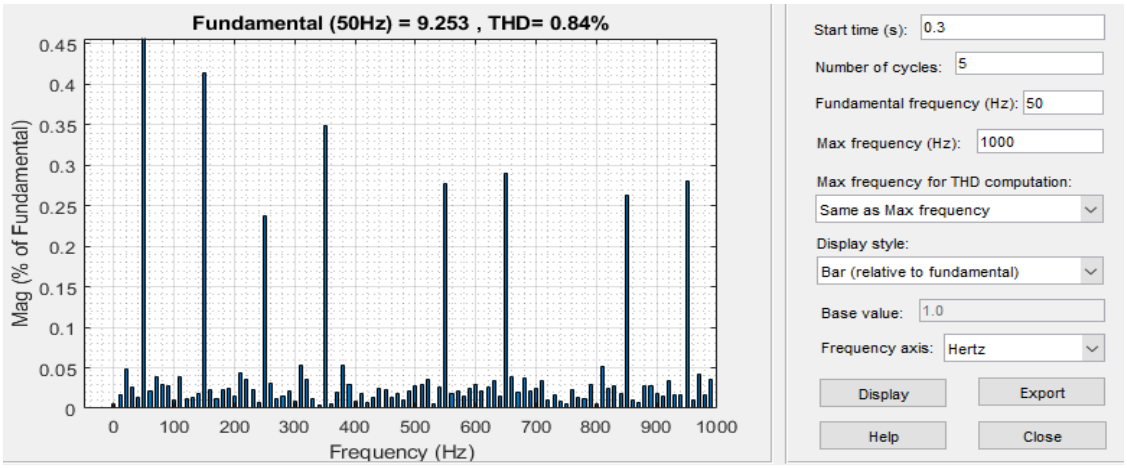


Fig. 16. THD result of I_S (Grid current) by ABC tuned ANN based SAPF

ABC-ANN parameters are listed in Table 1 and Table 2 presents the results of the SAPF investigations into all six incidents.

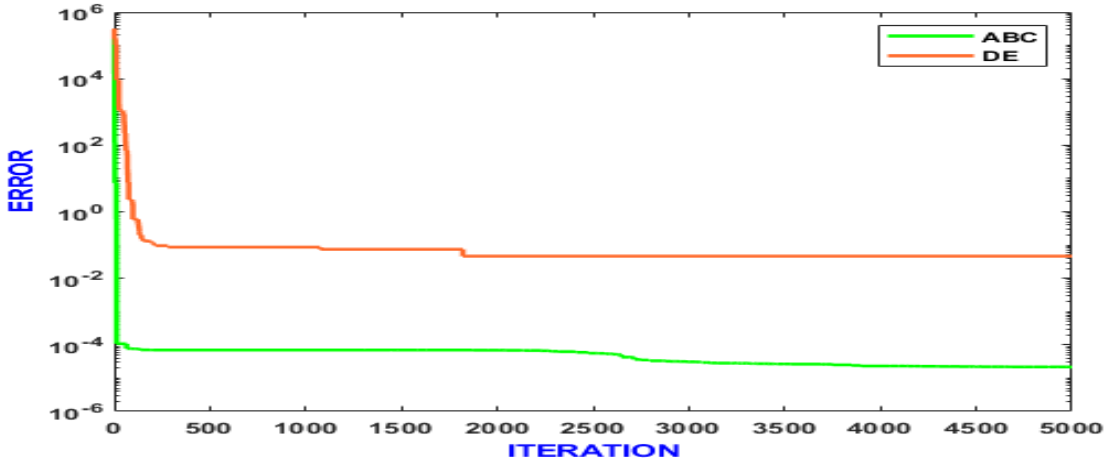


Fig. 17. Converges graph for the three optimization algorithms

Table 1
Parameters of ABC trained ANN

Total number of iterations	5000
Number of Population	25
Number of Onlooker Bees	25
Abandonment Limit Parameter	15
Acceleration Coefficient	1
Hidden number of Neurons	12
Total number of Variables	1
Max weights	200
Min weights	0

Table 2
Table of Comparisons

S_no	Type of Controller	Component	THD value(%)
1	Without using SAPF	I_S (Source Current)	18.42
2	PI based SAPF	I_S (Source Current)	3.76
3	PSO tuned PI Based SAPF [22]	I_S (Source Current)	0.93
4	DE tuned ANN based SAPF	I_S (Source Current)	0.90
6	ABC tuned ANN based SAPF	I_S (Source Current)	0.84

7. Conclusion

A novel Artificial Bee Colony based optimized Artificial Neural Network (ANN) controller is proposed for the purpose of improving the power quality in a SAPF-based power system with non-linear loads. Harmonics from nonlinearities are compensated and THD values are far below norms. This article recommends using the ABC-ANN control approach with the SAPF to reduce the THD in the power grid's source current. The successful implementation of the SAPF is evaluated and compared across a number of circumstances. The Matlab-Simulink software simulates total five situations and reports the results. Simulations show that DE-ANN, PSO tuned PI based SAPF and SAPF with PI controller minimize the THD, The ANN-ABC-based SAPF that was suggested provides better performance in terms of reducing THD in source current in comparison to other scenarios. According to the results, this improvement in performance is satisfactory (that is, within 5% of the recommended IEEE standard).

Future work will involve incorporating a hardware-in-loop implementation of the proposed shunt active filter. To further improve the SAPF's response, an ANFIS controller will be used that is predetermined with ABC and other optimization strategies.

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Optimized PI tuning of DG-Integrated Shunt Active Power Filter Using Biogeography-Based Optimization Algorithm

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ABSTRACT

This article proposes a biogeography-based optimization (BBO) approach to optimizing the PI controller gains of the PV integrated shunt active power filter (SAPF). This method is also used to analyze how these optimum gains affect the performance of SAPF. When nonlinear loads draw reactive power from the source, harmonics are produced, which can lead to power quality issues for the utility. Our ultimate goal is to achieve sinusoidal source current, which can only be accomplished with the help of FACT devices that enhance power quality in the distribution network. SAPF is a commonly utilized device. Solar is the most popular alternative energy source because it is the most cost-effective. Therefore, this article takes into account PV-integrated SAPF for analysis. To get the highest amount of power from a PV panel, a technique called maximum power point tracking (MPPT) is used. This technique is based on perturbation and observation (P&O) in MPPT. When the SAPF converter uses this maximum power, it also sends active power to the load, so that the SAPF converter has dual functionality like reactive power compensation (FACT) and active power supply (DG Functionality) to the load. The performance of this PV-Integrated SAPF depends on many things, like how the reference current is made, how switching pulses are made, how the voltage on the dc link is controlled, etc. In order to obtain the best possible performance from SAPF, certain design parameters, such as the gains of the PI-controller, need to be optimized. Modeling and simulation of a PV-integrated SAPF are performed in Matlab/Simulink. Gain optimization of the PI controller-based PV integrated SAPF is performed using both the proposed biogeography-based optimization method and the PSO algorithm, and the results are compared. The proposed BBO-trained PV- SAPF converter's active power injection was also investigated.

1. INTRODUCTION

Fossil fuels have been burned to meet power demand for decades, but they are nonrenewable and cannot be reused [1]. They aren't ecologically sound. Pollution-friendly and contribute to climate change, so [2] renewable energy sources like solar, wind, and geothermal are essential. There are clean sources of energy generation, such as hydro, etc., and there is an abundance of them. Photovoltaic power plants have widespread application; solar energy is naturally abundant, and electrical power is widely available. Solar power as dc from the arrays, which is converted to an alternating current one that uses an inverter. Due to the energy's reactive power balancing capabilities, this equipment can be used anywhere [3]. There are more harmonics in the network because of the rise in nonlinear electronic loads and devices. Presents of a harmonic nature as well as voltages that are powers of the fundamental frequency led to systemic cases of power degradation, and as a result, the machinery got hot. To better understand the role of alterations that happens when voltage and Currents are not proportional. The impedance of the load [4] Short-circuit current is drawn by these loads. Damage electronic devices with pulses and harmonics. Rectifiers and other electronic devices are examples of non-linear loads. Everything from computers and motors to SMPSs (switch mode power supplies) to get rid of harmonics uses passive filters, but they have a few drawbacks. Have bounds, such as in resonance, and evolve in accordance as the workload shifts. To reduce grid current harmonics, active power filters are being developed; unlike passive filters, which require an external power source, these don't affect demand levels [5, 6]. Active filters can achieve the required gain while simultaneously addressing issues with attenuation. They're diminutive, but they're more effective than passive filtering systems. Their ability to avert major active power filters can handle wider frequency ranges. Photovoltaic shunt-clearing harmonics are a common application for active filters. The module's findings or those found Maximizing power generation from PV systems while keeping costs as low as possible necessitates the use of power point tracking (MPPT) techniques [7]. Additionally, a boost converter is used to increase the voltage output. When PV is implemented, it depends on a variety of factors in the real world, including things like climate and solar radiation. There's been a lot of

study into improving old power in the grids employing various filtering strategies [8]. SAHF yields the contrasting major-minor harmonics so that it nullifies itself. Turn a nonlinear load into a linear one with linear pressure.

The goal of this work is to lessen harmonic distortion [9] in a distribution system with a non-linear load. By utilizing a shunt active power filter that is integrated with solar panels. Figure 1 represents the PV-integrated SAPF, which typically provides a current that is 90 degrees out of phase with the source current [10, 11]. As a result of the nonlinear load, the converter's output voltage dips, and the filter capacitor draws a greater amount of current than usual during the compensation process. So, in order to mitigate these unforeseen effects, it is proposed [12] that a SAPF be constructed with optimal parameters.

There has been a lot of study done on the topic of using an active power filter with a photovoltaic (PV) system. The filter's structure and tuning parameters are ignored, while a variety of methods for controlling current in a 3-phase, 4-wire distribution network are proposed in the study [13]. An improved current control approach [14] using a maximum power point tracking controller has been implemented to lessen system harmonics via a grid-connected inverter. Filtering techniques, such as a self-tuning PI controller [15, 16], have been used to decrease harmonic distortions in a grid, which comprises a voltage source converter, a hysteresis controller, and a DC voltage capacitor.

The parameters of today's automatic control systems are often optimized with the help of state-of-the-art soft computing techniques. The gains of PI controllers are optimized using particle swarm optimization (PSO) techniques [17, 18]. Evolutionary algorithm optimization techniques such as the genetic algorithm (GA) [19], bacterial foraging (BF) [20], firefly [21], ant colony optimization (ACO) [22], and differential evolution (DE) [23] have all been applied to the problem of determining the best possible gain settings for the PI controller in SAPFs.

In this study, BBO, a stochastic optimization method based on swarm intelligence, has been used for the fine tuning of PV-integrated SAPF PI parameters to control the DC link voltage to achieve the best THD. Using active power control theory, the SAPF converter also works like the DG converter.

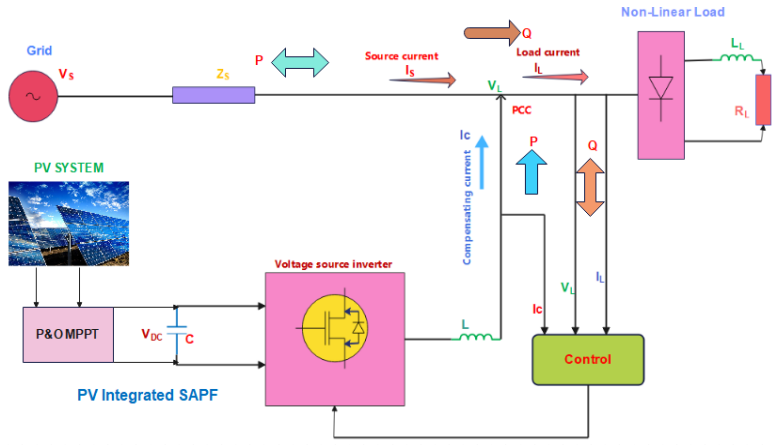


Figure 1. Model configuration of PV integrated SAPF

2. SYSTEM MODEL

The photovoltaic (PV) integrated shunt active power filter model that is the focal point of the present study is depicted in Figure 2. This model in its entirety includes the PV configuration, PV model, and PV array.

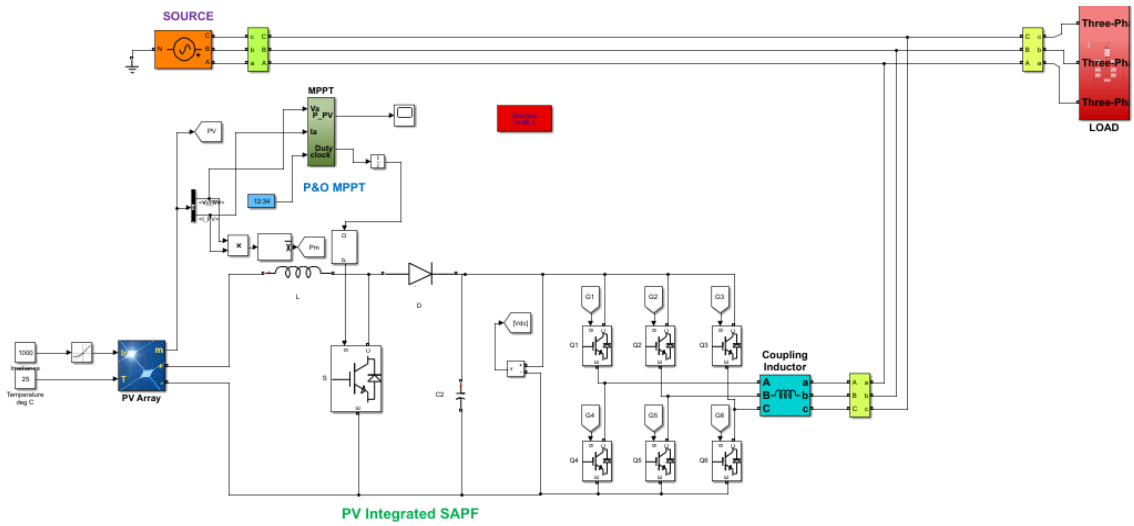


Figure 2. Simulink diagram of PV integrated SAPF when connected to non linear load

2.1 Mathematical modeling of shunt active power filters

The following assumptions need to be made in order to select the parameters for the SAPF, such as the interfacing inductance L_f and the DC capacitor C_{dc} as well as the reference dc voltage.

• The source current needs to have a sinusoidal pattern.
• The amount of distortion in the system current is no more than 5%.
• Converting takes place in a linear fashion.

The Q_C and I_h can be calculated using the two equations that are provided below.

$$Q_C=3V_CI_C = 3V_S \frac{V_C}{\omega L_f} (1 - \frac{V_S}{V_C}) \quad (1)$$

$$I_h = \frac{V_h}{m_f \omega L_f} \quad (2)$$

The V_{dcref} value can be adjusted in response to the rated voltage. The following equation is used to determine the appropriate value of C_{dc} to achieve the desired peak-to-peak voltage ripple level.

$$C_{dc} = \frac{\pi * I_c^{rated}}{\sqrt{3}\,\omega\, V_{PP}^{ripplee}} \quad (3)$$

where,

V_{dc}: The injected voltage from the filter.
L_f: The inductance of coupling for the SAPF.
C: The capacitor on the DC side of the filter.
V_s: The voltage of SAPF.
I_c: Compensating current from filter.
V_h: Harmonic voltage.

2.2 Basics of PV system

In order to convert solar energy into usable electricity, a PV system will use a series or parallel connection of PV modules or panels. Electrical output is generated via photovoltaic (PV) panels and associated mechanical and electrical connections. Solar photovoltaic (PV) output is normally dependent on solar irradiance, or the amount of sunlight available.

PV Cells, Modules, and Arrays PV cells can be connected together to make a module. Adding more modules to a PV plant works the same way, either in series or parallel, to boost the plant's power output.

A solar power plant's crucial fundamental component is PV cells. Silicon (Si) is the primary material used in solar panel construction. To generate an electric field, a thin semiconductor coating is polarized positively on one side and negatively on the other. The layer's surface is the source of the emitted electrons.

A PV cell typically produces a voltage in the range of 0.5 V to 0.7 V. As a result, the necessary output voltage and current can be obtained by connecting a series and parallel array of PV cells. In the event of partial shading, diodes in the PV array may be necessary to prevent the flow of current in the opposite direction. There is a risk of inefficiency when temperatures are very high. To counteract this, PV systems incorporate ventilation systems.

In order to convert the DC power from the PV panels into AC power for use in homes and businesses, inverter systems are installed. By connecting modules in series and parallel, higher voltage and current capacities can be achieved. The configuration is depicted in the Figure 3.

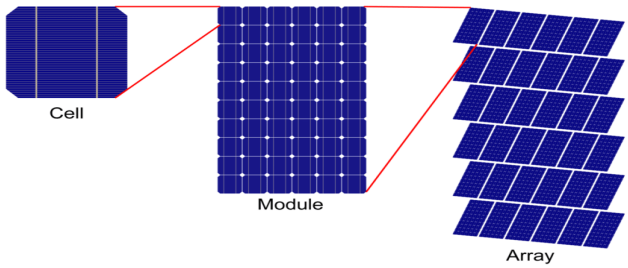


Figure 3. Interconnection diagram of solar cell, module, array

2.3 Module of PV system

The PV cell's circuit is depicted in Figure 4. It consists of only one diode, which is connected in parallel to the power supply. The function of a diode is to permit current to flow smoothly in one direction but substantially prevent it from flowing in the opposite direction. Diodes are sometimes referred to as rectifiers due to their ability to convert AC current into DC current. Both series resistance R_s and shunt resistance R_{sh} are denoted. There are two conditions for the cell, and the amount of current it draws from its source is directly related to the amount of sunlight it receives [24]. One is the potential difference between the terminals in a circuit that is open, and the other is the current in a short circuit.

When the diode is open, the voltage across it is zero, and the current through the short circuit I_{sc} is equal to the current through the current source, Voc.

The equation gives information about PV's properties.

$$I = I_L\text{-}I_0\,(e^{(v+R_s/n_s v_t Q_d)} - 1) - \frac{v+R_s}{R_{sh}}) \quad (4)$$

where, V is the array's voltage, I is the array's current, I_L is the light current, I_0 is the diode's reverse saturation current, Q_d is the diode's ideality factor, ns is the number of series cells, Rs is the series resistance, R_{sh} is the shunt resistance, V_t is the thermal voltage, and I_d is the diode current.

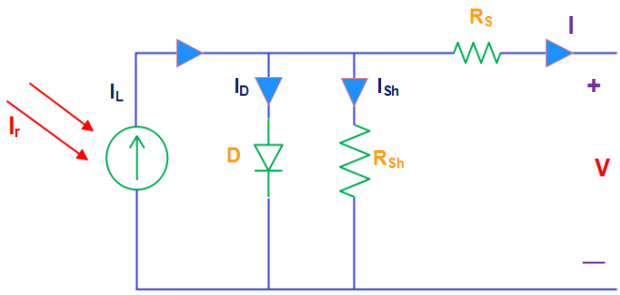


Figure 4. Single line diagram of photovoltaic system

Sun power SPR-315E-WHT-D modules were used in this study; their parameters and technical specifications are listed in Table 1.

Table 1. PV panel specifications

Parallel Strings	12
Series-connected modules per string	7
PV module name	Sun power SPR-315E-WHT-D
Max power	315.072
Open-circuit voltage (V)	64.6
Short -circuit current (A)	6.14
Voltage at MPPT (v)	54.7
Current at MPPT (a)	5.76
Irradiation (w/m^2)	1000

2.4 P&O MPPT algorithm

The P&O method uses the PV module to its full potential by maximizing efficiency in any environment. The primary benefit of this technique is the accessibility and preciseness of its algorithm, so that it can even be performed efficiently with a low-cost processor. However, a current and voltage sensor that measures the array's voltage and current is required for its implementation [25]. The power output of the PV is then calculated based on the data obtained for voltage and current.

If the duty cycle is altered by the expression P(n-1)=V(n-1)×I(n-1), and if the expression P(n)=V(n)×I(n) increases from the previous value, then n is an even number. The direction of the perturbation remains the same as P(n)=V(n)×I(n) grows larger, while when it decreases, the perturbation and, by extension, the duty cycle, switch directions [26]. Using the P&O technique, the system is represented in Figure 5.

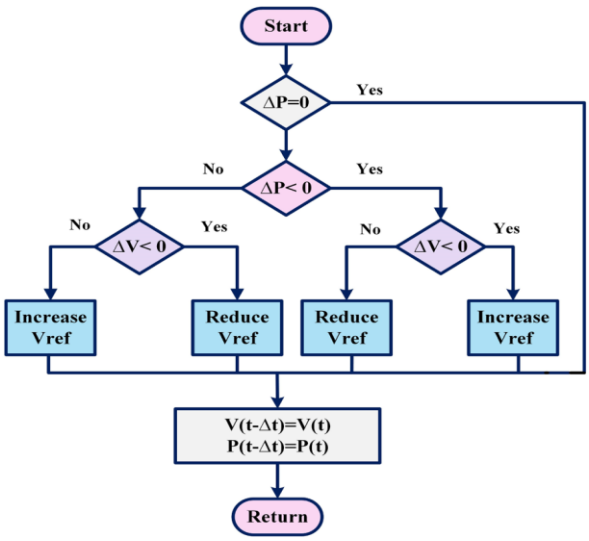


Figure 5. Flow chart representation of P&O MPPT

3. BBO OPTIMIZATION ALGORITHM

The natural phenomenon of biogeography acted as inspiration for a new metaheuristics technique called "biogeography-based optimization" (BBO). Biogeography is the study of how the geographic distribution of different species varies over time and space [27]. Simon [28] first proposed the BBO method for resolving certain continuous functions. Furthermore, this approach was developed on the basis of some principals, including species' ability to travel from island to island, the development of novel species, and the eventual extinction of extant ones. Some crucial BBO concepts are as follows:

3.1 Biogeography

According to biogeography principles, islands that are more favorable to life support systems tend to have more species, while less favorable islands tend to have fewer. Thus, the answers to the issues are like those islands. An excellent Habitat Suitability Index (HSI) value would characterize the ideal island. HSI is more commonly called "fitness" in other algorithms for population-based optimization, like the Genetic Algorithm. Suitability Index Variables (SIV) are the characteristics of the HSI. The HSI is the dependent variable in the habitat, and the SIV is taken as an independent variable.

3.2 Migration

High-HSI (or abundant species) habitats or islands will see high rates of emigration and low rates of immigration. Therefore, the higher HSI habitat is more likely to remain unchanged over time. Since these species have a high emigration rate, they are likely to relocate to nearby habitats. However, the migratory species wouldn't vanish entirely from the island of their ancestry. Those species would simultaneously appear on both islands. In most cases, the migration process would force the inferior solution to adopt the characteristics of the superior ones. If an island has a high emigration rate, it also has a low immigration rate, and vice versa. However, the island's rate of emigration is influenced by the variety of species that call it home. It stands to reason that islands with higher rates of emigration would be home to more species overall.

3.3 Mutation and elitism

In addition to migration, mutation and elitism occur during the BBO process. Mutation is a devastating ecological event. The rate at which mutations occur in various environments is known as the mutation rate. In some ecosystems, the mutation rate is proportional to the number of species present. The mutation rate in high-HSI environments is expected to be lower than in low-HSI environments. As a result, it is unusual for the mutation to preserve the good solution until the next generation is selected. Because of this mutation, novel environments would emerge to replace those with low HSI values. Without mutation, low-HSI solutions would become more prevalent, leading to a possible trap at the local optimum. Each habitat's mutation rate can be expressed as follows:

$$m_k = m_{max}\left(\frac{1 - P_k}{P_{max}}\right) \quad (5)$$

For any given habitat, the probability of having k different species is denoted by P_k, the mutation rate is denoted by m_k, and the maximum mutation rate is denoted by m_{max}, with Pmax being the maximum probability. Becauseof the mutation, a new habitat would appear in its place. The best previous solutions would also survive the elitism. All solutions, except the optimal ones with the highest probability (P_k), are equally susceptible to mutation. BBO's mutation mechanism is flexible in the same way that the mechanism of mutation that has been applied to the GA. Flow chart representation of BBO algorithm as shown in Figure 6.

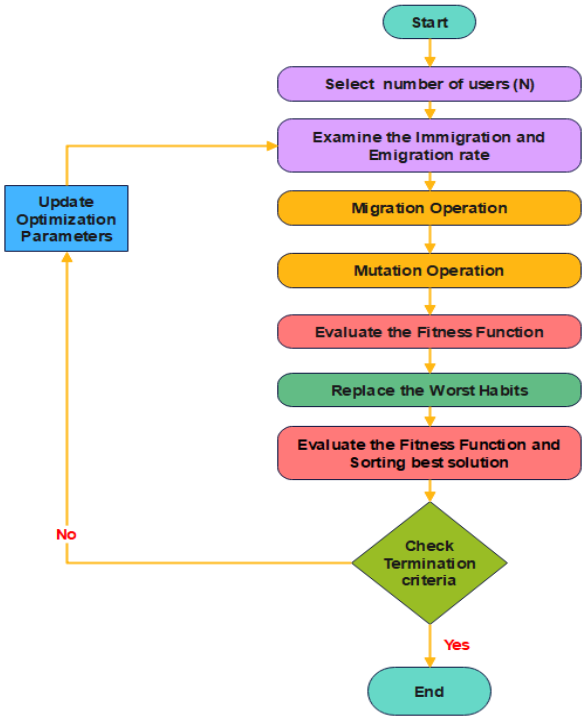


Figure 6. Flow chart representation of biogeography-based optimization (BBO)

4. PROPOSED METHODS

4.1 Tuning of PI controller by using BBO algorithm

The efficiency of a PV-integrated SAPF is dependent on the stability of the DC link voltage, which is regulated by the PI controller. Finding the gain (K_P, K_I) values of the PI controller in the critical controller is a complex mathematical process. The calculated gains are not optimal for the PI controller. To determine the best gains for the PI controller, this work implements BBO. Figure 7 shows the objective function, integral absolute error (IAE), as the discrepancy between the measured and target DC voltages. The BBO algorithm minimizes these objective functions and gives the best possible gains for the PI controller.

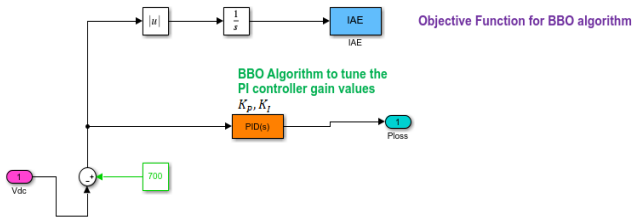


Figure 7. Simulink model of PI controller tuning with BBO algorithm

4.2 Active current coefficient control

This theory is proposed to find the actual active current required by the load, which is supplied from the PV source. Here first we need to sense the grid voltage (phase to phase) that is converted to phase to ground voltage, then these phase to ground voltages are again converted to α-β frame by using the clarck transformation, and again these α-β frame voltages are converted to an a-b-c reference frame by using the inverse clarck transformation. From that, we will get grid voltages in the a-b-c reference frame (Vg_a, Vg_b, Vg_c). These voltages pass through a band pass filter in order to remove some higher-order harmonics, and here we generate some unique vectors for synchronization of the grid with PV. And again, we need to sense the load current. With these load currents and the unique vectors, we need to find the active current coefficients for lines a, b, and c, as shown in Figure 8. Finally, we will take the average of these and get the actual active current requirement for the load (I_L).

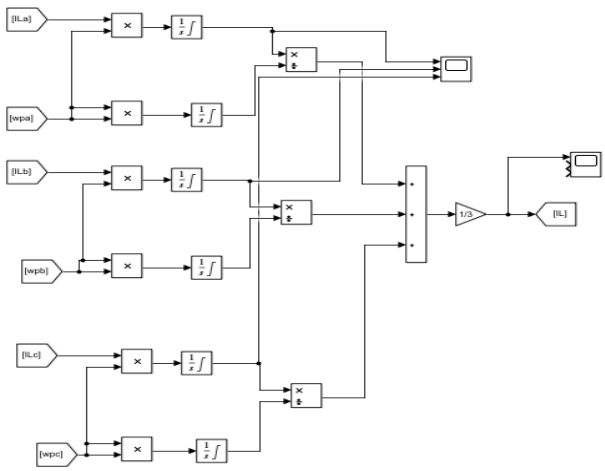


Figure 8. Simulink representation of active power coefficient theory

5. RESULTS AND DISCUSSION

This model implements a photovoltaic (PV)-based shunt active filter to mitigate undesired harmonics and enhance the power quality of the system. In order to produce gate pulses for the inverter, a hysteresis controller is built into the voltage source inverter (VSI). The model utilizes the P&O-based Maximum Power Point Tracking (MPPT) technique in order to optimize solar power extraction. The model is evaluated both with and without the inclusion of SAHF in order to analyze the network. By analyzing the data, we can determine the V-I characteristics. The shunt active filter based on photovoltaic (PV) technology is evaluated and examined using the MATLAB/SIMULINK software in order to mitigate current harmonics and facilitate power enhancement. The input supplied to the photovoltaic panel consists of solar irradiance of 1000 w/m^2 and a temperature of 25°C.Max power, open circuit voltage, and short circuit current are shown in Figure 9.

Since PV cells and other nonlinear loads are used, the source current is mostly made up of harmonic components, which affect all other loads in the distribution system. Here, the effects of a nonlinear load and the PV cell on harmonics have been looked into. A nonlinear load is used in the FFT analysis. Also, the gains of PV-SAPF's PI controller are chosen at random using trial and error. So, to improve the performance of SAPF, getting the gains of the PI controller to be as good as possible can be accomplished by employing the BBO optimization technique. In this study, the active power injection from this PV-SAPF is further examined.

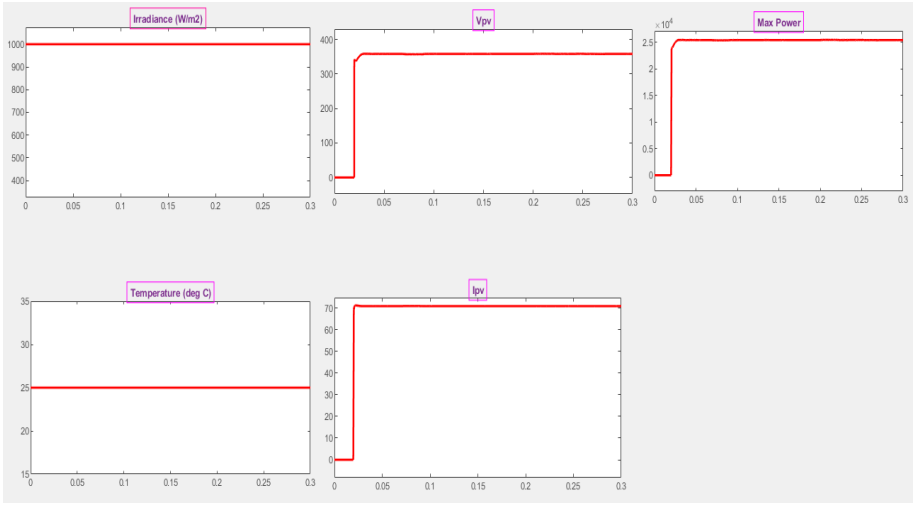


Figure 9. Output characteristics (P_{max}, V_{PV}, I_{PV}, Irradiation) of PV module

5.1 Harmonic spectrum of PV-SAPF with PSO-PI controller

Here, the PV-integrated SAPF utilizes a PSO-PI controller to control the voltage on the DC capacitor. Conventional controllers involve a lot of mathematical calculation, which is not accurate, so the gain values of the PI controller are tuned with the support of PSO's optimization algorithm. The PSO technique uses a minimization of the objective function known as the integral absolute error (IAE) to find the best possible values for the gains. With a maximum number of 100 iterations and 25 populations, For K_p and K_i, we chose 0 and 200 as the absolute minimum and maximum values, respectively.

Figure 10 shows the harmonic spectrum of PV-SAPF with the PSO-PI controller, where the THD in the grid current is 1.18%, and it shows that it is reduced from 3.08% to 1.18%.

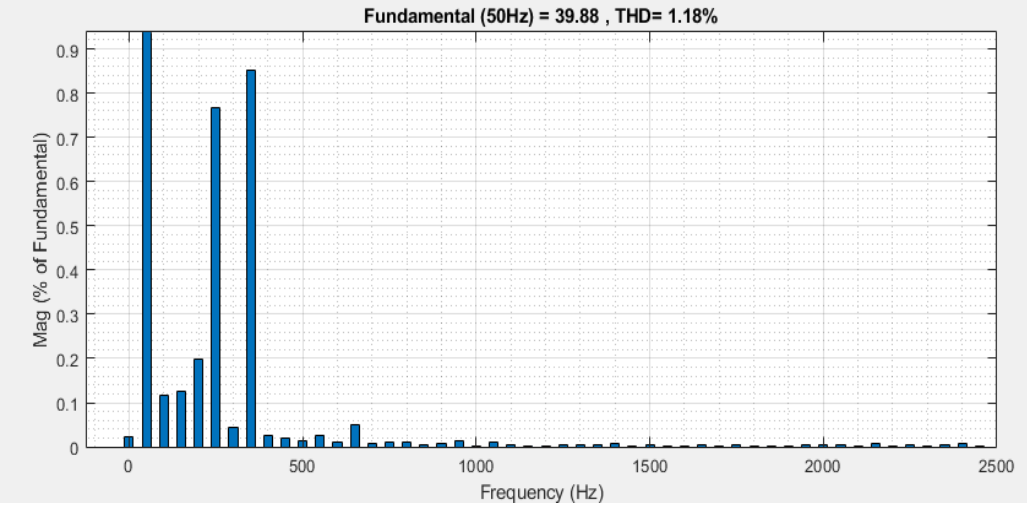


Figure 10. Grid current THD of PSO trained PI controller based PV-SAPF

5.2 Harmonic spectrum of PV-SAPF with BBO trained PI controller

Here, the PV-integrated SAPF utilizes a BBO-trained PI controller to control the voltage on the DC capacitor. A biogeography-based optimization (BBO) strategy will be used to make the necessary correction of the error voltage (IAE), which is the objective function, by adjusting the K_p and K_i gains of the PI controller. Figure 11 provides a graphic representation of source-side voltage (V_S) and source-side current (I_S) that are generated by a PV-SAPF that is controlled by a BBO-PI controller. In the event that a nonlinear load is connected to the grid at the same time, for the grid current to continue to have its normal sinusoidal shape maintained, SAPF will inject the compensating current at the PCC. Figure 12 represents the harmonic spectrum of PV-SAPF with a BBO-PI controller. From observing the figure, it is very easy to see that the THD value at the source current is 0.91%, and it shows that it is reduced from 1.18% to 0.91%. Table 2 represents the parameters of the BBO-PI controller.

Table 2. BBO configurations

BBO Parameters	Values
Maximal Iterations	100
Tuned Parameters	2
Keep Rate	0.2
Total Quantity of Reatained Habitats	5
Total Quantity of Fresh Habitats1	20
Total Populations	25
Alpha	0.9
Mutation	0.1
Emigration and Immigration Rates	1

5.2.1 Active power (P) & reactive power(Q) from PV-SAPF inverter

When PV is integrated into SAPF using active power coefficient theory, the SAPF converter will have dual functionality.

The PV-SAPF-SAPFrter works like DG; it will inject active power into the load.

The PV-SAPF-SAPFrter works like a FACT device; it will inject reactive power into the load.

Figure 13 represents the active and reactive power from the PV-SAPF inverter. From that, we can clearly observe that the PV-SAPF inverter is injecting 25.4 KW of active power and 2.054 KVAR of reactive power at the PCC.

5.2.2 Active power (P) & reactive power(Q) at load

Figure 14 represents the active power (P) and reactive power (Q) at the nonlinear load. From that, we can clearly observe that the load requires active power of 5.226 KW, which is taken from the PV-SAPF converter, and reactive power of 2.058KVAR, which is also taken from the PV-SAPF inverter.

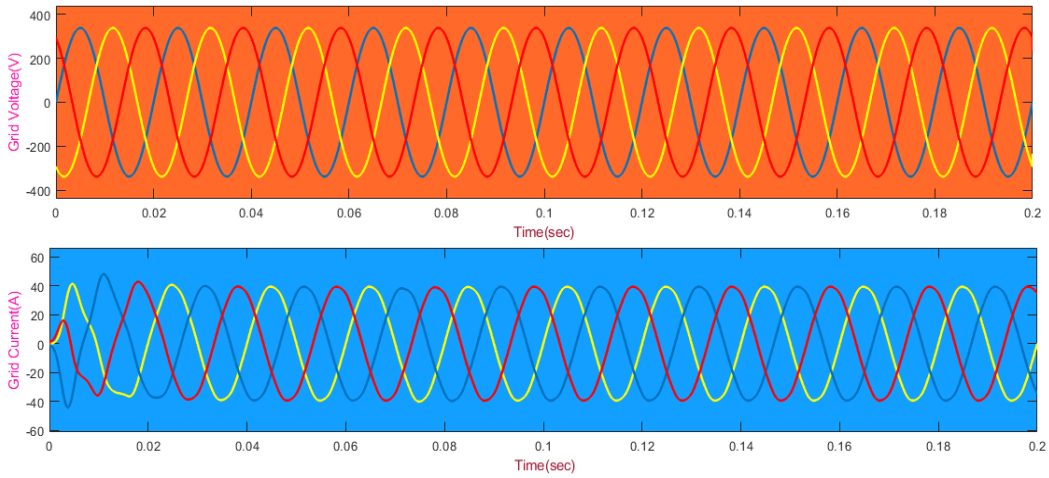


Figure 11. Source voltage and source current wave forms of BBO trained PI based PV-SAPF

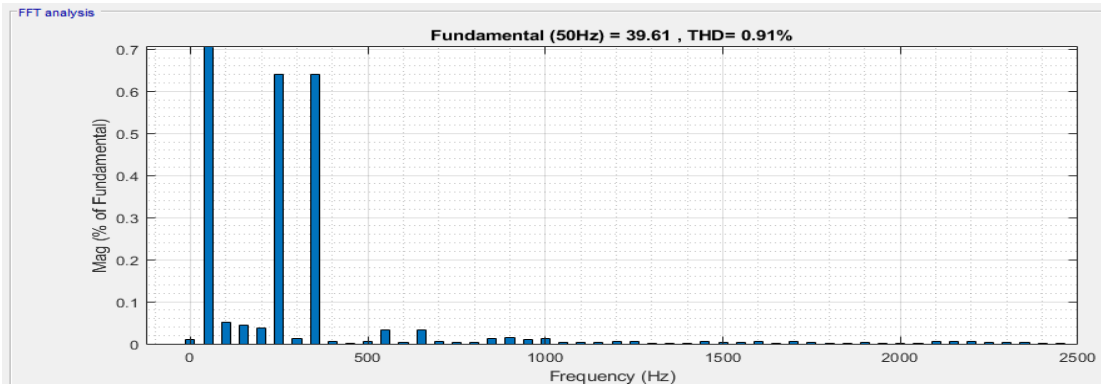


Figure 12. Grid side current THD of BBO trained PI controller based PV-SAPF

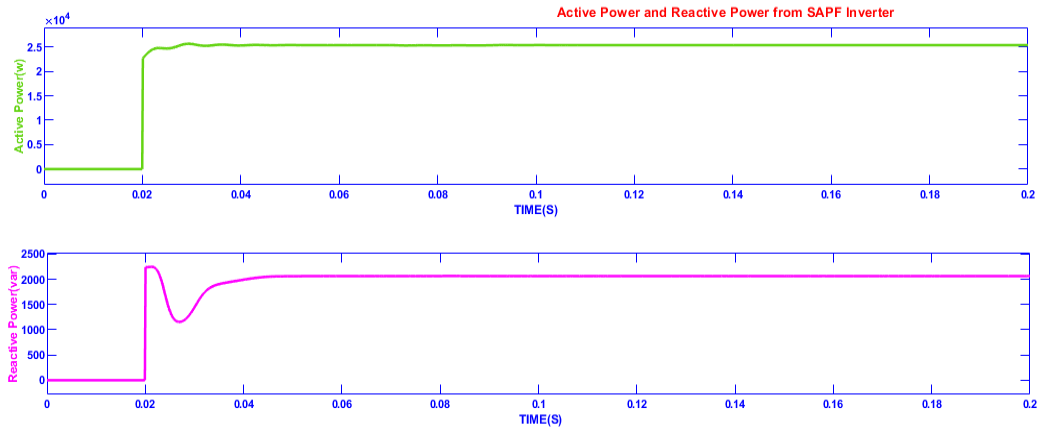


Figure 13. Active power and reactive power wave forms from PV-SAPF converter

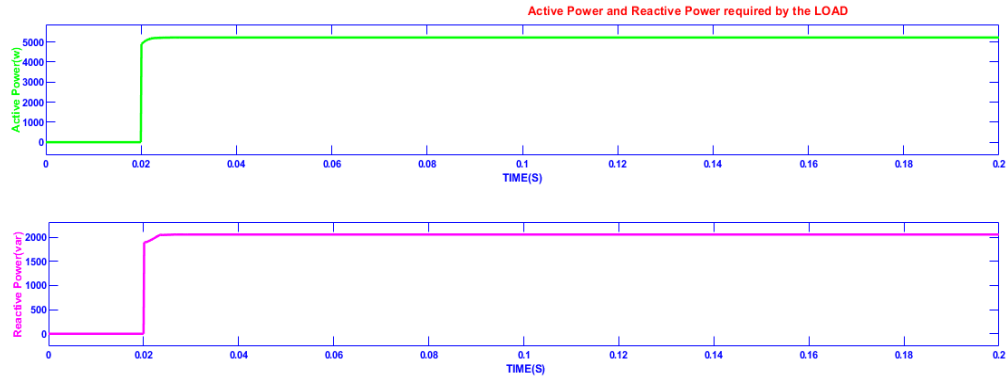


Figure 14. Active power and reactive power wave forms required by the load

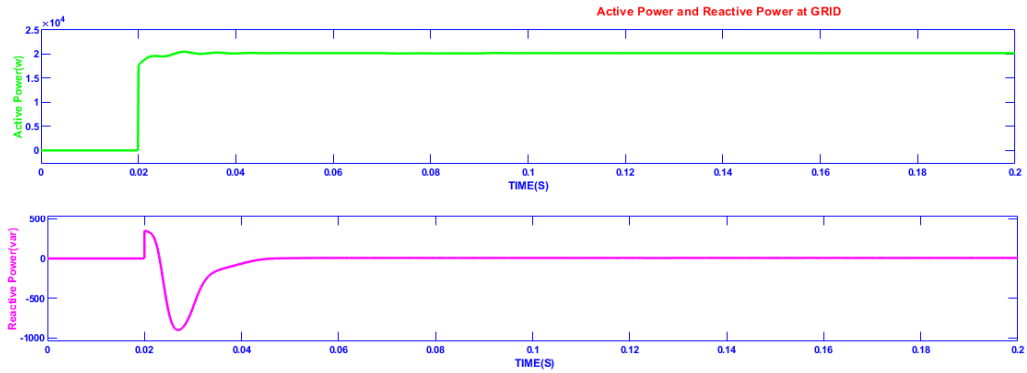


Figure 15. Active power and reactive power wave forms at GRID side

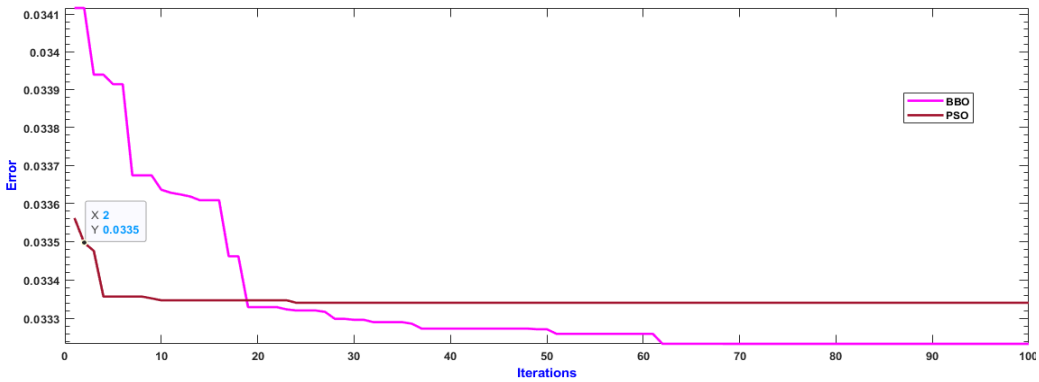


Figure 16. Converges spectrum of PSO & BBO trained PI controller based PV-SAPF

Table 3. Quantification comparisons

S_no	Type of Controller	Component	THD Value (%)
1	Without SAPF	I_S(SourceCurrent)	18.42
2	PI based PV- SAPF	I_S(SourceCurrent)	3.08
3	PV-SAPF with PSO-Trained PI cotroller	I_S(SourceCurrent)	1.18
4	PV-SAPF with BBO-Trained PI controller	I_S(SourceCurrent)	0.91

5.2.3 Active power (P) &reactive power(Q) at grid

Figure 15 represents the active power and reactive power (P&Q) at the source side; from that, we can clearly observe that the grid is not generating any reactive power (Q) for the load. At PCC PV-SAPF injecting 25.4 KW of active power, the load is taking around 5.226 KW, and the remaining 20.17 KW of active power is sent to the grid.

The converging spectrum of the BBO-PI-based PV-SAPF controller is depicted here in Figure 16, as it can be seen. It has been demonstrated that the error that is measured by the BBO-PIcontroller is less than that which is measured by the PSO-PIcontroller. The SAPF investigation findings for different incidents are listed in Table 3.

From the Table 3, we can clearly observe that the THD with a PSO-tuned PI-based PV-SAPF is 1.18%, and the proposed BBO-tuned PI-based PV-SAPF achieves a THD of 0.91%, which means the quality of grid current is better with BBO-trained PV-SAPF when compared to PSO algorithm-based PV-SAPF.

Active Power and Reactive power from SAPF inverter, Load, Grid at irradiation 0 w/m^2 and 10000 w/m^2 as given in Table 4.

Table 4. Power comparisons

Power/Irradiation	With Out DG Integration (0 W/m^2)		With DG Integration (1000 W/m^2)	
	Active Power (KW)	Reactive Power (KVAR)	Active Power (KW)	Reactive Power (KVAR)
Grid power ((P_s) & (Q_s))	5.239	0.3186	20.17	0.006
Load power ((P_L) & (Q_L))	5.226	2.058	5.226	2.058
SAPF inverte power ((P_F) & (Q_F))	0.0139	2.058	25.4	2.054

6. CONCLUSION

In this paper, we investigate the effectiveness of a PV-based shunt active filter with nonlinear loads in reducing harmonic distortion and improving overall power quality. Active filters are not the only option available, and passive filters are used for this purpose too. However, passive filters have issues such as load variation that active filters do not. It's a more cost-effective system because active filters are cheaper than passive ones. Solar irradiation and ambient temperature are two of the variables used in the PV module simulation. The P&O algorithm is used in conjunction with maximum power point tracking techniques to extract the maximum amount of power possible from PV. To increase the array's voltage, a boost converter is connected to it.

This study presents a proposed configuration for a photovoltaic (PV) integrated shunt active power filter. The configuration incorporates a biogeography-based optimization (BBO) for DC-link control, operating under ideal voltage conditions. The objective of this configuration is to improve power quality by reducing total harmonic distortion (THD). The Matlab-Simulink software runs simulations of two different scenarios and then presents the findings. The simulation results show that the THD with a PSO-tuned PI-based PV-SAPF using a PI controller is 1.18%, and the proposed BBO-tuned PI-based PV-SAPF achieves THD 0.91%, which is even better results in reducing THD in the source current than the PSO-tuned PI-based PV-SAPF. The proposed BBO-trained PV-SAPF provides not only reactive power compensation but also injects active power as required by the load.

7. FUTURE SCOPE

This suggested shunt active power filter will be implemented in hardware-in-loop in the future. The response of the PV-integrated SAPF can be improved through the implementation of an ANN, an ANFIS controller using BBO, as well as additional optimization strategies.

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Mitigation Of Grid Current Harmonics By Using Anfis Based Shunt Active Power Filter

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Abstract:
More applications are using non-linear power electronic equipment, which distorts the current distribution system and creates significant Power-Quality (PQ) issues. These sophisticated non-linear power electronics, such as rectifiers and switch-mode power supplies, cause reactive power issues and harmonic current distortions that deteriorate the purity of source waveforms at the distribution system's common coupling/feeding point (PCC). Modern power systems must be designed with dependable power filters that reduce voltage and current harmonics in order to satisfy utility grid power quality standards.

This project discusses a thorough, methodical approach to designing a shunt active power filter (SAPF) for improving power quality. The DC-link voltage is controlled by an ANFIS controller. The extraction of the reference current makes use of the instantaneous reactive power theory. Based on PQ theory, the best Shunt Active Power Filter has been created for PQ improvement; this is the technologically and commercially ideal equipment. MATLAB/Simulink is used to generate and simulate the detailed SAPF for balanced nonlinear loads.

Key Word*: Power Quality (PQ), Common Coupling Point(PCC), Shunt Active Power Filter(SAPF), Adaptive Neuro-Fuzzy Inference System (ANFIS).*

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I. Introduction

Power electronic switches are the foundation of nonlinear electric appliances, which are extensively employed in both residential and commercial applications across the globe [1,2]. Power quality issues such harmonic distortion, voltage fluctuation, and noise are caused by nonlinear loads like arc furnaces, variable frequency drives (VFDs), and personal computers [3-5]. Power losses, electric device heating, insulation failures and the communication system interference, in the worst situations, electric power systems failures are all caused by harmonic distortion in low-voltage distribution systems[6]. As a result, fixing power quality issues has emerged as a crucial concern for both the utility and the consumer [7-8]. This standard specifies that the total harmonic distortion (THD) cannot be greater than 5%. Power filters are thus utilised in order to adhere to the 5% restriction [9]. Power filters are readily available, effective technologies that are frequently employed to stop the spread of harmonic distortion. Typically, passive power filters in series and shunt configurations are connected to the distribution network in order to enhance power quality [10]. Designing a passive power filter that can successfully remove harmonic current distortion in industrial nonlinear loads connected to a stiff power source is difficult, tough[11]. Additionally, the passive filter is connected to intrinsic flaws include its massive bulk, resonance with utility or load impedance, unpredictability and rigidity [12–14]. On the other hand, passive filters have been substituted by active power filters (APFs) that use voltage source inverters (VSIs) in order to overcome the classic filters limitations.

APFs are a great way to address power quality issues because of their many advantages, which include flexibility, quick dynamic response, and accurate progressive filtering [15]. The current harmonics, reactive power sensing technique, compensation control algorithm, and other factors primarily dictate the harmonic mitigation capability of the shunt active power filter [16–17]. The instantaneous reactive power theory (P-Q theory) is commonly used to compare the various reference compensation current control systems. The following steps are taken in order to finish the donations listed above: Section II provides ANN based SAPF, Fuzzy tuned PI based SAPF, ANFIS based SAPF.

Shunt Active Power Filter:

The most widely used kind of active filter is SAPF. A SAPF converter can be single-phase or three-phase, and it can be a voltage source or current source inverter. With a 180° phase shift, this filter functions as a current source, injecting the harmonic components of the load. Its controller forces a power electronic converter

to accurately synthesize the compensating current reference by computing it in real time. Selective and adaptive active filtering is made possible by this technique. Stated differently, a SAPF may track changes in the harmonic content of a nonlinear load on a regular basis and adjust for the harmonic current of the load. The shunt active filter of source current harmonics is controlled by four different algorithms. For this project, PQ theory is being used. In order to create the SAPF reference current for source current harmonic mitigation, the theory (PQ), an adaptive phase-locked loop (PLL), the instantaneous active and reactive current method (DQ), and the synchronous detection method (SD) are designed in Matlab Simulink. For this project, PQ theory is being applied.

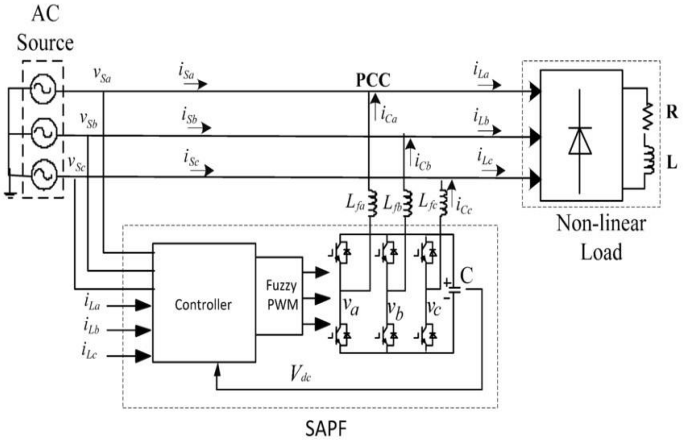


Figure 1.1: Block diagram of SAPF

P-Q Theory:

According to (PQ) theory, the reference current signal computation is based on detecting the three-phase currents and voltages to the power system and then using an algebraic transformation (Clarke Transformation) to convert them into (ϱ-β) coordinates and generates reference currents. DC voltage regulation done by PI controller.

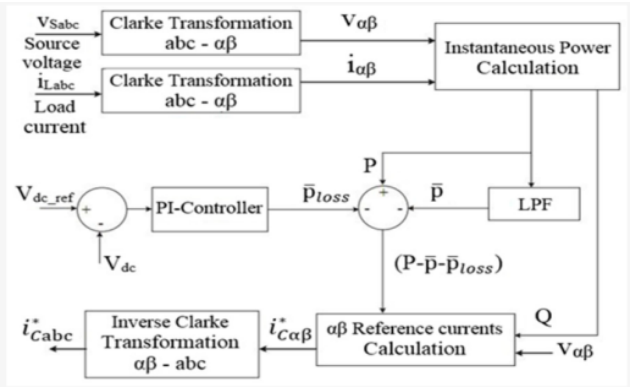


Figure 1.2: Block Diagram of PQ Theory

II. Proposed Controllers

The MATLAB simulative environment was used for the implementation of the proposed reference generation and current control techniques for a SAPF. This study was implemented according to the following scenarios.

- ANN based SAPF
- FUZZY tuned PI based SAPF
- ANFIS based SAPF

ANN Based SAPF:

Shunt active power filter performance is based on how well harmonic components are removed from distorted current waveforms with respect to accuracy and precision. The optimal performance for removing harmonic components from the voltage or current waveform has led to the development of the shunt active power filter control algorithm. In order to control voltage, a conventional PI controller is typically used.

However, because of its limitations, such as the time-consuming and difficult process of detecting PI parameters, as well as other drawbacks like the inability to improve the system's transient response, an artificial neural network (ANN) controller has been introduced in this research work. This is because of the controller's high speed of recognition, learning ability, and adaptability to any system. A mathematical model that draws inspiration from biological neural networks is called an artificial neural network (ANN).

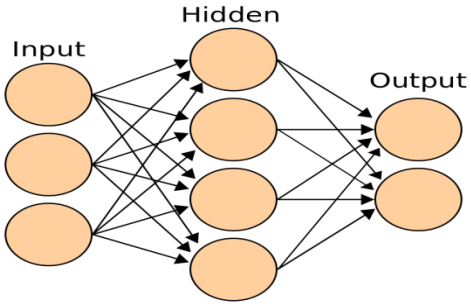


Figure 2.1: Structure of ANN

An artificial neural network is made up of a network of connected artificial neurons that compute information using the connectionist technique. It is similar to the brain in two ways: one is the learning process is how the network gathers the data, two is The data is stored using interneuron connection strengths. The MATLAB workspace has the vast amount of DC-link voltage data for the "n" and "n-1" intervals obtained via the traditional method. After that, the ANN Controller is trained using this data that has been retrieved. To process the information, the number of neurons in the input and output layers is essentially fixed. In order to reduce the likelihood of errors occurring, six validation checks and seven hidden layers with 1000 iterations are performed at each training session. The necessary conditions for the intended compensation in the case of SAPF are the quick identification of the disruptive signals with high accuracy and the quick processing of the reference signals.

Fuzzy Tuned PI Controller Based SAPF:

Fuzzy logic is a control approach used in control system engineering for issue solving. In 1965, Zadeh created the idea of fuzzy logic. Mamdani and Pappis produced the first fuzzy controller in 1977, which was a steam engine controller. Later, they developed fuzzy traffic lights [8]. Three regions typically make up the FLC design depicted in Figure 3: allocating the fuzzy area to a linguistic value, developing a fuzzy inference system (rules), and defuzzify into a real value.

Control System Design:

The process of creating a controller for a complicated physical system comprises the subsequent stages: Dividing the large-scale system into a number of different smaller systems, Linearizing is the nonlinear plane dynamics about a set of operational locations by gradually varying the plant dynamics, Assembling a collection of output characteristics, control variables, or state variables for the system under study, Creating basic P, PD, and PID controller designs for the subsystems. Additionally, optimal controllers can be created.

Fuzzification:

The FLC's first component is the fuzzifier that transforms crisp inputs into a set of membership values in the interval [0,1] in the corresponding fuzzy sets. The membership function shapes are typically triangular, trapezoidal, and Gaussian. In these membership functions, Gaussian MF's is good robustness than other membership functions. Gaussian membership function inputs are error (e) and its change in error (Δe) with fuzzy labels NB (negative big), NS (negative small), ZO (zero), PS (positive small) and PB (positive big). The membership functions' corresponding outputs are propagation gain (KP) and integration gain (KI) for respective input labels.

Rule Elevator:

FLC uses linguistic variables instead of numerical values. The basic FLC operation uses the following fuzzy set rules to control the system.

$$\text{AND–Intersection} \quad \mu A \cap B = \min[\mu A(X), \mu B(X)]$$
$$\text{OR–Union} \quad \mu A \cup B = \max[\mu A(X), \mu B(X)]$$

Defuzzification:

FLC rules produce the necessary output in a linguistic variable (Fuzzy Number) based on real-world requirements. It is necessary to convert linguistic variables into clear output (Real number).

(x, mf, type) = defuzz(x)

The argument states that defuzz (x, mf, type) employs multiple defuzzification algorithms to deliver a defuzzified
result from a membership function (MF) positioned at the associated variable value x. The following are possible choices for the variable type:

- Principle of maximum membership
- Weighted average approach
- Centroid Approach

Fuzzy-PI:

The non-linear plant with unpredictable parameter variations requires automatic tuning of the settings of the standard PI controllers. A formal approach for applying human heuristic knowledge gleaned from any system experience is the fuzzy system. To achieve excellent system performance and lessen the impact of parameter fluctuations, a self tuning fuzzy PI controller can be created. Figure displays the block diagram for the suggested self-tuning fuzzy PI controller for the SAPF.

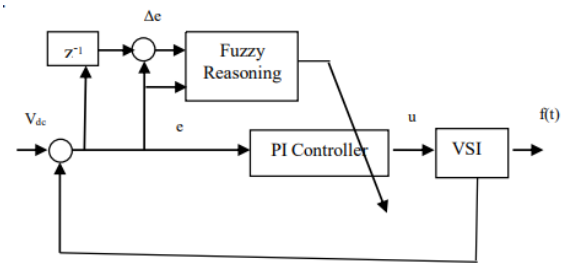


Figure 2.2: Fuzzy tuned PI controller.

ANFIS BASED SAPF:

The Adaptive Neuro-Fuzzy Inference System (ANFIS) combines artificial neural networks with fuzzy logic, two popular soft computing techniques. The fuzzy logic system has numerous inputs and a single output, whereas the neural system has many inputs and multiple outputs. This combination is known as ANFIS, and it is utilised in nonlinear applications. It endows non-linear systems with accuracy. Because of this, ANFIS is the most extensively used controller and is superior to other controllers. ANFIS has the capacity to learn from data and forecast outcomes using that data. The weights of the connections between the neurons in the network can be changed by the learning algorithm. An artificial neural network that is based on the Takagi-Sugeno fuzzy inference system is called an adaptive network-based fuzzy inference system (ANFIS).The early 1990s saw the development of the method. It can combine the advantages of neural networks and fuzzy logic in one framework because it incorporates both of these concepts. Two components of the network structure can be distinguished, namely the premise and the portions that follow. To be more specific, there are five levels that make up the architecture. The initial layer decides which membership functions correspond to the input values. It's often referred to as the fuzzification layer.

Structure Of ANFIS:

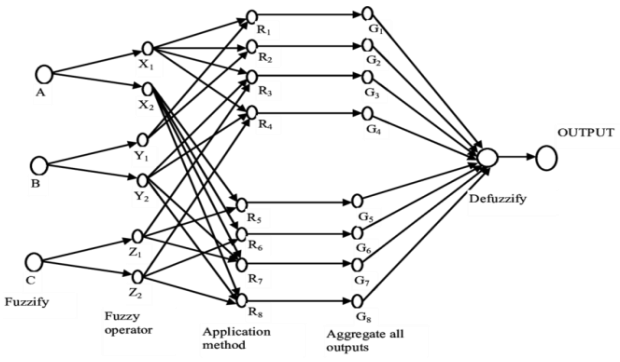


Figure 2.3: Structure of ANFIS

The node functions in each layer are as described below.
Fuzzification Layer: In this layer, membership functions are used to transfer the input variables to fuzzy sets. The linguistic variables that reflect the system's imprecision and uncertainty are represented by the fuzzy sets**.**
Rule Layer: Fuzzy if-then rules are applied to the input variables by the rule layer. A collection of fuzzy if-then statements that are developed based on expert knowledge or taken from data are used to express the rules.
Normalization Layer: To guarantee that the total firing strength is equal to one, the firing strength of each rule is normalized in this layer**.**
Defuzzification Layer: The output of every rule is combined by the defuzzification layer to produce a clear output value. Depending on the application, several defuzzification techniques may be employed, including weighted average, maximal defuzzification, and centre of gravity.
Learning Layer: The ANFIS controller adjusts to system changes in the learning layer. A neural network that has been trained to understand fuzzy rules and membership functions makes up the learning layer. A hybrid learning approach that combines least squares and back propagation techniques is used to train the neural network. When the ANFIS controller is operating, it receives input values and uses the fuzzy rules to produce an output value. In order to modify the input values, the output value is then given back into the system as feedback. By using the learning layer to update the membership functions and fuzzy rules, the ANFIS controller can adjust to changes in the system. All things considered, the ANFIS controller makes use of neural networks to learn from and adjust to system
changes, as well as fuzzy logic to capture the uncertainty and imprecision of the system. The ANFIS controller is an effective tool for managing complex systems with nonlinear or unpredictable dynamics because of its hybrid approach.

III. Result And Discussion

The MATLAB simulative environment was used for the implementation of the following scenarios.

- Without SAPF
- SAPF with conventional PI controller
- ANN
- FUZZY tuned PI
- ANFIS based SAPF

Without SAPF: In this case, SAPF is disabled as shown in figure 3.1 and a Fast Fourier Transform (FFT) analysis is used to determine the distortion in source current caused on by the nonlinear load.

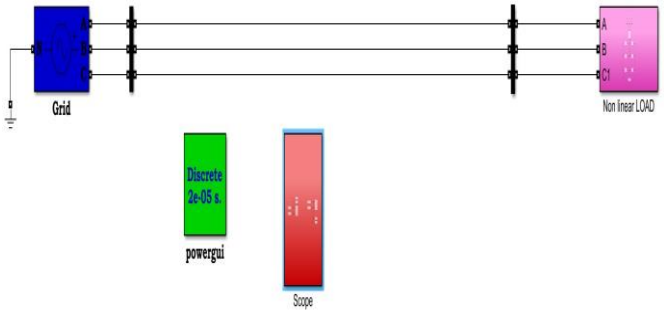


Figure 3.1: Simulink model for without SAPF

Due to the nonlinear loads connected at distribution network lead to distortion in the grid current waveform. After analyzing the FFT spectrum it gives the THD 22.24% as shown in figure 3.2 and figure 3.3.

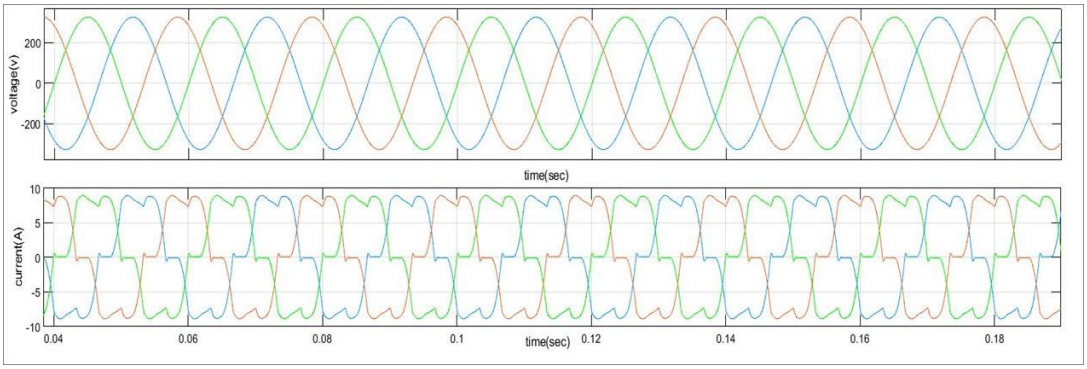


Figure 3.2: Waveforms of Voltage and Current for the system without SAPF

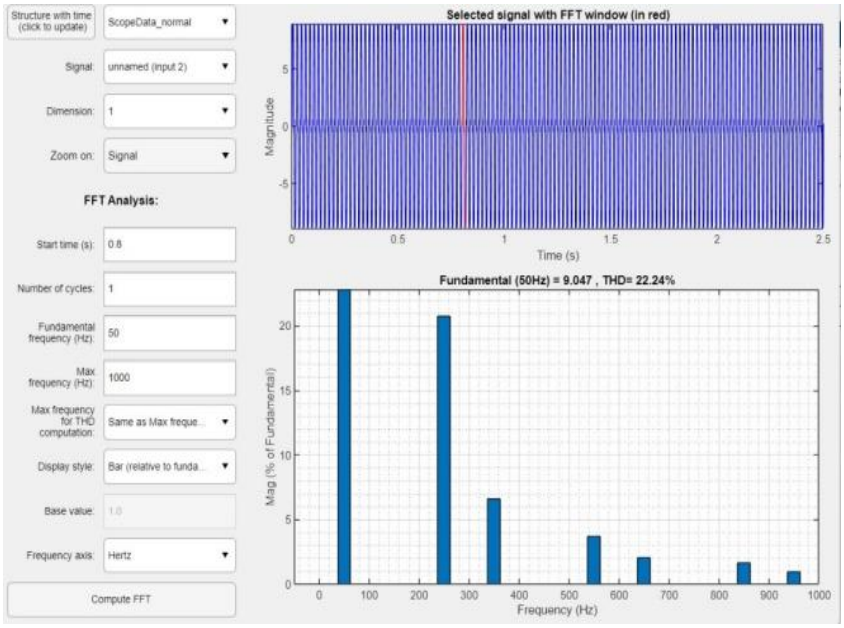


Figure 3.3: THD for without SAPF

SAPF With Conventional PI: In this case Conventional PI controller is connected to SAPF shown in figure 3.4. Fast Fourier Transform (FFT) analysis is performed to know the distortion in source current.

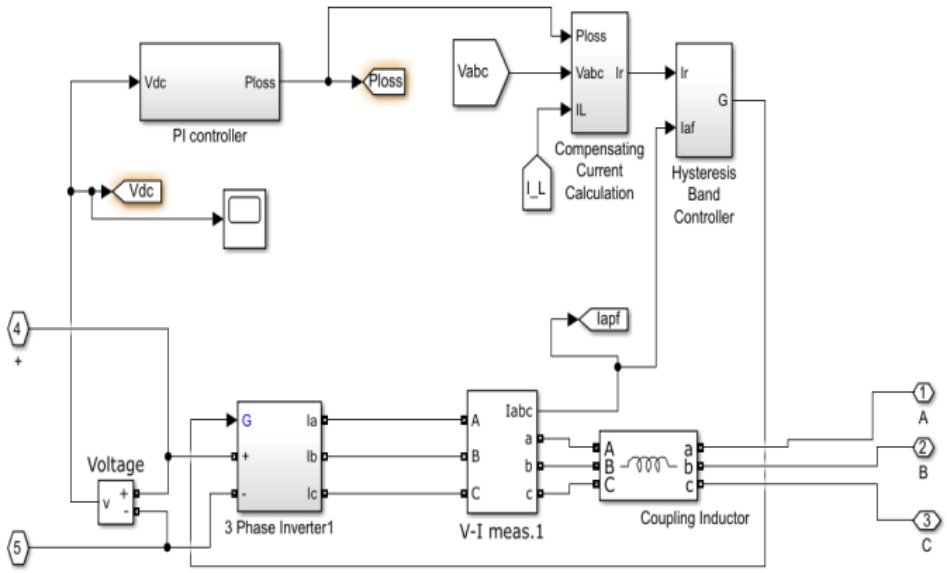


Figure 3.4: Simulink model for SAPF with conventional PI controller.

By using SAPF with PI Controller in Power system network reduces the distortion in the grid current waveform, which makes the current waveform sinusoidal. THD reduces to 1.83% as shown in figure 3.5 and 3.6.

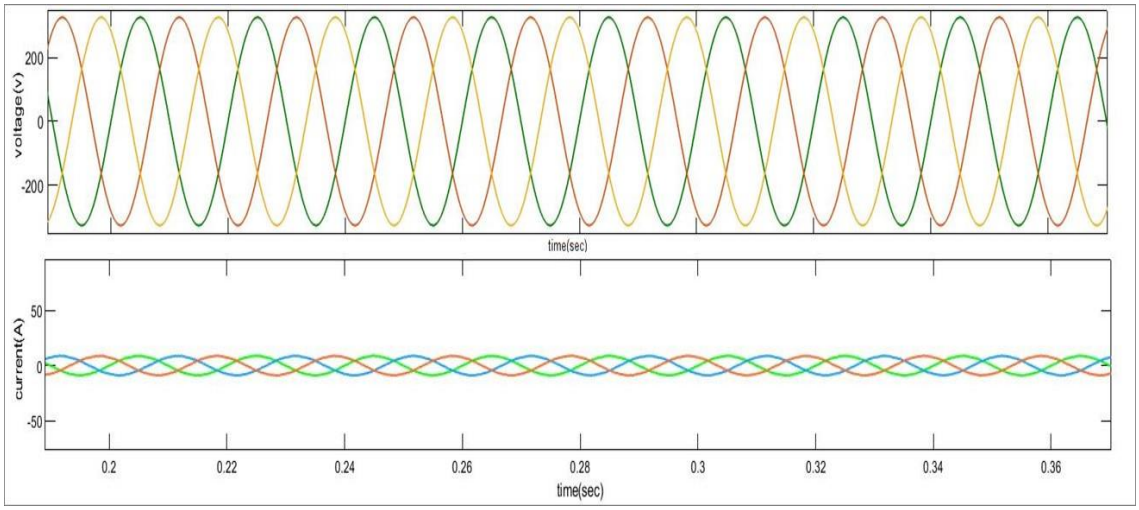


Figure 3.5: Waveforms of Voltage and Current of system with SAPF

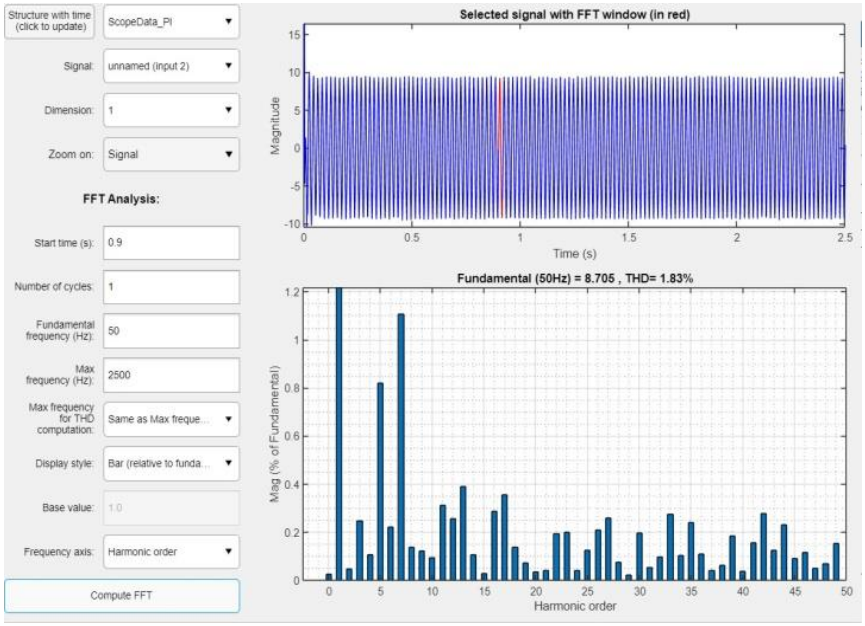


Figure 3.6: THD for Conventional PI Controller based SAPF

ANN Based SAPF: In this case ANN is connected to SAPF shown in figure 3.7. Fast Fourier Transform (FFT) analysis is performed to know the distortion in source current.

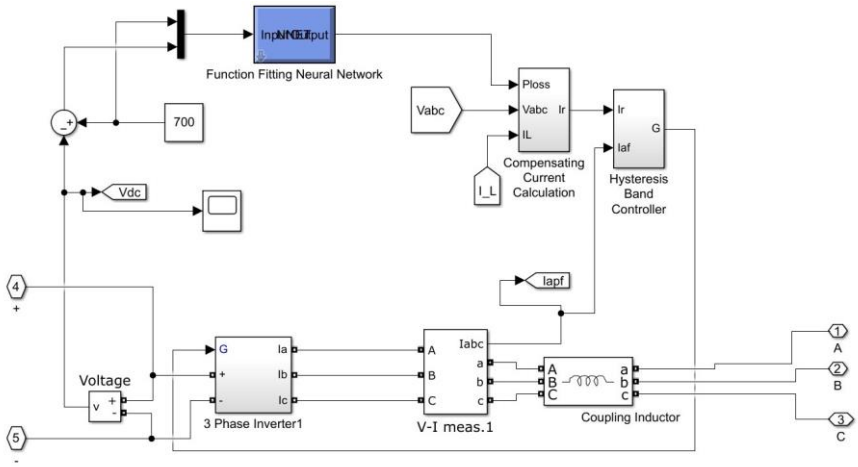


Figure 3.7: Simulink model for ANN based SAPF

The total harmonic distortion (THD) by using Artificial Neural Network based Shunt active power filter is 1.77% as shown in figure 3.8 and figure 3.9. We observed that the total harmonic distortion by ANN is reduced when compared with conventional PI controller based SAPF.

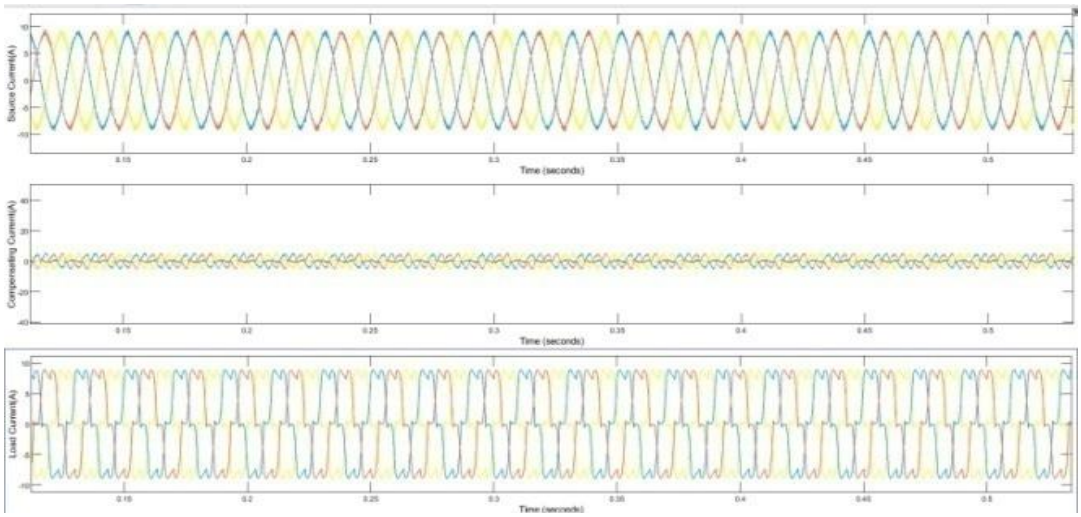


Figure 3.8: Voltage and Current waveforms of network with ANN based SAPF

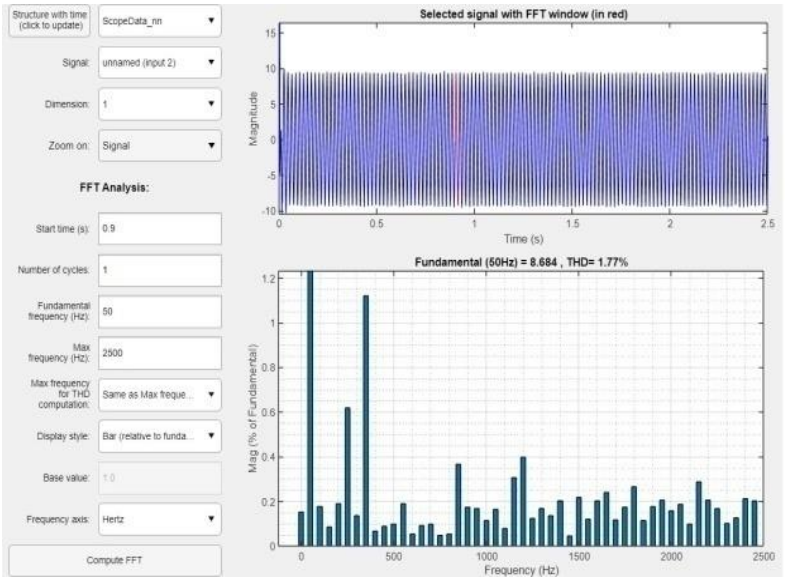


Figure 3.9: THD for ANN based SAPF

Fuzzy Tuned PI Controller: In this case Fuzzy tuned PI controller is connected to SAPF shown in figure 3.10. Fast Fourier Transform (FFT) analysis is performed to know the distortion in source current.

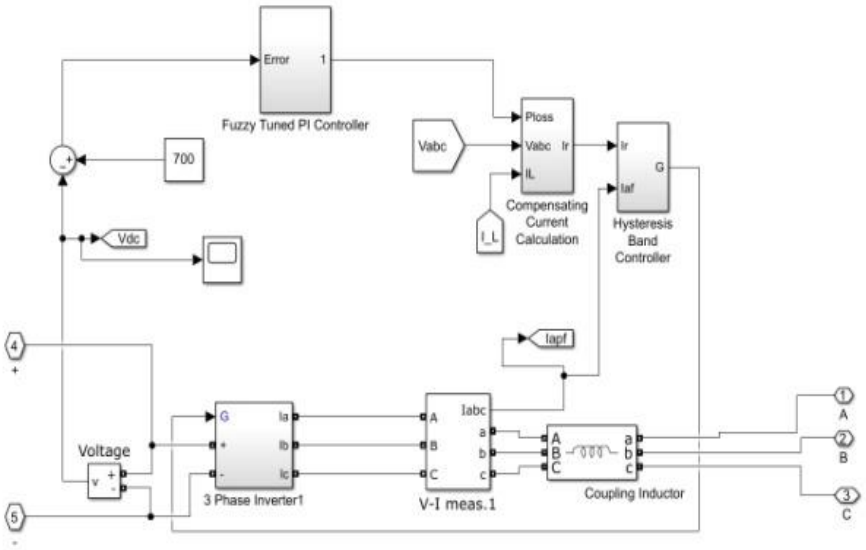


Figure 3.10: Simulink model for Fuzzy tuned PI controller based SAPF

The total harmonic distortion (THD) by using Fuzzy tuned PI based SAPF is 1.62%. We can observed that the total harmonic distortion by fuzzy tuned PI is reduced when compared with ANN based SAPF shown in figure 3.11 and figure 3.12.

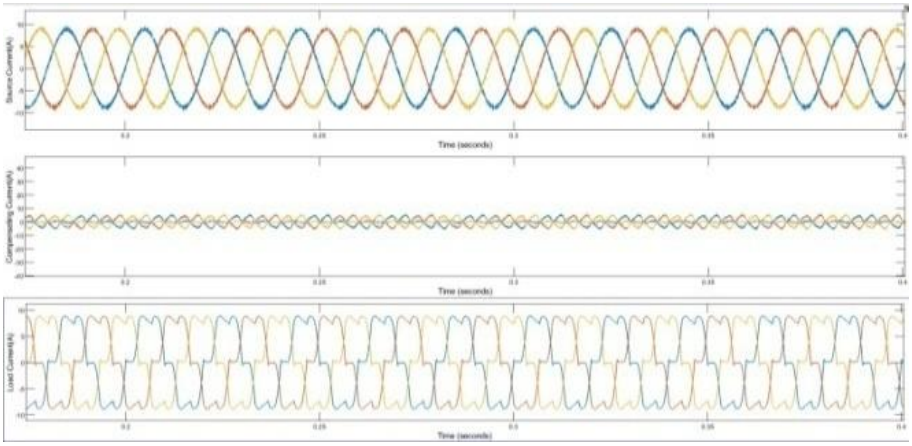


Figure 3.11: Voltage and Current waveforms of network with Fuzzy tuned PI based SAPF

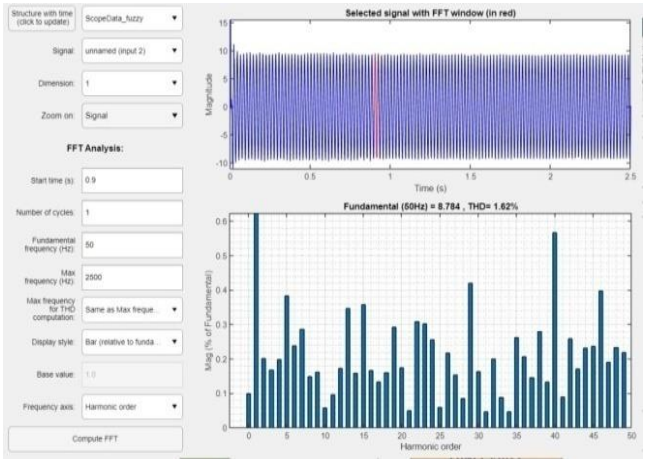


Figure 3.12: THD for Fuzzy tuned PI controller based SAPF

ANFIS based SAPF:

In this case ANFIS (Adaptive Neuro Fuzzy Inference System) is connected to SAPF shown in figure 3.13. Fast Fourier Transform (FFT) analysis is performed to know the distortion in source current. ANFIS controls the DC link voltage and reduces the harmonics in source current. Hence, ANFIS based SAPF able to restore the distorted source current to its original sinusoidal waveform. ANFIS consists of set of fuzzy rules and neural network and trained by fuzzy rule base. The fuzzy rule base defines the mapping between input variables and output variables and these are represented by fuzzy sets and linguistic variables.

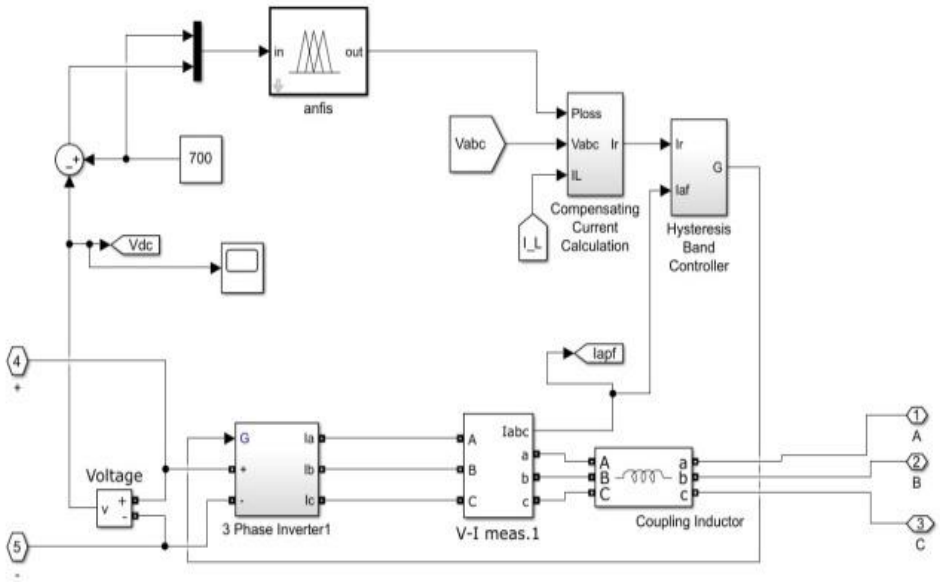


Figure 3.13: Simulink model for ANFIS based SAPF

The total harmonic distortion (THD) by using ANFIS based SAPF is 1.57%. We can observed that the total harmonic distortion by ANFIS based SAPF is reduced when compared with Fuzzy tuned PI based SAPF shown in figure 3.14 and 3.15.

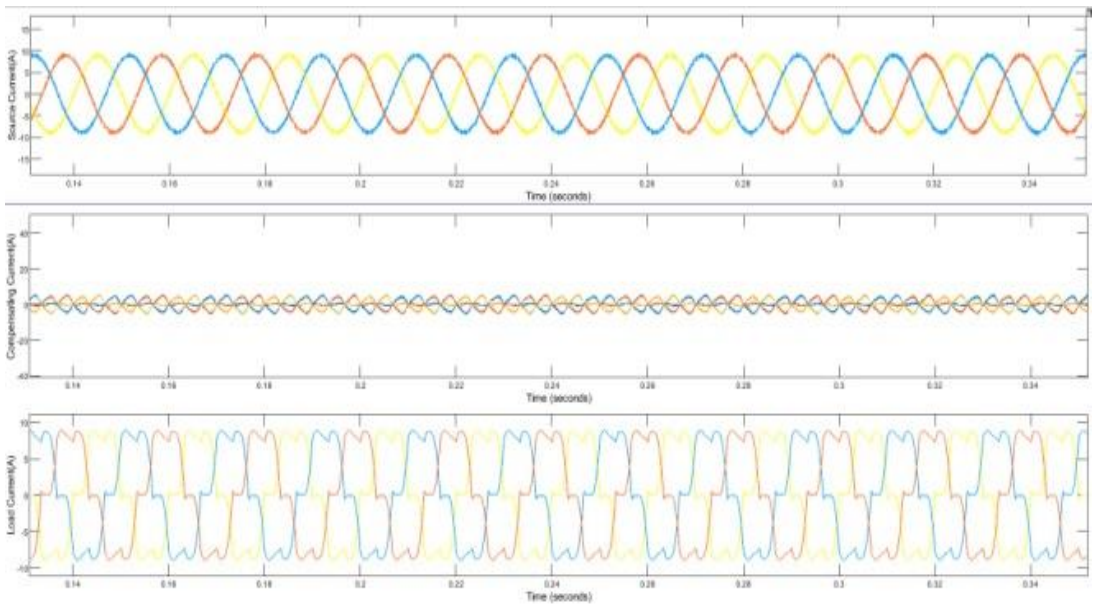


Figure 3.14: Voltage and Current waveforms of network with ANFIS based SAPF

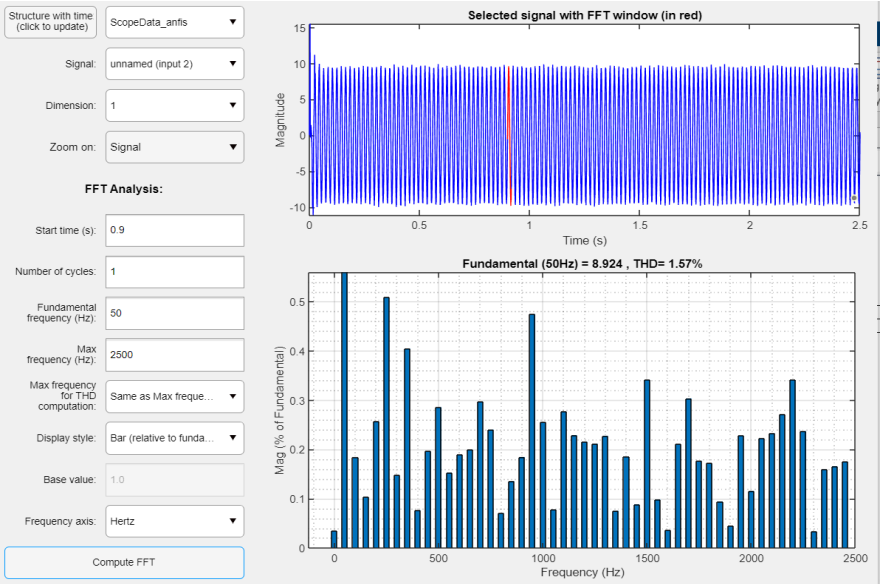


Figure 3.15: THD for ANFIS based SAPF.

Table no 1: Comparison of THD

CONTROLLER	THD%
Without SAPF	22.24%
Conventional PI CONTROLLER based SAPF	1.83%
ANN based SAPF	1.77%
FUZZY tuned PI CONTROLLER based SAPF	1.62%
ANFIS based SAPF	1.57%

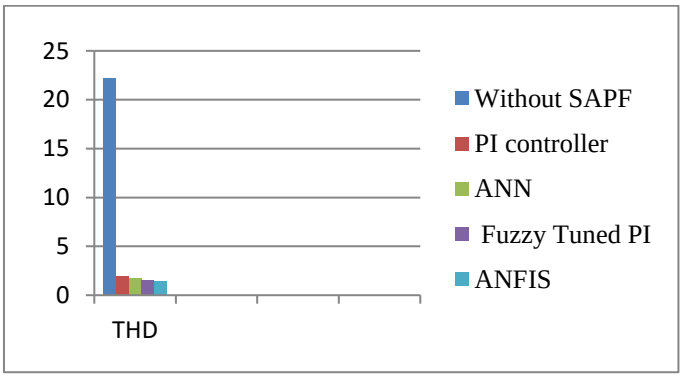


Figure 3.16: THD Comparison

IV. Conclusion

Reactive power and harmonics are only two instances of the growing intricacy of power quality problems. Artificial intelligence-developed solutions used by active filters are very good at reducing harmonics and balancing reactive power. We suggest using the ANFIS based SAPF control approach as a substitute to the SAPF within the context of this paper. The efficacy of the SAPF is evaluated and contrasted in a range of contexts. Five distinct scenarios are simulated using Matlab-Simulink, which then displays the results. Simulation results show that in terms of lowering THD in the source current, the suggested ANFIS based SAPF performs better than alternative scenarios. The distribution system WITHOUT SAPF, CONVENTIONAL PI, ANN, FUZZY TUNED PI, ANFIS Controllers are developed and verified for three phase three wire system. In this work it has been observed without any control circuitry the THD is very high around 22.24% . With PI Controller based SAPF, it is reduced to 1,83% and with ANN Controller it is reduced to 1.77% ,with FUZZY

TUNED PI based SAPF it is reduced to 1.62% and with ANFIS based SAPF further THD reduced to 1.57%. The performance of these all controllers has been studied and compared in MATLAB. It has been seen that, ANFIS based SAPF controller is more efficient to reduce THD than WITHOUT SAPF,CONVENTIONAL PI, ANN, FUZZY TUNED PI Controllers.

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Sri Venkateswara University, Tirupati

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Director/Coordinator (MM-TTC)

PSO Trained Feed Forward Neural Network Based SAPF for Power Quality Enhancement in Distribution Networks

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***Abstract*—Power distribution infrastructure is being harmed by the advent of nonlinear devices, which cause harmonics to enter into the power system networks and distort the voltage and current signals. Shunt Active Power Filter (SAPF) is a new power electronics-based technology that can reduce harmonics and improve the power quality in distribution networks. This research provides an efficient and inexpensive strategy to minimizing harmonics and improving the power quality in power distribution networks by employing Shunt Active Power Filter's (SAPF), which uses the Particle Swarm Optimized Artificial Neural Network Controller (PSO-ANN). The goal of the PSO-ANN algorithms have been developed for SAPF is to improve system performance by lowering the amount of Total Harmonic Distortion (THD). In this work, the standard PI controller is initially tuned using the PSO algorithm to obtain the optimal gain values (K_i, K_p) for the PI controller. After that, these values of the PSO-PI controller's input and output will serve as a dataset for the ANN controller. Now, the PSO algorithm is being used to tune this ANN controller in order to acquire the optimal values for the weight and bias. Using the MATLAB/SIMULINK tool, the proposed algorithm's performance is evaluated and compared to that of a PSO-PI based SAPF and the conventional PI based SAPF. The results of the simulation demonstrate that a SAPF which is based on a PSO-ANN controller is capable of achieving superior THD in the drawing source current while maintaining minimum levels and which are acceptable in accordance with the IEEE-519 standard for harmonics.**

***Index Terms*—ANN-controller tuning, particle swarm optimization algorithm, PI-controller tuning, power quality, shunt active power filter, total harmonic distortion**

I. Introduction

Harmful harmonic currents are produced at the Point of Common Coupling (PCC) due to the usage power electronics devices and non-linear load in huge quantities [1]. Because of the many issues that can arise from distribution system current harmonics, loss, instability, noises, heating appliances, etc. It would be preferable to reduce their risk and bring them down to an acceptable level, as specified by the IEEE-519 standards for Total Harmonic Distortion (THD) [2].

To reduce current harmonics, compensate for reactive power, and improve power factor, a Shunt Active Power Filter (SAPF) could be the solution. Fig. 1 (next page) depicts the SAPF setup, this consists of the active filter controller as well as the Voltage Source Inverter (VSI). In order to achieve the desired result of injecting a controlled compensating current into the power system, the VSI requires instantaneous adequate firing signals from the control unit [3, 4]. The reactive power control to the grid is supplied by the DC-link capacitor employed on the front side of the VSI [5]. In order to connect the DC component to the three-phase power distribution system, a VSI is necessary. To reduce the amount of distortion in the source current, VSI injects a compensating current in response to the firing signals [6].

To analyze the VSI switching operation, either reference generating methods or control techniques are used. The SAPF control techniques are able to be implemented in two steps, which are as follows: first, by using reference current generation theories to extract compensating signals from distorted signals, and then, by using signal estimated reference methods to produce appropriate firing signals for the purpose of controlling the SAPF switching devices [7]. Several writers have compared SAPF control techniques ([8, 9]).

The PI-controller, which is an integral aspect of reference current theory, is responsible for minimizing the impact of harmonics. K_i and K_p gain settings of the PI-controller need to be properly tuned in order to obtain the best possible results. The traditional approach for tuning the gains of the PI-controller utilizes linear modeling, which ultimately results in a less-than-optimal setting for the gains [10, 11]. Consequently, PI-controller tuning makes use of a variety of different metaheuristic optimization strategies. There are a variety of control methods that can lower current harmonics and introduce the converter to brand new opportunities [12]. Consider, for example, the Particle Swarm Optimization (PSO) [13−17] method and Genetic algorithm (GA) [18].

Artificial Neural Network (ANN) is a network that is set up and works in a way that is similar to how the human brain works. To simply stated, the brain is a network of cells called neurons. The behavior of the

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whole network depends on how strong the connections between interneuron's are and how they are set up. During the training of the network, the weights are changed and tweaked [19]. At the moment, Artificial Neural Network (ANN) techniques are only used on SAPF for producing reference compensation current, which is used to control the compensation that SAPF gives [20, 21]. Learning weights can be accomplished in a variety of techniques [22]. Some examples include the Widrow-Hoff (W-H) approach, the Steepest Descent method of variable learning, the Levenberg-Marquardt method, and others.

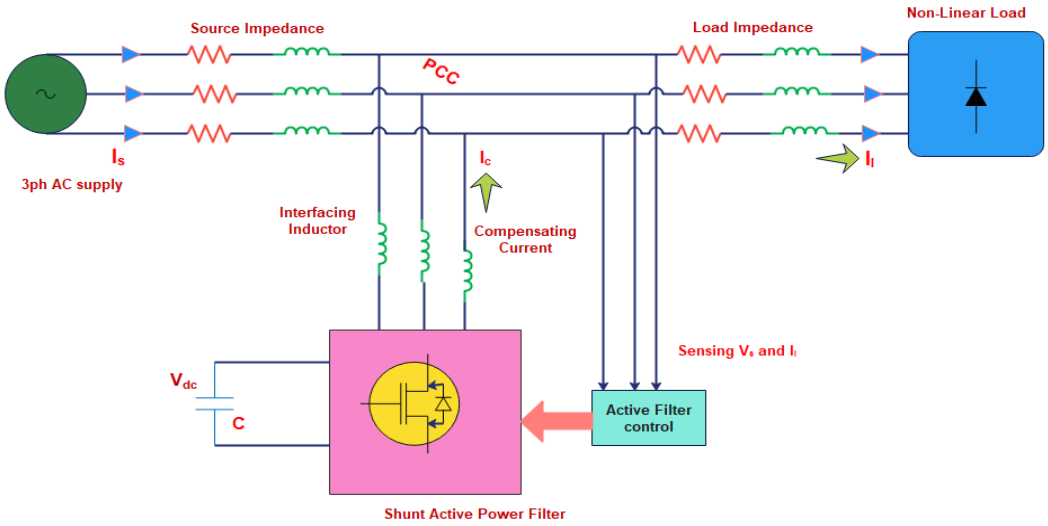


Fig. 1. Basic elements of the shunt active power filter.

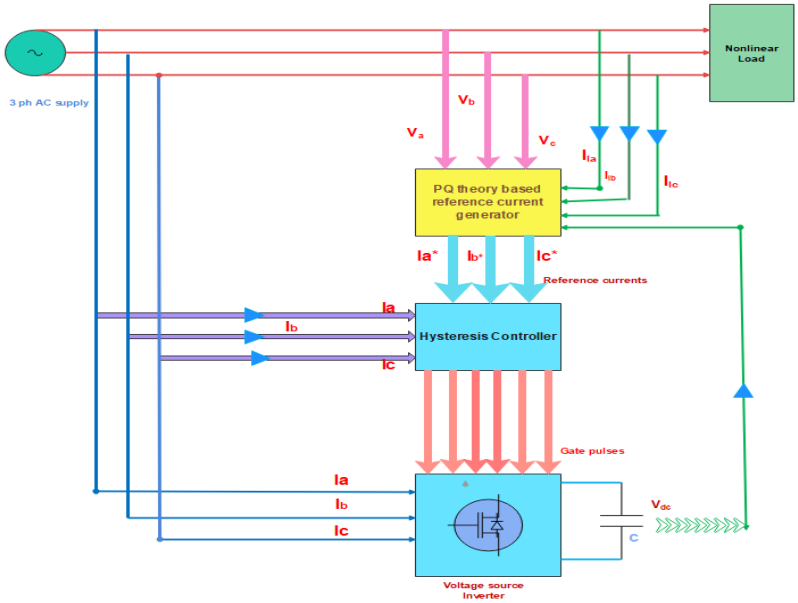


Fig. 2. SAPF controller configuration.

This work uses the concepts of instantaneous active and reactive power to derive the reference current (PQ-theory). Hysteresis current controller technique, as shown in Fig. 2 [23], estimates reference currents to provide necessary gating pulses. For optimum performance of a PQ-theory based ANN-controller for a dc-link voltage requires fine-tuning of weight and bias values. For the optimum ANN-controller weight and bias particle swarm optimization algorithm is implemented in order to identify its optimal state.

II. PQ Theory

In the case of three-phase, three-wire systems that have sinusoidal and balanced source voltages, a PQ-theory-based constant instantaneous power control approach has been developed. The instantaneous power is calculated by sensing the source voltage (V_a, V_b, V_c) and load current (I_{la}, I_{lb}, I_{lc}) and transforming them using Clarke transformation into (α, β) components. Error signal is derived from reference and measured dc-link voltages, then introduced to PI or ANN controller to obtain power losses component of dc-link voltage (P_{loss}). As illustrated in Fig. 3 (next page) [24], the reference current signals are obtained by inverting the components (α, β) with the real and reactive power by use of the inverse Clarke transformation (α, β to three phase values (V_a, V_b, V_c, I_{la}, I_{lb}, I_{lc}).

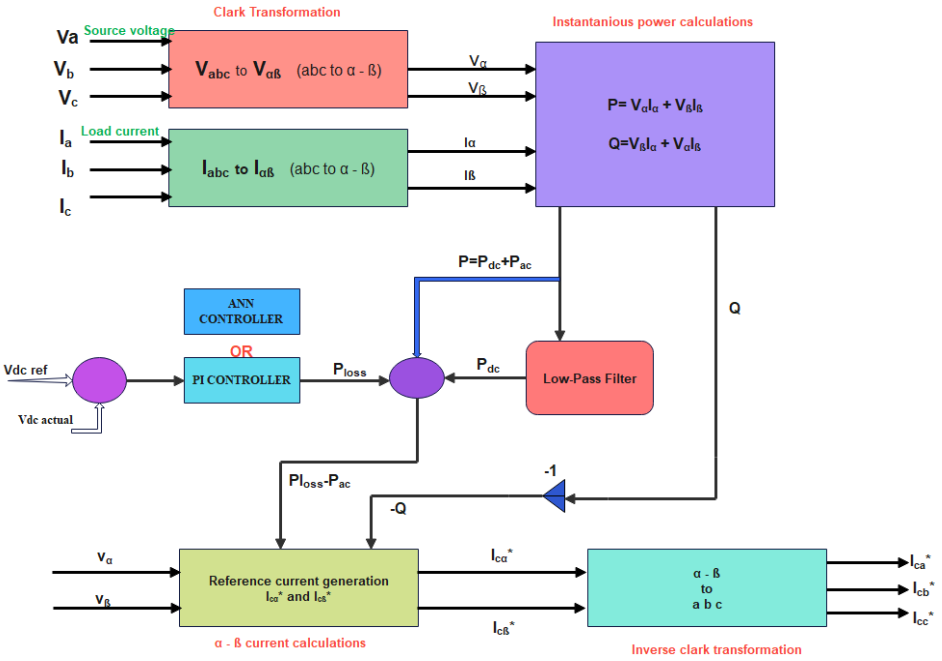


Fig. 3. Work flow of PQ theory based reference current generation.

III. Artificial Neural Network (ANN)

The human brain's structure is built on neural networks, hence the terminology "Artificial Neural Network" is adopted from the neuroscience area. Multiple layers of interactions are present between neurons in artificial neural networks, just like the neurons in the human brain are connected to each other. These nerve cells are called nodes as shown in Fig. 4. A nominal neuron is a processing element that, in general, possesses one or more outputs and n inputs (x_1, x_2,⋯, x_n) which are the independent inputs or outcomes of the different neurons. Fig. 5 provides a visual representation of these inputs and outputs. The neuron begins by computing the sum of its inputs, and then it transfers this value through its activation function in order to form its output, which is indicated by the value Y_i [25].

$$Y_i = f_i\left(\sum_{j=1}^{n} w_{i,j}x_j + b_i\right) \quad (1)$$

where $w_{i,j}$ are the weight of the connection between the input neuron and the output neuron, b_i is the bias of the neuron, x_j represents the neuronal input, and f is activation function that controls the characteristics of the neural network.

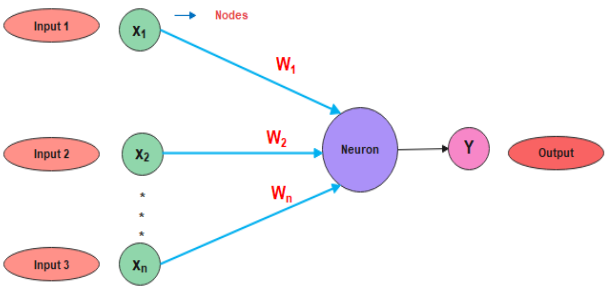


Fig. 4. Basic structure of artificial neural network.

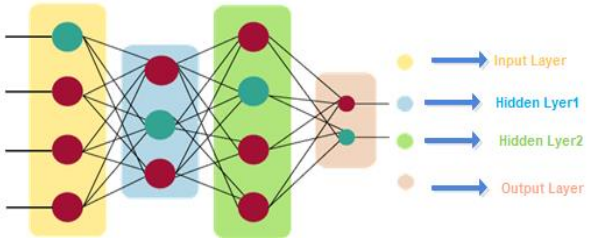


Fig. 5. Architecture of the artificial neural network.

Neural networks adjust to input data by changing connection weights (including biases) and sometimes layer number and neurons number.

IV. Introduction to PSO

The comprehensive implementation of PSO algorithm starts with the movement of a group of possible random solutions, which are represented in the form of moving particles in inside target region. This movement is done in order to find the optimal solution. Every one of the nearby particles that are being assumed has some a speed as well as a selective memory, which enables each other to recall the position and value that corresponds to their optimal level of performance. This is being done by taking into account all of the information that is currently being taken into account. A predetermined objective function that is tied to the problem that needs to be resolved [26] is used to evaluate the efficacy of each individual particle. The velocity of each particle at iteration is determined by linearly combining the velocity and position at iteration, as well as the intervals that separate the existing position of the particle from its preceding best position and finest position, respectively. This information is then used to calculate the velocity of each particle. This leads to the development of a formula for determining the velocity of the particle at the next iteration, which is denoted by t+1. The motion of the

particles is formalized for us by Eqs. (2) and (3), which provide us a representation of the movement of the particles.

$$v_i(t) = wv(t-1) + \left[P_{\text{best}}(t-1) - x_i(t-1)c_1r_1\right] + \left[G_{\text{best}} - x_i(t-1)\right]c_2r_2 \quad (2)$$

$$x_i(t) = x(t-1) + v_i(t) \quad (3)$$

where x_i is the ith particle position, v_i is the ith particle velocity, P_{best} is particle best position, G_{best} is target position, w is coefficient of inertia, c_1 and c_2 are coefficients of acceleration, and r_1 and r_2 are values at random between 0 and 1.

Iterate (2) and (3) until convergence is achieved [27].

V. Proposed Implementation

A. PSO Tuned PI Controller

The primary function of SAPF is dependent on DC link voltage regulation, which is controlled by standard PI controller. This controller requires a great deal of mathematical calculation, and it is possible that it will not produce optimal gain values for k_p and k_i. With the help of the PSO algorithm, we can determine the optimal values for k_p and k_i.

The actual dc voltage as compared to the reference dc voltage and the error that will be fed to the PSO-PI controller can be seen in the Fig. 6. The Integral Absolute Error (IAE) is the objective function that needs to be minimized with the help of the PSO algorithm in order to obtain the optimal gain values. The parameters for the PSO are specified in the Table I.

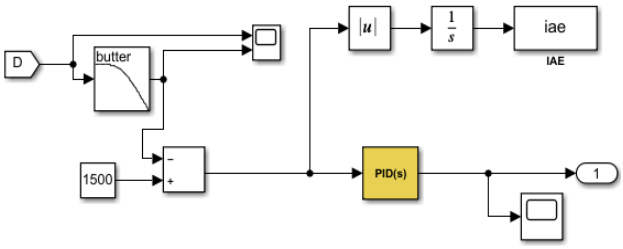


Fig. 6. DC voltage regulation of SAPF with PSO-PI controller.

TABLE I: PSO Parameters

Maximum iterations	1000
Total Population	50
Weight of Inertia	0.89
Constant of Acceleration (C_1)	2
Constant of Acceleration (C_2)	2
Total Variables	2
Higher Limit of K_i, K_p	200
Lower limit of K_i, K_p	0
Optimum value of K_p	5.65119
Optimum value of K_i	7.93019

B. PSO Tuned ANN Controller

The objective of ANN training is to arrive at the most accurate possible values for the network's weights and biases. The right values of the ANN's weights and biases are determined by the application of a variety of methodological approaches. The PSO method was utilized in this paper. According to the Fig. 7, the input (e) and output of the PSO-PI controller will serve as the dataset for the neural network feed forward controller.

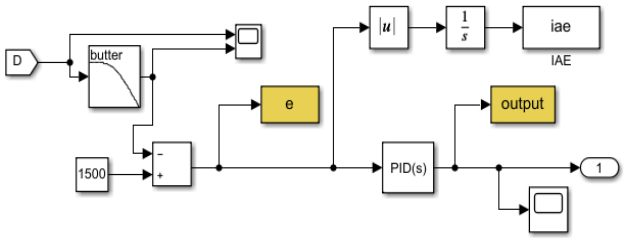


Fig. 7. The workspace representation of the PSO-PI controller's input (e) and output.

The Initialization of the neural network code shown in below says to get the input and target values from the PSO-PI controller, then initialize the hidden neurons are 10, configure the neural network based on the input and output, get the weights and bias of the configured neural network, create the objective function as root mean squire error, and use the PSO algorithm to fine-tune the weights and bias of the pre-trained neural network.

Initialize the neural network problem

- inputs = e';
- expects = output';
- hn = 10; (number of hidden neurons)
- Nn = feedforwardnet (hn);
- Nn = configure (Nn, inputs, expects);
- getwb(Nn) (Getting initial weight and biases)
- Based on weights and bias(y), Nn, inputs, and expects, calculate the objective function which is root mean square error denoted by (g).
- Train the neural network by applying the PSO algorithm .From that we can obtain the updated weights, bias (y), and error (e).
- Nn = setwb(Nn, y');
- getwb(Nn)
- e = expects - Nn (inputs);
- def = mean(e.^2)/mean(var(expects',1));
- gensim(Nn)

The algorithm's operation can be summed up using the steps as follows:

- Initialization at random of all of the local positions X_i (weights and biases).
- Evaluate the fitness function for each initialized particle, which is provided by (4), then establish the local locations $P_{i\text{-best}}$ and the global positions G_{best}.

$$f = \sum\sqrt{(\text{target} - \text{actual output})^2} \quad (4)$$

- Update all $P_{i\text{-best}}$ local positions
- Assess the current best in the area and the fitness function. If $(fP_{\text{best}}) < f(G_{\text{best}})$ then $G_{\text{best}} = P_{\text{best}}$.
- Using (2) and (3), modify the neural networks' weights and biases.
- The process should end if the stop condition holds true. If not, proceed to Step 2 to display the updated weights and biases.

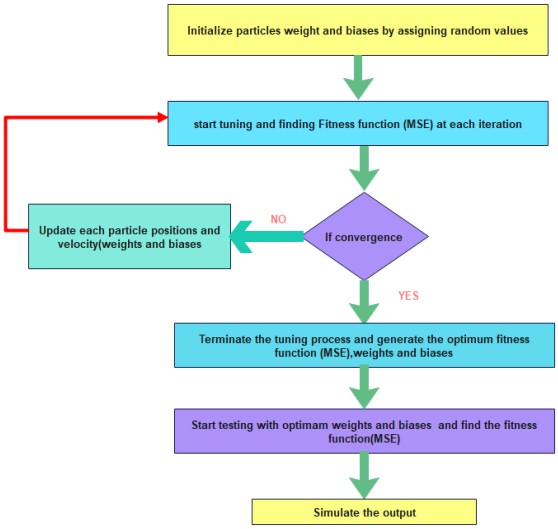


Fig. 8. Flow chart representation of PSO trained ANN controller.

Convergence is reached when the synaptic coefficients settle on a final value and the network's Mean square error (NMSE) drops below a specified threshold. Limiting the number of possible iterations is another way to interrupt the learning process. Fig. 8 depicts the training algorithm's flowchart.

Finally for a given input and an output, we will get the feed-forward neural network as shown in Fig. 9, which will be replaced by the PSO-PI controller.

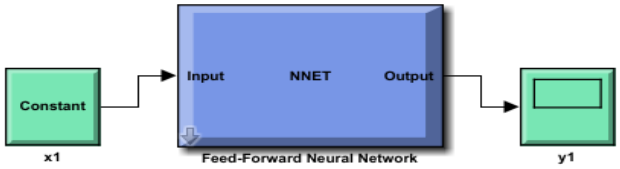


Fig. 9. Simulink block of PSO-ANN algorithm.

TABLE II: SIMULINK MODEL FRAMEWORK

Specification	Values
Source Voltage	415V
Source Frequency	50 Hz
Source Impedance	0.1 ohm, 15mH
Interfacing impedance	15mH
Load Real Power	4472 W
Load Reactive Power	1718 VAR
DC link Capacitance	100μF

VI. MODEL CONFIGURATION

The configuration of the suggested model is shown in Fig. 10, which consists of a three-phase power grid coupled to a three-phase un-controlled diode rectifier coupled to a non-linear load represented by an inductive load on the DC side. SAPF with a VSI design and a capacitor on the DC link are incorporated into the system at the PCC.

The simulation diagram of a PQ theory-based reference control method for SAPF is represented in the Fig. 11. Table II contains a listing of the suggested model's parameters.

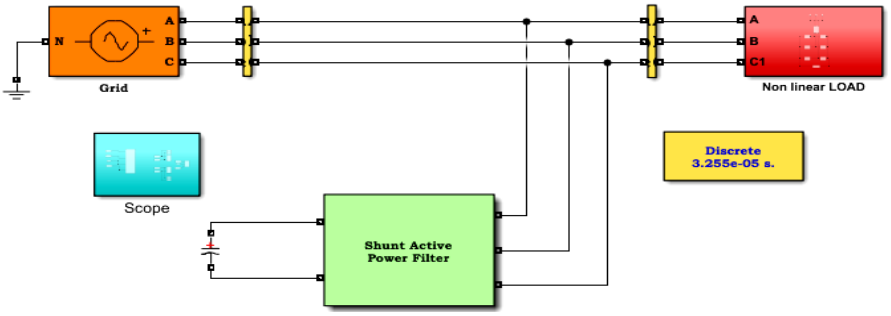


Fig. 10. Simulink model of Grid connected nonlinear load with SAPF.

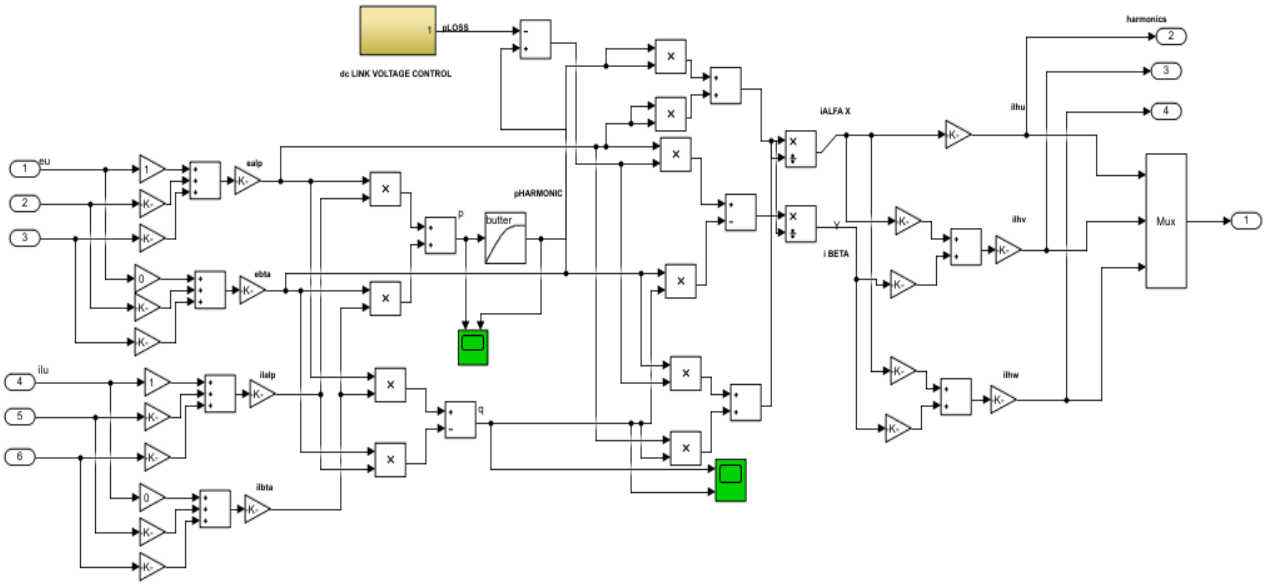


Fig. 11. Simulink model of PQ theory based SAPF.

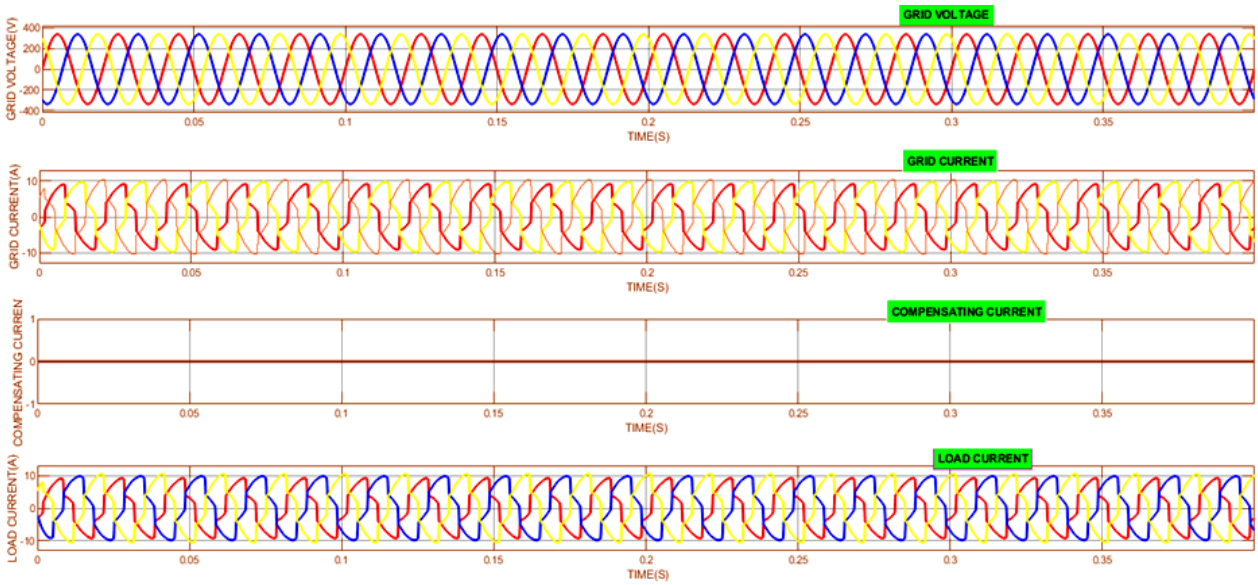


Fig. 12. The source voltage, source current, compensation current, and load current waveforms without SAPF.

VII. Simulation Results

The MATLAB simulative environment was used for the implementation of the proposed reference generation and current control techniques for a SAPF. This research was performed in accordance with the following scenarios.

- Without SAPF
- SAPF with conventional PI controller
- SAPF with PSO-PI controller
- SAPF with PSO-ANN controller

A. Without SAPF

In this scenario, SAPF is switched off, and a distortion in source current induced by a nonlinear load is evaluated using Fast Fourier Transform (FFT) analysis, which came out to be about 18.42%. Fig. 12 shows the source and load current waveforms from the three-phase simulation. Fig. 13 shows the source current FFT harmonic spectrum.

B. SAPF with Conventional PI Controller

In this scenario, SAPF is linked to the PCC, and the results of the simulation are obtained without any adjustment to the PI-controller gains. After SAPF connection, the supply current distortion is brought down to 3.76% of its original value as shown in Fig. 14.

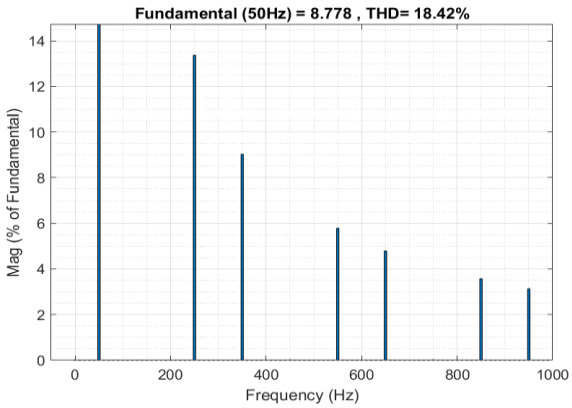


Fig. 13. Grid current THD value of distribution system without SAPF.

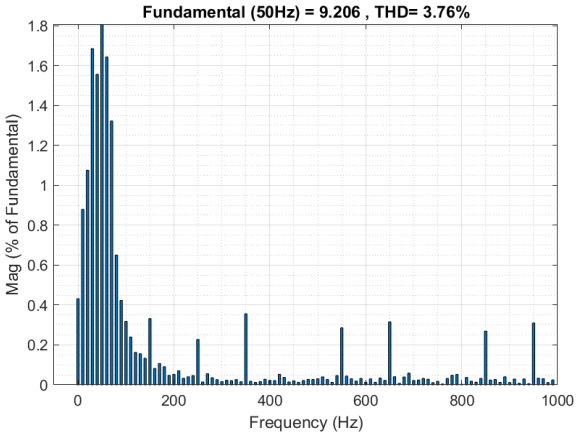


Fig. 14. Grid current THD value of distribution system with PI controller based SAPF.

C. SAPF with PSO-PI Controller

In this particular instance, the simulation was run using the SAPF compensation action, and the PSO Algorithm was utilized to modify the PI-controller gains. The findings that were collected suggest that the THD of the source current has been drastically reduced to 0.93%, as shown in Fig. 15.

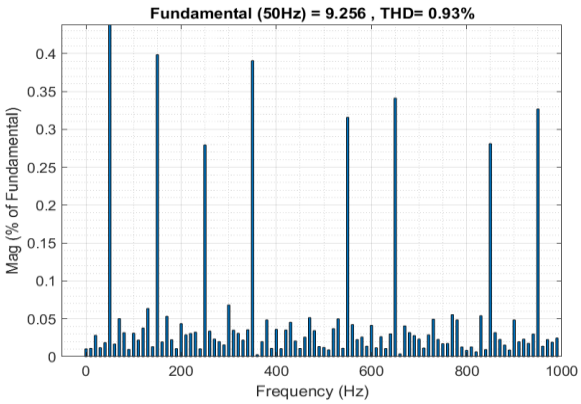


Fig. 15. Grid current THD value of distribution system with PSO-PI controller based SAPF.

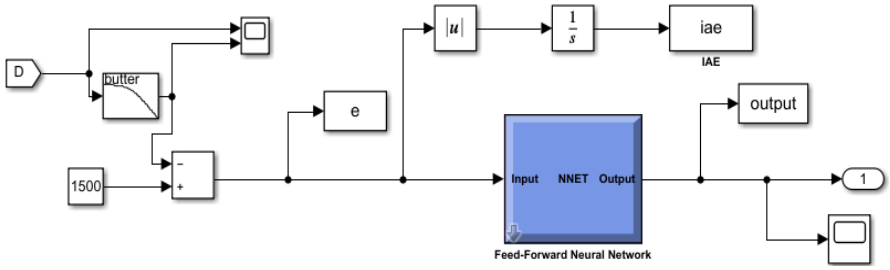


Fig. 16. DC voltage regulation of SAPF by using PSO-ANN controller.

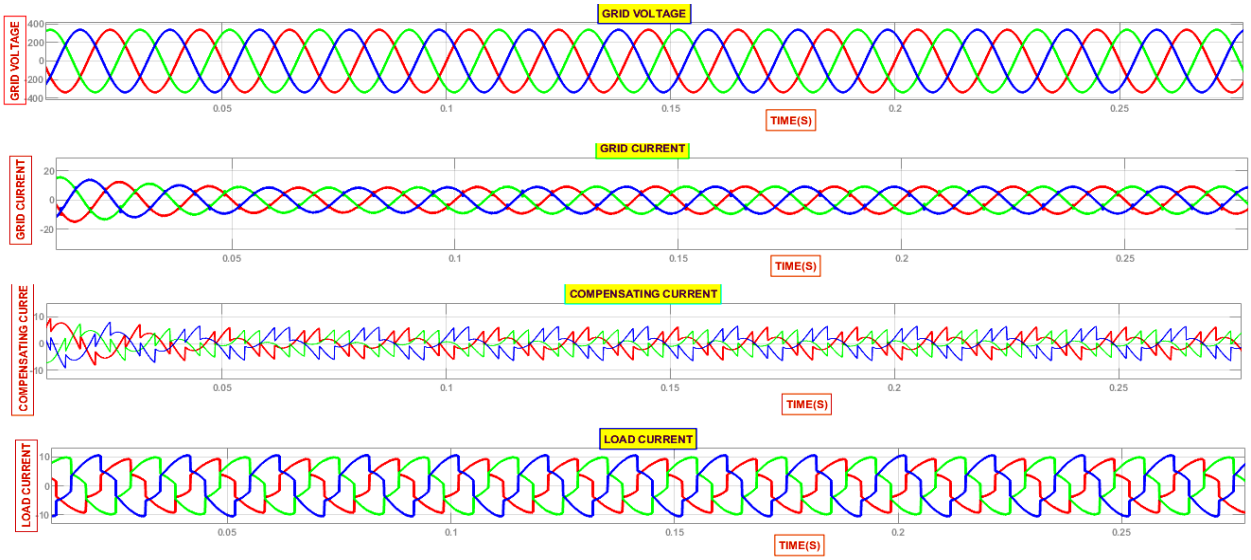


Fig. 17. The source voltage, source current, compensation current, and load current wave forms of PSO-ANN controller based SAPF.

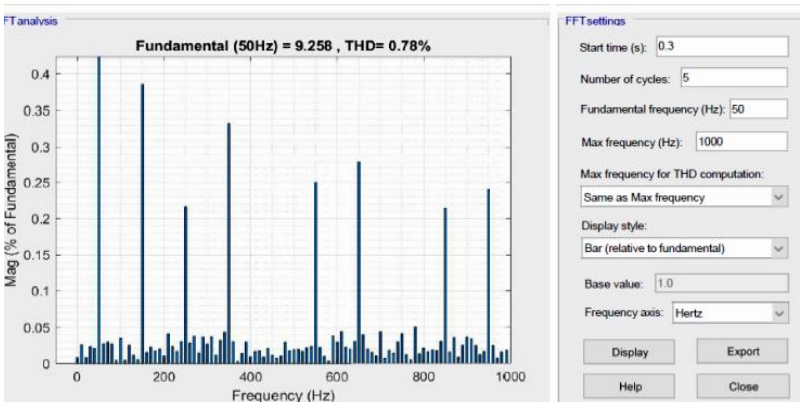


Fig. 18. Grid current THD of distribution system with PSO-ANN controller based SAPF.

D. SAPF with PSO-ANN Controller

In this particular instance, The PSO-PI controller is replaced by PSO-ANN controller Simulink block which was obtained from Fig. 9 Simulink representation with feed forward neural network block as shown in Fig 16. The findings that were collected suggest that the THD of the source current has been drastically reduced to 0.78%.

The source current, load current, and SAPF compensatory current waveforms are depicted in Fig. 17. Fig. 18 depicts the source current's harmonic spectrum. Fig. 19 depicts the converging spectrum for PSO-ANN controller.

PSO-ANN parameters are listed in Table III (next page). The SAPF performances of all four cases are given in Table IV (next page).

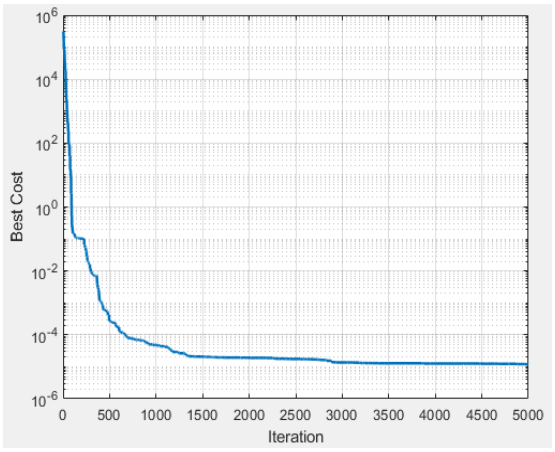


Fig. 19. Converges graph for the PSO-ANN controller.

TABLE III: PSO-ANN PARAMETERS

Maximum iterations	5000
Total Population	50
Weight of Inertia	0.89
Constant of Acceleration(C_1), (C_2)	2
Hidden Neurons	10
Total Variables	1
Higher Limit of weights	200
Lower limit of weights	0

TABLE IV: COMPARISON TABLE

Case studies	FFT -Analysis	Parameters	THD in %
1	Without SAPF	Grid current	18.42
2	SAPF with PI controller	Grid current	3.76
3	SAPF with PSO-PI controller	Grid current	0.93
4	SAPF with PSO-ANN controller	Grid current	0.78

The SAPF performance interns of power factor for all four scenarios as follows: Without SAPF, the power factor is 0.81, with conventional PI being 0.89, with PSO-PI being 0.94, and with proposed PSO-ANN being 0.96.

VIII. CONCLUSION AND FUTURE WORK

The power quality issues, such as harmonics and reactive power, are always expanding and becoming more complex. It has been discovered that implementing strategies derived from artificial intelligence on active filters can produce excellent results in the reduction of harmonics and the correction of reactive power. In this article, the PSO-ANN control method is proposed for use with the SAPF in order to lower the amount of total harmonic distortion occurring on the source side of the distribution system. The SAPF's effectiveness in a wide range of situations is studied and contrasted. The tool MATLAB/SIMULINK is used to perform simulations of four distinct scenarios, and the findings are reported. According to the results of simulations, both the PSO-PI-based SAPF and the traditional PI-based SAPF perform effective in terms of minimizing THD. It has been found that the proposed ANN-PSO-based SAPF is more effective in simulation in terms of achieving a lower THD value. This improved performance has been determined to be acceptable (within 5% of the IEEE standard), according to the findings of the investigation.

In future work, a hardware-in-loop implementation will be added to the proposed shunt active filter. Also, an ANFIS controller with PSO and other optimization methods will be used to make the SAPF's response even better.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Venkata Anjani Kumar G. was responsible for the development of the theoretical formalism, the working out of analytical calculations, and the performance of numerical simulations. Venkata Anjani Kumar G. is responsible for the final draught of the manuscript and M. Damodar Reddy acted as the project's supervisor throughout its entirety.

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TLBO-trained ANN-based Shunt Active Power Filter for Mitigation of Current Harmonics

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Abstract: The increased utilization of nonlinear devices is resulting in damage to power distribution infrastructure by introducing harmonics into power system networks, which in turn causes distortion in voltage and current signals. A novel solution called Shunt Active Power Filter (SAPF) has been developed to address this issue using power electronics. This study aims to provide a method that is efficient and cost-effective for lowering harmonics and improving power quality in distribution infrastructure. The proposed method combines the Teaching learning-based optimization (TLBO) technique with an Artificial Neural Network Controller (TLBO-ANN) in conjunction with SAPF. The primary objective of the TLBO-ANN algorithms in SAPF is to minimise total harmonic distortion (THD) for maximum system efficiency. Initially, Gain values (K_i, K_p) for a regular Proportional-Integral controller are optimised with the Particle Swarm Optimisation (PSO) technique. Those optimized parameters obtained from the PSO-tuned PI controller serve as input and target datasets for training the ANN controller. Subsequently, the TLBO algorithm is utilized to further refine the ANN controller by finding the optimal weight and bias values. Using MATLAB/SIMULINK software, we compare the performance of the proposed algorithm to that of the PSO-tuned PI controller and traditional PI controller. The findings from the simulation suggest that a SAPF utilizing a TLBO-trained ANN controller could improve THD in the supplying current while maintaining harmonics within IEEE-519 accepting levels.

Introduction

Bonding An imbalance between the quality of power available and the power needed by the load apparatus indicates a power quality issue. In order to protect electronic components from power outages, many power enhancement devices have been developed over time (Vishwakarma, 2020). These can be anything from specifically designed power sources to power conditioning devices. Isolation transformers and power conditioning equipment include capacitors, filters, voltage regulators, and uninterruptible sources of power (UPS) to prevent power outages caused by lightning and power surges. Surge capacitors for transient voltage are another type of power conditioning equipment. The Shunt Active Power Filter (SAPF) (Rajeshwari et al., 2017) is an example of a device that enhances power quality. There are many potential sources of damage in alternating current (AC) supply systems. Natural causes include lightning strikes, flashovers, equipment breakdowns and faults, whereas voltage distortions and notches are examples of human-made factors. Because it acts as a nonlinear load and develops non-sinusoidal current, much of the customer's equipment contributes to pollution in the supply system. Power quality is measured in terms of these factors because of the potential for damage to electronic devices due to fluctuations in

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voltage, current, or frequency. Power quality problems can often be traced back to the voltage at the point of common coupling (PCC), where numerous loads are connected (Gowtham et al., 2016; Dorigo et al., 1999; Janga et al., 2020; Huaisheng et al., 2012) Some examples of such problems are harmonics in the voltage, surges of electricity spikes, notches, and sag/dip/swell/imbalance/fluctuations/glitches/flickers/outages.

Non-linear loads, such as heaters, UPSs and variable-speed motors, can place a burden on the power grid and cause outages and other problems in the supply system. Some nonlinear loads can cause power quality concerns by drawing excessive current from the AC mains, creating the low power factor, harmonic currents, reactive power stress, imbalanced currents, and an excess neutral current in three-phase systems are all caused by the unbalancing and harmonic currents that come from using certain non-linear loads. Problems with dielectric breakdown, communication system interference, breaker issues, incorrect measurement, negative sequence currents in rotating electrical machines (especially rotors overheating) and disturbances affecting motor control units and technological control devices., and many others can all contribute to poor power quality (Sabarimuthu et al., 2021).

In some loads, however, the current changes in a way that is out of proportion with the voltage changes that occur at each half-cycle. Non-linear loads refer to this category of conditions. These non-linear loads produce the current and voltage harmonics. Many issues that utilities and power supply organizations face, such as low power factor, inefficient consumption of energy, and voltage fluctuations in the power system, can be traced back to non-sinusoidal current. A perfect compensator is necessary to prevent the harm caused by harmonics (Soliman et al., 2022). Over time, many different types of power enhancement devices have been developed to shield electronics from the consequences of grid failures. Methods that are both effective and efficient include those that are listed below. Implementing power conditioners and substitute energy sources. Power conditioning equipment includes isolation transformers, lightning arrestors, surge capacitors, filters, voltage regulators and an uninterruptible power supply. (Mikkili S et al., 2012; Om P et al., 2016). A Shunt Active Power Filter (SAPF) is one power conditioning device that enhances the supplied electricity's quality. By synchronizing the source current and voltage, current harmonics on the alternating current (Grid) side are cancelled out, and the DC link voltage is maintained at a constant level (Chelli et al., 2015). In order to achieve this goal, the real power flow in the system as well as the there must be no fluctuation in the amount of reactive power flowing into or out of the source.

The SAPF can be controlled by a single controller or multiple controllers working together to maintain a constant DC voltage. This is accomplished by balancing the real power flow in the system with the reactive power flow that comes from or towards the source, which brings the source current in phase with the source voltage (Babu et al., 2020). This cancels out current harmonics on the AC side. SAPF is necessary to eliminate current harmonics. The fundamental compensation principle of the active power filter is depicted in Figure 1. This principle serves as a form of energy storage to provide the real power difference between the load and the source throughout the transient period. When the load state changes, it affects the system's actual power; when that happens, the system will automatically. When compared to the reference voltage, the value of the voltage that is measured across the DC link capacitor is found to be different (Diab et al., 2019; Diab et al., 2018; Wen-guan Wang et al., 2012; Vadi et al., 2021) which leads to the dysfunction of the system. The reduction of the real power disturbance by using different controllers including chicken swarm optimization (Ramesh et al., 2023; Venkata and Reddy, 2023) at the DC link capacitor.

In this study, the utilization of IRP principles is employed to establish the desired current reference (referred to as PQ-theory). The hysteresis current controller technique estimates the reference currents to generate the required gating pulses (Kazemzadeh et al., 2014). Achieving optimal performance of an artificial neural network (ANN)-controller (Tekwani et al., 2020) based on PQ theory for a direct current (dc) link voltage necessitates precise adjustment of weight and bias values (Wilamowski et al., 2010). To determine the optimal state of the ANN controller, a Teaching learning-based optimization (TLBO) (Satapathy et al., 2013) algorithm is implemented, enabling the fine-tuning of weight and bias values.

PQ-Theory-based Reference Current Generation

PQ theory-based constant instantaneous power control is for 3-phase, 3-wire power distribution systems with sinusoidal and symmetrical source voltages. To apply this theory, the three-phase source voltage (V_a, V_b, V_c) and load current (I_{la}, I_{lb}, I_{lc}) must be sensed and transformed by the Clarke transformation into the (α, β) components.

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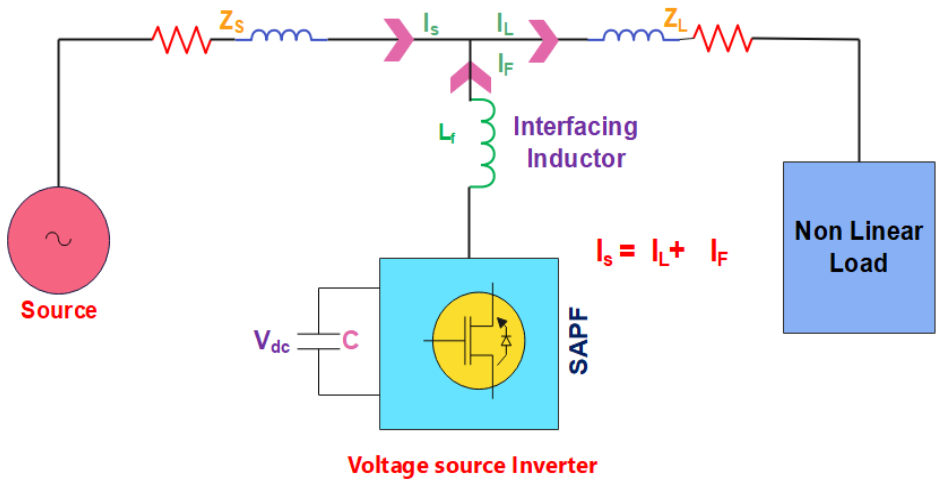


Figure 1. Schematic diagram of a Shunt Active Power Filter (SAPF).

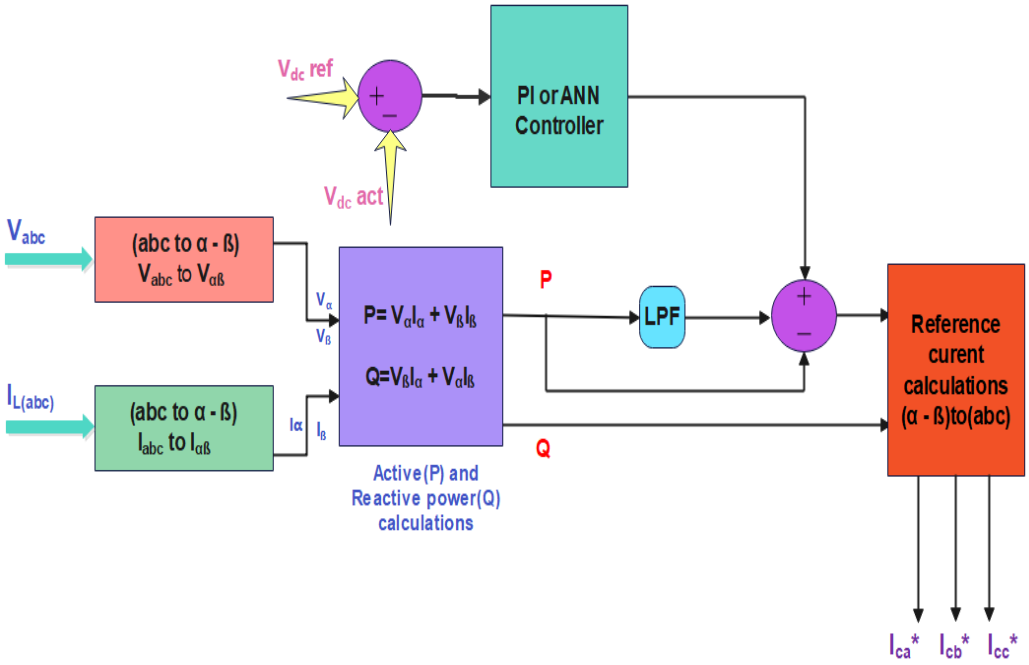


Figure 2. Reference generation diagram with PQ theory.

These components are input for instantaneous power calculations (Akagi et al., 2017). An error signal from the reference and measured dc-link voltages determines the power losses component. A PI controller receives this error signal to calculate power losses (Ploss). The (α, β) components, active and reactive powers, and current calculation are used to estimate the reference (α, β) components. An inverted Clarke transformation transforms these components to 3 phase abc values ($I_{abc,}V_{abc}$) as shown in Figure 2, to obtain the desired reference current signals.

Artificial Neural Network

An "Artificial Neural Network" is a system inspired by the way the human brain works, which is composed of interconnected neural networks Similar to the human brain. Multiple layers of neurons that are coupled to one another constitute artificial neural networks. These neurons, represented as nodes in Figure 3, are responsible for processing information. Typically, a neuron will have a single or multiple outputs and n inputs (x1, x2,... xn) that will receive or send information to other neurons in the network. In equation 1, the neuron's output, denoted by Yi (Asadi et al., 2022), is the result of multiplying the sum of its inputs by the activation function.

$$Y_i = f_i\left(\sum_{j=1}^{n} w_{i,j}x_j + b_i\right) \quad (1)$$

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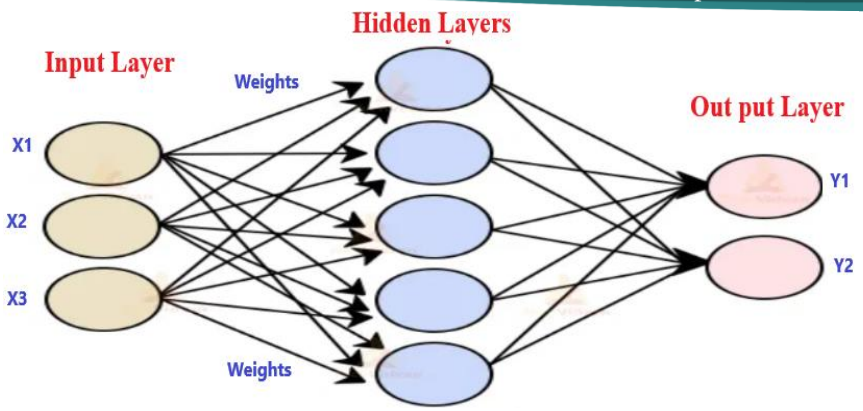


Figure 3. The fundamental structure of an artificial neural network

The $w_{i,j}$ notation represents the connection weight between a neuron on the input and a neuron at target. while b_i represents the neuron's bias. The input to the neuron is represented by x_j and the activation function f determines the neural network's actions. By changing the weights and biases and, in some cases, the number of layers and neurons, neural networks can adapt to new data.

Introduction to TLBO algorithm

Teaching-learning-based optimization, frequently referred to as TLBO, is an acronym given to one of the population-based algorithms that was recently proposed. In the year 2011, Rao et al. presented the teaching learning-based optimization (TLBO) method (Rao et al., 2011). It was inspired by the teaching and learning phenomenon that takes place in a classroom (Rao et al., 2012). In the context of the population-based algorithm TLBO, the class is considered as a population, and each individual learner within the class is considered as an individual member of this population. It is intended that the students in the class will have a greater level of knowledge by the end of the lesson to fulfill this objective. The process has two stages, known as the "teacher phase" and the "learner phase," respectively. This serves as the foundation for achieving this goal.

A. Teacher phase

The student who presents the most outstanding solution in the class is chosen as the teacher. The teacher is regarded as the most proficient learner among the entire population, possessing extensive knowledge and experience in a particular subject. As a result, other students enhance their understanding by leveraging the expertise of the teacher. If a student provides a superior solution compared to the teacher, they will replace the teacher's role. In the k^{th} iteration, the knowledge of the ith learner is updated using the following equation 2.

$$X_i^{new} = X_i + r_I(X_T - T_F{}^i . X_{mean}) \quad (2)$$

In the above scenario, knowledge of the teacher refers to "X_T,","r_I "is a random two-digit number between zero and one, mean results of the learners refers to "X_{mean}," and teaching factor refers to $T_F{}^i$ which can be obtained by the following equation 3.

$$T_F{}^i = round\,[1 + rannd(0,1)] \quad (3)$$

At the end of the teacher phase, all of the learners' knowledge is updated, and these values are now ready to be used as input values in the learner phase.

B. Learner phase

When students are in a real classroom, they can learn more by talking to the other students. This is what the TLBO learner phase is built on. During this step, the knowledge of the i^{th} student is compared to that of a randomly chosen j^{th} student as given in equation 4. When students are in a real classroom, they can learn more by talking to the other students. This is what the TLBO learner phase is built on. During this step, the knowledge of the i^{th} student is compared to that of a randomly chosen j^{th} student as given in equation 5.

If $f(X_i) < f(X_j)$ $then,$ $X_i^{new} = X_i + r_I(X_i - X_j)$ (4)

If $f(X_i) > f(X_j)$ $then,$ $X_i^{new} = X_i + r_I(X_j - X_i)$ (5)

If the knowledge of the **j^{th}** student is better at the end of the learner phase, the knowledge of the **i^{th}** student can be improved as given in equation 6.

If $f(X_i^{new}) < f(X_i)$ $than,$ $X_i = X_i^{new}$ (6)

The TLBO algorithm, consisting of the teacher and learner phases, will continue until either the termination condition or the maximum number of iterations has been reached.

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Proposed Methodology

PI controller tuned by PSO

For SAPF, a particularly important role depends on the abilities of a standard PI controller to regulate the DC link voltage. This controller probably produces for kp and ki will not be optimal values. Because it needs a great degree of mathematical calculation, The PSO method can be used to determine the best possible values for both kp and ki.

As shown in Figure 4, the PSO-PI controller will be given an error signal based on the difference between the actual and reference DC voltages. The PSO method must minimize the Integral Absolute Error (IAE) objective function to acquire the ideal gain values. With 1000 maximum number of iterations and 50 Populations, the Optimum values of gains (K_i, K_p) are 5.65119 and 7.93019 (Venkata et al., 2023).

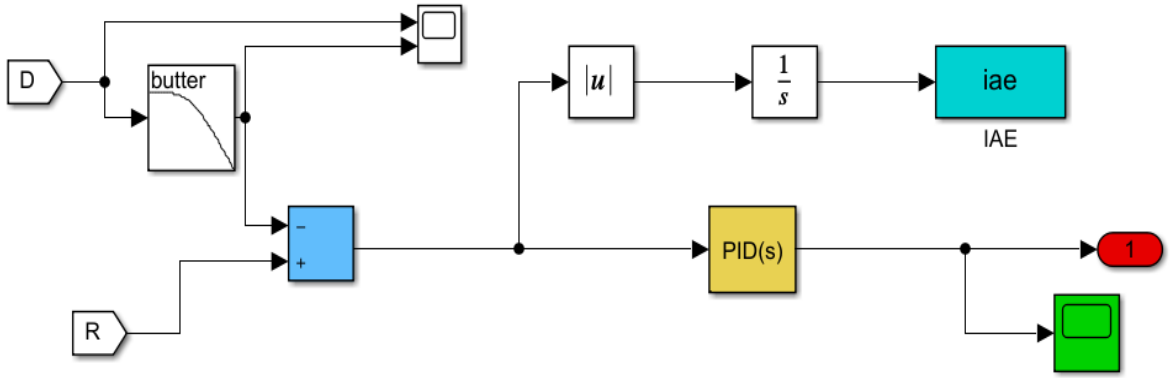


Figure 4. DC link voltage regulation by PSO trained PI based SAPF

TLBO trained ANN Controller

The main objective of a Neural Network algorithm is to obtain the appropriate weights and biases of the network to be as accurate as possible. ANN's weights and biases are given the right values using various methodological approaches. This paper used a method called TLBO. Figure 5 shows that the inputs (e) and outputs (out) of the PSO-PI controller are going to be used as a source of data for the neural network controller.

The necessary code to set up the neural network is provided below. The PSO-PI controller's input and target values are retrieved, hidden neurons are initialised. This data is used to configure the ANN, and finally, the network's weights and biases are extracted. Then, we'll define a pre-trained neural network's weights and bias using the TLBO algorithm, with the objective function defined as the root mean square error.

Step by Step approach of TLBO trained ANN

Step1: Take the input (e) from the workspace of PSO-PI controller.

Step 2: Take the Target (output) from the workspace of PSO-PI controller.

Step 3: Assign the number of Hidden Neurons.

Step 4: Define the Feed Forward Neural network based on hidden Neurons.

Step 5: Set up the Neural Network with the specified input and output values..

Step 6: Generate the initial weight and biases

Step 7: Use the root-mean-square-error as the objective function, by utilizing the weights and bias, Feed Forward Neural network, inputs and target values.

Step 8: The neural network is trained using the TLBO algorithm, resulting in the updated weights, biases and error.

Step 9: With this updated weights and biases again

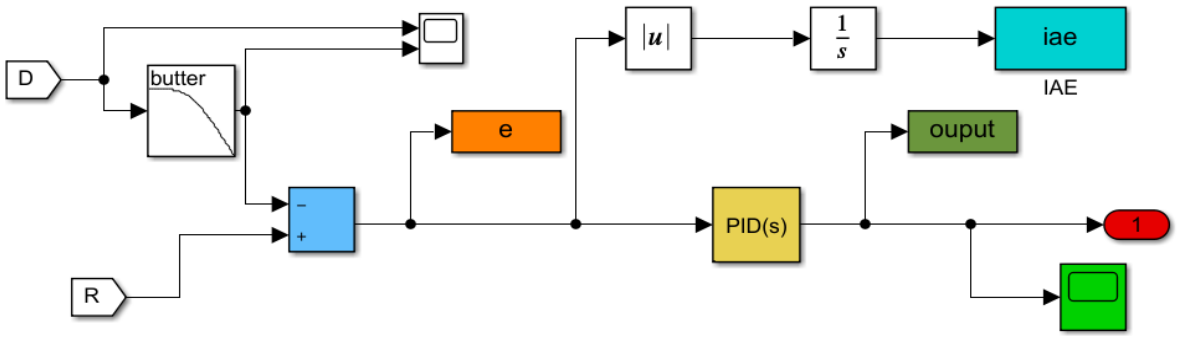


Figure 5. Output (o) and input (e) representation in the workspace for the PSO-PI controller.

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configure the Feed Forward Neural network.

Step 10: Repeat steps 7 to 9 until objective function is at a minimum.

Synaptic coefficients converge when they have settled on steady-state value and the network's Root Mean Square Error (NMSE) decreases below a predetermined threshold. Another approach to stop the learning process is to set a limit on the maximum number of iterations. The flowchart of the training algorithm is illustrated in Figure 6.

We will ultimately obtain the feed-forward neural network block and inside layering structure shown in Figure 7 response to a given input and output. The PSO-PI controller will substitute this feed-forward neural network block.

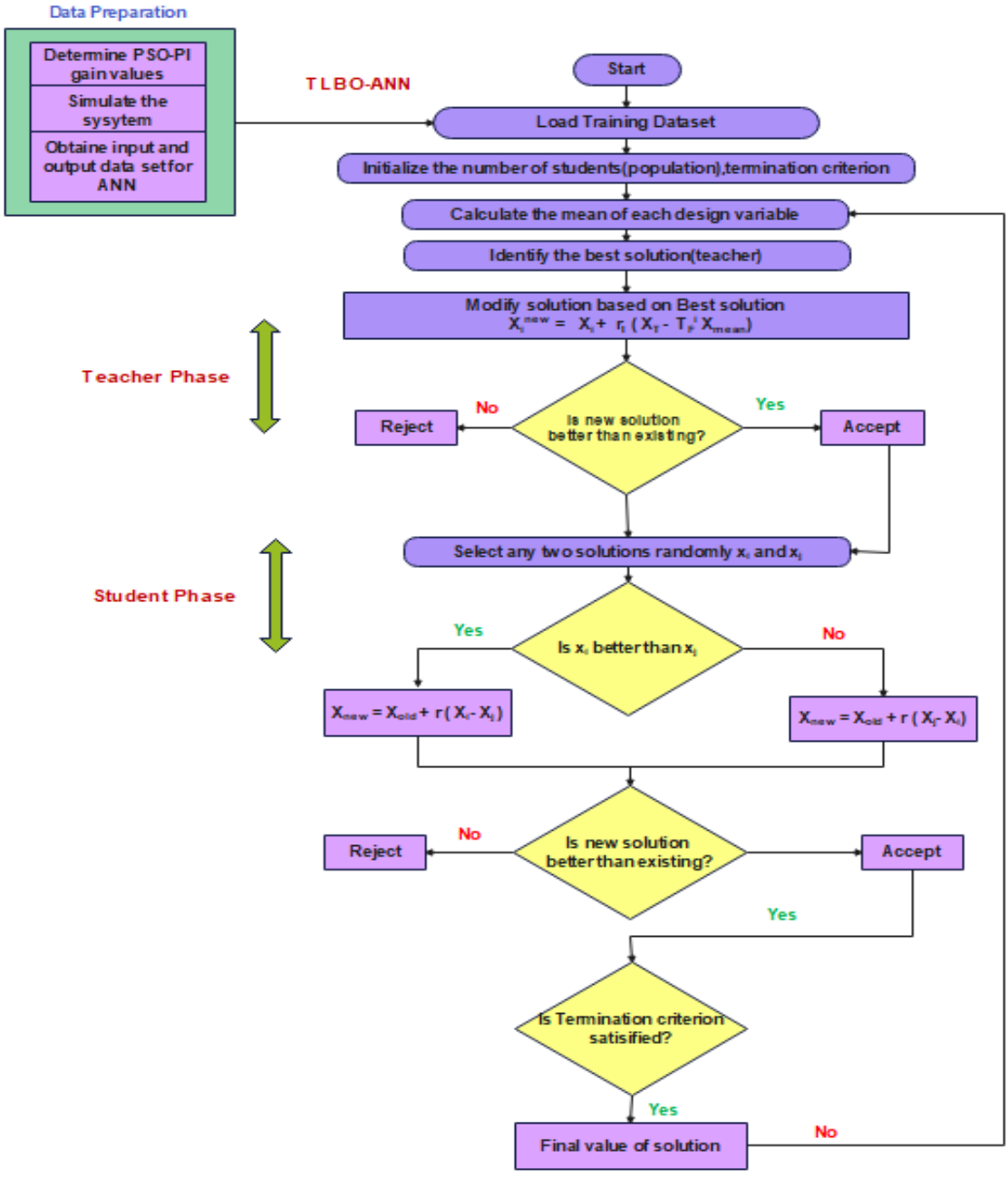


Figure 6. Flow chart of TLBO-ANN.

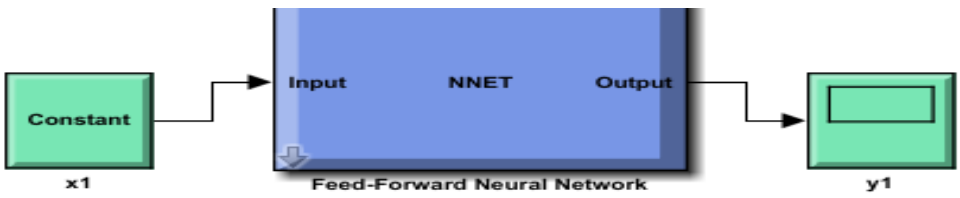


Figure 7. Simulink block of TLBO-ANN algorithm.

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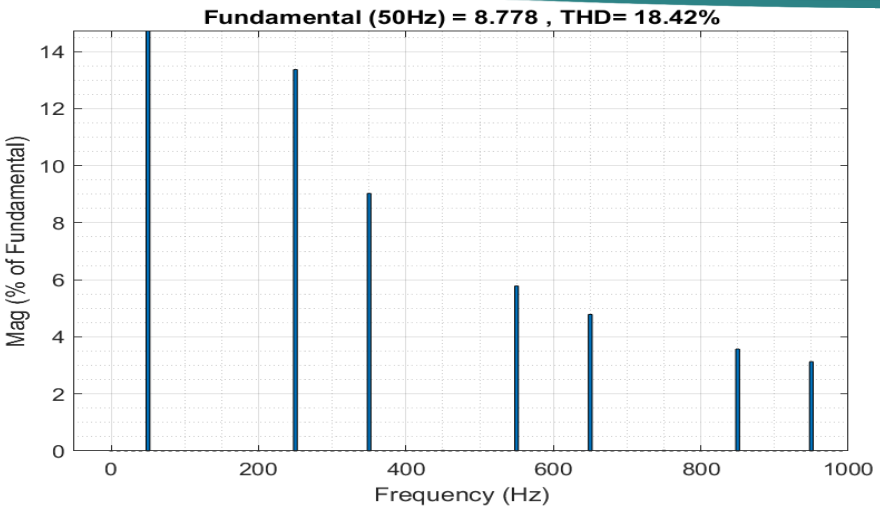


Figure 8. THD result of source current without using SAPF.

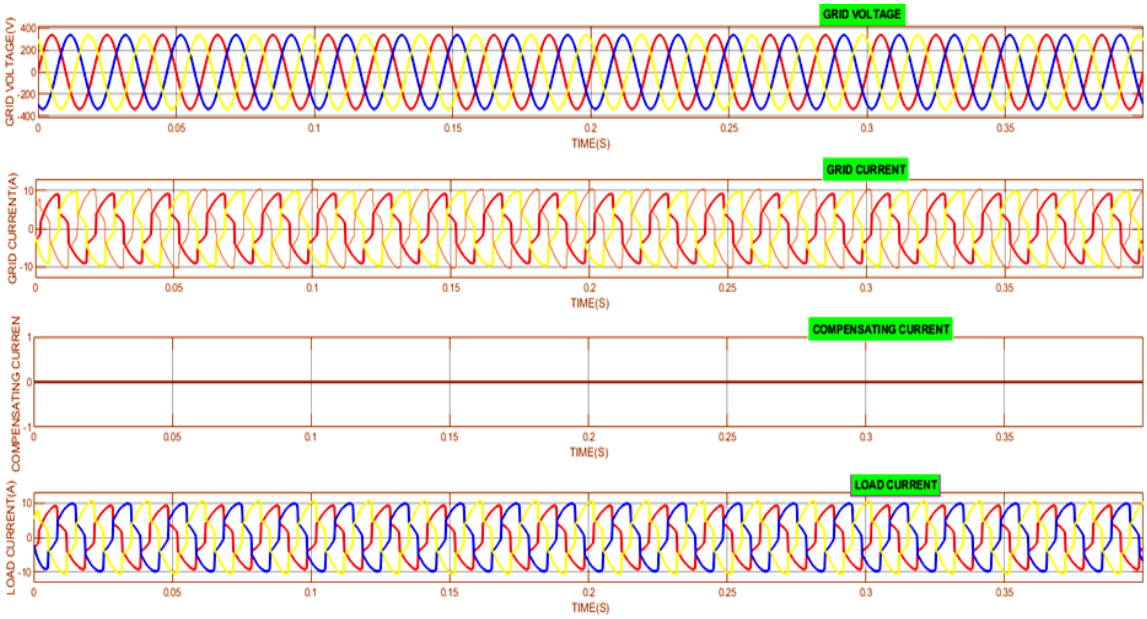


Figure 9. The waveforms of the IL, IS, IC and IS, without using SAPF.

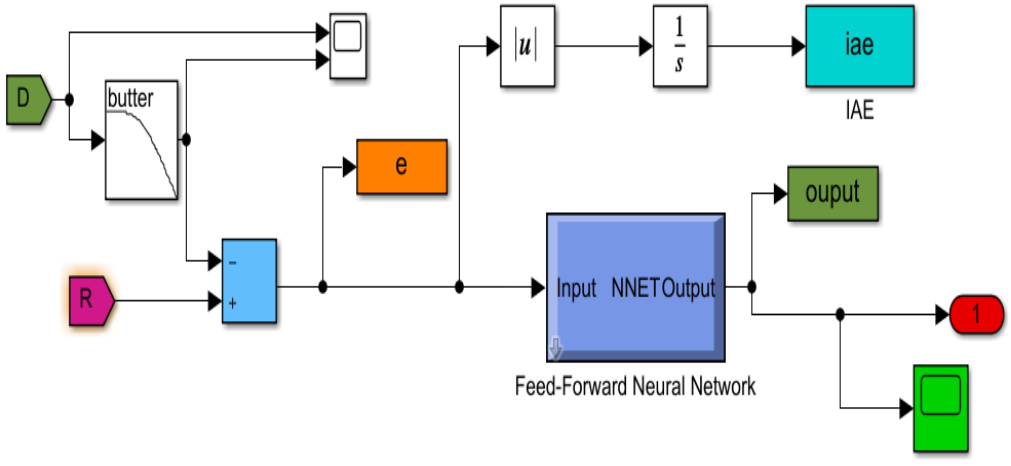


Figure 10. Controlling the DC voltage in a SAPF with a TLBO-ANN regulator.

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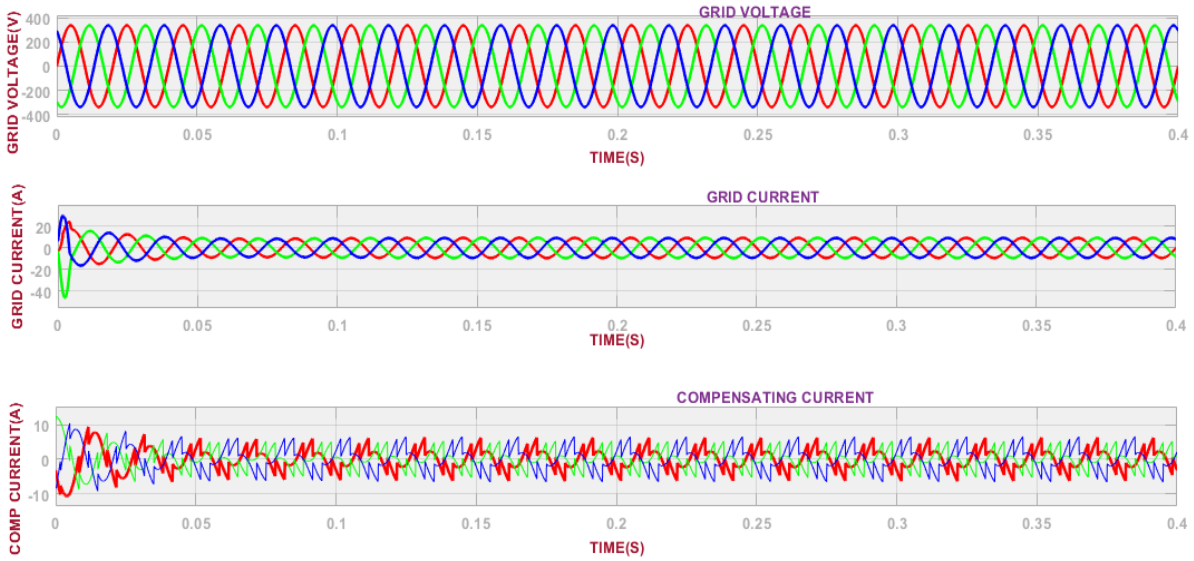


Figure 11. The waveforms of the IL, IS, IC and IS, by using TLBO trained ANN based SAPF

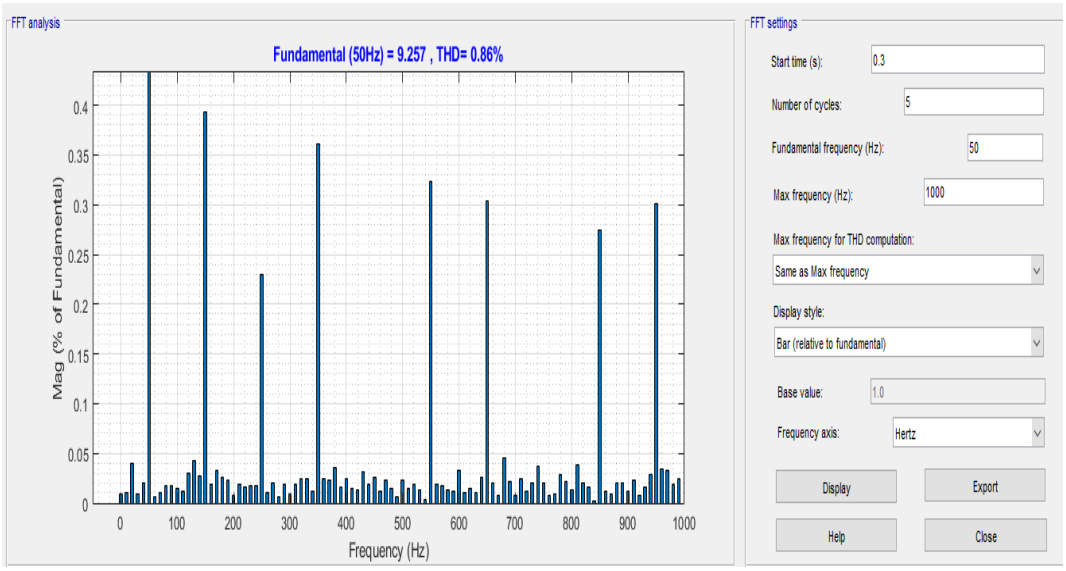


Figure 12. THD result of IS (Grid current) by TLBO tuned ANN-based SAPF.

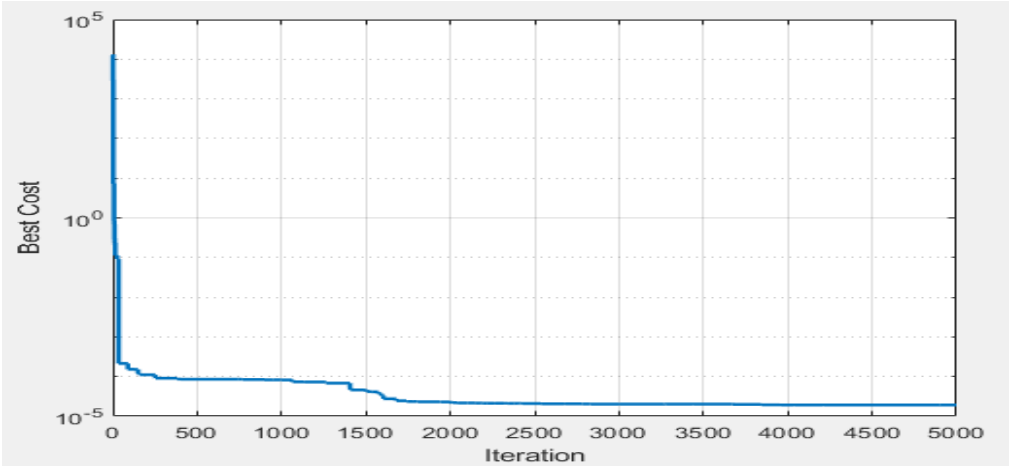


Figure 13. Converges graph for the TLBO-ANN based SAPF.

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Results and discussions

The proposed methods for a SAPF's current control and reference generation were implemented with the help of the MATLAB simulative environment. This study was carried out taking into account the various possibilities that were presented below. A tabulation of the simulation's parameters that were used for the simulation's purposes can be found in Table 1.

Table 1. Modeling framework in Simulink

Particulars	Values
Voltage at the Grid	415V
Frequency at the Grid	50 Hz
Impedance at the Source	0.15 ohm,15mH
Coupling inductance	15mH
Active Power at the Load	4472 W
Reactive Power at the Load	1718 VAR
Connected DC Capacitance	100µF

Without SAPF

In this case, we turn off SAPF and use Fast Fourier Transform (FFT) analysis to look at how the nonlinear load distorts the source current. This analysis showed that the distortion was close to 18.42%. The harmonic spectrum of the source current, as calculated by the fast Fourier transform, is shown in Figure 8. Figure 9 shows the waveforms of the I_S (Grid current), I_L (load current) that resulted from the simulation. The SAPF converter is not injecting a compensating current to reduce grid-side harmonics, as shown in Figure 9.

TLBO-trained ANN-based SAPF

Here, the TLBO-ANN controller Simulink block has taken the place of the PSO-PI controller. This Simulink block was taken from Figure 7 and is shown interacting with a feed-forward neural network in Figure 10. According to the results, the source current's total harmonic distortion (THD) appears to have dropped to 0.86%.

Table 2. Parameters of TLBO-trained ANN

Maximum iterations	5000
Total no of Students	25
Teaching Factor	0.5
Hidden Neurons	10
No of Variables	1
Weight Scale Upper Limits	200
Weight Scale Lower Limits	0

Figure 11 illustrates the waveforms of the currents flowing from the source, the load, and the SAPF compensating current. The harmonic spectrum of the source current is depicted in Figure 12. The TLBO-ANN controller's converging spectrum can be seen as depicted in Figure 13. This indicates that the MSE is steadily reducing and eventually reaching a constant value.

The parameters for the TLBO-ANN are detailed in Table II (on the following page). Table III (on the following page) provides an overview of how the SAPF performed in each of the four scenarios.

Table 3. Table of Comparison

Slno	Type of Controller	Component	THD value(%)
1	Without using SAPF	I_S (Source Current)	18.42
2	PI based SAPF	I_S (Source Current	3.76
3	PSO tuned PI Based SAPF	I_S (Source Current	0.93
4	TLBO tuned ANN based SAPF	I_S (Source Current	0.86

Conclusion

Harmonics and reactive power are just two examples of the increasing complexities of power quality issues.Active filters that employ strategies developed through artificial intelligence are particularly effective at mitigating harmonics and resolving reactive power. Within the scope of this article, we propose the TLBO-trained ANN control technique. as an alternative solution to be used in conjunction with the SAPF. The SAPF's effectiveness is measured and compared in a variety of settings. Matlab-Simulink runs simulations of four different scenarios and presents the findings. According to simulation findings, the proposed ANN-TLBO-based SAPF outperforms alternative scenarios in reducing THD in the source current. The PSO-tuned PI-based SAPF and SAPF with PI controller are also effective. According to the results, this performance improvement is satisfactory (within 5% of the recommended IEEE standard).

A hardware-in-the-loop version of the proposed shunt active filter will be developed for further research. In addition, we plan to improve the SAPF's flexibility by using an ANFIS controller that includes TLBO and other optimization techniques.

Conflict of interest

The authors have no competing interests to disclose.

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Mitigation of Grid Current Harmonics by ABC- ANN based Shunt Active Power Filter

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ABSTRACT

Harmonics are being introduced into power system networks as a result of the increasing use of nonlinear devices. These harmonics cause distortion of current and voltage signals, which in turn causes damage to power distribution systems. As a result, the suppression of harmonics is of extreme significance in power systems. This paper proposes Shunt Active Power Filters (SAPF) based on neural network algorithms like Artificial Neural Network (ANN) as a feasible approach to mitigating harmonic distortion and raising power quality in electrical distribution systems. This research shows that using shunt active power filters (SAPF), which use the Artificial Bee Colony Optimized Artificial Neural Network Controller (ABC-ANN), is an efficient method for enhancing power quality and minimizing harmonic distortion in distribution systems. The ABC-ANN algorithms have been produced for SAPF with the goal of improving system performance by reducing Grid current Harmonics. In the first stage of this work, PSO Technique is used to tune a standard PI controller to its optimum gain values (K_i ,K_p). Then, these target and input data of PSO tuned PI controller will be supplying inputs to the ANN controller. To find the optimal weight and bias values, this ANN controller has been tuned with the help of the ABC algorithm. Using MATLAB/SIMULINK software, we compare the performance of the proposed algorithm to that of other optimization algorithm like Differential Evaluation (DE) algorithm, as well as the PSO tuned PI controller and traditional PI controller. The findings from the simulation suggest that a SAPF utilizing an ABC trained ANN controller could improve THD in the supplying current while maintaining harmonics within IEEE-519 accepting levels.

1. Introduction

Power electronics components and large quantities of non-linear load bring about destructive harmonics in Grid current at the Point of Common Coupling or P.C.C [1]. Because harmonics in distribution system current can trigger an extensive range of problems, including loss, instability, noise, heating appliances, and so on, In order to reduce potential harm, it is essential to reduce them to an acceptable level of Total Harmonic Distortion [2] as defined by the IEEE-519 guidelines.

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In the 1970s, Gyugyi [3] was the first to discuss the power quality problems that arise when the current changes. Power quality analyzers and synthesizers, also known as shunt active power filters, can be used to fix the problem of current variation. Active filters dealing with power quality variations and their measurement in processed control and power utility systems were also stressed by Akagi [4], another notable researcher. Power engineers and researchers are on the lookout for transit solutions to maintain the distributed side of the system in light of the development of flexible AC transmission devices in the transmission line, which lower the operational cost without raising the installation cost. Typically, these are referred to as "custom power devices" (CPDs). Shunt active power filters are one low-cost method for lowering current fluctuations. Topological structures, sizes, optimal placement, and control factors for SAPF have all been investigated. These have left a few gaps, including issues with improper compensation and switching. Researchers looked into improved filter architecture as a solution.

One possible way to deal with current harmonics, reactive power, and poor power factor is to install a shunt active power filter (SAPF). The SAPF configuration shown in Figure 1 consists of a voltage source inverter (VSI) and an active filter controller. For the VSI to inject compensating reverse current at PCC, the control unit must provide timely and accurate firing signals [5,6].This will make it possible for the VSI to accomplish its goal. Reactive power control is provided to the grid via a DC-link capacitor installed on the VSI's input side [7].

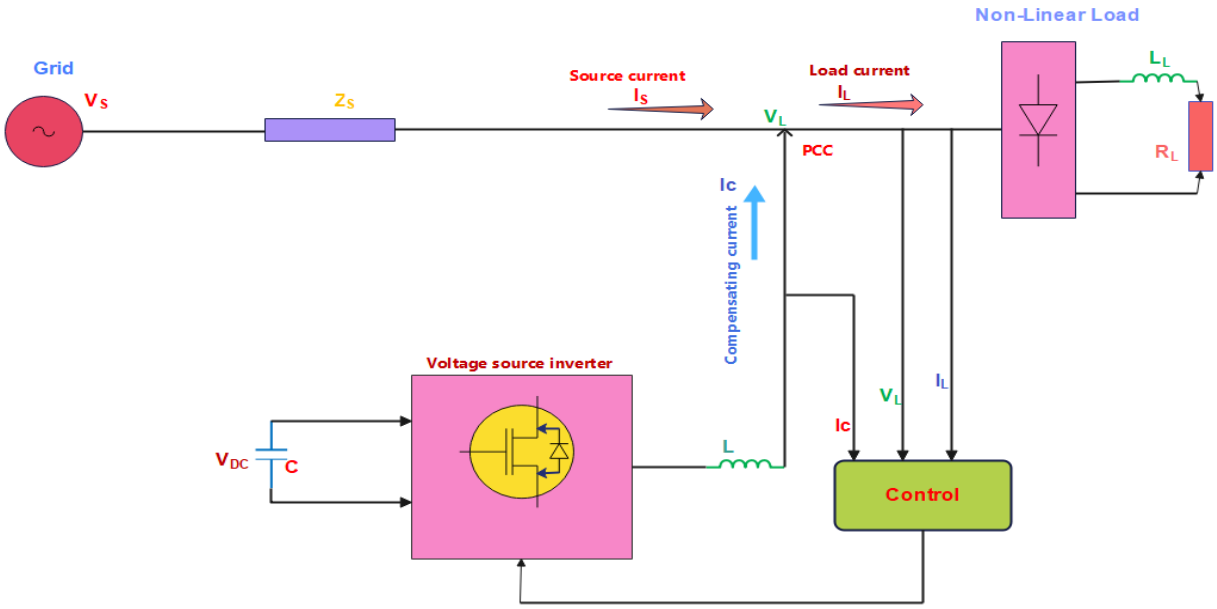


Fig. 1. Circuit diagram of the shunt active power filter

Either reference generating methods or control strategies can be utilized in the process of analyzing the VSI switching operation. Compensating signals are extracted from distorted signals using reference current generation theories, and then appropriate firing signals are generated using signal determined reference techniques to control the SAPF switching devices [8]. These two steps together constitute the SAPF control techniques. These are the two steps that are able to be implemented. Numerous authors have made comparisons between the various SAPF control strategies [9,10].

The harmonic content mitigation is performed by the PI controller that is a part of the control strategy. The PI proportional and integral gain values must be calculated for the controller. Methods such as Ziegler–Nichols and Cohen–Coon, for example, are helpful in determining the K_i and K_p values

explicitly for power systems that have linear loads. These linear control strategies will not function for a system that is subjected to nonlinear loads. In the present day, intelligent and optimal tuning algorithms such as Evolutionary Programming (EP) like Genetic Algorithm (GA) , Particle Swarm optimization (PSO), Simulated Annealing (SA), Differential Evolution (DE) [11-15] .Algorithm have been developed to solve the problems of dynamic electric system problems with enhanced optimal tuning SAPF devices.

The word Artificial Neural Network shortly ANN is used to describe a system which is designed and operates similarly to the human brain. Neurons form a network all over the brain. The overall network's behavior is determined by the strength of the connections between interneuron as well as the configuration of those connections. During network training, the weights are able to and will be adjusted and changed [15]. Only for the purpose of supplying reference compensation current is SAPF currently using Artificial Neural Network (ANN) techniques [16]. This current is then utilized to manage the compensation that SAPF provides. There are a number of approaches that can be used to learn weights. Methods include the Steepest Descent strategy to learning variables, the Levenberg-Marquardt [17] method, and the Widrow-Hoff (W-H) method are just a few examples.

In this work the reference current is calculated using instantaneous active and reactive power (PQ-theory) and hysteresis current controllers estimate reference currents to generate gating pulses [18]. Regulating dc link voltage using an ANN-controller [19] based on IRP theory requires tuning of weight and bias parameters. In addition, the Artificial Bee Colony Optimization Algorithm (ABC), which was proposed and tested against other Optimization algorithm such as Differential Evaluation (DE) algorithm, was used as the motivation for this article in order to find the ideal ANN-controller weight and bias and acquire the objective function while minimizing Total Harmonic Distortion(THD).

2. PQ Theory

PQ theory-based constant instantaneous power control is for 3-phase, 3-wire power distribution systems with sinusoidal and symmetrical source voltages. To apply this theory, the three-phase source voltage (V_a, V_b, V_c) and load current (I_{la}, I_{lb}, I_{lc}) must be sensed and transformed by the Clarke transformation into the (α,β) components. These components are input for instantaneous power calculations [20]. An error signal from the reference and measured dc-link voltages determines the power losses component. To calculate power losses (Ploss), a PI-controller receives this error signal. The (α, β) components, active and reactive powers, and current calculation are used to estimate the reference (α, β) components. An inverted Clarke transformation (α, β) transforming these components to three phase abc values ($I_{abc,}V_{abc}$) as shown in Figure 2 to obtain the desired reference current signals.

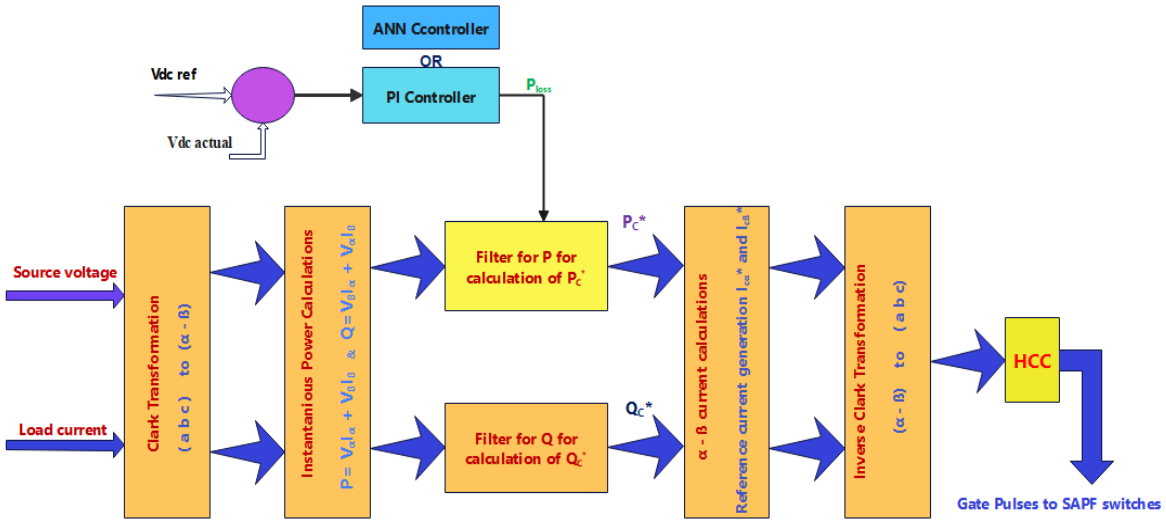


Fig. 2. Reference current generation with IRP (PQ) Technique

3. Structure of Artificial Neural Network (ANN)

The term artificial neural networks or ANN refers to a type of algorithm that is modeled after the way the brain operates and is used to model complicated patterns and predict future events. The concept of the Biological Neural Networks found in the human brain was the inspiration for the development of a technique known as the Artificial Neural Network, or ANN. An attempt was made to model the behavior of the human brain, which led to the development of artificial neural networks (ANN). The functioning of ANN is strikingly comparable to that of biological neural networks, despite the fact that the two systems are not identical. The ANN algorithm will only take in data that is numeric or structured.

- The architecture of the network is composed of three levels: the input layer, the hidden layer and the output layer as shown in Figure 3. As a result of the many layers, they are often referred to as the MLP (Multi-Layer Perceptron).
- The hidden layer can be thought of as a "distillation layer" that takes the most important patterns from the inputs and sends them to the next layer for more analysis. It speeds up the network and makes it more efficient by picking out the most important information from the inputs and getting rid of the rest.
- The activation function is useful for two reasons. First, it enables you to turn on your computer.
  - The presence of non-linear interactions between the inputs is captured by this model.
  - It aids in the transformation of the input into a more useable output.
- To construct an effective model, it's important to find the "optimal values of W—weights" that minimize Mean Square Error. This is done by the "back propagation algorithm," which turns ANN into an algorithm that learns from mistakes.
- The "gradient descent" method is used to measure prediction errors in the "optimization" approach. To find the best value for W, small changes are made and the effects on prediction errors are looked at. Lastly, those W values are chosen as the best because changing W any more doesn't make mistakes less likely.

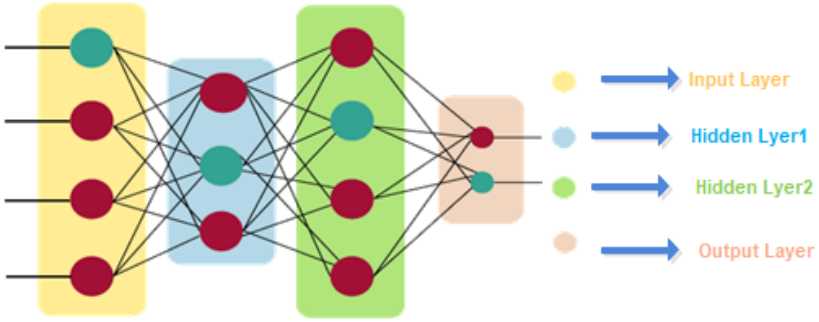


Fig. 3. Architecture of the artificial neural network.

To extract a fundamental component from SAPF while avoiding harmonic pollution, ANN architecture was utilized. For a given source voltage, it can be ensured by accurately predicting the reference current in ideal and real-time load applications. In the context of increasing reliance on nonlinear loads in residential and industrial applications, the mitigation of harmonic pollution has been a significant problem. ANN has been proven to be more applicable than p-q theory in circumstances of inaccurate voltage involving harmonic contamination in the source current and additional harmonic contamination due to the load current.

4. Artificial Bee Colony (ABC)

The ABC optimization method is an example of a meta-heuristic approach. Karaboga [21] came up with this idea first. The main idea behind ABC is how honey bees get food. In the ABC algorithm, there are three groups: worker bees, watcher bees, and scout bees. Bees were sent around the hive at random to find out where food was coming from. This information is shared with onlookers, who then decide which food source to choose. The random search is being done by Scout.

Figure 4 shows how honey bees act in general. Let's say that A and B are food. One of the possible bee starts out as a jobless bee. It has two options: it could be looking for food (S) or it could be doing the waggle dance (R). After it finds a food source, it will remember where it is and start taking advantage of it. Now, the Bee is a working bee. Once the food is turned into nectar, the same bee has three choices. may it lose its job, find new nest mates, and go back to the food source or keep looking for food in the same place.

The probability of a food source is given by the equation (1).

$$P_i = \frac{fit_i}{\sum_{n=1}^{SN} fit_i} \tag{1}$$

where, fit_i fitness value and SN is number of food sources.

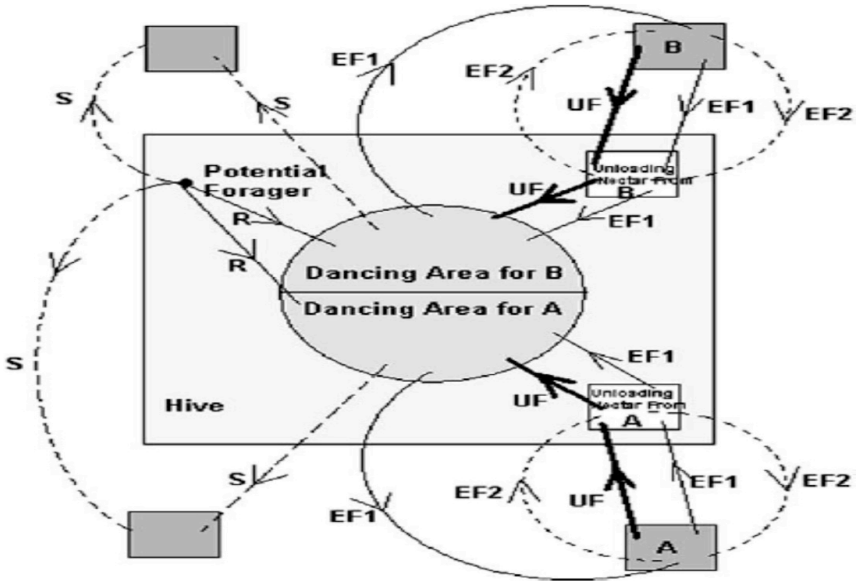


Fig. 4. ABC architecture

The candidate's food position from memory is given by equation (2).

$$v_{ij} = x_{ij} + {}^{\Phi}{}_{ij}(x_{ij} - x_{kj}) \quad (2)$$

$k\boldsymbol{\varepsilon}\{1,2,\ldots..SN\}andj\boldsymbol{\varepsilon}\{1,2,\ldots..D\}$, ϕ_{ij} random [0,1]
The following is a list of the stages that constitute the algorithm's procedure:

1. Read data
2. Read data
3. The distribution of working bees across various food sources
4. Distribute onlooker bees to the food sources in proportion to the amount of nectar they collect.
5. To find fresh sources of food, you should send the scouts to the area that is being searched.
6. In the meantime, keep the knowledge you've acquired regarding the greatest food source in storage.
7. Determine whether or not the requirements have been fulfilled.

5. Proposed Implementation

5.1 PI tuning with PSO Algorithm

The key function of SAPF is dependent on the abilities of a standard PI controller‘s regulation of the DC link voltage. It is probable that this controller produces for K_p and K_i will not be optimal values. Because it needs a great degree of mathematical calculation The PSO method can be used to determine the best possible values for both K_p and K_i.

As shown in Figure 5, the PSO-PI controller will be given an error signal based on the difference between the actual and reference dc voltages. To acquire the ideal gain values, the PSO method must minimize the Integral Absolute Error (IAE) objective function. With 1000 maximum number of iterations and 50 Populations, the Optimum values of gains (K_i, K_p) are 5.65119 and 7.93019. We set the bare minimum and highest possible values for K_p and K_i respectively at 0 and 200.

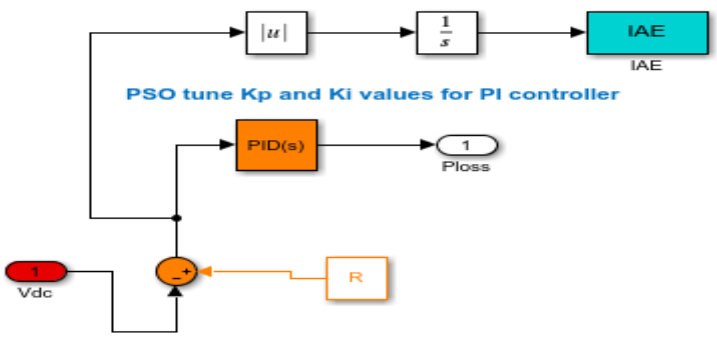


Fig. 5. DC link voltage regulation by PSO trained PI based SAPF

5.2 ABC Trained ANN Algorithm

The goal of ANN algorithm is to get the weights and biases of the network to be as accurate as possible. ANN's weights and biases are given the right values by using a variety of methodological approaches. This paper used a method called ABC. Figure 6 shows that The inputs (e) and outputs (out) of the PSO-PI controller are going to be used as a source of data for the neural network controller.

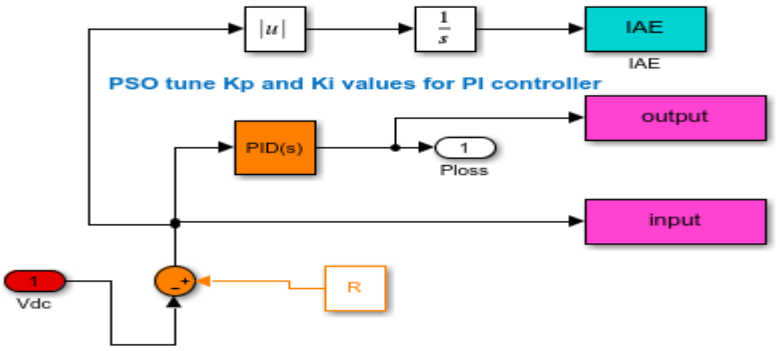


Fig. 6. PSO tuned PI controller's input and target extraction

The necessary code to set up the neural network is provided below. The PSO-PI controller's input and target values are retrieved, hidden neurons are initialised.This data is used to configure the ANN, and finally, the network's weights and biases are extracted. Then, we'll define a pre-trained neural network's weights and bias using the ABC algorithm, with the objective function defined as the root mean square error.

Initialization of ANN

- I = input(e)';
- T = output(out)';
- N = 12;
- Nnet = Feedforwardneuralnet (N);
- Nnet = configurate (Nnet, I, T);
- getingwb(Nnet) (W- weight and B- biases)
- Root-mean-squared error in expressing (g) is the objective function. and it is determined by the weights, bias(y), Nnet, I, and T.
- The ABC algorithm should be used to train the neural network.Weights, bias, and error (y, e), all updated, can be calculated from this.
- Nnet = setingwb(Nnet, y');

- getingwb(Nnet)
- error= T - Nnet (I);
- difference = mean(error.^2)/mean(var(T',1));
- generatesim(Nnet)

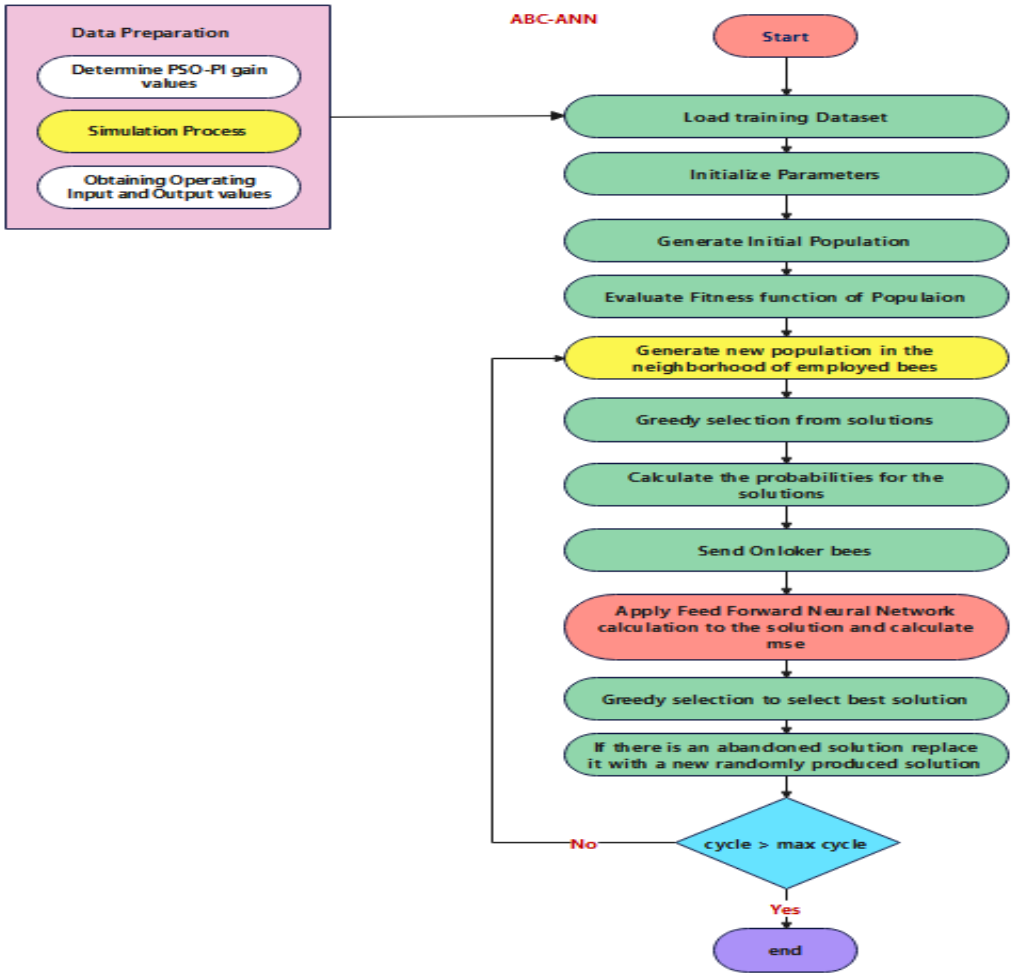


Fig. 7. Flowchart representation of ABC-ANN algorithm

Once the converges reaches steady state and the Mean Square Error (MSE) of the network decreases below a specific threshold, the network has reached convergence. Another way to stop learning is to limit the number of times something can be tried. The flowchart for the training algorithm is shown in Figure 7. Therefore, The PSO-PI controller will replace the feed-forward neural network shown in Figure 8 when input and output data are provided.

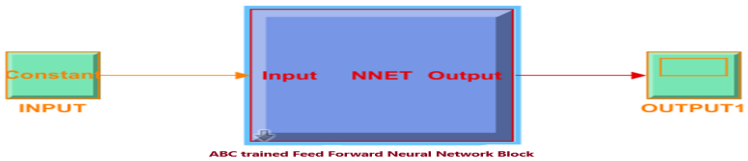


Fig. 8. Simulink block of ABC-ANN algorithm

6. Results and discussions

This section contains a discussion of the simulation results that were obtained using MATLAB. It is simulated both for the proposed ABC-ANN based controller as well as for the TLBO-ANN and DE-ANN controller based SAPF, and then comparing all of the obtained results.

The ANN- controller's weights and bias are adjusted to improve the source current THD value. Then, the controller's performance is measured with a static non-linear load connected to the PCC. The following situations were used to carry out this evaluation.

I. Without SAPF

In this case, SAPF is turned off, and a Fast Fourier Transform (FFT) analysis was used to figure out that the nonlinear load caused a 18.42% of THD change in the source current as shown in Figure 10 and Figure 9 shows how the source and load currents look in a three-phase simulation.

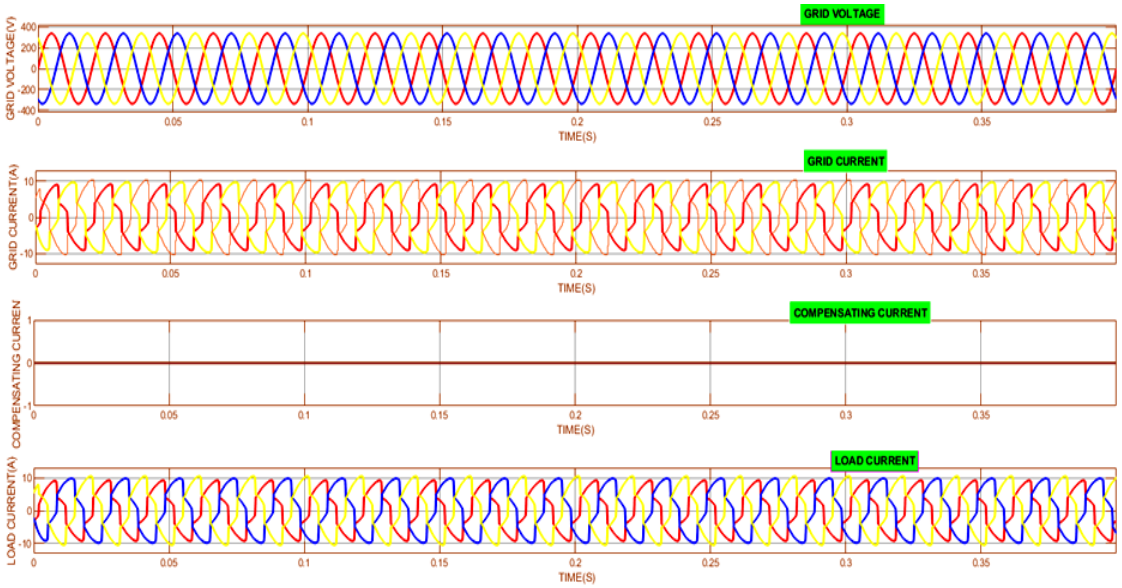


Fig. 9. The waveforms of the I_L, I_S, I_C, I_S, without using SAPF

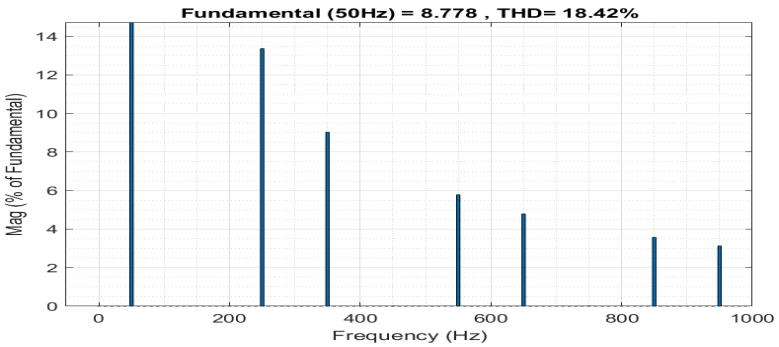


Fig. 10. THD result of source current without using SAPF

II. PI Controller based SAPF

Here, SAPF is attached to PCC, and conventional PI controller gains were used to obtain simulated results. Following the use of SAPF compensation, the distortion in the supply current was cut down

to 3.76 percent from its initial value. Moreover, the harmonic spectrum of the source current may be seen in Figure 11, as depicted correspondingly.

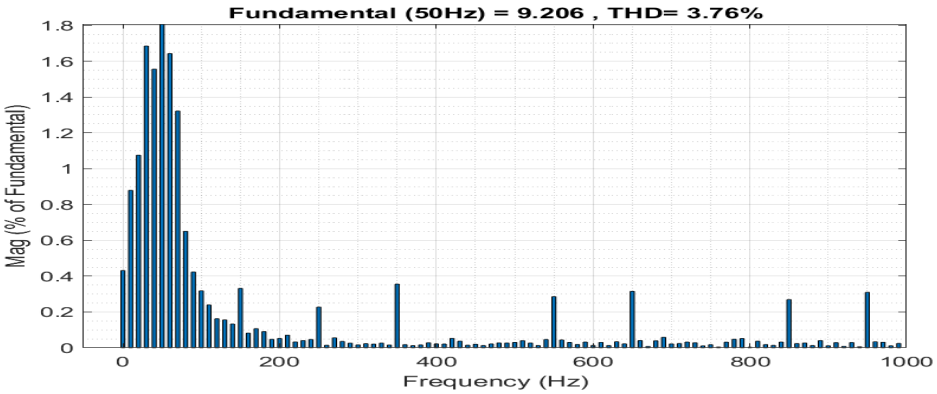


Fig. 11. THD result of I_S (Grid current) by PI based SAPF

III. PSO-PI based SAPF

In this present scenario, the SAPF compensation action was used to run the simulation, and the PI-controller gains were adjusted with the help of the PSO Algorithm. Both of these procedures were carried out in order to achieve the best possible results. According to Figure 12, the findings that were collected point to the possibility that there has been a significant decrease in the THD of the source current to an extremely manageable level of 0.93%.

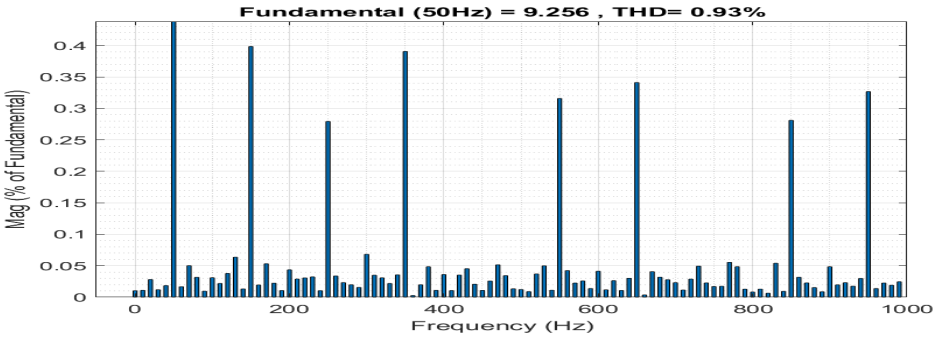


Fig. 12. THD result of I_S (Grid current) by PSO tuned PI based SAPF

IV. DE tuned ANN based SAPF

Here, instead of using a PSO-PI controller, a DE-ANN controller Simulink block was used. THD in the source current was mitigated to 0.90%, as displayed in Figure 13.

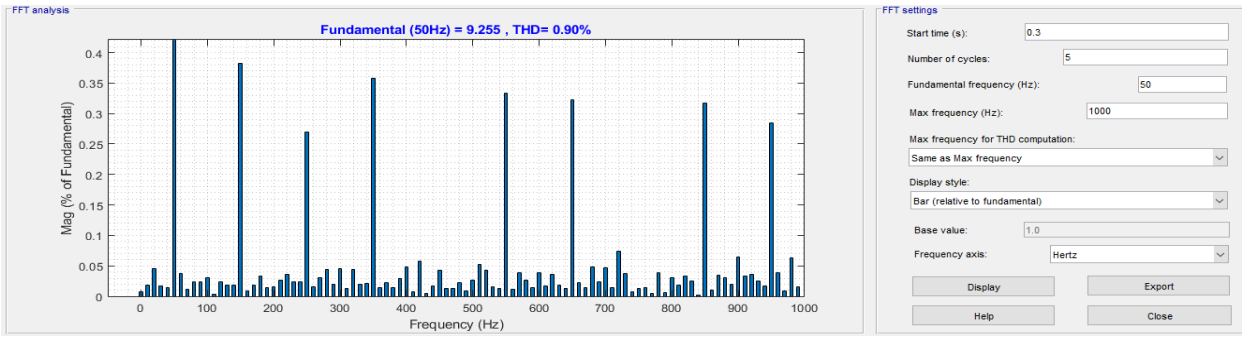


Fig. 13. THD result of I_S (Grid current) by DE tuned ANN based SAPF

V. ABC tuned ANN based SAPF

Here, the PSO-PI controller has been swapped out for the ABC-ANN controller Simulink part. Utilizing block of a feed-forward neural network, depicted in Figure 14. That is acquired from the Figure 9. Based on the results of the measurements, the total harmonic distortion (THD) of the source current appears to have diminished to 0.84%.

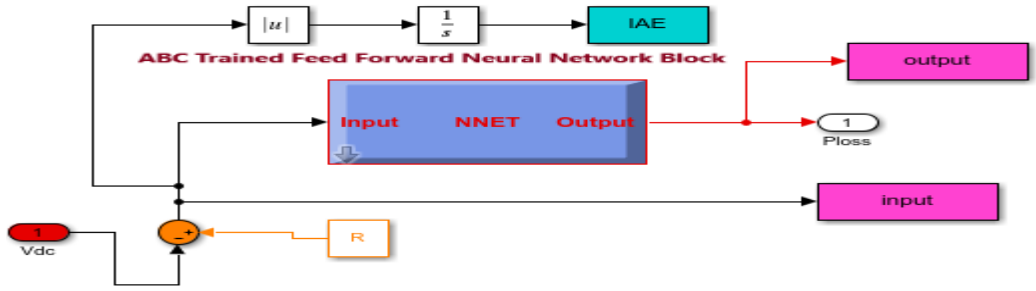


Fig. 14. Controlling the DC voltage in a SAPF with an ABC-ANN regulator

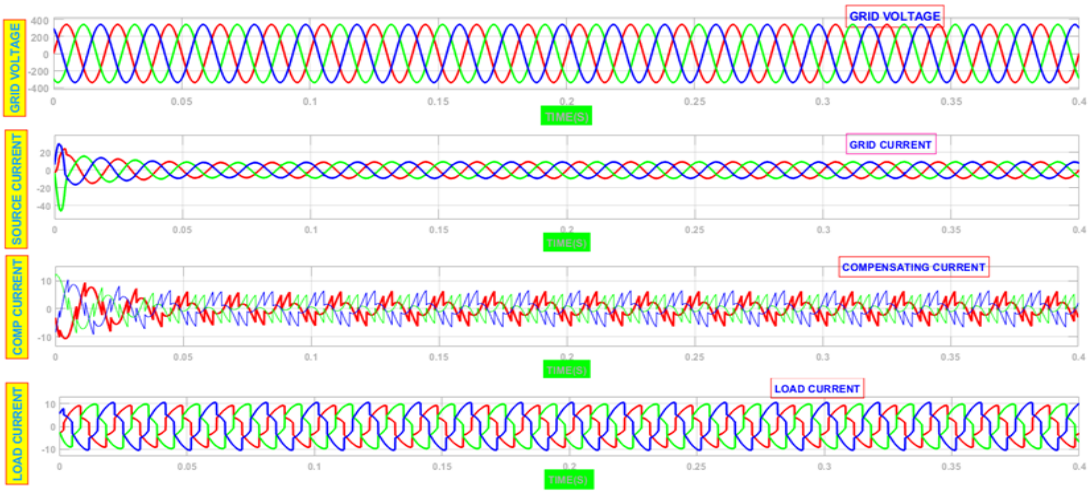


Fig. 15. The waveforms of the I_L, I_S, I_C, I_S, by using ABC trained ANN based SAPF

Figure 15 illustrates the waveforms of the currents flowing from the source, the load, and the SAPF compensating current. In order to maintain a sinusoidal source current, SAPF injects compensating current at the PCC using an ANN controller that was trained using the ABC algorithm. The harmonic spectrum of the source current is depicted in figure 16. The ABC-ANN controller's converging spectrum can be seen depicted in Figure 17. The error measured by the ABC ANN controller is shown to be smaller than that measured by the DE -ANN controller.

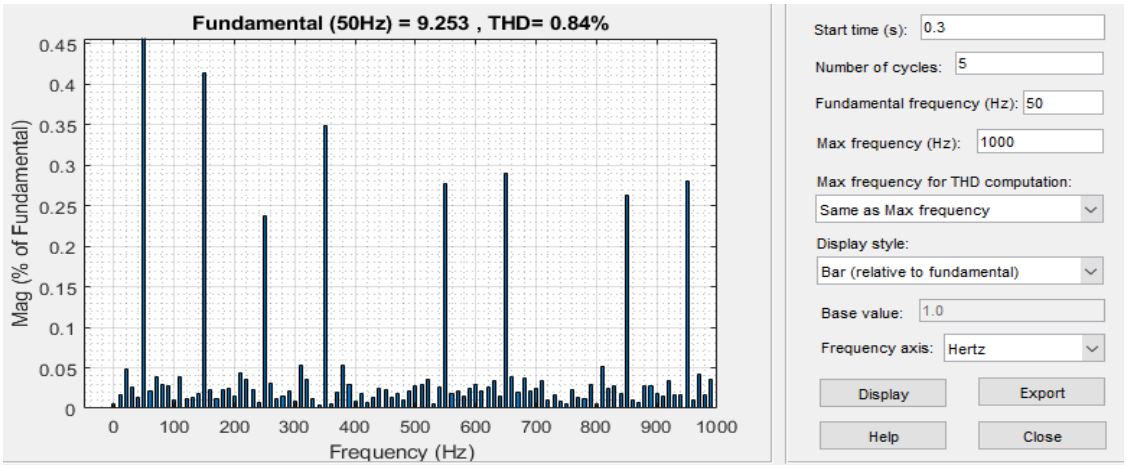


Fig. 16. THD result of I_S (Grid current) by ABC tuned ANN based SAPF

ABC-ANN parameters are listed in Table 1 and Table 2 presents the results of the SAPF investigations into all six incidents.

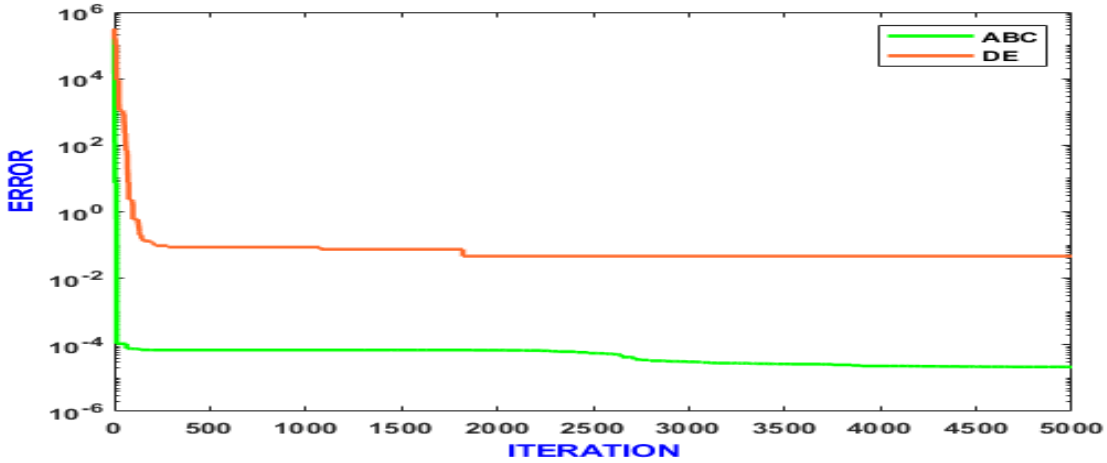


Fig. 17. Converges graph for the three optimization algorithms

Table 1
Parameters of ABC trained ANN

Total number of iterations	5000
Number of Population	25
Number of Onlooker Bees	25
Abandonment Limit Parameter	15
Acceleration Coefficient	1
Hidden number of Neurons	12
Total number of Variables	1
Max weights	200
Min weights	0

Table 2
Table of Comparisons

S_no	Type of Controller	Component	THD value(%)
1	Without using SAPF	I_S (Source Current)	18.42
2	PI based SAPF	I_S (Source Current)	3.76
3	PSO tuned PI Based SAPF [22]	I_S (Source Current)	0.93
4	DE tuned ANN based SAPF	I_S (Source Current)	0.90
6	ABC tuned ANN based SAPF	I_S (Source Current)	0.84

7. Conclusion

A novel Artificial Bee Colony based optimized Artificial Neural Network (ANN) controller is proposed for the purpose of improving the power quality in a SAPF-based power system with non-linear loads. Harmonics from nonlinearities are compensated and THD values are far below norms. This article recommends using the ABC-ANN control approach with the SAPF to reduce the THD in the power grid's source current. The successful implementation of the SAPF is evaluated and compared across a number of circumstances. The Matlab-Simulink software simulates total five situations and reports the results. Simulations show that DE-ANN, PSO tuned PI based SAPF and SAPF with PI controller minimize the THD, The ANN-ABC-based SAPF that was suggested provides better performance in terms of reducing THD in source current in comparison to other scenarios. According to the results, this improvement in performance is satisfactory (that is, within 5% of the recommended IEEE standard).

Future work will involve incorporating a hardware-in-loop implementation of the proposed shunt active filter. To further improve the SAPF's response, an ANFIS controller will be used that is predetermined with ABC and other optimization strategies.

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Optimized PI tuning of DG-Integrated Shunt Active Power Filter Using Biogeography-Based Optimization Algorithm

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ABSTRACT

This article proposes a biogeography-based optimization (BBO) approach to optimizing the PI controller gains of the PV integrated shunt active power filter (SAPF). This method is also used to analyze how these optimum gains affect the performance of SAPF. When nonlinear loads draw reactive power from the source, harmonics are produced, which can lead to power quality issues for the utility. Our ultimate goal is to achieve sinusoidal source current, which can only be accomplished with the help of FACT devices that enhance power quality in the distribution network. SAPF is a commonly utilized device. Solar is the most popular alternative energy source because it is the most cost-effective. Therefore, this article takes into account PV-integrated SAPF for analysis. To get the highest amount of power from a PV panel, a technique called maximum power point tracking (MPPT) is used. This technique is based on perturbation and observation (P&O) in MPPT. When the SAPF converter uses this maximum power, it also sends active power to the load, so that the SAPF converter has dual functionality like reactive power compensation (FACT) and active power supply (DG Functionality) to the load. The performance of this PV-Integrated SAPF depends on many things, like how the reference current is made, how switching pulses are made, how the voltage on the dc link is controlled, etc. In order to obtain the best possible performance from SAPF, certain design parameters, such as the gains of the PI-controller, need to be optimized. Modeling and simulation of a PV-integrated SAPF are performed in Matlab/Simulink. Gain optimization of the PI controller-based PV integrated SAPF is performed using both the proposed biogeography-based optimization method and the PSO algorithm, and the results are compared. The proposed BBO-trained PV- SAPF converter's active power injection was also investigated.

1. INTRODUCTION

Fossil fuels have been burned to meet power demand for decades, but they are nonrenewable and cannot be reused [1]. They aren't ecologically sound. Pollution-friendly and contribute to climate change, so [2] renewable energy sources like solar, wind, and geothermal are essential. There are clean sources of energy generation, such as hydro, etc., and there is an abundance of them. Photovoltaic power plants have widespread application; solar energy is naturally abundant, and electrical power is widely available. Solar power as dc from the arrays, which is converted to an alternating current one that uses an inverter. Due to the energy's reactive power balancing capabilities, this equipment can be used anywhere [3]. There are more harmonics in the network because of the rise in nonlinear electronic loads and devices. Presents of a harmonic nature as well as voltages that are powers of the fundamental frequency led to systemic cases of power degradation, and as a result, the machinery got hot. To better understand the role of alterations that happens when voltage and Currents are not proportional. The impedance of the load [4] Short-circuit current is drawn by these loads. Damage electronic devices with pulses and harmonics. Rectifiers and other electronic devices are examples of non-linear loads. Everything from computers and motors to SMPSs (switch mode power supplies) to get rid of harmonics uses passive filters, but they have a few drawbacks. Have bounds, such as in resonance, and evolve in accordance as the workload shifts. To reduce grid current harmonics, active power filters are being developed; unlike passive filters, which require an external power source, these don't affect demand levels [5, 6]. Active filters can achieve the required gain while simultaneously addressing issues with attenuation. They're diminutive, but they're more effective than passive filtering systems. Their ability to avert major active power filters can handle wider frequency ranges. Photovoltaic shunt-clearing harmonics are a common application for active filters. The module's findings or those found Maximizing power generation from PV systems while keeping costs as low as possible necessitates the use of power point tracking (MPPT) techniques [7]. Additionally, a boost converter is used to increase the voltage output. When PV is implemented, it depends on a variety of factors in the real world, including things like climate and solar radiation. There's been a lot of

study into improving old power in the grids employing various filtering strategies [8]. SAHF yields the contrasting major-minor harmonics so that it nullifies itself. Turn a nonlinear load into a linear one with linear pressure.

The goal of this work is to lessen harmonic distortion [9] in a distribution system with a non-linear load. By utilizing a shunt active power filter that is integrated with solar panels. Figure 1 represents the PV-integrated SAPF, which typically provides a current that is 90 degrees out of phase with the source current [10, 11]. As a result of the nonlinear load, the converter's output voltage dips, and the filter capacitor draws a greater amount of current than usual during the compensation process. So, in order to mitigate these unforeseen effects, it is proposed [12] that a SAPF be constructed with optimal parameters.

There has been a lot of study done on the topic of using an active power filter with a photovoltaic (PV) system. The filter's structure and tuning parameters are ignored, while a variety of methods for controlling current in a 3-phase, 4-wire distribution network are proposed in the study [13]. An improved current control approach [14] using a maximum power point tracking controller has been implemented to lessen system harmonics via a grid-connected inverter. Filtering techniques, such as a self-tuning PI controller [15, 16], have been used to decrease harmonic distortions in a grid, which comprises a voltage source converter, a hysteresis controller, and a DC voltage capacitor.

The parameters of today's automatic control systems are often optimized with the help of state-of-the-art soft computing techniques. The gains of PI controllers are optimized using particle swarm optimization (PSO) techniques [17, 18]. Evolutionary algorithm optimization techniques such as the genetic algorithm (GA) [19], bacterial foraging (BF) [20], firefly [21], ant colony optimization (ACO) [22], and differential evolution (DE) [23] have all been applied to the problem of determining the best possible gain settings for the PI controller in SAPFs.

In this study, BBO, a stochastic optimization method based on swarm intelligence, has been used for the fine tuning of PV-integrated SAPF PI parameters to control the DC link voltage to achieve the best THD. Using active power control theory, the SAPF converter also works like the DG converter.

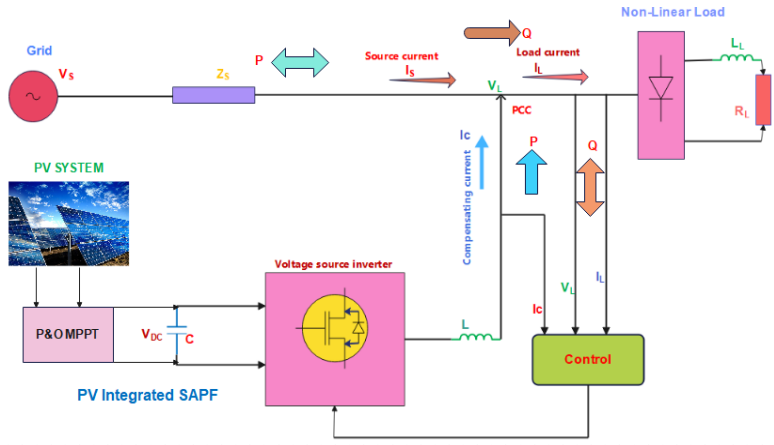


Figure 1. Model configuration of PV integrated SAPF

2. SYSTEM MODEL

The photovoltaic (PV) integrated shunt active power filter model that is the focal point of the present study is depicted in Figure 2. This model in its entirety includes the PV configuration, PV model, and PV array.

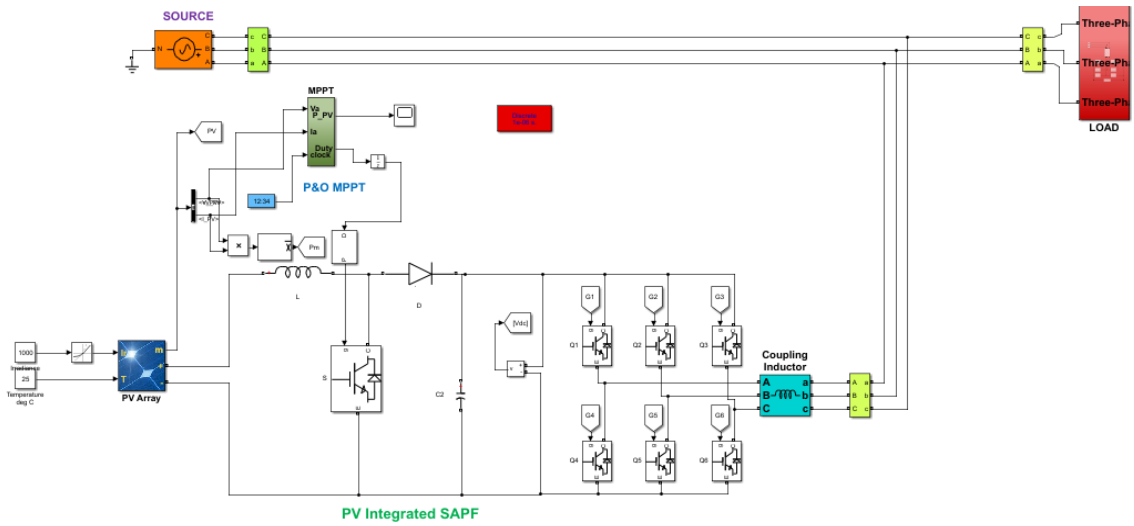


Figure 2. Simulink diagram of PV integrated SAPF when connected to non linear load

2.1 Mathematical modeling of shunt active power filters

The following assumptions need to be made in order to select the parameters for the SAPF, such as the interfacing inductance L_f and the DC capacitor C_{dc} as well as the reference dc voltage.

• The source current needs to have a sinusoidal pattern.
• The amount of distortion in the system current is no more than 5%.
• Converting takes place in a linear fashion.

The Q_C and I_h can be calculated using the two equations that are provided below.

$$Q_C=3V_CI_C = 3V_S \frac{V_C}{\omega L_f} (1 - \frac{V_S}{V_C}) \quad (1)$$

$$I_h = \frac{V_h}{m_f \omega L_f} \quad (2)$$

The V_{dcref} value can be adjusted in response to the rated voltage. The following equation is used to determine the appropriate value of C_{dc} to achieve the desired peak-to-peak voltage ripple level.

$$C_{dc} = \frac{\pi * I_c^{rated}}{\sqrt{3}\,\omega\, V_{PP}^{ripplee}} \quad (3)$$

where,

V_{dc}: The injected voltage from the filter.
L_f: The inductance of coupling for the SAPF.
C: The capacitor on the DC side of the filter.
V_s: The voltage of SAPF.
I_c: Compensating current from filter.
V_h: Harmonic voltage.

2.2 Basics of PV system

In order to convert solar energy into usable electricity, a PV system will use a series or parallel connection of PV modules or panels. Electrical output is generated via photovoltaic (PV) panels and associated mechanical and electrical connections. Solar photovoltaic (PV) output is normally dependent on solar irradiance, or the amount of sunlight available.

PV Cells, Modules, and Arrays PV cells can be connected together to make a module. Adding more modules to a PV plant works the same way, either in series or parallel, to boost the plant's power output.

A solar power plant's crucial fundamental component is PV cells. Silicon (Si) is the primary material used in solar panel construction. To generate an electric field, a thin semiconductor coating is polarized positively on one side and negatively on the other. The layer's surface is the source of the emitted electrons.

A PV cell typically produces a voltage in the range of 0.5 V to 0.7 V. As a result, the necessary output voltage and current can be obtained by connecting a series and parallel array of PV cells. In the event of partial shading, diodes in the PV array may be necessary to prevent the flow of current in the opposite direction. There is a risk of inefficiency when temperatures are very high. To counteract this, PV systems incorporate ventilation systems.

In order to convert the DC power from the PV panels into AC power for use in homes and businesses, inverter systems are installed. By connecting modules in series and parallel, higher voltage and current capacities can be achieved. The configuration is depicted in the Figure 3.

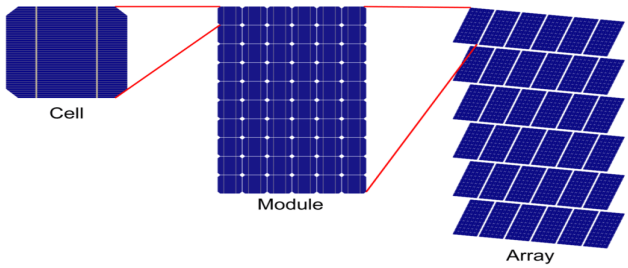


Figure 3. Interconnection diagram of solar cell, module, array

2.3 Module of PV system

The PV cell's circuit is depicted in Figure 4. It consists of only one diode, which is connected in parallel to the power supply. The function of a diode is to permit current to flow smoothly in one direction but substantially prevent it from flowing in the opposite direction. Diodes are sometimes referred to as rectifiers due to their ability to convert AC current into DC current. Both series resistance R_s and shunt resistance R_{sh} are denoted. There are two conditions for the cell, and the amount of current it draws from its source is directly related to the amount of sunlight it receives [24]. One is the potential difference between the terminals in a circuit that is open, and the other is the current in a short circuit.

When the diode is open, the voltage across it is zero, and the current through the short circuit I_{sc} is equal to the current through the current source, Voc.

The equation gives information about PV's properties.

$$I = I_L\text{-}I_0\,(e^{(v+R_s/n_s v_t Q_d)} - 1) - \frac{v+R_s}{R_{sh}}) \quad (4)$$

where, V is the array's voltage, I is the array's current, I_L is the light current, I_0 is the diode's reverse saturation current, Q_d is the diode's ideality factor, ns is the number of series cells, Rs is the series resistance, R_{sh} is the shunt resistance, V_t is the thermal voltage, and I_d is the diode current.

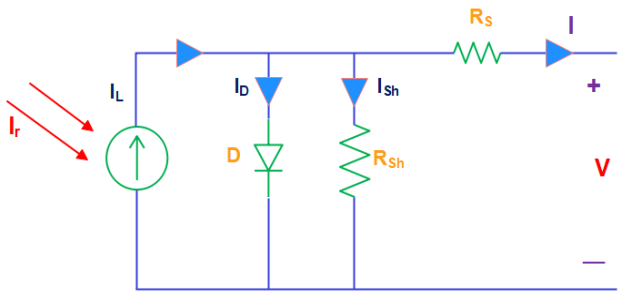


Figure 4. Single line diagram of photovoltaic system

Sun power SPR-315E-WHT-D modules were used in this study; their parameters and technical specifications are listed in Table 1.

Table 1. PV panel specifications

Parallel Strings	12
Series-connected modules per string	7
PV module name	Sun power SPR-315E-WHT-D
Max power	315.072
Open-circuit voltage (V)	64.6
Short -circuit current (A)	6.14
Voltage at MPPT (v)	54.7
Current at MPPT (a)	5.76
Irradiation (w/m^2)	1000

2.4 P&O MPPT algorithm

The P&O method uses the PV module to its full potential by maximizing efficiency in any environment. The primary benefit of this technique is the accessibility and preciseness of its algorithm, so that it can even be performed efficiently with a low-cost processor. However, a current and voltage sensor that measures the array's voltage and current is required for its implementation [25]. The power output of the PV is then calculated based on the data obtained for voltage and current.

If the duty cycle is altered by the expression P(n-1)=V(n-1)×I(n-1), and if the expression P(n)=V(n)×I(n) increases from the previous value, then n is an even number. The direction of the perturbation remains the same as P(n)=V(n)×I(n) grows larger, while when it decreases, the perturbation and, by extension, the duty cycle, switch directions [26]. Using the P&O technique, the system is represented in Figure 5.

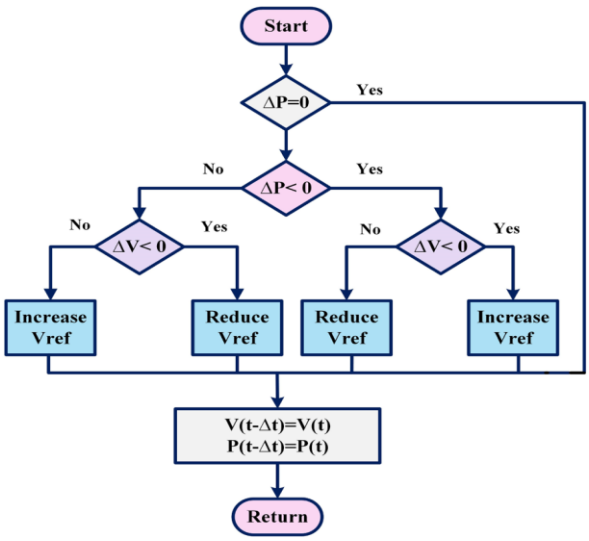


Figure 5. Flow chart representation of P&O MPPT

3. BBO OPTIMIZATION ALGORITHM

The natural phenomenon of biogeography acted as inspiration for a new metaheuristics technique called "biogeography-based optimization" (BBO). Biogeography is the study of how the geographic distribution of different species varies over time and space [27]. Simon [28] first proposed the BBO method for resolving certain continuous functions. Furthermore, this approach was developed on the basis of some principals, including species' ability to travel from island to island, the development of novel species, and the eventual extinction of extant ones. Some crucial BBO concepts are as follows:

3.1 Biogeography

According to biogeography principles, islands that are more favorable to life support systems tend to have more species, while less favorable islands tend to have fewer. Thus, the answers to the issues are like those islands. An excellent Habitat Suitability Index (HSI) value would characterize the ideal island. HSI is more commonly called "fitness" in other algorithms for population-based optimization, like the Genetic Algorithm. Suitability Index Variables (SIV) are the characteristics of the HSI. The HSI is the dependent variable in the habitat, and the SIV is taken as an independent variable.

3.2 Migration

High-HSI (or abundant species) habitats or islands will see high rates of emigration and low rates of immigration. Therefore, the higher HSI habitat is more likely to remain unchanged over time. Since these species have a high emigration rate, they are likely to relocate to nearby habitats. However, the migratory species wouldn't vanish entirely from the island of their ancestry. Those species would simultaneously appear on both islands. In most cases, the migration process would force the inferior solution to adopt the characteristics of the superior ones. If an island has a high emigration rate, it also has a low immigration rate, and vice versa. However, the island's rate of emigration is influenced by the variety of species that call it home. It stands to reason that islands with higher rates of emigration would be home to more species overall.

3.3 Mutation and elitism

In addition to migration, mutation and elitism occur during the BBO process. Mutation is a devastating ecological event. The rate at which mutations occur in various environments is known as the mutation rate. In some ecosystems, the mutation rate is proportional to the number of species present. The mutation rate in high-HSI environments is expected to be lower than in low-HSI environments. As a result, it is unusual for the mutation to preserve the good solution until the next generation is selected. Because of this mutation, novel environments would emerge to replace those with low HSI values. Without mutation, low-HSI solutions would become more prevalent, leading to a possible trap at the local optimum. Each habitat's mutation rate can be expressed as follows:

$$m_k = m_{max}\left(\frac{1 - P_k}{P_{max}}\right) \quad (5)$$

For any given habitat, the probability of having k different species is denoted by P_k, the mutation rate is denoted by m_k, and the maximum mutation rate is denoted by m_{max}, with Pmax being the maximum probability. Becauseof the mutation, a new habitat would appear in its place. The best previous solutions would also survive the elitism. All solutions, except the optimal ones with the highest probability (P_k), are equally susceptible to mutation. BBO's mutation mechanism is flexible in the same way that the mechanism of mutation that has been applied to the GA. Flow chart representation of BBO algorithm as shown in Figure 6.

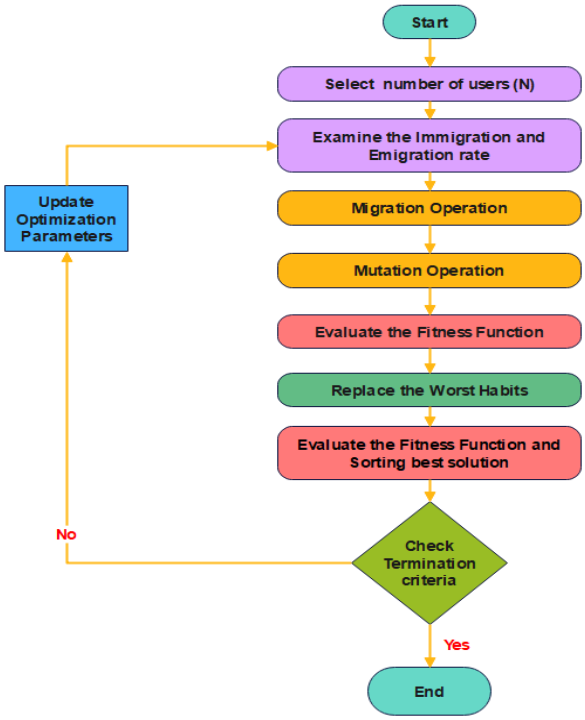


Figure 6. Flow chart representation of biogeography-based optimization (BBO)

4. PROPOSED METHODS

4.1 Tuning of PI controller by using BBO algorithm

The efficiency of a PV-integrated SAPF is dependent on the stability of the DC link voltage, which is regulated by the PI controller. Finding the gain (K_P, K_I) values of the PI controller in the critical controller is a complex mathematical process. The calculated gains are not optimal for the PI controller. To determine the best gains for the PI controller, this work implements BBO. Figure 7 shows the objective function, integral absolute error (IAE), as the discrepancy between the measured and target DC voltages. The BBO algorithm minimizes these objective functions and gives the best possible gains for the PI controller.

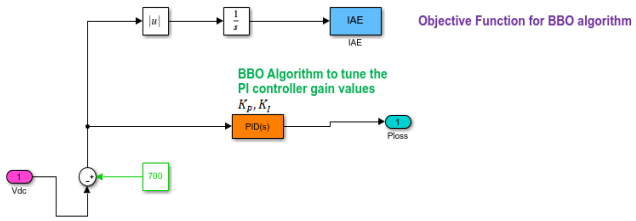


Figure 7. Simulink model of PI controller tuning with BBO algorithm

4.2 Active current coefficient control

This theory is proposed to find the actual active current required by the load, which is supplied from the PV source. Here first we need to sense the grid voltage (phase to phase) that is converted to phase to ground voltage, then these phase to ground voltages are again converted to α-β frame by using the clarck transformation, and again these α-β frame voltages are converted to an a-b-c reference frame by using the inverse clarck transformation. From that, we will get grid voltages in the a-b-c reference frame (Vg_a, Vg_b, Vg_c). These voltages pass through a band pass filter in order to remove some higher-order harmonics, and here we generate some unique vectors for synchronization of the grid with PV. And again, we need to sense the load current. With these load currents and the unique vectors, we need to find the active current coefficients for lines a, b, and c, as shown in Figure 8. Finally, we will take the average of these and get the actual active current requirement for the load (I_L).

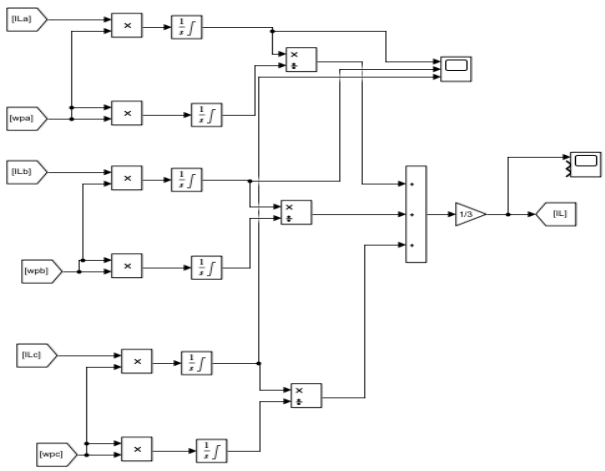


Figure 8. Simulink representation of active power coefficient theory

5. RESULTS AND DISCUSSION

This model implements a photovoltaic (PV)-based shunt active filter to mitigate undesired harmonics and enhance the power quality of the system. In order to produce gate pulses for the inverter, a hysteresis controller is built into the voltage source inverter (VSI). The model utilizes the P&O-based Maximum Power Point Tracking (MPPT) technique in order to optimize solar power extraction. The model is evaluated both with and without the inclusion of SAHF in order to analyze the network. By analyzing the data, we can determine the V-I characteristics. The shunt active filter based on photovoltaic (PV) technology is evaluated and examined using the MATLAB/SIMULINK software in order to mitigate current harmonics and facilitate power enhancement. The input supplied to the photovoltaic panel consists of solar irradiance of 1000 w/m^2 and a temperature of 25°C.Max power, open circuit voltage, and short circuit current are shown in Figure 9.

Since PV cells and other nonlinear loads are used, the source current is mostly made up of harmonic components, which affect all other loads in the distribution system. Here, the effects of a nonlinear load and the PV cell on harmonics have been looked into. A nonlinear load is used in the FFT analysis. Also, the gains of PV-SAPF's PI controller are chosen at random using trial and error. So, to improve the performance of SAPF, getting the gains of the PI controller to be as good as possible can be accomplished by employing the BBO optimization technique. In this study, the active power injection from this PV-SAPF is further examined.

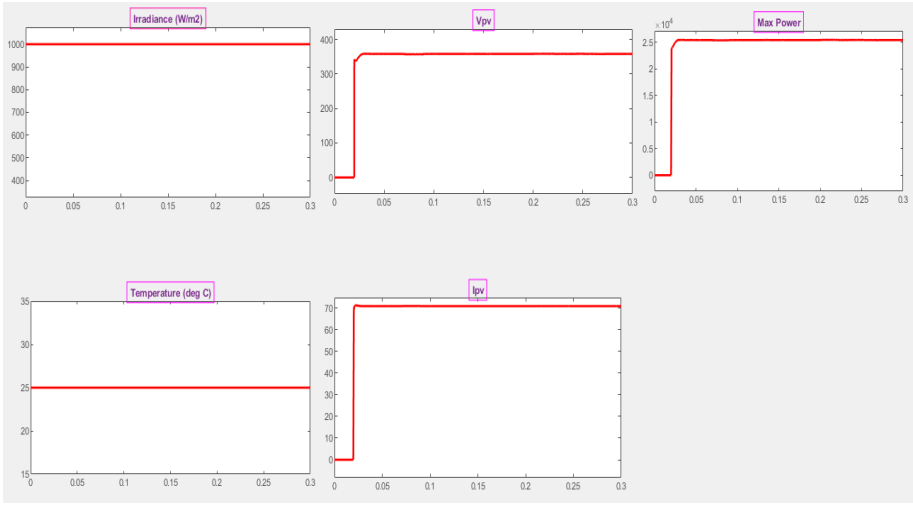


Figure 9. Output characteristics (P_{max}, V_{PV}, I_{PV}, Irradiation) of PV module

5.1 Harmonic spectrum of PV-SAPF with PSO-PI controller

Here, the PV-integrated SAPF utilizes a PSO-PI controller to control the voltage on the DC capacitor. Conventional controllers involve a lot of mathematical calculation, which is not accurate, so the gain values of the PI controller are tuned with the support of PSO's optimization algorithm. The PSO technique uses a minimization of the objective function known as the integral absolute error (IAE) to find the best possible values for the gains. With a maximum number of 100 iterations and 25 populations, For K_p and K_i, we chose 0 and 200 as the absolute minimum and maximum values, respectively.

Figure 10 shows the harmonic spectrum of PV-SAPF with the PSO-PI controller, where the THD in the grid current is 1.18%, and it shows that it is reduced from 3.08% to 1.18%.

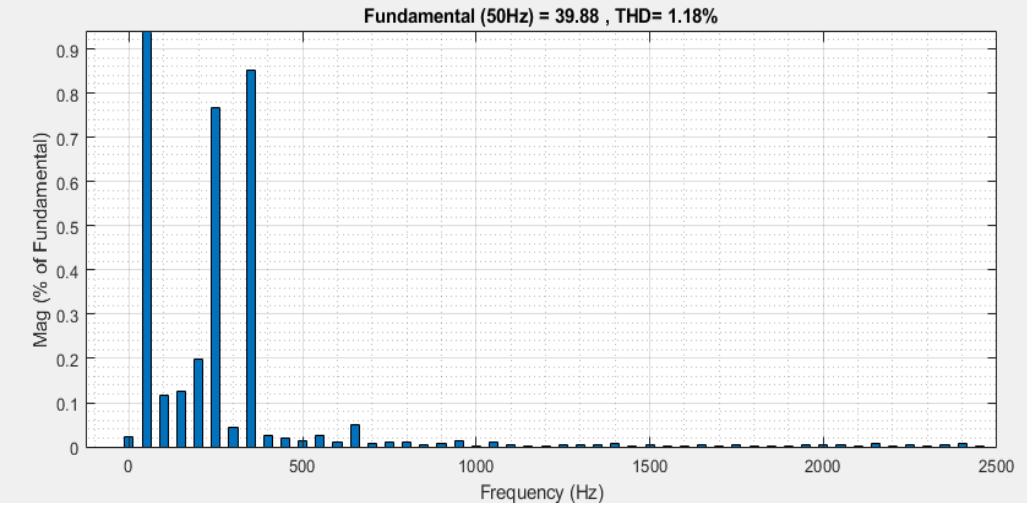


Figure 10. Grid current THD of PSO trained PI controller based PV-SAPF

5.2 Harmonic spectrum of PV-SAPF with BBO trained PI controller

Here, the PV-integrated SAPF utilizes a BBO-trained PI controller to control the voltage on the DC capacitor. A biogeography-based optimization (BBO) strategy will be used to make the necessary correction of the error voltage (IAE), which is the objective function, by adjusting the K_p and K_i gains of the PI controller. Figure 11 provides a graphic representation of source-side voltage (V_S) and source-side current (I_S) that are generated by a PV-SAPF that is controlled by a BBO-PI controller. In the event that a nonlinear load is connected to the grid at the same time, for the grid current to continue to have its normal sinusoidal shape maintained, SAPF will inject the compensating current at the PCC. Figure 12 represents the harmonic spectrum of PV-SAPF with a BBO-PI controller. From observing the figure, it is very easy to see that the THD value at the source current is 0.91%, and it shows that it is reduced from 1.18% to 0.91%. Table 2 represents the parameters of the BBO-PI controller.

Table 2. BBO configurations

BBO Parameters	Values
Maximal Iterations	100
Tuned Parameters	2
Keep Rate	0.2
Total Quantity of Reatained Habitats	5
Total Quantity of Fresh Habitats1	20
Total Populations	25
Alpha	0.9
Mutation	0.1
Emigration and Immigration Rates	1

5.2.1 Active power (P) & reactive power(Q) from PV-SAPF inverter

When PV is integrated into SAPF using active power coefficient theory, the SAPF converter will have dual functionality.

The PV-SAPF-SAPFrter works like DG; it will inject active power into the load.

The PV-SAPF-SAPFrter works like a FACT device; it will inject reactive power into the load.

Figure 13 represents the active and reactive power from the PV-SAPF inverter. From that, we can clearly observe that the PV-SAPF inverter is injecting 25.4 KW of active power and 2.054 KVAR of reactive power at the PCC.

5.2.2 Active power (P) & reactive power(Q) at load

Figure 14 represents the active power (P) and reactive power (Q) at the nonlinear load. From that, we can clearly observe that the load requires active power of 5.226 KW, which is taken from the PV-SAPF converter, and reactive power of 2.058KVAR, which is also taken from the PV-SAPF inverter.

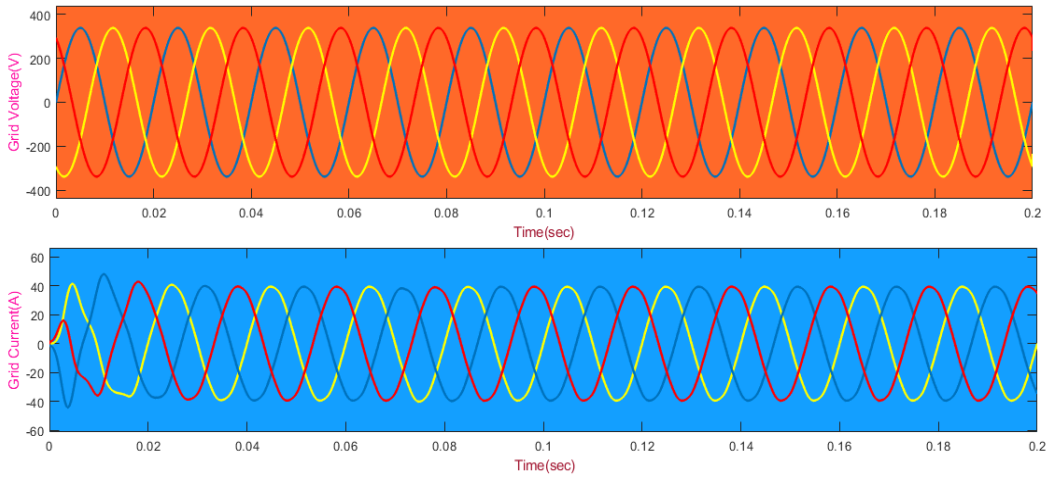


Figure 11. Source voltage and source current wave forms of BBO trained PI based PV-SAPF

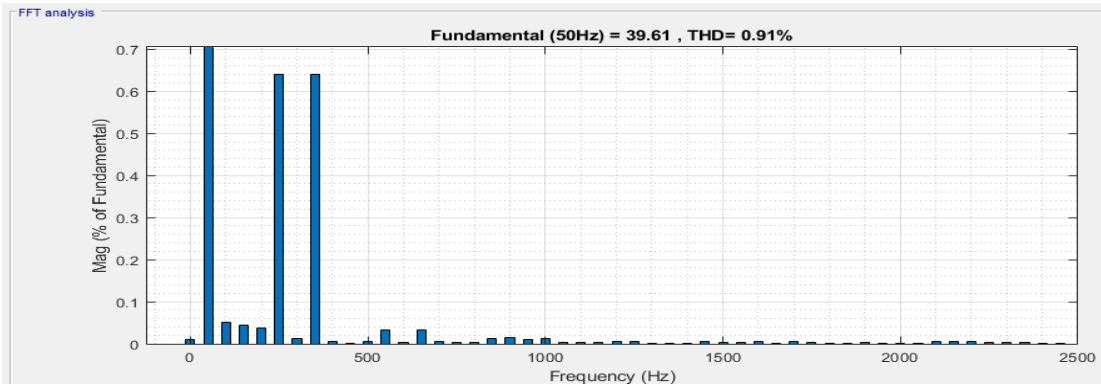


Figure 12. Grid side current THD of BBO trained PI controller based PV-SAPF

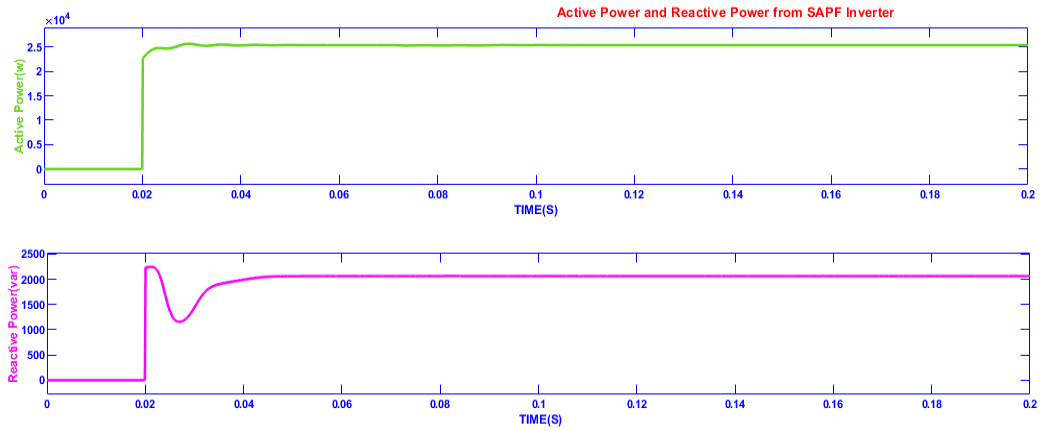


Figure 13. Active power and reactive power wave forms from PV-SAPF converter

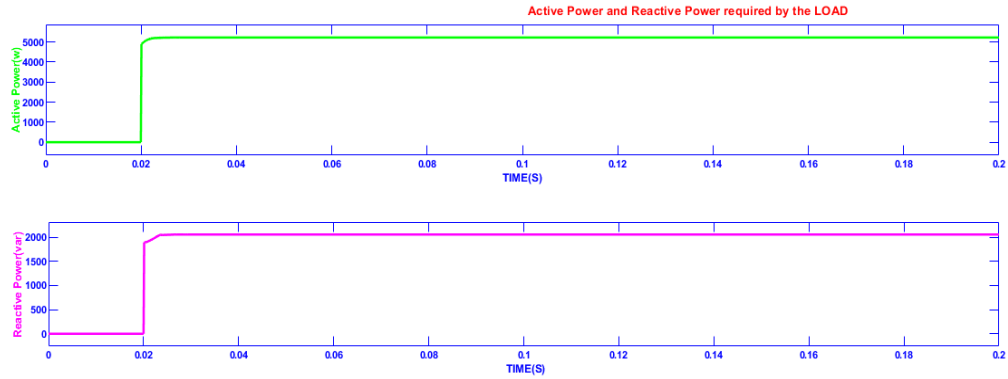


Figure 14. Active power and reactive power wave forms required by the load

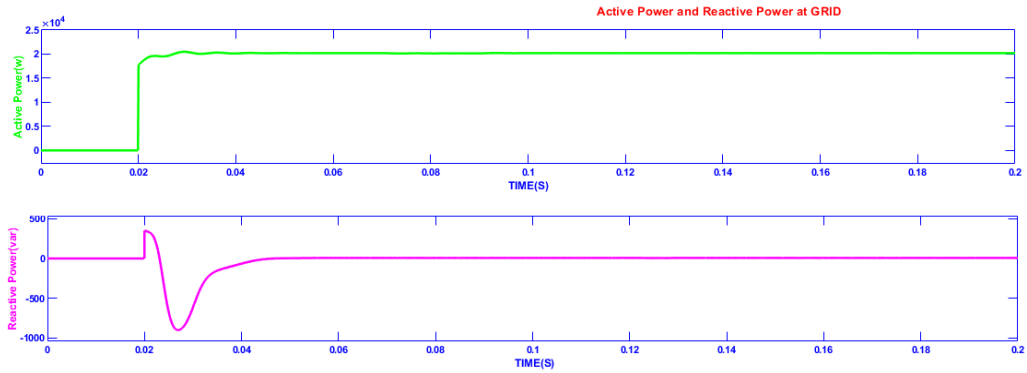


Figure 15. Active power and reactive power wave forms at GRID side

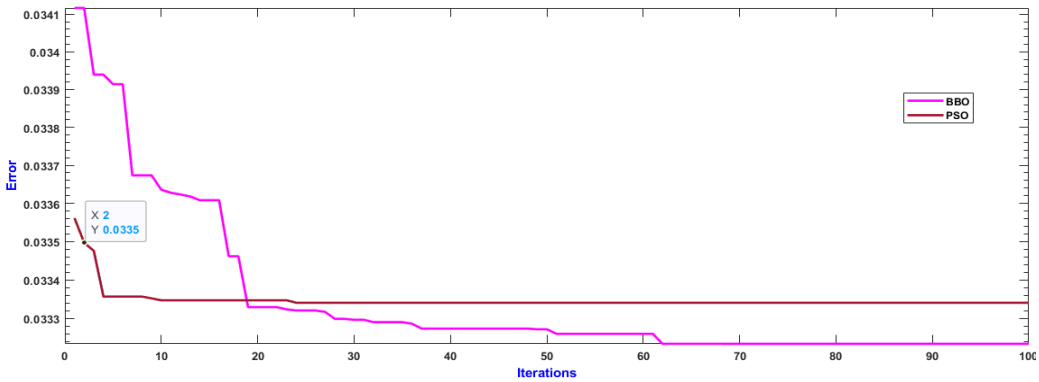


Figure 16. Converges spectrum of PSO & BBO trained PI controller based PV-SAPF

Table 3. Quantification comparisons

S_no	Type of Controller	Component	THD Value (%)
1	Without SAPF	I_S(SourceCurrent)	18.42
2	PI based PV- SAPF	I_S(SourceCurrent)	3.08
3	PV-SAPF with PSO-Trained PI cotroller	I_S(SourceCurrent)	1.18
4	PV-SAPF with BBO-Trained PI controller	I_S(SourceCurrent)	0.91

5.2.3 Active power (P) &reactive power(Q) at grid

Figure 15 represents the active power and reactive power (P&Q) at the source side; from that, we can clearly observe that the grid is not generating any reactive power (Q) for the load. At PCC PV-SAPF injecting 25.4 KW of active power, the load is taking around 5.226 KW, and the remaining 20.17 KW of active power is sent to the grid.

The converging spectrum of the BBO-PI-based PV-SAPF controller is depicted here in Figure 16, as it can be seen. It has been demonstrated that the error that is measured by the BBO-PIcontroller is less than that which is measured by the PSO-PIcontroller. The SAPF investigation findings for different incidents are listed in Table 3.

From the Table 3, we can clearly observe that the THD with a PSO-tuned PI-based PV-SAPF is 1.18%, and the proposed BBO-tuned PI-based PV-SAPF achieves a THD of 0.91%, which means the quality of grid current is better with BBO-trained PV-SAPF when compared to PSO algorithm-based PV-SAPF.

Active Power and Reactive power from SAPF inverter, Load, Grid at irradiation 0 w/m^2 and 10000 w/m^2 as given in Table 4.

Table 4. Power comparisons

Power/Irradiation	With Out DG Integration (0 W/m^2)		With DG Integration (1000 W/m^2)	
	Active Power (KW)	Reactive Power (KVAR)	Active Power (KW)	Reactive Power (KVAR)
Grid power ((P_s) & (Q_s))	5.239	0.3186	20.17	0.006
Load power ((P_L) & (Q_L))	5.226	2.058	5.226	2.058
SAPF inverte power ((P_F) & (Q_F))	0.0139	2.058	25.4	2.054

6. CONCLUSION

In this paper, we investigate the effectiveness of a PV-based shunt active filter with nonlinear loads in reducing harmonic distortion and improving overall power quality. Active filters are not the only option available, and passive filters are used for this purpose too. However, passive filters have issues such as load variation that active filters do not. It's a more cost-effective system because active filters are cheaper than passive ones. Solar irradiation and ambient temperature are two of the variables used in the PV module simulation. The P&O algorithm is used in conjunction with maximum power point tracking techniques to extract the maximum amount of power possible from PV. To increase the array's voltage, a boost converter is connected to it.

This study presents a proposed configuration for a photovoltaic (PV) integrated shunt active power filter. The configuration incorporates a biogeography-based optimization (BBO) for DC-link control, operating under ideal voltage conditions. The objective of this configuration is to improve power quality by reducing total harmonic distortion (THD). The Matlab-Simulink software runs simulations of two different scenarios and then presents the findings. The simulation results show that the THD with a PSO-tuned PI-based PV-SAPF using a PI controller is 1.18%, and the proposed BBO-tuned PI-based PV-SAPF achieves THD 0.91%, which is even better results in reducing THD in the source current than the PSO-tuned PI-based PV-SAPF. The proposed BBO-trained PV-SAPF provides not only reactive power compensation but also injects active power as required by the load.

7. FUTURE SCOPE

This suggested shunt active power filter will be implemented in hardware-in-loop in the future. The response of the PV-integrated SAPF can be improved through the implementation of an ANN, an ANFIS controller using BBO, as well as additional optimization strategies.

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Mitigation Of Grid Current Harmonics By Using Anfis Based Shunt Active Power Filter

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Abstract:
More applications are using non-linear power electronic equipment, which distorts the current distribution system and creates significant Power-Quality (PQ) issues. These sophisticated non-linear power electronics, such as rectifiers and switch-mode power supplies, cause reactive power issues and harmonic current distortions that deteriorate the purity of source waveforms at the distribution system's common coupling/feeding point (PCC). Modern power systems must be designed with dependable power filters that reduce voltage and current harmonics in order to satisfy utility grid power quality standards.

This project discusses a thorough, methodical approach to designing a shunt active power filter (SAPF) for improving power quality. The DC-link voltage is controlled by an ANFIS controller. The extraction of the reference current makes use of the instantaneous reactive power theory. Based on PQ theory, the best Shunt Active Power Filter has been created for PQ improvement; this is the technologically and commercially ideal equipment. MATLAB/Simulink is used to generate and simulate the detailed SAPF for balanced nonlinear loads.

Key Word*: Power Quality (PQ), Common Coupling Point(PCC), Shunt Active Power Filter(SAPF), Adaptive Neuro-Fuzzy Inference System (ANFIS).*

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I. Introduction

Power electronic switches are the foundation of nonlinear electric appliances, which are extensively employed in both residential and commercial applications across the globe [1,2]. Power quality issues such harmonic distortion, voltage fluctuation, and noise are caused by nonlinear loads like arc furnaces, variable frequency drives (VFDs), and personal computers [3-5]. Power losses, electric device heating, insulation failures and the communication system interference, in the worst situations, electric power systems failures are all caused by harmonic distortion in low-voltage distribution systems[6]. As a result, fixing power quality issues has emerged as a crucial concern for both the utility and the consumer [7-8]. This standard specifies that the total harmonic distortion (THD) cannot be greater than 5%. Power filters are thus utilised in order to adhere to the 5% restriction [9]. Power filters are readily available, effective technologies that are frequently employed to stop the spread of harmonic distortion. Typically, passive power filters in series and shunt configurations are connected to the distribution network in order to enhance power quality [10]. Designing a passive power filter that can successfully remove harmonic current distortion in industrial nonlinear loads connected to a stiff power source is difficult, tough[11]. Additionally, the passive filter is connected to intrinsic flaws include its massive bulk, resonance with utility or load impedance, unpredictability and rigidity [12–14]. On the other hand, passive filters have been substituted by active power filters (APFs) that use voltage source inverters (VSIs) in order to overcome the classic filters limitations.

APFs are a great way to address power quality issues because of their many advantages, which include flexibility, quick dynamic response, and accurate progressive filtering [15]. The current harmonics, reactive power sensing technique, compensation control algorithm, and other factors primarily dictate the harmonic mitigation capability of the shunt active power filter [16–17]. The instantaneous reactive power theory (P-Q theory) is commonly used to compare the various reference compensation current control systems. The following steps are taken in order to finish the donations listed above: Section II provides ANN based SAPF, Fuzzy tuned PI based SAPF, ANFIS based SAPF.

Shunt Active Power Filter:

The most widely used kind of active filter is SAPF. A SAPF converter can be single-phase or three-phase, and it can be a voltage source or current source inverter. With a 180° phase shift, this filter functions as a current source, injecting the harmonic components of the load. Its controller forces a power electronic converter

to accurately synthesize the compensating current reference by computing it in real time. Selective and adaptive active filtering is made possible by this technique. Stated differently, a SAPF may track changes in the harmonic content of a nonlinear load on a regular basis and adjust for the harmonic current of the load. The shunt active filter of source current harmonics is controlled by four different algorithms. For this project, PQ theory is being used. In order to create the SAPF reference current for source current harmonic mitigation, the theory (PQ), an adaptive phase-locked loop (PLL), the instantaneous active and reactive current method (DQ), and the synchronous detection method (SD) are designed in Matlab Simulink. For this project, PQ theory is being applied.

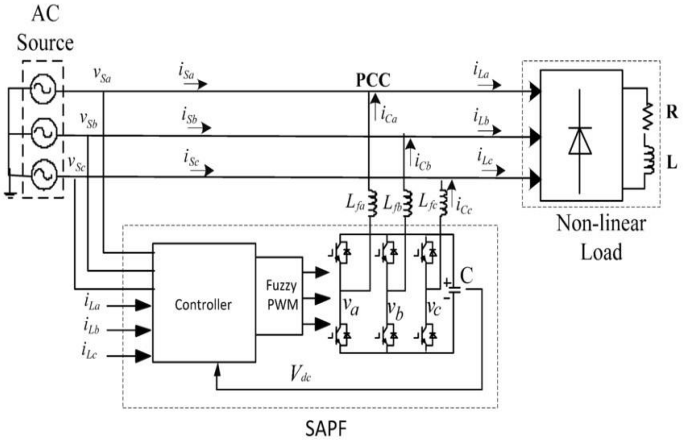


Figure 1.1: Block diagram of SAPF

P-Q Theory:

According to (PQ) theory, the reference current signal computation is based on detecting the three-phase currents and voltages to the power system and then using an algebraic transformation (Clarke Transformation) to convert them into (ϱ-β) coordinates and generates reference currents. DC voltage regulation done by PI controller.

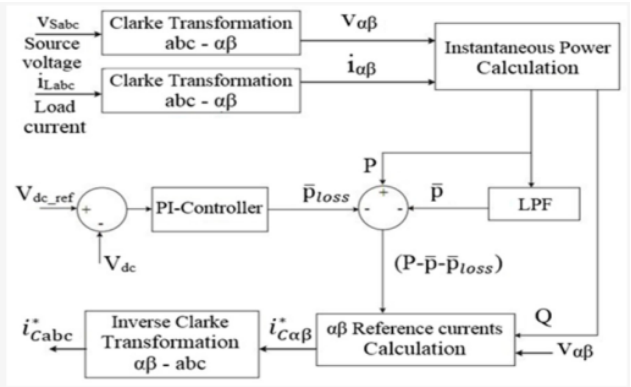


Figure 1.2: Block Diagram of PQ Theory

II. Proposed Controllers

The MATLAB simulative environment was used for the implementation of the proposed reference generation and current control techniques for a SAPF. This study was implemented according to the following scenarios.

- ANN based SAPF
- FUZZY tuned PI based SAPF
- ANFIS based SAPF

ANN Based SAPF:

Shunt active power filter performance is based on how well harmonic components are removed from distorted current waveforms with respect to accuracy and precision. The optimal performance for removing harmonic components from the voltage or current waveform has led to the development of the shunt active power filter control algorithm. In order to control voltage, a conventional PI controller is typically used.

However, because of its limitations, such as the time-consuming and difficult process of detecting PI parameters, as well as other drawbacks like the inability to improve the system's transient response, an artificial neural network (ANN) controller has been introduced in this research work. This is because of the controller's high speed of recognition, learning ability, and adaptability to any system. A mathematical model that draws inspiration from biological neural networks is called an artificial neural network (ANN).

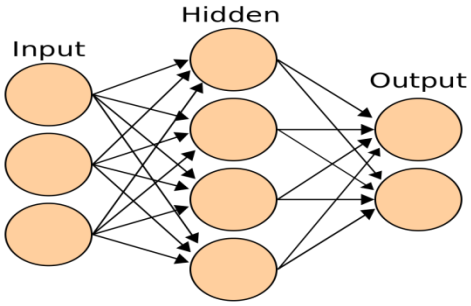


Figure 2.1: Structure of ANN

An artificial neural network is made up of a network of connected artificial neurons that compute information using the connectionist technique. It is similar to the brain in two ways: one is the learning process is how the network gathers the data, two is The data is stored using interneuron connection strengths. The MATLAB workspace has the vast amount of DC-link voltage data for the "n" and "n-1" intervals obtained via the traditional method. After that, the ANN Controller is trained using this data that has been retrieved. To process the information, the number of neurons in the input and output layers is essentially fixed. In order to reduce the likelihood of errors occurring, six validation checks and seven hidden layers with 1000 iterations are performed at each training session. The necessary conditions for the intended compensation in the case of SAPF are the quick identification of the disruptive signals with high accuracy and the quick processing of the reference signals.

Fuzzy Tuned PI Controller Based SAPF:

Fuzzy logic is a control approach used in control system engineering for issue solving. In 1965, Zadeh created the idea of fuzzy logic. Mamdani and Pappis produced the first fuzzy controller in 1977, which was a steam engine controller. Later, they developed fuzzy traffic lights [8]. Three regions typically make up the FLC design depicted in Figure 3: allocating the fuzzy area to a linguistic value, developing a fuzzy inference system (rules), and defuzzify into a real value.

Control System Design:

The process of creating a controller for a complicated physical system comprises the subsequent stages: Dividing the large-scale system into a number of different smaller systems, Linearizing is the nonlinear plane dynamics about a set of operational locations by gradually varying the plant dynamics, Assembling a collection of output characteristics, control variables, or state variables for the system under study, Creating basic P, PD, and PID controller designs for the subsystems. Additionally, optimal controllers can be created.

Fuzzification:

The FLC's first component is the fuzzifier that transforms crisp inputs into a set of membership values in the interval [0,1] in the corresponding fuzzy sets. The membership function shapes are typically triangular, trapezoidal, and Gaussian. In these membership functions, Gaussian MF's is good robustness than other membership functions. Gaussian membership function inputs are error (e) and its change in error (Δe) with fuzzy labels NB (negative big), NS (negative small), ZO (zero), PS (positive small) and PB (positive big). The membership functions' corresponding outputs are propagation gain (KP) and integration gain (KI) for respective input labels.

Rule Elevator:

FLC uses linguistic variables instead of numerical values. The basic FLC operation uses the following fuzzy set rules to control the system.

$$\text{AND–Intersection} \quad \mu A \cap B = \min[\mu A(X), \mu B(X)]$$
$$\text{OR–Union} \quad \mu A \cup B = \max[\mu A(X), \mu B(X)]$$

Defuzzification:

FLC rules produce the necessary output in a linguistic variable (Fuzzy Number) based on real-world requirements. It is necessary to convert linguistic variables into clear output (Real number).

(x, mf, type) = defuzz(x)

The argument states that defuzz (x, mf, type) employs multiple defuzzification algorithms to deliver a defuzzified
result from a membership function (MF) positioned at the associated variable value x. The following are possible choices for the variable type:

- Principle of maximum membership
- Weighted average approach
- Centroid Approach

Fuzzy-PI:

The non-linear plant with unpredictable parameter variations requires automatic tuning of the settings of the standard PI controllers. A formal approach for applying human heuristic knowledge gleaned from any system experience is the fuzzy system. To achieve excellent system performance and lessen the impact of parameter fluctuations, a self tuning fuzzy PI controller can be created. Figure displays the block diagram for the suggested self-tuning fuzzy PI controller for the SAPF.

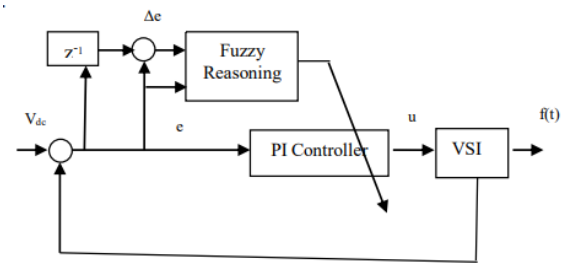


Figure 2.2: Fuzzy tuned PI controller.

ANFIS BASED SAPF:

The Adaptive Neuro-Fuzzy Inference System (ANFIS) combines artificial neural networks with fuzzy logic, two popular soft computing techniques. The fuzzy logic system has numerous inputs and a single output, whereas the neural system has many inputs and multiple outputs. This combination is known as ANFIS, and it is utilised in nonlinear applications. It endows non-linear systems with accuracy. Because of this, ANFIS is the most extensively used controller and is superior to other controllers. ANFIS has the capacity to learn from data and forecast outcomes using that data. The weights of the connections between the neurons in the network can be changed by the learning algorithm. An artificial neural network that is based on the Takagi-Sugeno fuzzy inference system is called an adaptive network-based fuzzy inference system (ANFIS).The early 1990s saw the development of the method. It can combine the advantages of neural networks and fuzzy logic in one framework because it incorporates both of these concepts. Two components of the network structure can be distinguished, namely the premise and the portions that follow. To be more specific, there are five levels that make up the architecture. The initial layer decides which membership functions correspond to the input values. It's often referred to as the fuzzification layer.

Structure Of ANFIS:

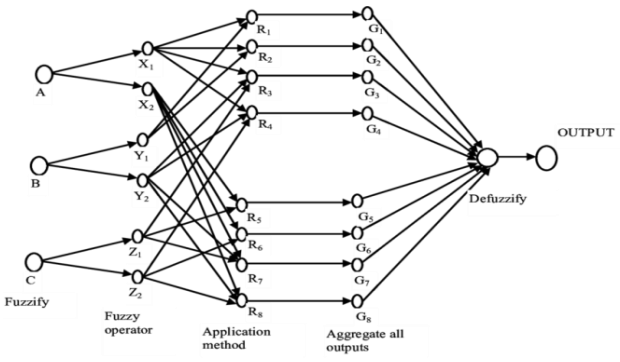


Figure 2.3: Structure of ANFIS

The node functions in each layer are as described below.
Fuzzification Layer: In this layer, membership functions are used to transfer the input variables to fuzzy sets. The linguistic variables that reflect the system's imprecision and uncertainty are represented by the fuzzy sets**.**
Rule Layer: Fuzzy if-then rules are applied to the input variables by the rule layer. A collection of fuzzy if-then statements that are developed based on expert knowledge or taken from data are used to express the rules.
Normalization Layer: To guarantee that the total firing strength is equal to one, the firing strength of each rule is normalized in this layer**.**
Defuzzification Layer: The output of every rule is combined by the defuzzification layer to produce a clear output value. Depending on the application, several defuzzification techniques may be employed, including weighted average, maximal defuzzification, and centre of gravity.
Learning Layer: The ANFIS controller adjusts to system changes in the learning layer. A neural network that has been trained to understand fuzzy rules and membership functions makes up the learning layer. A hybrid learning approach that combines least squares and back propagation techniques is used to train the neural network. When the ANFIS controller is operating, it receives input values and uses the fuzzy rules to produce an output value. In order to modify the input values, the output value is then given back into the system as feedback. By using the learning layer to update the membership functions and fuzzy rules, the ANFIS controller can adjust to changes in the system. All things considered, the ANFIS controller makes use of neural networks to learn from and adjust to system
changes, as well as fuzzy logic to capture the uncertainty and imprecision of the system. The ANFIS controller is an effective tool for managing complex systems with nonlinear or unpredictable dynamics because of its hybrid approach.

III. Result And Discussion

The MATLAB simulative environment was used for the implementation of the following scenarios.

- Without SAPF
- SAPF with conventional PI controller
- ANN
- FUZZY tuned PI
- ANFIS based SAPF

Without SAPF: In this case, SAPF is disabled as shown in figure 3.1 and a Fast Fourier Transform (FFT) analysis is used to determine the distortion in source current caused on by the nonlinear load.

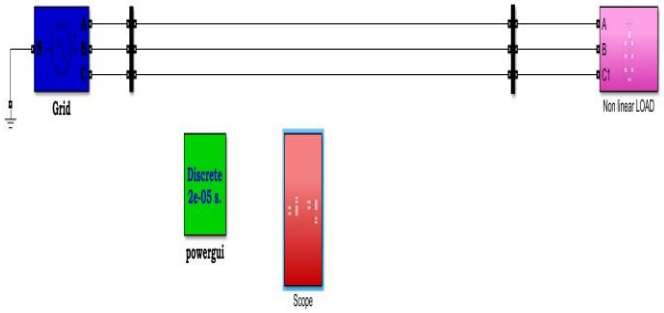


Figure 3.1: Simulink model for without SAPF

Due to the nonlinear loads connected at distribution network lead to distortion in the grid current waveform. After analyzing the FFT spectrum it gives the THD 22.24% as shown in figure 3.2 and figure 3.3.

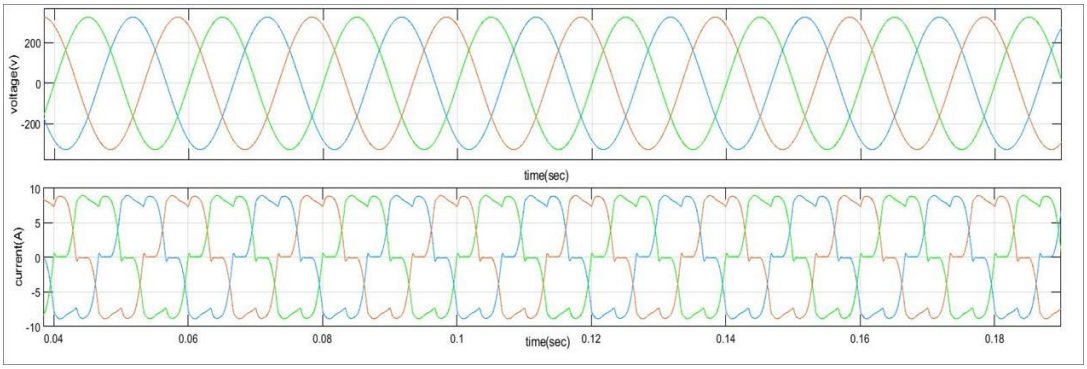


Figure 3.2: Waveforms of Voltage and Current for the system without SAPF

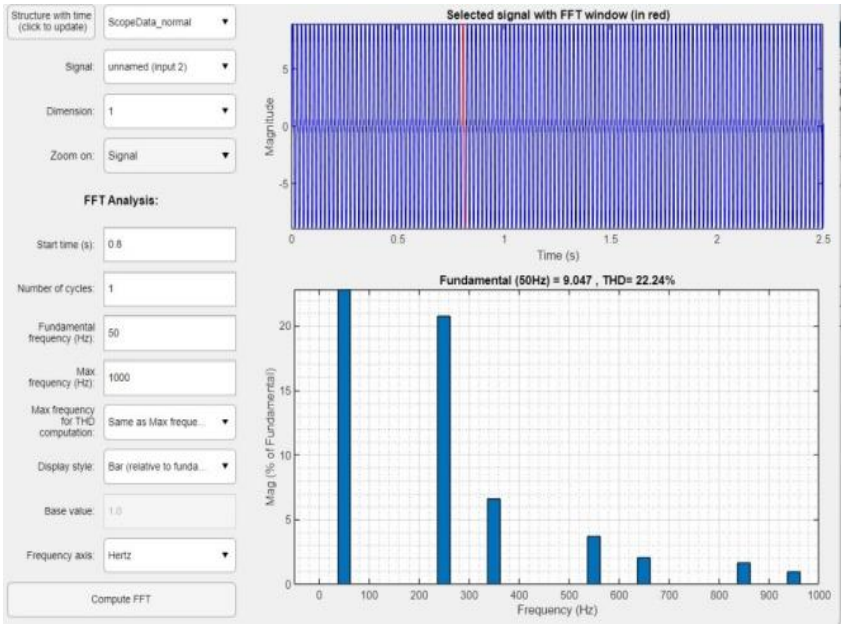


Figure 3.3: THD for without SAPF

SAPF With Conventional PI: In this case Conventional PI controller is connected to SAPF shown in figure 3.4. Fast Fourier Transform (FFT) analysis is performed to know the distortion in source current.

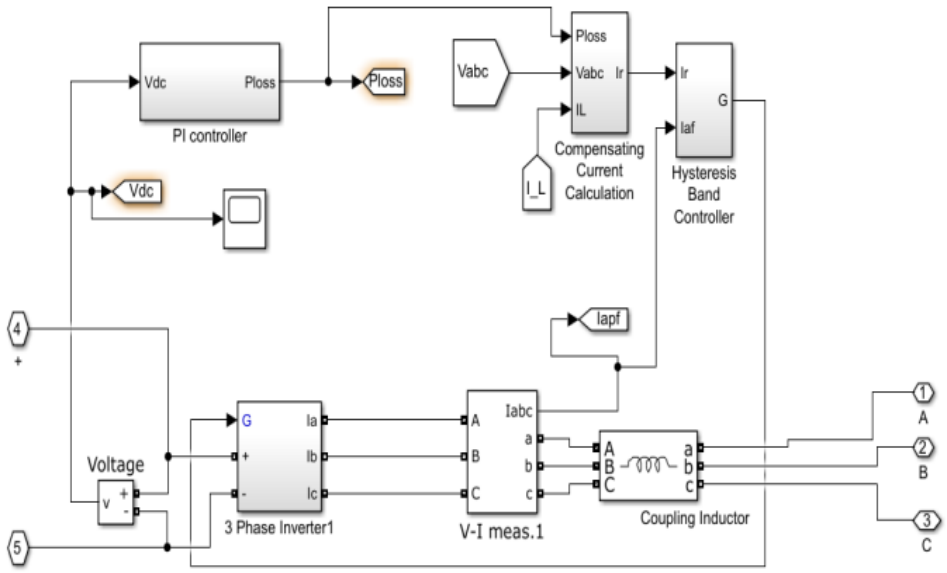


Figure 3.4: Simulink model for SAPF with conventional PI controller.

By using SAPF with PI Controller in Power system network reduces the distortion in the grid current waveform, which makes the current waveform sinusoidal. THD reduces to 1.83% as shown in figure 3.5 and 3.6.

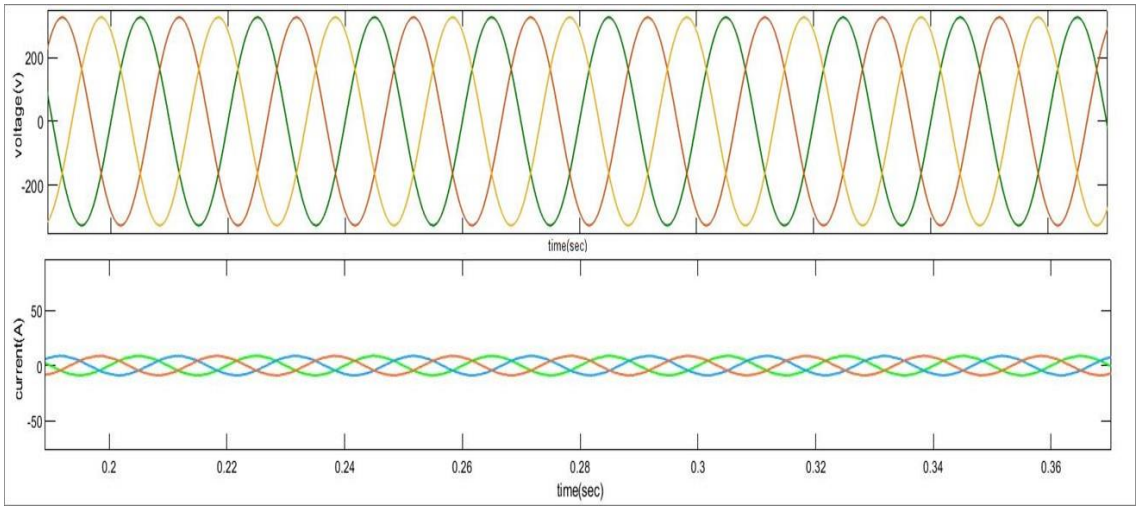


Figure 3.5: Waveforms of Voltage and Current of system with SAPF

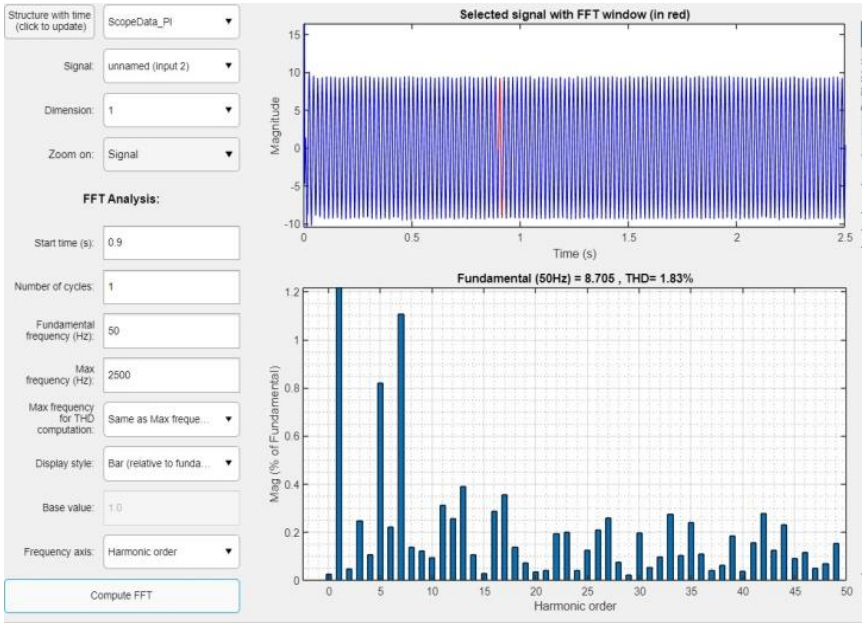


Figure 3.6: THD for Conventional PI Controller based SAPF

ANN Based SAPF: In this case ANN is connected to SAPF shown in figure 3.7. Fast Fourier Transform (FFT) analysis is performed to know the distortion in source current.

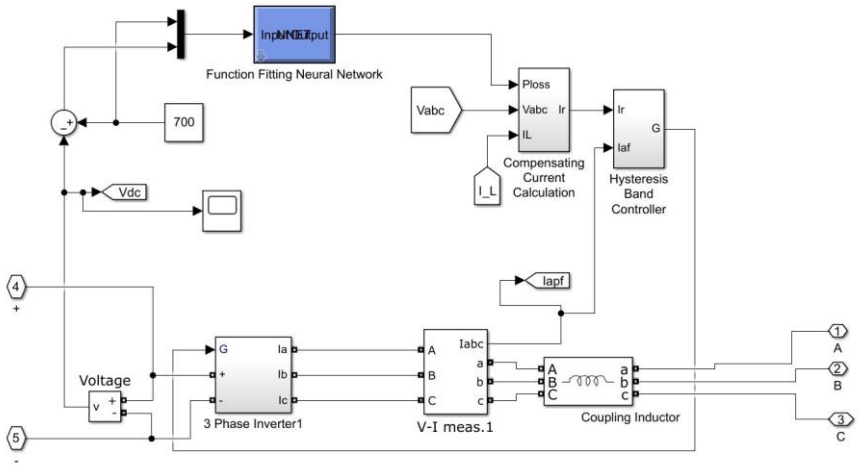


Figure 3.7: Simulink model for ANN based SAPF

The total harmonic distortion (THD) by using Artificial Neural Network based Shunt active power filter is 1.77% as shown in figure 3.8 and figure 3.9. We observed that the total harmonic distortion by ANN is reduced when compared with conventional PI controller based SAPF.

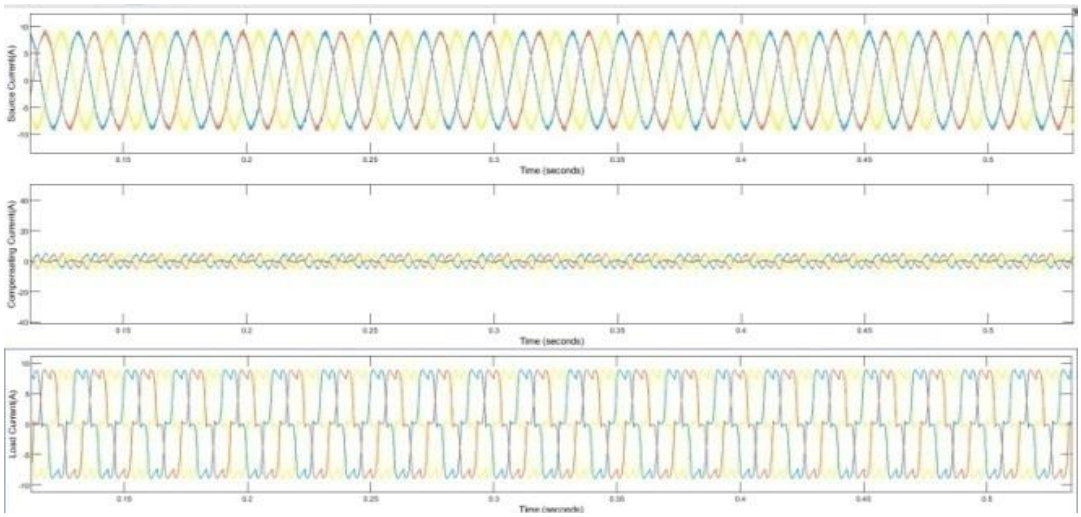


Figure 3.8: Voltage and Current waveforms of network with ANN based SAPF

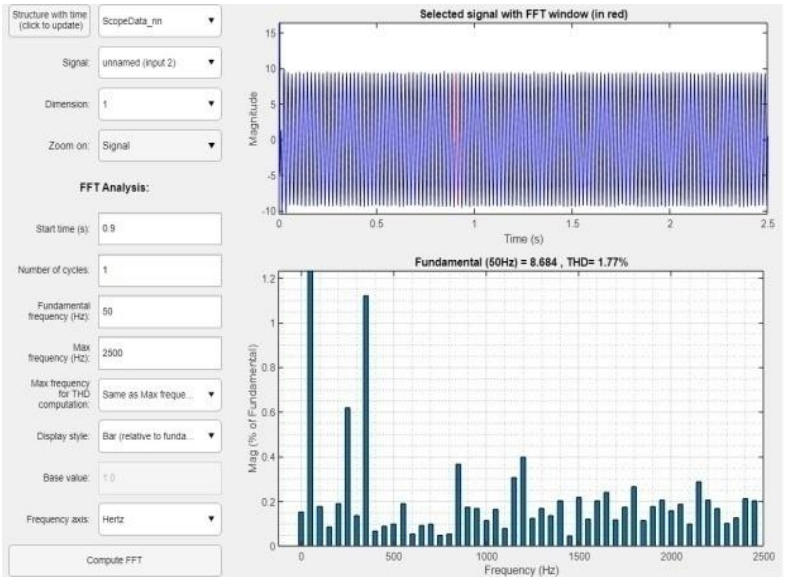


Figure 3.9: THD for ANN based SAPF

Fuzzy Tuned PI Controller: In this case Fuzzy tuned PI controller is connected to SAPF shown in figure 3.10. Fast Fourier Transform (FFT) analysis is performed to know the distortion in source current.

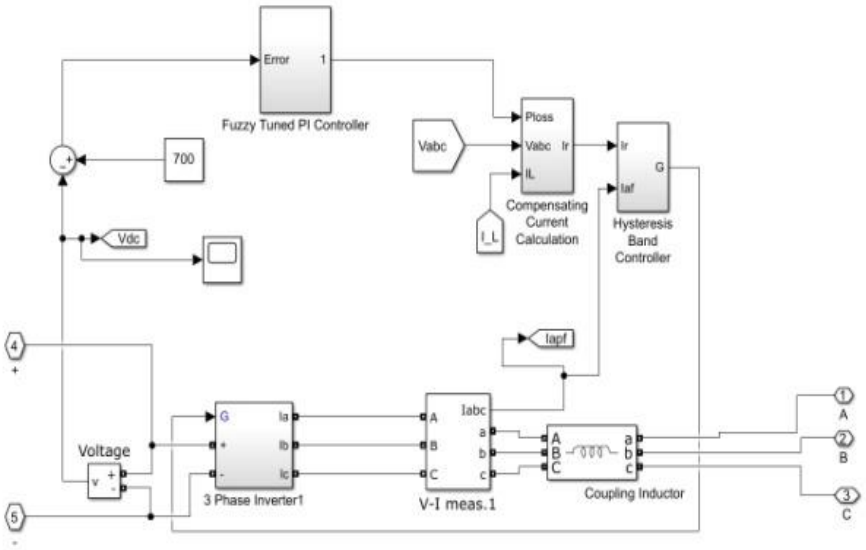


Figure 3.10: Simulink model for Fuzzy tuned PI controller based SAPF

The total harmonic distortion (THD) by using Fuzzy tuned PI based SAPF is 1.62%. We can observed that the total harmonic distortion by fuzzy tuned PI is reduced when compared with ANN based SAPF shown in figure 3.11 and figure 3.12.

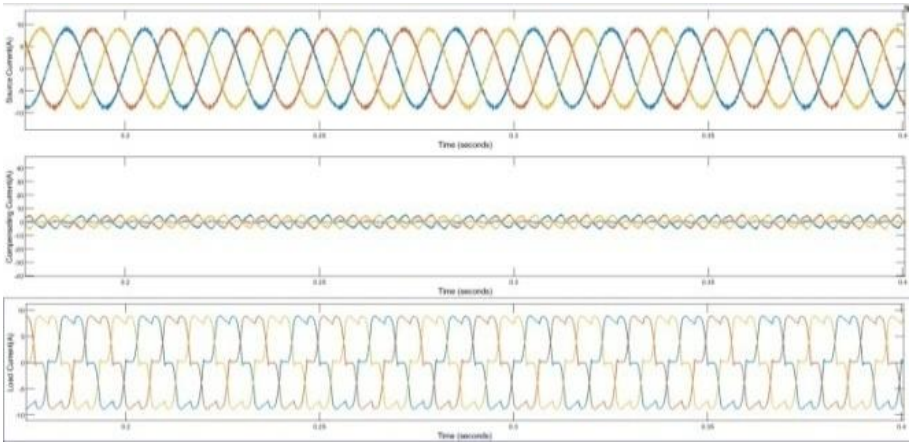


Figure 3.11: Voltage and Current waveforms of network with Fuzzy tuned PI based SAPF

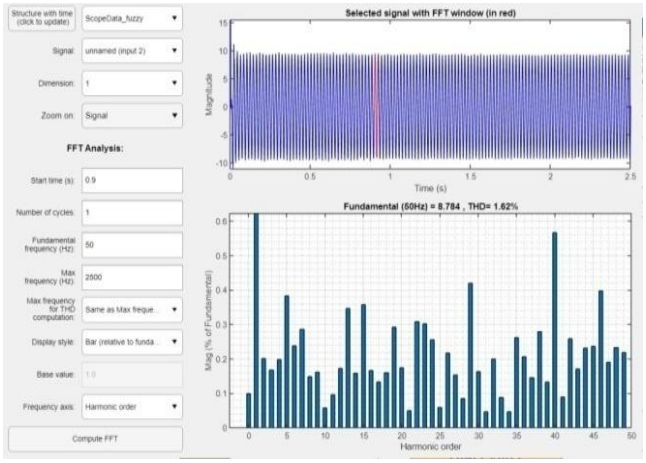


Figure 3.12: THD for Fuzzy tuned PI controller based SAPF

ANFIS based SAPF:

In this case ANFIS (Adaptive Neuro Fuzzy Inference System) is connected to SAPF shown in figure 3.13. Fast Fourier Transform (FFT) analysis is performed to know the distortion in source current. ANFIS controls the DC link voltage and reduces the harmonics in source current. Hence, ANFIS based SAPF able to restore the distorted source current to its original sinusoidal waveform. ANFIS consists of set of fuzzy rules and neural network and trained by fuzzy rule base. The fuzzy rule base defines the mapping between input variables and output variables and these are represented by fuzzy sets and linguistic variables.

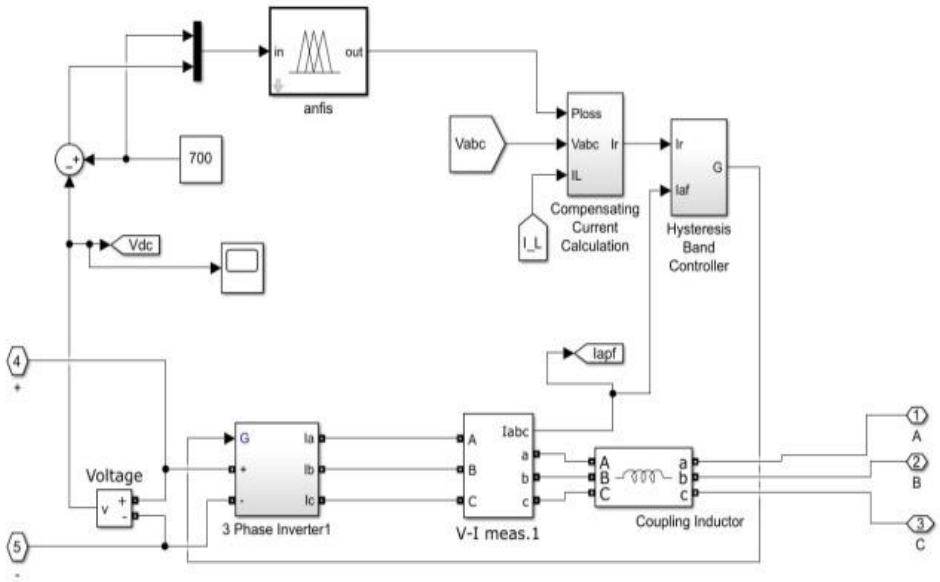


Figure 3.13: Simulink model for ANFIS based SAPF

The total harmonic distortion (THD) by using ANFIS based SAPF is 1.57%. We can observed that the total harmonic distortion by ANFIS based SAPF is reduced when compared with Fuzzy tuned PI based SAPF shown in figure 3.14 and 3.15.

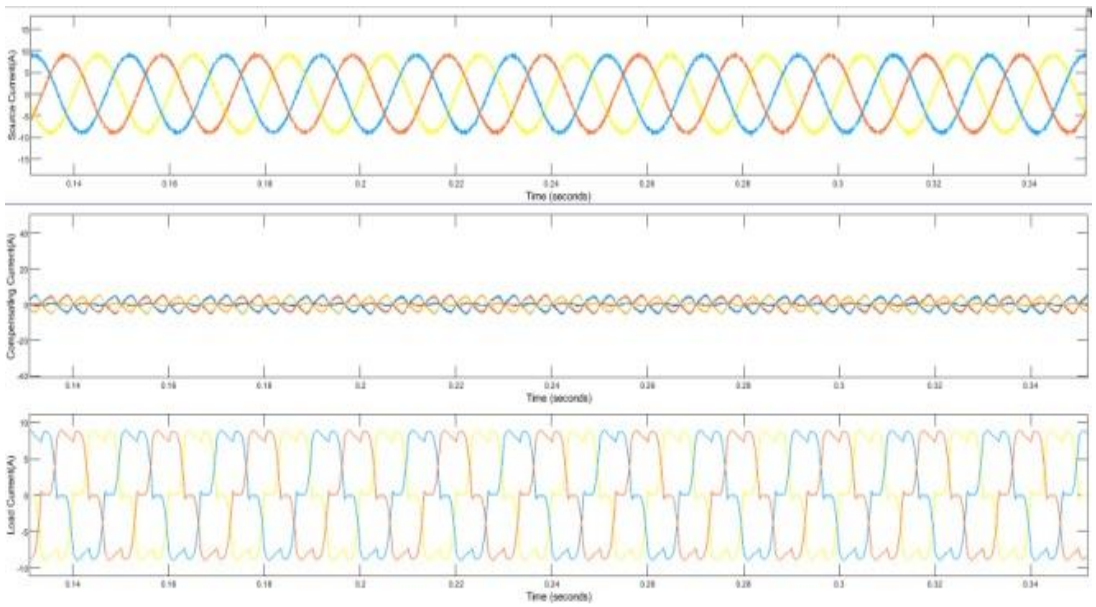


Figure 3.14: Voltage and Current waveforms of network with ANFIS based SAPF

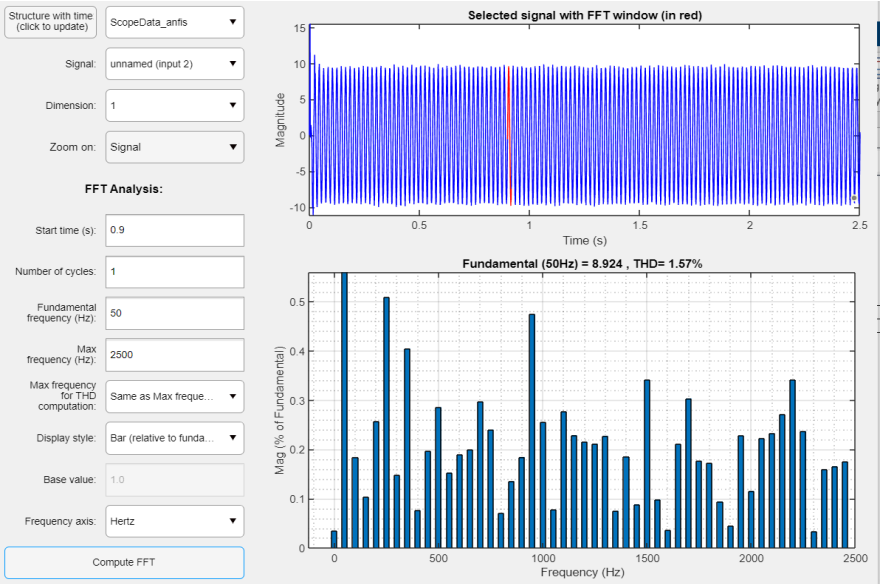


Figure 3.15: THD for ANFIS based SAPF.

Table no 1: Comparison of THD

CONTROLLER	THD%
Without SAPF	22.24%
Conventional PI CONTROLLER based SAPF	1.83%
ANN based SAPF	1.77%
FUZZY tuned PI CONTROLLER based SAPF	1.62%
ANFIS based SAPF	1.57%

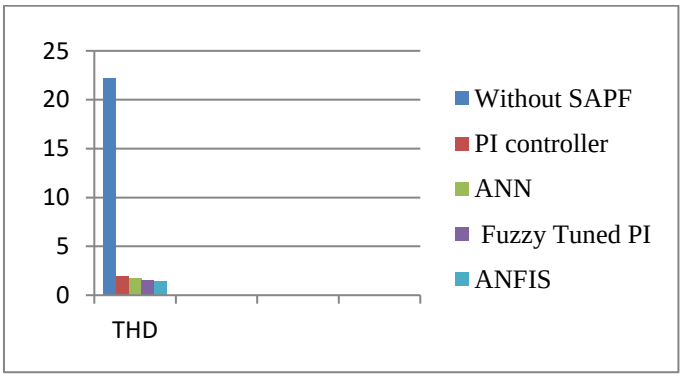


Figure 3.16: THD Comparison

IV. Conclusion

Reactive power and harmonics are only two instances of the growing intricacy of power quality problems. Artificial intelligence-developed solutions used by active filters are very good at reducing harmonics and balancing reactive power. We suggest using the ANFIS based SAPF control approach as a substitute to the SAPF within the context of this paper. The efficacy of the SAPF is evaluated and contrasted in a range of contexts. Five distinct scenarios are simulated using Matlab-Simulink, which then displays the results. Simulation results show that in terms of lowering THD in the source current, the suggested ANFIS based SAPF performs better than alternative scenarios. The distribution system WITHOUT SAPF, CONVENTIONAL PI, ANN, FUZZY TUNED PI, ANFIS Controllers are developed and verified for three phase three wire system. In this work it has been observed without any control circuitry the THD is very high around 22.24% . With PI Controller based SAPF, it is reduced to 1,83% and with ANN Controller it is reduced to 1.77% ,with FUZZY

TUNED PI based SAPF it is reduced to 1.62% and with ANFIS based SAPF further THD reduced to 1.57%. The performance of these all controllers has been studied and compared in MATLAB. It has been seen that, ANFIS based SAPF controller is more efficient to reduce THD than WITHOUT SAPF,CONVENTIONAL PI, ANN, FUZZY TUNED PI Controllers.

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Experimental investigations on oleic acid stabilized nano- Al_2O_3 / beeswax phase change materials for thermal energy storage applications

P. Venkata Vineeth, K. Dharma Reddy

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Abstract

The primary focus of the current work is the effectiveness of Nano Particle-dispersed beeswax PCM-based solar thermal energy storage systems. During the experimental investigation into the effects of Al_2O_3 Nanoparticles on the thermal behavior of a beeswax-based Phase Change Material, it is observed that the Nanoparticles had a substantial effect. To increase the thermal conductivity of the PCM, Al_2O_3 particles of 2%, 4%, 6%, and 8% by weight are dispersed throughout the material. Due to the integration of Al_2O_3 Nanoparticles into beeswax, thermal conductivity increased, but the material's capacity to retain heat decreased. A mixture of beeswax and Al_2O_3 melts quicker than a pure phase-change material, according to the research. 4wt% Nano Particle dispersed PCM is better suitable for the storage of thermal energy because of its lower drop in latent heat and desirable increase in thermal conductivity.

Introduction

Researchers have been focusing on the development of renewable energy sources in order to meet the rising global demand for energy and to avoid the continued depletion of non-renewable energy sources, which has negative effects on the local ecosystem. It is likely that a sustainable solar energy source will be the key to our prosperity in the future [1].

The intermittent nature of solar-generated electricity has also contributed to the rise of thermal storage devices. As a direct result, there has been an increased emphasis on solar thermal storage research in recent years. Considering that energy storage affects the overall efficiency of solar thermal systems, it is vital to develop new materials for thermal storage and processing. [2].

Utilizing the latent heat of phase transition materials as an energy storage medium is one of the most feasible and practical ways to increase overall energy effectiveness and reduce energy consumption. This might be performed in a variety of ways. During the phase change process, phase change materials are distinguished by a high latent heat density and extended thermal energy storage and delivery at certain temperatures. [3].

Experimental study on palmitic acid's potential use as a PCM for energy storage has been carried out by Hasan. Mathematical research is conducted on the effects of changing time, thermal gradient, and boundary dispersion, and the results are combined with the heat flow rate parameters of the ring tube storage system.[4].

Feldman and Shapiro examined the thermal characteristics of fatty acids (capric, lauric, palmitic, and stearic acids) and their binary combinations. The results indicate that these substances are viable candidates for the storage of latent heat, a kind of thermal energy, in space heating applications. The melting point of fatty acids varied between 30 and 65 degrees Celsius, and their latent heat of transition varied between 153 and 182 kJ per kilogram.[5].

Commercial PCMs, fatty acids, organics, and inorganics are the four most often used kinds of PCMs. Inorganic PCMs are used as well [6]. Organic PCMs constitute the overwhelming bulk of all known PCMs. Paraffin is a kind of organic PCM that may be found in petroleum, minerals, plants, and animals, among other locations. Coconuts are utilised to produce paraffin, which is subsequently used to produce palm wax. Beeswax, which is generated by bees while they are working in their colonies, is an example of paraffin obtained from

animals. This experiment mainly depended on the use of beeswax as its primary component.

Organic PCM materials have the disadvantage of poor heat conductivity. Adding Nanoparticles, which themselves have a high thermal conductivity [7], [8], [9], [10], to a PCM to increase its thermal conductivity is one of the most effective ways to do so. When Nanoparticles are spread evenly throughout a PCM, the PCM's thermal conductivity is enhanced, and slightly decreasing its latent heat. Copper Oxide (CuO) has been analyzed several times as a Nano Particle in PCM materials. Copper oxide Nanoparticles were introduced to PCM materials by Harikrishnan and Kalaiselvam, and the findings demonstrated an increase in thermal conductivity as the number of copper oxide Nanoparticles added to oleic acid increased [11]. Elarem, Raja, et al observed that 2% Al and 1% Cu Nanoparticles enhanced paraffin wax show better enhancements in the thermal energy storage characteristics.[12].

Despite the fact that several studies have revealed that raising the Nano Particle volume fraction enhances the thermal conductivity of Nano fluids, they discovered that at concentrations more than 2%, the thermal conductivity is reduced in the solid form, and the increase in measured value is smaller compared to that associated with small concentrations. [13], [14], [15], [16], [17], [18], [19].

It was reported by Ho and Gao that there is a slight improvement in the melting/freezing behavior of PCM with the addition of alumina Nanoparticles.[20].Aluminum Oxide Nanoparticles have good thermal conductivity and are more stable and cheaper when compared to Aluminum Nano particles. [21], [22], [23], [24]. However, similar to other Nanoparticles, they tend to precipitate in solvents, preventing their ability to increase thermal conductivity. Though precipitation is the most significant drawback in using them in Thermal energy storage, there are few studies about the preparation and their stability in using Nanocomposites. In the current study, oleic acid is used as a surfactant for preventing the precipitation of Nanoparticles. [25], [26], [27], [28], [29], [30], [31], [32], [33].

The main objectives of the current study are a) to prepare stable Al_2O_3 dispersed beeswax Nano PCMs, b) to study the thermal characteristics of Nano Particle dispersed Beeswax/ Al_2O_3 PCMs like thermal conductivity, latent heat capacity, and sensible heat capacity and c) to study the behaviour of the Nano Particle dispersed PCM during the charging and discharging of the Thermal energy storage system.

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Section snippets

Beeswax

In the present study, laboratory-grade Beeswax (Product of SRL Chem, https://www.srlchem.com ↗) is selected as a PCM (melting point 61 degreesC to 67 degreesC) because of its high Latent Heat Capacity of 170 kJ/kg, which is excellent for heating water to the necessary temperature (40 degreesC to 60 degreesC). The chosen PCM has good thermal and chemical stability, does not have phase separation, has a high thermal energy storage density, and is environmentally friendly.(Fig. 1Table. 1 …

Nanoparticles

…

Stability of nano-dispersed phase change material

To test the stability of the Nano Particle dispersed PCM, twenty heating and cooling cycles are performed. If there is any indication that the Nanoparticles have started to settle after heating and cooling cycles, 1 ml of oleic acid further added and the process is repeated until the Nanoparticles are evenly distributed throughout the PCM without settling at the bottom. As shown in Table 3, the weight compositions of Nano Particle dispersed PCMs containing 2%, 4%, 6%, and 8% oleic acid are …

Conclusions

The thermal characteristics of Nano Particle dispersed PCMs containing 2%, 4%, 6%, and 8% concentrations of Al_2O_3 Nanoparticles are examined. Nano Particle dispersed phase transition materials exhibit much higher heat transfer rates throughout both the charging and discharging operations compared to pure beeswax. The thermal conductivity of 8% Aluminum oxide Nanoparticles is 22% greater than the thermal conductivity of Pure PCM. In contrast, Latent Heat is decreased to 154.71 kJ/kg for the same …

CRediT authorship contribution statement

P Venkata Vineeth: Conceptualization, Methodology, Validation, Writing – original draft. **K. Dharma Reddy:** Supervision, Writing – review & editing. …

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

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EXPERIMENTAL INVESTIGATION ON INCONEL 718 ALLOY METAL BY USING ADDITIVE MANUFACTURING PROCESS

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ABSTARCT

The Additive Manufacturing (AM) process is a computer-controlled process that uses CAD representations to build physical parts layer by layer. Almost all computer-aided design (CAD) packages allow the creation of stereo lithography (STL) files, which are translated into machine commands to drive the AM process. The process is commonly used for producing complex and intricate metal components with high accuracy. Inconel 718 is a high-strength, corrosion-resistant nickel-based super alloy. It is one of the most widely used materials in demanding applications where high-temperature and extreme environment resistance is required. In present research work the IN718 samples are manufactured by using DMLS and modeled by using CAD as per ASTM Standards. The modeled samples were saved in STL file and fabricated by DMLS method in different orientations. To know the mechanical properties of additively manufactured INCONEL 718 samples by mechanical tests like Tensile, compression, impact wear and corrosion tests will be performed. The results obtained for both the set of samples fabricated in different orientations will be compared with the values of wrought or casted samples of INCONEL 718 alloy and determine the DMLS fabricated parts has good mechanical properties compared to casted samples of INCONEL 718.

Keywords: Inconel 718, DMLS Process, Horizontal, Vertical, Tensile and Compression Strength, impact strength.

1. INTRODUCTION

To a large extent, the advantages of modern civilization can be attributed to the higher standard of goods that now have access to. The quality of goods can be improved through proper design, which takes into account both functional and manufacturing requirements. Products are made by converting raw materials into finished goods, which include the design and production of goods using a wide range of techniques and methods.

1.1 HISTORY OF ADDITIVE MANUFACTURING

In the early 2000s, additive manufacturing (AM) became popular because of the idea of materials being combined. As an alternative, the term "subtractive manufacturing" was coined to refer to a broad range of machining methods in which material removal is the primary method of producing a finished product.

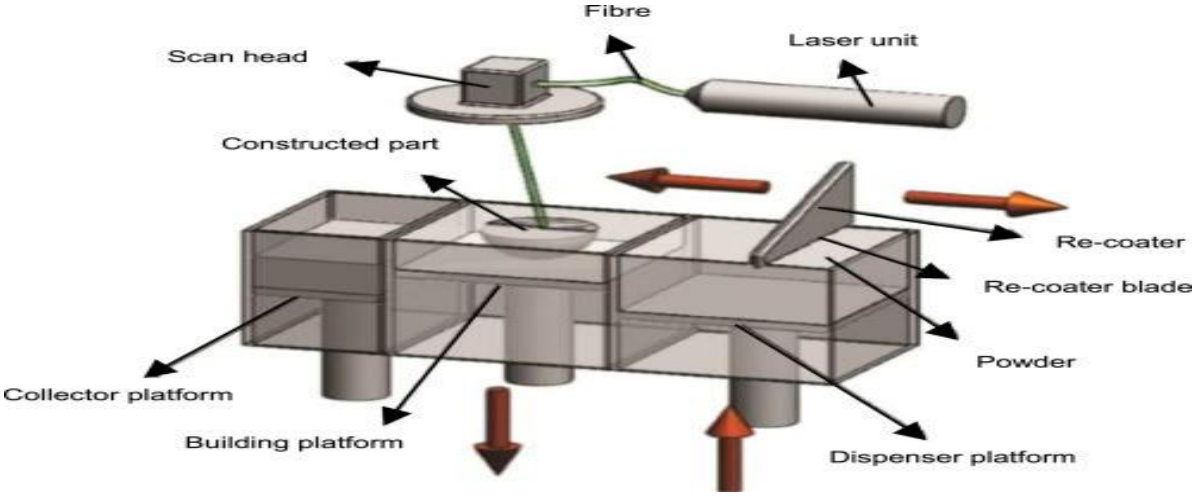


Figure. 1.1 : Schematic Diagram of DMLS

2. LITERATURE REVIEW

The experimentally investigated the mechanical properties of the components through DMLS process. mechanical properties of a component fabricated through DMLS process is more inferior to traditional manufacturing process. Process parameters such as layer thickness, scan speed, laser power has showing large impact on hardness [1].

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3. METHODOLOGY AND MATERIAL DESCRIPTION AND FABRICATION

Selection of Material:

Material used for fabrication of samples is Inconel 718. Initially the material is taken in the form of powder. In718 powder was obtained from EOS engineering Inc. The powder is sieved with a mesh size of 90 μm to avoid inhomogeneity in the distribution of the particle size. The machine which is used for fabricating the samples is EOSM290.Produces highest quality metal parts in additive manufacturing. The robust system design and the powerful 400-watt fiber laser enable a reliably high performance day in, day out. Powder bed fusion (PBF) is an additive manufacturing process and works on the same basic principle in that parts are formed through adding material rather than subtracting it through conventional forming operations such as milling**.** Cross sectional area we then begin to apply weight to the material gripped. In this chapter experimental results obtained from the tensile test, compression test, corrosion test, wear test, of horizontal and vertical orientation Inconel 718 samples has been discussed.



Figure. 3. 1: Schematic Diagram of UTM



Figure 3. 2: Tensile Inconel specimens

Tensile test is performed on this vertical orientation specimen and the results are carried out. After getting results of individual orientations of both the specimens we then compared their results.

3.1 DIMENSIONS OF COMPRESSION INCONEL 718 SAMPLES:

Dimensions of compression test horizontal orientation specimen as per ASTM standards are as follows: in our study we are considering only length and height of the specimen for compression test. There are various types of corrosion tests.in our experiment we are using electro chemical corrosion testing. A potentiostat instrument is usually used to perform this sort of this test. A three electrode setup, including working electrode, reference electrode and counter electrode are usually used. Potential, current, and time are three important parameters in electrochemical tests.in these tests an applied potential generally scans in a certain range and the current is measured.

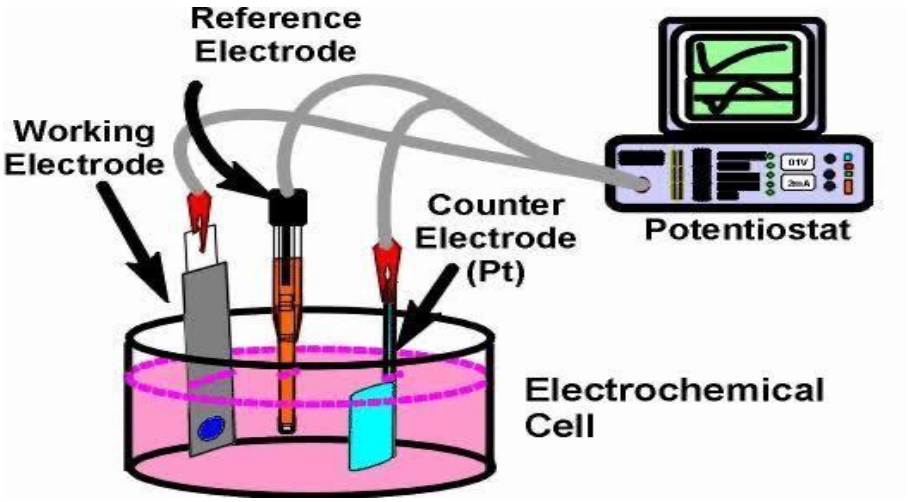


Figure 3. 3 : Schematic diagram of corrosion test

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Table 3.1: Chemical composition of In718 (Metal Composition Data)

Element	Sample composition (%)	Standard composition (%) [2]
Ni	53	55.0-55.5
Cr	18.2	17.0-21.0
Fe	18.1	18.5
Mo	2.8	3.0
Ti	1.1	0.65-1.15
Co	0.98	1.00
Nb+Ta	5.2	5.1

4. RESULTS AND DISCUSSIONS

4.1 Tensile test:

After performing the tensile test on Inconel 718 specimens of both horizontal and vertical layer orientations which are fabricated through DMLS process, the results obtained are yield strength and tensile strength, The reason behind that is, in horizontal layer orientation the tensile load applied is parallel to the layer fabrication and the bonding between the layers is more when compared to the vertically layer oriented Inconel specimen which results in more tensile strength.

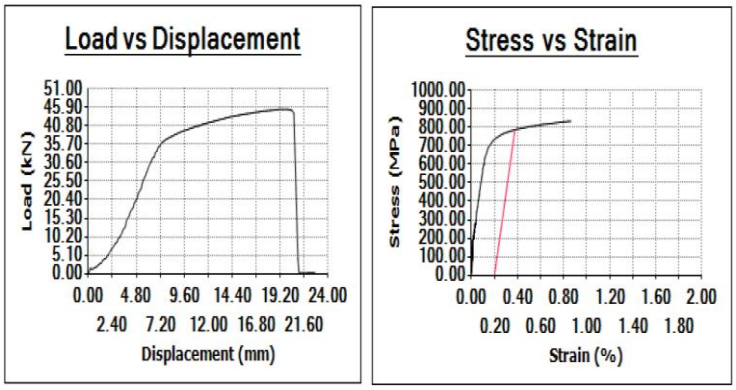


Figure 4. 1 : Stress strain graph of horizontal orientation Inconel tensile specimen:

Table .4.2

Hardness test	Horizontal layer orientation Inconel 718 specimen		Vertical layer orientation Inconel 718 specimen	
No of trails	Vickers hardness (HV)	Rockwell hardness (HRC)	Vickers hardness (HV)	Rockwell hardness (HRC)
Trail 1	401.1	40.9	703.2	60.2
Trail 2	465.4	46.2	541.6	51.8
Trail 3	472.2	47.1	436.5	44.2
Trail 4	452.8	45.5	418.4	42.5
Trail 5	510.8	49.8	474.7	47.2
Average Hardness Value	**460.26**		**514.88**	

Figure 4.1 shows the stress strain relationship of vertically oriented tensile specimen. From the graph it is observed that percentage of strain 0.36% is occurred when the stress of 794.18 MPA is applied on the specimen. Table 4.2: Vickers hardness (HV) and Rockwell hardness (HRC) results of horizontal and vertical orientation Inconel 718 specimens: It is observed that average hardness for vertically oriented Inconel 718 specimen is higher than horizontal layer oriented Inconel specimen.

5. CONCLUSIONS

The mechanical properties such as hardness, tensile strength, compression strength, impact resistance, wear resistance, corrosion resistance of Inconel 718 specimen of both horizontal and vertical layer orientations, fabricated by powder bed fusion process was studied experimentally. The following conclusions are drawn from the experimental results. Based on the experimental results it is concluded that the ultimate tensile strength, percentage of elongation, wear resistance, wear resistance, corrosion and impact resistance of horizontally fabricated sample is higher than that of vertically fabricated sample.

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6. FUTURE SCOPE

The work can be extended to analyze other parameters and other mechanical properties. The level of experiments can be increased for better results. For better results and accuracy we can also use optimization techniques like taguchi analysis, in addition to experimental analysis.

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Experimental investigations on nano-Fe_2O_3/ beeswax phase change materials for thermal energy storage applications

P Venkata Vineeth, K. Dharma Reddy

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Abstract

The efficacy of solar thermal energy storage mechanisms that use Nanoparticle distributed Beeswax Phase Change Material (PCM)is the presentsubject ofstudy. To acquire a stronger insight intothe thermal behaviourof this PCM made from beeswax, a series of experiments have been carried out. These investigations were aimed at understanding how the presence of Fe_2O_3 nanoparticles inPCM altered both thermal properties. Fe_2O_3 particles were distributed at varied concentrations, comprising 1%, 2%, 3%, and 4%, to increase the heat transfer of the beeswax based PCM. The findings of these trials suggested that the addition of Fe_2O_3 Nanoparticles to the composite material increased its melting rates. This higher melting rate is attributable to the enhanced heat conductivity of composite material by 1.2%, 5.2%, 7.2%, and 8.8%, by the introduction of 1%, 2%, 3%, and 4% Fe_2O_3 nanoparticles. This rise in thermal conductivity is followed by a reduction in the material's heat capacity. The composite material comprised of Beeswax and Fe_2O_3 exhibited a lowermelting temperature

over the pure phase material, according to further measurements. The implications of these results for the development of more efficient and effective solar thermal energy storage devices are significant, which encourages their use in space heating, water heating and battery cooling applications.

Introduction

Owing to the ongoing exhaustion of resources for energy and their detrimental impact on the environment, researchers have already been investigating renewable energy sources to solve the ever expanding energy requirements. Solar power is a potential renewable energy source [1]. The intermittent nature of solar energy, however, pushed researchers to concentrate on thermal storage systems. Hence, research into solar thermal storage has lately received a great deal of interest. While energy storage plays a vital part in the total solar thermal efficiency, developing novel materials for heat storage and processing is essential. [2].

Phase change materials (PCMs) are one of the most feasible and practical energy storage media, since they may use the latent heat created during the phase transformation process to increase overall efficiency and decrease energy consumption [3]. During the phase transition process, materials are differentiated from one another by their high latent heat for unit mass and considerable thermal energy storage and the ability to provide energy at particular temperatures [4]. Four categories of PCMs are distinguished: commercial PCMs, fatty acids, organics, and inorganic [5]. Most often used are organic PCMs, such as paraffin. Palm wax is a form of paraffin extracted from coconuts. Paraffin may be found in petroleum, minerals, plants, and animals. Beeswax, which is generated by bees in their hives, is another animal-derived version of paraffin. In this investigation, beeswax was the substance of major interest.

The limited heat conductivity of PCM materials is one of its major drawbacks. Using high-thermal-conductivity nanoparticles is one effective technique to enhance the thermal conductivity of a PCM [6]. Notably, the addition of nanoparticles to a PCM in order to boost the thermal conductivity may result in a reduction in the PCM's latent heat.

In conclusion, the development of thermal storage materials is essential for improving the overall performance of solar thermal systems. Using PCM’s, such as beeswax, as an energy storage medium has been shown to be a potential alternative. Adding nanoparticles into PCMs may also increase their thermal conductivity; nevertheless, it is essential to strike a balance between thermal conductivity and latent heat. CuO was added to PCM materials by

Harikrishnan and Kalaiselvam (2012), and the results showed that with the increase in percentage of CuO Nanoparticles mixed with oleic acid, the enhancement in Thermal Conductivity was observed the problem with organic PCMs is that their thermal conductivity is less. Addition of Nano Particle having high thermal conductivity to PCMs is one of the best ways to improve the thermal conductivity of a PCM [7], [8], [9], [10].

Copper oxide Nano Particles were added to PCMs by Harikrishnan and Kalaiselvam, and the findings demonstrated an increase in thermal conductivity as the number of copper oxide Nano Particles added to oleic acid increased. Elarem, Raja, et al studied the thermophysical properties of Nano composite PCMs prepared by dispersing aluminum and copper in the mass fractions of 0.1%,0.3%,0.6%,1%,2%,2.5%, and 5%. They observed that 2% Al and 1% Cu Nano Particles enhanced paraffin wax shows better performance fir thermal energy storage [11], [12]. Even though many studies have shown that increasing the volume fraction of Nano Particles increases the thermal conductivity of Nanofluids, amounts above 2% have been shown to decrease the thermal conductivity of solids. Also, the size of the rise seen is smaller at higher doses than at lower concentrations [13], [14], [15], [16], [17], [18], [19], [20], [21]. Ho and Gao reported that the incorporation of alumina nanoparticles improved the melting and chilling behaviour of PCMs slightly. Aluminium Oxide Nanoparticles, which are renowned for their exceptional thermal conductivity, are more stable and cost-effective than Aluminium Nano Particles [22], [23], [24], [25], [26], [27], [28], [29].

Fe_2O_3 nanoparticles were added to paraffin wax by Abhishek Agarwal which increased the performance of heat absorption by 1.3% [30]. A recent study by Meriem JEBALIA et.al ↗ showed that by adding Fe_2O_3 nanoparticles an increase of 16.99% in thermal conductivity is observed [31]. Nanoparticles have a propensity to precipitate in solvents, which inhibits their capacity to boost thermal conductivity. This is due to the fact that solvents prefer to dissolve nanoparticles. The problem of precipitation is the primary drawback associated with their employment in the thermal energy storage process. On the other hand, there have only been a few of research done on the process of producing nanocomposites that include these particles and determining their durability. Within the scope of this particular area of investigation, oleic acid is used as a surfactant in order to prohibit the precipitation of nanoparticles [32], [33], [34], [35], [36], [37], [38].

Comprehensive study shows that little work has been reported on using beeswax as a phase change material for thermal energy storage and little work has been done on the performance of metal oxide nano particle dispersed PCMs. There were no reports on using oleic acid as a surfactant for the proper dispersion of nano particles in beeswax.

The key objectives of the current study are to produce stable Fe_2O_3 -dispersed beeswax nano PCMs to investigate the thermal characteristics of the PCMs comprising beeswax and Fe_2O_3, such as their thermal conductivity, latent heat capacity, and sensible heat capacity and to examine the performance of the nano particle-dispersed PCM inside a thermal energy storage system while the charging and discharging procedures are being carried out.

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Section snippets

Materials and method

In this investigation, the chosen Beeswax PCM (Product of SRL Chem, https://www.srlchem.com ↗) has a melting point range of 61 °C to 65 °C and a high Latent Heat Capacity of 170 kJ/kg (Figure 1). These characteristics make it appropriate for heating water to temperatures between 40 and 60°Celsius (1). In addition, the selected PCM has superior thermal and chemical stability, with no phase separation and a high thermal energy storage density (Table 1). Additionally, it is an eco-friendly material, …

Stability of nano dispersed PCM

A number of heating and cooling cycles were conducted on the nano-dispersed PCM to evaluate its stability. This was done to see if any settling of nanoparticles happened during the heat cycling procedure. If settling was noticed, the amount of oleic acid was progressively increased, and the material was retested until the nanoparticles were completely dispersed throughout the PCM. Several tests revealed that the weight compositions of 1%, 2%, 3%, and 4% nano-dispersed PCMs were stable for a …

Conclusions

The research investigated the thermal characteristics of nano-dispersed PCMs with various concentrations of Fe_2O_3 nanoparticles (1%, 2%, 3%, and 4%). Following are the conclusions drawn from the work.

- For both charging and discharging, the nano dispersed PCMs demonstrated greater heat transfer rates than pure beeswax. The 4% weight composition of Iron oxide nanoparticles produced the greatest increase in thermal conductivity, 8.8%, but also a higherdrop in latent heat, to 81.8 kJ/kg. …
- The 1%, 2%, …

…

CRediT authorship contribution statement

P Venkata Vineeth: Conceptualization, Methodology, Validation, Writing – original draft. **K. Dharma Reddy:** Supervision, Writing – review & editing. …

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

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E3S Web of Conferences 430, 01234 (2023)

Experimental Studies on Hastealloy C276 while Machining with CO_2 Laser Cutting Machine

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Laser cutting process is well suitable process for the cutting applications of high strength temperature resistant alloys, that are very difficult to cut with conventional process. Moreover, the lasers are widely using now-a-days for variety of cutting operations in many varieties of industries. Because of its complex nature of its operation, it is not easy to control so as to get the desired quality of cut in case of laser beam cutting process. This necessitates the importance of research to be carried out on the various processes i.e cutting, drilling, and welding etc by using the laser apparatus. The research mainly concentrated on the conduction of experiments i.e the cutting operation on Haste alloy C276 with CO2 laser beam. Total 31 trails are done using the CO2 laser beam apparatus. Laser power, speed, gas pressure and focal distance were the parameters chosen to vary. The outputs measured are surface roughness and the burr height which are direct measure to the quality of the cut surfaces. Two dimensional plots are plotted and analyzed the reasons for the increase or decrease of output with either the increase or decrease of input process parameters. Also, 3D plots are plotted to know the interactions.

Key words: Laser Machining / Cutting process / Haste alloy C278 / Process variables / Output responses

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Experimental study of vibration attenuation at rail joints by using Ethylene propylene Diene Monomer (EPDM) rubber

Lochela Prabhu Kiran [a], P. Venkataramiah [a], Seedari Ujwala Rani [b]

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Abstract

In railways the damage of rails at the joints due to heavy load transport has been a common issue for the last few years. To overcome this problem to some extent in this project, the projects will try to reduce dynamic vibration at rail joints. In this project, we will compare the frequencies of conventional rail pad in railways with the EPDM (Ethylene Propylene Diene Monomer) material-based pads with different layers at rail joints in railway track. EPDM rubber exhibits very good mechanical properties which last for long period. All the frequencies will be recorded with the help of vibration meter which consists of the sensor. The behavior of the track is also finding with the analysis tool (ANSYS – harmonic analysis).The main motto of this project is to Analysis of Vibration Attenuation at Rail Joints with Dynamic Vibration Absorber by Using EPDM Rubber. The Attenuation of dynamic vibration will be found through the collection of data from the rail with vibration meter and those values are utilized for harmonic analysis. The final output will be giving us how effectively EPDM rubber pads will optimize and sustain under the dynamic vibration in

rails. This project is helpful in the future scope of railways, vibration reduction mechanisms and other sectors.

Introduction

Railway is seen as a means of environmental-friendly transportation by providing clean and efficient mass transit. However, problems arising by the railway transportation become public, technical and administrative concern. The predominant source of noise from railway is related with the rolling of wheel on the rail. The rail track roughness on the wheel causes vibration and the structure radiates noise. Rail tracks are equipped with rail pads which are underneath the rail.(See Table 2.1 Table 2.2).

The following Fig. 1.1 shows the typical ballast railway track. It consists of ballast and sub-ballast underneath, concrete sleepers; the two rails fasten to the sleepers. It also includes sub-grade which gives support to the track from deformation.

The rail fastener is equipped with rail clip, rail insulator, rail pad and rail shoulder which is shown in Fig. 1.2. Rail pad is insulated between concrete sleeper and the steel rail. Rail pad is a provision of comforting element between the steel rail and concrete surface. All together are finally fastened to the sleeper. The main function of rail fastener is to give firm stiffness to the rail and transfer the dynamic progressive frequencies from rail to sleeper.

The concrete sleepers are the barriers that transfer high frequencies forces from rail to the ballast. It acts as an insulator between the rails. The vibrations are reduced from rail to ballast through sleepers.

Vincent N et al. [1] explained theoretical optimization of track components to reduce rolling noise. For the noise from the track, it has been shown that the stiffness of the rail pads, located between the rail and sleepers, has a strong influence on the levels of noise. It controls the balance of the vibration response of the rail and sleeper and the rate of decay of vibration along the rail.

Thompson DJ et al. [2] explained about track dynamic behavior at high frequencies, theoretical models and laboratory measurements. A track model is used in which the rail is represented as a Timoshenko beam on a continuous spring–mass–spring foundation representing the rail pad, sleeper and ballast.

Nashif ADet al. [3] discussed in addition, a number of test samples of 0.15m lengths of rail were assembled with the absorber using the different materials. These were tested to

ensure that the expected tuning frequencies were obtained in practice.

Cremer Let al. [4] explained in frequency response measurements on a 4m length of rail, the modes of the finite length can be clearly seen in the response at low frequencies, whilst the decay along the length of the 4m section is small. A procedure is therefore required based on measuring the modal damping (expressed as a damping loss factor) and converting this to an equivalent decay rate.

Hay et al. [5] found that the majority of the track failures and maintenance cost are ascribed to the track substructures (especially ballast and sub grade). These have raised the concern to observe static and dynamic behaviors of the substructure whereas many theories and methods have been developed.

Ford et al. [6] Determined how systems comprising a concrete sleeper, rail section, and rail pads respond to vibration. In a laboratory, a sleeper was embedded in ballast contained by a wooden box on a concrete floor. The tests were done using an electro-dynamic shaker to excite the top surface of the rail in the frequency of 0–1000Hz.
From the literature, it is revealed that many studies have been carried out for the dynamic behavior of the railways and is mainly depending on the railway track which analyzes the frequencies of the track. The problem statement is to evaluate the modal analysis and harmonic response to the rail structure and by using EPDM rubber material. The vibrations can be reduced by using absorber material in rails. To study the dynamic frequencies of rail in various cases in the modal analysis is the present objective of this work. To analyze the dynamic parameter at the rail joints with single-layer HDPE pad, single and double-layer EPDM pad. To compare the results of the dynamic frequencies responses and also receptance at the rail joints cross section along with selected rubber material to HDPE from the experimental data.

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Section snippets

Modal 1: I-cross-section of rail

The dimensional data is taken from standards of Indian Railways. The most common rail sections used in Indian railways are 52 kg and 60 kg rail. This I-cress section is used in modal analysis for design. The rail track structure is modeled by using Solid Edge 2020 software and the model is analyzed. In this model, EPDM pads are used in the place of HDPE pads in the rail track. The cross-section of rail track I-section is shown in Fig. 2. …

Modal analysis on rail

The rail model is created in Solid Edge 2020 in pact module (Fig. 4.) the cross-section is created in sketch module shown in Fig. 5. Pad operation is done to extrude the cross-section. The rail length of is 3000 mm, web and flange lengths are 150 mm and 97 mm, flange thickness is 22 mm and web thickness is 16.5 mm which is shown in Fig. 6. …

Experimental readings

Placement of single layer EPDM pad in railway track in Fig. 12. The minimum frequency range exhibits 90 Hz and maximum frequency of 1112 Hz is shown in the graph of Fig. 13. Mean frequency value in single layer EPDM pad is 499.21 Hz.

Harmonic response is generated in HTC VB − 8205 Software, RS-232 USB Cable is used as data transmission cable in between system and vibration meter shown in Table 3.1.

The total deformation is done; the modal is set to harmonic response. The minimum frequency is …

Results and discussion

Vibrations which are occurred by the contact of the rail wheel and track makes the vehicle initiates dynamic loading by using railway track structure. In this work modal analysis and experimental work is done for HDPE rubber pads, single layered EPDM pads and double layered EPDM pads. Three types of modals are created in Solid Edge 2020 and modal analysis. The dimensions and materials have taken from literature review and present analysis results are compared. Absorbers arrangement considered …

Conclusions

The EPDM rubber material has high resistance to dynamic forces and shows effective nature than other rubber pads.

Based on the experimental work following conclusions are drawn.

i) The dynamic frequency of welded rails with HDPE pads is having 1190Hz mean value. Whereas, the dynamic frequency of rail track with single- and double-layers EPDM pad their mean values are 499Hz and 335Hz respectively. …

ii) The experimental values clearly show that single- and double-layers EPDM pad dynamic frequencies are …

…

Future scope

The EPDM rubber that has chosen has high mechanical and thermal properties to withstand high frequencies compared to other rubber pads. The performance of rubber material, elastomeric materials may be the only choice in critical sensitive locations. The specifications of ballast materials structures include dynamic stiffness requirements for the intended frequency range over which vibrations isolation is desired. The rubber chosen for reducing the vibrations in the rail track having the minimum …

CRediT authorship contribution statement

Lochela Prabhu Kiran: Conceptualization. **P. Venkataramiah:** Supervision, Methodology, Validation, Writing – original draft. **Seedari Ujwala Rani:** Writing – review & editing. …

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: L .Prabhukiran reports was provided by Sri Venkateswara University College of Engineering. P.Venkatramaiah reports a relationship with Sri Venkateswara University College of Engineering that includes: employment. No has patent no pending to no. …

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Experimental study on mechanical behavior of corn-based reinforced composites using GRA and PCA

Venugopal Naidu Manubolu, V. Diwakar Reddy

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Abstract

The present technology, composites are playing an important role in industrial application as well as human applications. Natural fibers provide better features and advantages than synthetic fibers. The naturally reinforced polymer matrix composites are familiar with the exploration of lightweight, degradable, durable materials. This paper mainly focuses on the preparation of sample specimens according to ASTM standards with help of corn powder which is collected by refining the corn tree stem part along with reinforcements by using the hand-layup method. Perform mechanical tests like tensile, compression, and Izod impact tests on prepared specimens to draw the mechanical properties and analyze the mechanical behavior of composition factors. The DoE (Design of Experiments) is to draw the input parameters, and Grey relational analysis and Principal component analysis are used for finding the weights of process parameters. By analyzing the results it is observed that the most significant parameter carried out at ABS-12%, Guar Gum-12%, and CMC-8% with

values 0f compression strength is 80.48 MPa, Tensile strength is 60.45 MPa, and Izod Impact strength is 0.276 Joules.

Introduction

In recent days due to the increase in environmental effects [1] most industries and individuals are more concerned about polymer-based composite materials [2]. Polymer-based materials are made up of natural organic fillers [3] which are eco-friendly and recyclable and are also termed Green Composites [4]. This makes polymer-based composite materials one of the major research areas. Natural composites are more effective because of their biodegradability, general availability, and recyclability [5]. Specific properties of regular fiber composite [6] are lightweight, low cost, inexhaustible, and high strength. These composites exhibit better mechanical behaviour [7] under various loading conditions. The plant fibers can also be utilized in various methodologies for improving the lattice structure and can also mix with recyclable lattice materials like polyester, epoxy, etc.

The flexural modulus of a composite can be improved by utilizing extruder fibers [8]. As these fibers are treated with salt, it has a high concentration of salt. Normal plant fibers can also be utilized to build up a mix with non-biodegradable lattice material like unsaturated polyester, and epoxy tar. Most of the researchers are as used different bio-degradable polymers such as fiber in a different orientation, banana woven [9] sisal [10], saw dust [11] along with reinforcements like coconut fiber, and shell-type materials which are made up of natural materials. The strengths of these polymers are has improved with these different bio-degradable materials in different proportions. Based on the above literature I have chosen a plants base material that is eco-friendly with an objective to enhance its strength. The chosen material is mixed with various polymers in different proportions and is tested for strength, compression, and impact tests.

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Section snippets

Workflow

The flow chart as shown in Fig. 1. describes the step-by-step procedure followed to obtain the optimum process parameters.

Define the quality characteristics: It defines the inherent characteristic of product, each characteristic distinguished product future. The characteristic of the product depends on several parameters such as usability, function ability, availability, portability, reliability and maintainability.

Find the noise factors: Generally, most of the researchers considered noise …

Compression and tensile tests

The specimen sizes and prepared specimens are shown in Fig. 2 and Fig. 3. The electronic tensiometer as shown in Fig. 4(a) is a versatile and compact bench model horizontal testing machine [2], [4] with capacity of 20KN. The specimen was mounted in the grips of an electronic tensiometer model PC-2000 with a 10mm gauge length. In this mini universal tensile testing machining is popularly used for testing tensile, compression, shear, and flexural properties of various materials. The tests were …

Scanning electron Microscopy(SEM)

SEM is a mature technology that is used widely in various scientific applications. In the field of materials metallurgy, SEM is a strong tool. It operates in a high vacuum environment. The essential premise is that a suitable source such as a tungsten filament or field emission cannon produces an electron beam. The electron beam is accelerated by a high voltage (i.e., 10–30 KV) and is passed through a series of apertures and electromagnetic lenses to produce a thin beam of an electron, which …

Grey relational Analysis(GRA) and principal components Analysis(PCA)

The grey relational analysis theory was developed and implemented by Deng. Most of the researchers carried out the weights of the performance characteristics considered as substitute relative weights which were helpless to get optimum results by a selection of individual decision using GRA.

In this case, GRA with principal component analysis (PCA) helps to draw the optimized process parameters. Based on the original data which come from basic analysis with help of

independent principal …

GRA and PCA

There are several steps involved in Grey Relational Analysis(GRA) with PCA to carry out the weights for respective optimized process parameters.

Step 1:Find out the Signal to noise ratio(SNRA) values for corresponding responses drawn from various tests as shown in Table 2.

When Small value is the high-quality parameter then follow Eq. (1),

$$\eta = -10\log_{10}\left(\frac{1}{n}\right)\sum_{i=1}^{n}\frac{1}{y_{ij}^2}$$

When Larger value is the high-quality parameter then follow Eq. (2),

$$\eta = -10\log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}y_{ij}^2\right)$$

If not (i.e, Nominal the better) use this …

Comparative study

The Fig. 9 represents the comparative study between present and past/proposed work. By the observing data it can be stated that there is consider improvement in the compression strength and tensile strength. …

Conclusion

The mechanical behavior of corn powder reinforced composites is studied under variation in compositions. The experimental results validate that the strength of composite materials used in this paper has increased when compared with polymeric resin in terms of tensile and compression strengths and also shows a considerable improvement in Izod impact tests. Grey relational analysis(GRA) and PCA are applied to optimize the process parameters for tensile, compression, and Impact tests.

The following …

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2025, Composites Part A: Applied Science and Manufacturing

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Experimental Study on Mechanical Behaviour of Arhar-Reinforced Composites using GRA with PCA

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Keywords: Arhar Powder, FEA Analysis, GRA and PCA, Mechanical Tests, SEM and XRD

Abstract

The fiber composite plays a vital role in various applications in the current scenario. Natural fibers provide the desired advantages over synthetic fibers. Fiber composites deliver the exploration of durable, degradable, and lightweight materials. In several industrial sectors, transportation of materials from one place to another place is required. Materials like thermocoal boxes and iron boxes are inefficient in strength, weight, and cost. In order to overcome these, natural fiber-based composites, which give both strength and durability with low weight and cost, are chosen. This work explains the sample preparation using Arhar powder with an addition of reinforcements using the hand lay-up method by obeying the ASTM standards. To analyze the performance of the sample specimen, properties evaluated like Compression, Flexural, and other tests were conducted. GRA (Grey-Relational Analysis) with PCA (Principal-Component Analysis) was employed to carry out the most significant parameters, the most significant factor, and the weights of optimal parameters. Based on the output responses, it is experiential that the most effective parameter and best combination factor at Acrylonitrile butadiene styrene (ABS-4%), Guar Gum (8%), and Carboxy methyl cellulose (CMC-8%) with the values of 83.12 MPa compression strength, 61.70 MPa tensile strength and 0.249 joules of Impact strength.

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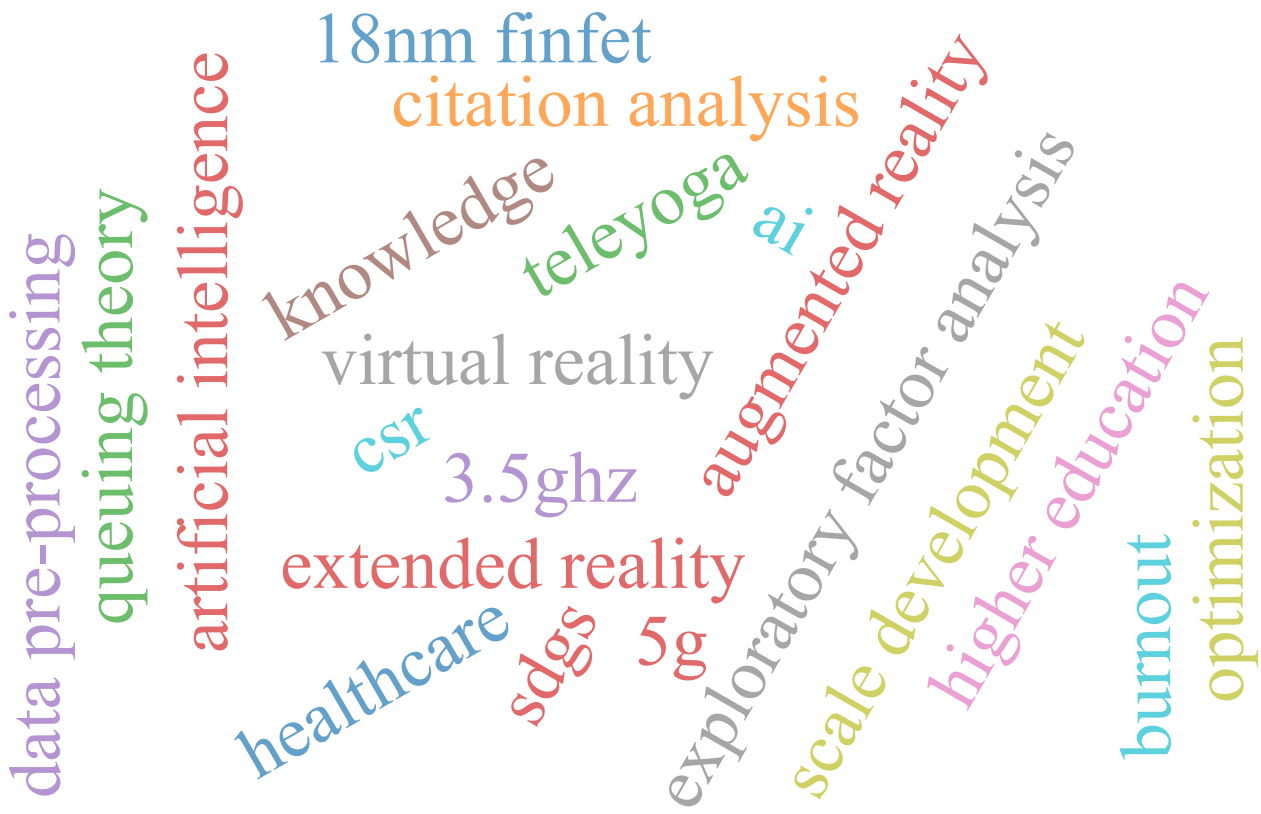
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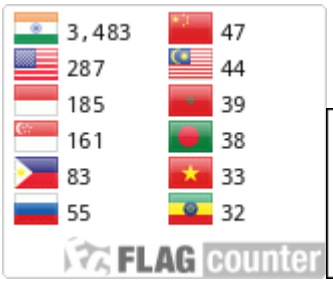

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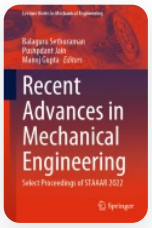
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Fabrication of Cooling Storage Device and Optimization Its Parameters for Thermal Energy Storage Application by Using Glycerine as a Phase Change Material (PCM)

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Abstract

Cooling storage devices are most important to store food items, medicines, etc. For long-term applications so that only we have designed these devices. Nowadays, we are using refrigerators to store food items and medicines, but due to these devices, the environment will be affected, because these are releasing harmful gases like Hydrofluorocarbon (HFCs) and chlorofluorocarbons (CFCs). Due to these gases, human respiratory will be affected, to prevent this defect thermoelectric module is used to produce cold temperatures as well as hot, it is worked based on the principles of both Peltier and Seebeck effect. Peltier module having semiconductor-based materials is thermally and electrically connected in parallel and series, respectively. By using this module to create the cooling device, we are able to shield the environment from the toxic gases that the refrigerator releases into the air. But this module never releases any harmful gases and never interferes with the human respiratory system, which is the only reason we were brought here. The TEC module had be chosen depending on calculations of passive heat load and the temperature that the cooling chamber must reach. Following the TEC's construction, cooling and discharge operations are tested both with and without the use of phase change material. The values are graphically depicted and tabulated. To find the multi-objective optimal solution, the value with the highest grey relatively grade is employed in the analysis and is regarded as the best option. Here, renewable energy source is used as an input power. In our solar system, solar energy is one of the abundant sources of renewable energy on the earth's surface.

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RESEARCH ARTICLE | JULY 31 2023

Fluid structure interaction analysis of the hyperloop capsule

Roopa Sai Reddy Venkatapuram ; Hema Pothur;
Mahammad Shareef Kadapa; Harsha Vardhan Penumadu;
Siva Naveen Gurram

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Vacuum transportation is envisioned as a futuristic method with the merits of ultra-high-speed in a low-pressure environment to address the rising demand for high-speed transportation. The Hyperloop is a novel concept involving traveling in capsules within a partially evacuated tube at transonic speeds. The study focuses on determining the effects of changes in physical parameters of the capsule in the low-pressure environment by carrying out a Fluid-Structure Interaction (FSI) analysis. The results are obtained by employing a k-ε turbulence model based on Reynolds Averaged Navier Stokes (RANS), considering steady-state and three-dimensional conditions. An aerodynamic simulation of the capsule in a partially evacuated tube is performed using ANSYS 2020 at a system pressure of 100 Pa, a blockage ratio of 0.625, and a capsule speed of 300 ms^{-1}. The residual analysis determines that the solution converges, whereas the grid check shows that the final solution is mesh independent and throughout the domain; a negligible flow rate reaffirms the conservation of mass. The one-way FSI results show that maximum deformation is in the nose region where fluid initially interacts with the capsule, and the streamline aids in reducing the pressure. Therefore, FSI must be taken into account while modeling the Hyperloop capsule.

Topics

Newtonian mechanics, **Computer software**, **Computational fluid dynamics**, **Navier Stokes equations**, **Transonic flows**

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Optimization of process parameters for wire electrical discharge machining of aluminium based metal matrix composite by Taguchi's approach

A. Hemalatha [a], V. Diwakar Reddy [b], S. Hemachandra [c]

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Abstract

Aluminum alloy is a common material used in various engineering projects due to its exceptional properties. Due to its exceptional mechanical properties, composites are becoming more popular.Metal Matrix Composites (MMC) showing better properties than aluminium alloy by the addition of reinforcements such as Al2O3, SiC, BC and BN. Due to this, the machining of these materials becomes difficult by conventional methods of machining and there is a need of developing alternate machining practices. WEDM (Wire Electrical Discharge Machining) is one type of non-traditional forms of cutting that was intended for machining harder materials. The various independent variables considered in this investigation are pulse on duration (Ton), pulse off duration (Toff) to study the effects of these variables on various performance indicators, such as surface roughness, material

removal rate. Multiple Regression Analysis was adopted to analyze the relationship between the various process variables and the consequent desired output attributes.

Introduction

Modern manufacturing industries expect components to be produced with higher quality and with fewer resources, and they have enabled the existence of materials with an unusual combination of properties that traditional materials can never achieve. The visible composite materials are primarily used in the manufacture of automobile components, aerospace, and a variety of engineering applications. As previously stated, industries require components with a high load carrying capacity, an excellent combination of high strength and hardness, corrosion resistance, fatigue and wear resistance, the ability to weld and forge, and the ability to machine and cast. As a result, there is a need to meet the demand for more extensive applications of those materials with better and improved properties [1], [2]. The need for lightweight materials with improved properties and a higher strength-to-weight ratio is becoming increasingly important in a wide range of engineering applications. Metal Matrix Composites (MMC) are one of the materials that are enticing customers due to their properties such as lightweight and stability in higher temperature environments. MMC's are used in the manufacture of components for automobiles and aerospace industries. Composite material uses in aerospace applications [3], [4], [5], [6], [7], [8].

MMCs have superior mechanical properties that are not present in traditional metals and alloys used in structural, aerospace, and automotive applications. Aluminium alloys have a significant presence in structural materials due to their easy application and manufacturing properties. However, due to their poor heat and wear resistance, conventional aluminium alloys are not fully suitable in some applications, such as aerospace. To overcome such unfavourablebehaviours, the properties of aluminium alloys are improved by adding appropriate reinforcement particulates to create MMCs. [9], [10], [11].

Stir casting is one of the simplest composite preparation methods, and it results in good dispersion of the created composites.One of the most common methods used for making composite materials is stir casting because of its flexibility and capability of uniform distribution of reinforcements, stir casting is preferred for fabricating composites. This process results in good dispersion of the finished product. Due to their various properties, such as their strength and stiffness, MMCs are becoming more popular, due to the increasing number of investigations on the proposed approach [12], [13], [14], [15], [16], [17], [18], [19].

MMC development is progressing toward Hybrid MMC, which has more than one reinforcement and will help to make materials with improved properties, particularly in aluminium base materials. The application of these newly developed composites is expanding to include pistons, shafts, and bicycle frames. Aluminium oxide/silicon carbide reinforcement can be used to make connecting rods, and the reinforcement selection is also dependent on the applications where the material will be used for various uses such as nuclear parts, electronics appliances, and medical equipment [20], [21]. These materials are commonly used in the manufacture of connecting rods and other components. Most of the HMMCs are composed of silicon carbide and alumina. This makes them ideal for a wide range of automotive applications. One of the most commonly used non-metal reinforcements in the production of HMMC is B4C. This material has attractive properties and is widely used in the manufacture of various components [22], [23], [24], [25].

The homogeneous distribution of the carbon layer in aluminum HMMC helps improve the wear resistance of the material. This is also beneficial for the mechanical properties of the product. Through the use of reinforcements, the manufacturing process can additionally increase the overall strength andmechanical properties of the material [26], [27], [28]. The impact of 'SiC' on the strength and hardness of a certain type of composite material is studied. It is found that the addition of reinforcements can improve the performance of the material [29], [30], [31], [32].

According to the existing literature, there is need on study of AHMMC that is reinforced with Al_2O_3 and BN which are to be fabricated by stir casting technique, because of its flexibility and capability of uniform distribution of reinforcements, stir casting is preferred for fabricating composites, that comprises of AA2024 as the matrix material aluminium alloy that has been used in various engineering applications such as manufacturing of aerospace components, automobile and marine applications as they possessed low density, higher strength-to-weight ratio, sufficient hardness, resistance to wear and corrosion. As per the literature survey, it was found that limited research is done on this alloyand Al_2O_3/BN as reinforcements in varied proportions. Also, the analysis on machinability investigations of fabricated AHMMC using WEDM needs much attention by considering the duration of 'T_{on}', 'T_{off}' and applied current as independent variables. In this present investigation, an endeavour has been taken to analyze the machinability of fabricated composite using Taguchi, regression and ANOVA approaches.

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Materials and methods

The input process variables pulse on time (T_{on}) (s), pulse off time (T_{off}) (s), and peak current at three levels have been taken into account in our current investigation, as shown in Table 1. There is a need for more experimentation to reveal the significance of process factors at different levels. Taguchi's design and analysis technique is used to tackle these types of challenges. For performing and assessing process parameters with the fewest number of experimental runs, a unique type of …

Results and discussion

The objective of the study is to analyze the various factors that affect the performance of HMMC in different applications. In order to identify the most effective process variables that can improve the performance of the material AHMMC (AA2024+Al_2O_3+BN) WEDM, the researchers conducted a series of experiments as per L_{27}.

MRR is an important performance measure for evaluating the efficiency of an unconventional machining process. WEDM is one of the advanced material removal processes …

Conclusions

The current exploratory work comprises the fabrication of AHMMC reinforced with (AA2024+Al2O3+BN) as well as machinability investigations on AHMMC WEDM. Taguchi's method has been advocated for experiment planning and analysis. The following are the findings of the investigations:

- Taguchi's technique was engaged to arrange the experiments based on the chosen independent variables for WEDM of AHMMC. Taguchi's response analysis was adopted to establish the most favourable factors for improved …

…

CRediT authorship contribution statement

S. Hemachandra: Conceptualization. …

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

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Processing and Characterization of Inconel 718 Alloy Metal by Using Selective Laser Sintering Method

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ABSTARCT

Direct Metal Laser Sintering (DMLS) is an additive manufacturing process that uses a high-powered laser to selectively fuse metal powder particles to create fully dense metal parts layer by layer. The process is commonly used for producing complex and intricate metal components with high accuracy. Inconel 718 is a high-strength, corrosion-resistant nickel-based super alloy. It is one of the most widely used materials in demanding applications where high-temperature and extreme environment resistance is required. In present research work the IN718 samples are manufactured by using DMLS and modeled by using CAD as per ASTM Standards. The modeled samples were saved in STL file and fabricated by DMLS method in different orientations. To know the mechanical properties of additively manufactured INCONEL 718 samples by mechanical tests like Tensile, compression, impact wear and corrosion tests will be performed. The results obtained for both the set of samples fabricated in different orientations will be compared with the values of wrought or casted samples of INCONEL 718 alloy and determine the DMLS fabricated parts has good mechanical properties compared to casted samples of INCONEL 718.

Keywords: *Inconel 718, DMLS Process, Horizontal, Vertical, Tensile and Compression Strength, impact strength.*

1.0 INTRODUCTION:

To a large extent, the advantages of modern civilization can be attributed to the higher standard of goods that now have access to. The quality of goods can be improved through proper design, which takes into account both functional and manufacturing requirements. Products are made by converting raw materials into finished goods, which include the design and production of goods using a wide range of techniques and methods. Subtractive manufacturing and additive manufacturing are the two broad categories under which the manufacturing industry can be divided. Nickel superalloys as Inconel are materials widely used in the aerospace industry among others for diffusers, combustion chamber, shells of gas generators and other, exposed to high temperature and pressure [3].

1.1 HISTORY OF ADDITIVE MANUFACTURING

In the early 2000s, additive manufacturing (AM) became popular because of the idea of materials being combined. As an alternative, the term "subtractive manufacturing" was coined to refer to a broad range of machining methods in which material removal is the primary method of producing a finished product. However, in the views of the general public, 3D printing still meant mainly polymer technologies, and the name AM was more commonly associated with the metalworking industry than polymer, inkjet, or stereolithography enthusiasts. Despite its invention in 1950, inkjet technology was the least known and, due to its complexity, was also the most misunderstood [6].

1.2 DIRECT METAL LASER SINTERING (DMLS)

Direct laser metal sintering (DLMS), also referred to as direct laser metal forming (DLMF) and selective laser melting (SLM), is a method wherein a highly intensive laser beam is directed onto a metal powder bed and fused metal particles according to a computer-aided design file (Shibli *et al.*, 2013). This technology is an extension of the SLS process, which also regenerates real 3D parts from layer-by-layer additions of fused metal powder. This technology allows the fabrication of human implants in minimum processing time, directly from computer-aided design models (Traini *et al.*, 2008). Laser-forming methods, like DLMS, allow the fabrication of functionally graded metallic implants with a gradient of porosity perpendicular to the long axis, which is helpful for bone in-growth. Schematic diagram of DMLS process is shown below:

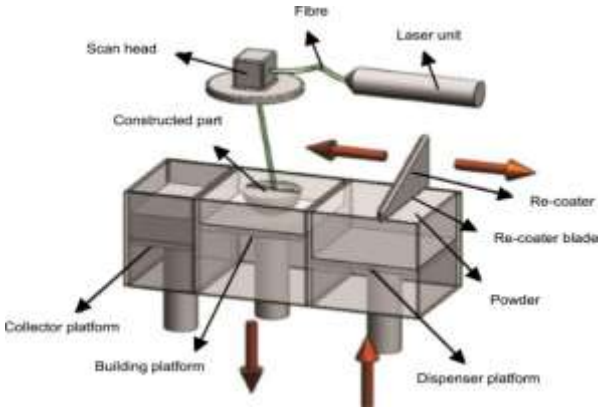


Figure 1.1: Schematic Diagram of DMLS

DMLS has the ability to produce fine features and thin walls, with good accuracy, resolution, and mechanical properties of the finished parts.

2. LITERATURE REVIEW

The experimentally investigated the mechanical properties of the components through DMLS process .mechanical properties of a component fabricated through DMLS process is more inferior to traditional manufacturing process. Process parameters such as layer thickness, scan speed, laser power has showing large impact on hardness [1].The study of the effect of tensile and fatigue properties of Inconel 718. Premature necking is generally seen in the specimen having t/d <1.Miniature specimens of Inconel718 has t/d>4 which provide good yield strength and uniform elongation and fatigue limit [2]. Investigated the fracture behaviour of nickel super alloy obtained from cast and additive manufacturing process [3]. Crack initiation has been significantly differs from microstructure of specimens. Specimen manufactured with additively manufacturing process has high fracture toughness at initiation and subsequent crack propagation [4].Analyzed the corrosion behavior of Inconel 718 manufactured with DMLS process is with commercial alloy. DMLS samples gives good corrosion resistance rather than commercial alloy due to high precipitation. In EDL analysis it was found that iron element is more in commercial alloy and nickel element is more in DMLS alloy [5].Experimentally investigated about build surface quality and fatigue behavior of additively manufactured Inconel718. SLM of Inconel 718powder is increasingly used to fabricate customized parts of jet engine. Surface quality of SLM parts is influenced by powder characteristics, process parameters and the layer wise fabrication [6].

3. METHODOLOGY

Selection of Material:

Material used for the present work is additively fabricated inconel718 samples, which is taken in powder form. Material composition will be mentioned below

Table 3.1: Chemical composition of In718 (Metal Composition Data)

Element	Sample composition (%)	Standard composition (%) [2]
Ni	53	55.0-55.5
Cr	18.2	17.0-21.0
Fe	18.1	18.5
Mo	2.8	3.0
Ti	1.1	0.65-1.15
Co	0.98	1.00
Nb+Ta	5.2	5.1

3.1 MATERIAL DESCRIPTION AND FABRICATION

Material used for fabrication of samples is inconel718. Initially the material is taken in the form of powder. In718 powder was obtained from EOS engineering Inc. The powder is sieved with a mesh size of 90 μm to avoid inhomogeneity in the distribution of the particle size. Table 3 represents the chemical composition of the employed Inconel 718 powder. The prepared files were transferred to a DMLS EOS M280 metal 3D printer (EOS GmbH Electro Optical Systems, Germany), equipped with a 400 W Ytterbium fiber laser. All samples were fabricated in 200 sliced layers.

3.2 MACHINE DESCRIPTION

The machine which is used for fabricating the samples is EOSM290.



Figure 3.1: EOSM280

(INTECH DMLS, Pvt Ltd, Bangalore**)**

EOS M 280 Produces highest quality metal parts in additive manufacturing. The robust system design and the powerful 400-watt fiber laser enable a reliably high performance day in, day out. The exceptional high beam quality of the laser spot and its excellent detail resolution is ideal for manufacturing highly complex DMLS components ensuring homogeneous part properties from part-to-part, job-to-job and machine-to-machine. The intuitive, open and productive CAM tool EOSPRINT allows optimization of CAD data ensuring a quick and easy job and workflow management.

Table 3.2: EOSM280 Machine specifications

(INTECH DMLS, Pvt Ltd, Bangalore**)**

Building volume	250 x 250 x 325 mm (9.85 x 9.85 x 12.8 in) (height incl. build plate)
Laser type	Yb fibre laser; 400 W
Precision optics	F-theta lens; high speed scanner
Layer thickness	40 microns
Scanning speed	960 mm/s
Focus diameter	100 µm (0.004 in)
Power consumption	MAX. 8,5 kW/ average 2,4 kW/with platform heating up to 3,2 Kw
Inert gas supply	7,000 hPa; 20 m³/h (102 psi; 706 ft³/h)
Dimensions (W x D x H)	2,500 x 1,300 x 2,190 mm (98.4 x 51.2 x 86.2 in)
Scan Strategy	Stripes

Powder bed fusion (PBF) is an additive manufacturing process and works on the same basic principle in that parts are formed through adding material rather than subtracting it through conventional forming operations such as milling**.** The PBF process begins with the creation of a 3D CAD model, which is numerically 'sliced' into several discrete layers.

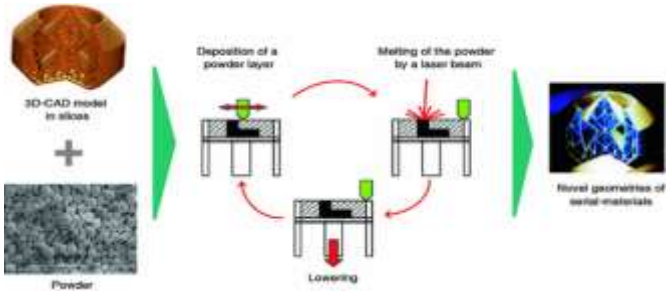


Figure 3.2: Powder Bed Fusion Method

In horizontal orientation we are taking length of the specimen in z direction and height of specimen in y direction.

Specimen length is along z direction =120mm

Specimen length is along y direction =2.50mm

One ends while the other end is fixed. We keep increasing the weight while at the same time measuring the change in the length of the sample. The tensile test is performed individually on both horizontal and vertical orientation and the results are compared. The material has known dimensions like length and cross sectional area .we then begin to apply weight to the material gripped.



Table 3.3: UTM specifications

Model	UTE 40
Max Capacity	400 KN
Measuring Range	0 – 400 KN
Clearances between columns	500 mm
Power supply	3Ø, 440 V, 1.7 KW

3.7.3 Dimensions of tensile Inconel 718 samples:

Dimensions of horizontal orientation sample for tensile test:



Figure 3.4: vertical orientation specimen

Tensile test is performed on the above mentioned dimensions of the specimen and the results are carried out. Dimensions of vertical orientation sample for tensile test:

In vertical orientation we are taking specimen length in x direction and height of the specimen in z direction.in our study we are considering only length and height of the specimen for tensile test.



Figure 3.5: l Horizontal orientation specimen

As per the ASTM standards

Specimen length is along x direction =120mm

Specimen height is along z direction = 2.50mm



Figure 3.6: Tensile Inconel specimens

Tensile test is performed on this vertical orientation specimen and the results are carried out.

After getting results of individual orientations of both the specimens we then compared their results .it was noticed that percentage of elongation tends to starts at tensile load of 78 N nearly. In which orientation better results are obtained are taken into consideration.

3.7.4 Compression test experimentation:

A compression test is a method for determining the behavior of materials under a compressive load. UTM is used for compressive test.

Compression test are conducted by loading the test specimen between the two plates and then applying a force to the specimen by moving the crossheads together.

Compression test generally used to determine mechanical properties such as elastic limit, proportional limit, yield point, yield strength and compressive strength.

During this test the specimen is compressed and deformation versus the applied load is recorded.

3.7.5 Dimensions of compression Inconel 718 samples:

Dimensions of compression test horizontal orientation specimen as per ASTM standards is as follows: in our study we are considering only length and height of the specimen for compression test.

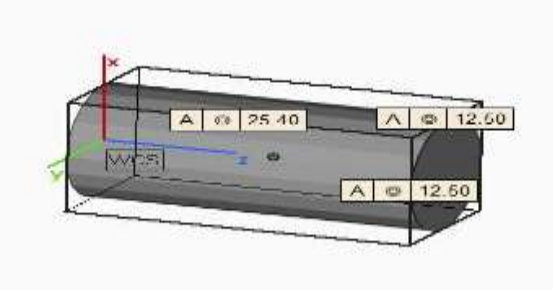


Figure 3.7: Compression specimen of horizontal orientation

Specimen length is along z direction =25.40mm

Specimen length is along x direction =12.50mm

Compression test is performed on these dimensions of the specimen and the results are carried out.

Compression test on the vertical orientation specimen:

In vertical orientation we are taking specimen length in z direction and height of the specimen in y direction.

Specimen length is along z direction =25.40mm

Specimen length is along y direction =12.50mm

Compression test is performed on this vertical orientation specimen and the results are carried out. It was noticed that compression tends to start at a compressive load of 120N.

In which orientation specimen will give best results are taken into consideration.

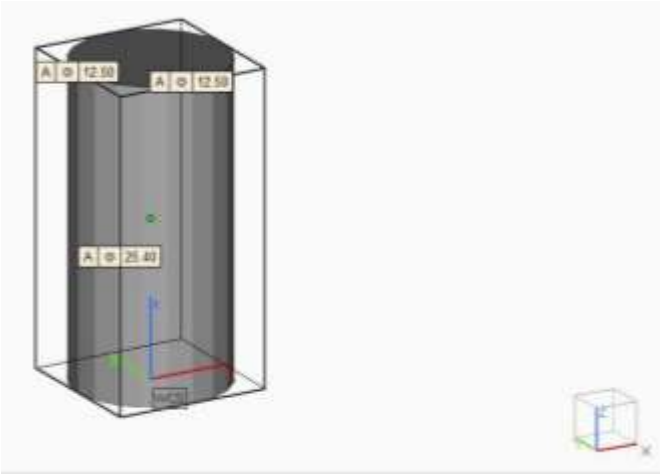


Figure 3.8: Compression specimen of vertical orientation

3.7.6 Impact test experimentation:



Figure 3.9: Charpy impact test machine

The process of impact testing is used to study the various characteristics of materials. These include toughness, hardness, ductility, and strength. It involves sudden application of a load to a specimen in order to determine its impact value.

Charpy impact test:

This test measures the amount of impact energy absorbed by the specimen when it is hit by pendulum and is considered as a good metal impact tester, it shows whether a specimen can be classified as ductile or brittle especially ferritic steels.

Table 3.4: Impact test machine specifications

Suitable for	**Charpy Tests**
Initial potential energy (joules)	300
Pendulum drop angle (degree)	140
Striking velocity of pendulum (m/sec)	5.182
Length of the pendulum (mm)	775
Effective weight of pendulum (kg)	22.5
Distance between pendulum and charpy impact specimen	± 7.75 mm Max

3.7.7 Dimensions of impact Inconel 718 samples:

Dimensions of impact test horizontal orientation of the specimen should be as follows: in our study we are considering only length and height of the specimen for the impact test



Figure 3.10: Impact specimen of horizontal orientation

Specimen length is along x direction = 55.00mm

Specimen height is along y direction =10.00mm

Impact test is performed on the specimen and results are carried out.

Vertical orientation of the specimen:

In vertical orientation of the specimen the dimensions is as follows:

Specimen length is along x direction = 55.00mm

Specimen height is along y direction = 10.00mm

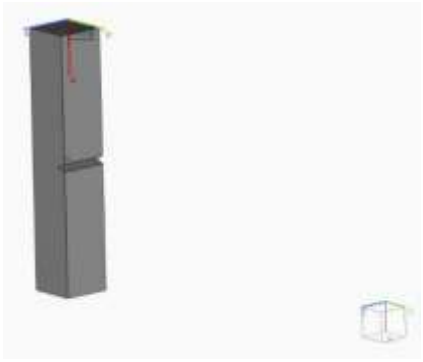


Figure 3.11: Impact specimen of vertical orientation

Results of vertical orientation are compared with horizontal orientation results.it was noticed that maximum energy absorbed by the specimen is at a impact load of nearly 250J. Better results are taken into consideration.

Impact specimen testing:



Figure 3.12: impact specimen before testing



Figure 3.13: Impact specimen after testing

The toughness of Inconel718 is determined by performing Charpy Impact test. The energy absorbed during the material fracture is given as **258 Joules.**

3.7.8 Corrosion test experimentation:

There are various types of corrosion tests.in our experiment we are using electro chemical corrosion testing. A potentiostat instrument is usually used to perform this sort of this test. A three electrode setup, including working electrode, reference electrode and counter electrode are usually used. Potential, current, and time are three important parameters in electrochemical tests.in these tests an applied potential generally scans in a certain range and the current is measured. In this test current is measured when the applied potential scans in a narrow range (-20mv) from lower to higher than corrosion potential.

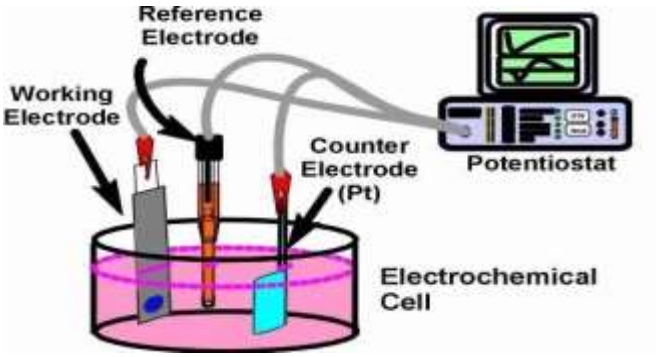


Figure 3.15: Schematic diagram of corrosion test

3.7.9 Dimensions of corrosion Inconel 718 samples:

Specifications of horizontal orientation specimen are as follows:

Specimen length is along x direction = 20.00mm

Specimen width is along y direction = 19.96mm

Specimen height is along z direction = 3.00mm

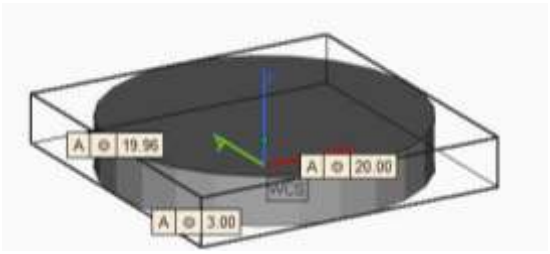


Figure 3.16: Corrosion specimen of horizontal orientation

Results are performed on the specimen and carried out.

Vertical orientation of corrosion specimen:

Specimen length is along y direction =20.00mm

Specimen width is along x direction

= 19.96mm

Specimen height is along z direction =3.00mm

3.8 SUMMARY:

In this chapter the properties of the material, process parameters, characteristics of the material and experimental setup are discussed briefly. The methodology and experimental procedure for fabrication are discussed elaborately.

4. RESULTS AND DISCUSSIONS

In this chapter experimental results obtained from the tensile test, compression test, corrosion test, wear test, of horizontal and vertical orientation Inconel 718 samples has been discussed.

4.1 Tensile test:

After performing the tensile test on Inconel 718 specimens of both horizontal and vertical layer orientations which are fabricated through DMLS process, the results obtained are yield strength and tensile strength, which is tabulated in table 4.1:

Table 4.1: Results of yield strength, tensile strength, % of elongation of horizontal and vertical layer orientation specimens as per ASTM standards are tabulated below

Tensile test results	Horizontal orientation specimen	Vertical orientation specimen
Yield strength (MPA)	787.52	794.18
Tensile strength (MPA)	974.67	885.30
% of elongation	17.18	36.18

From the above table it is observed that tensile strength for horizontal orientation specimen is higher than vertical orientation specimen. The reason behind that is, in horizontal layer orientation the tensile load applied is parallel to the layer fabrication and the bonding between the layers is more when compared to the vertically layer oriented Inconel specimen which results in more tensile strength.

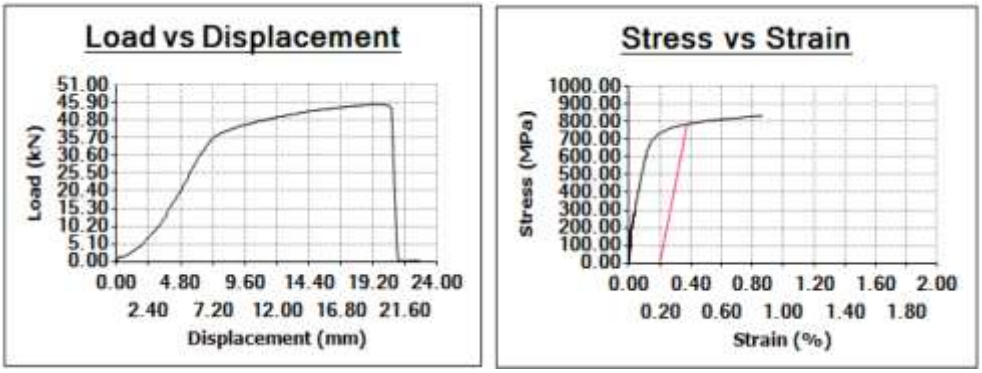


Figure 4.1: Stress strain graph of horizontal orientation Inconel tensile specimen:

Figure 4.1 shows the stress strain relationship of vertically oriented tensile specimen. From the graph it is observed that percentage of strain 0.36% is occurred when the stress of 794.18 MPA is applied on the specimen.

4.1.2 Compression test:

After performing the compression test on Inconel 718 specimens of both horizontal and vertical layer orientations which are fabricated through DMLS process, the results obtained are compression strength, which is tabulated in table 5.2:

Table 4.2: Results of compression strength of both horizontal and vertical layer orientation Inconel 718 specimen as per ASTM standards is tabulated below:

Compression test results	Horizontal orientation specimen	Vertical orientation specimen
Compression strength (MPA)	918.23	1156.29

From the above table it is observed that the compression strength of vertically oriented fabricated Inconel sample is higher than horizontally oriented fabricated sample. The reason behind that is in vertically oriented Inconel sample the no of specimen layers is more which offers more resistance to deformation. In horizontal orientation Inconel specimen the no of layers fabricated is less which offers less resistance to deformation.

Table 4.3: Results of corrosion resistance performed on horizontal and vertical orientation Inconel 718 specimens:

Corrosion test results	Horizontal layer orientation Inconel sample	Vertical layer orientation Inconel sample
Corrosion potential (Ecorr) mV	-305.110	-233.377
Corrosion current (I corr) uA	3.843	1.039
beta c (mV)	132.6	22.1
beta a (mV)	421.7	53.7

Chi²	25.0757	187.687
Chi / sqrt(N)	0.193315	2.7398
Equivalent weight(g/eq)	18.408	7.380
Density (g/cm3)	0.834	0.495
Surface area (cm2)	1.000	1
Corrosion rate (mmpy)	0.2337539	1.99518

With the help of tafel fit graph analysis tool, the corrosion rate can be determined if the user enters the values of equivalent weight, material density and the active surface area.



Figure 4.3: Tafel plot curve of Inconel 718 horizontal oriented specimen

Hardness test is performed on both horizontal and vertical layer orientation Inconel 718 samples. The results obtained are Rockwell hardness (HRC) and Vickers hardness (HV) values which are tabulated in the table 5.4

Table 4.4: Vickers hardness (HV) and Rockwell hardness (HRC) results of horizontal and vertical orientation Inconel 718 specimens:

Hardness test	**Horizontal layer orientation Inconel 718 specimen**		**Vertical layer orientation Inconel 718 specimen**	
No of trails	**Vickers hardness (HV)**	**Rockwell hardness (HRC)**	**Vickers hardness (HV)**	**Rockwell hardness (HRC)**
Trail 1	401.1	40.9	703.2	60.2
Trail 2	465.4	46.2	541.6	51.8
Trail 3	472.2	47.1	436.5	44.2
Trail 4	452.8	45.5	418.4	42.5
Trail 5	510.8	49.8	474.7	47.2
Average Hardness Value	**460.26**		**514.88**	

It is observed that average hardness for vertically oriented Inconel 718 specimen is higher than horizontal layer oriented Inconel specimen. The reason behind that is when the load is applied vertically on the samples the strength between the layers is more which causes buckling and indentation takes at more load.

4.1.3 Wear test:

Wear test is performed on both horizontal and vertical orientation Inconel 718 specimens by using wear testing machine. The input conditions applied for testing the wear is track diameter 70mm ,disc speed =500 rpm, distance run= 1KM, load applied = 20N.The results obtained the wear test are wear rate which is tabulated in table 5.5

Table 4.5: Wear rate results of horizontal and vertical orientation Inconel 718 samples:

Horizontal orientation Inconel 718 corrosion specimen			**Vertical orientation Inconel 718 corrosion specimen**		
Weight of specimen before testing (W1)	Weight of specimen after testing (W2)	Wear rate (mg) = (W1-W2)	Weight of specimen before testing (W1)	Weight of specimen after testing (W2)	Wear rate (mg) = (W1-W2)
8.0120	8.0106	1.4	21.6075	21.6041	3.4

It is observed that the wear rate of horizontal orientation corrosion specimen is less than vertically oriented corrosion specimen because in horizontally fabricated samples the strength between the two consecutive layers is comparatively less than the strength between the particles in a layer.



Figure 4.5: Time vs wear rate graph of horizontal orientation Inconel 718 corrosion specimen

Impact test is performed on both horizontal and vertical orientation Inconel 718 samples. The toughness of Inconel 718 is determined by performing charpy impact test. The result obtained from the impact test is impact resistance which is tabulated in the table 5.6:

Table 4.6: Impact resistance results of horizontal and vertical orientation Inconel 718 samples

Layer orientation	**Energy absorbed during fracture (joules)**
Horizontal layer orientation	258
vertical layer orientation	210

It is observed that impact resistance for horizontal orientation specimen is higher than vertical orientation Inconel specimen .the reason behind that is when the load applied parallel to layer fabrication the strength between the layers is more which offers high resistance to deformation.

5. CONCLUSIONS

The mechanical properties such as hardness, tensile strength, compression strength, impact resistance, wear resistance, corrosion resistance of Inconel 718 specimen of both horizontal and vertical layer orientations, fabricated by powder bed fusion process was studied experimentally. The following conclusions are drawn from the experimental results. Based on the experimental results it is concluded that the ultimate tensile strength, percentage of elongation, wear resistance, wear resistance, corrosion and impact resistance of horizontally fabricated sample is higher than that of vertically fabricated sample.

6. FUTURE SCOPE

The work can be extended to analyze other parameters and other mechanical properties. The level of experiments can be increased for better results. For better results and accuracy we can also use optimization techniques like taguchi analysis, in addition to experimental analysis. Material consumption can be reduced so that cost for fabricating the part is also reduced. The experiments can be planned by varying parameters and the orientation in angular.

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Editor's Note



Women's empowerment has become substantial in the development of any country. Women's empowerment is nothing but empowerment of the country in all genera. Women and girls represent half of the world's population and therefore also half of its potential. But gender inequality persists every where and stagnates social progress. On average, women in the labor market still earn 23 percent less than men globally and women spend about three times as many hours in unpaid domestic and care work as men. Sexual violence and exploitation, the unequal division of unpaid care and domestic work, and discrimination in public office, all remain huge barriers. All these areas of inequality have been exacerbated by the COVID-19 pandemic: there has been a surge in reports of sexual violence, women have taken on more care work due to school closures, and 70% of health and social workers globally are women.

Gender equality is not only a fundamental human right, but a necessary foundation for a peaceful, prosperous and sustainable world. There has been progress over the last decades, but the world is not on track to achieve gender equality by 2030. Gender equality is defined in USAID's Gender Equality and Female Empowerment Policy as a state "in which both men and women have equal opportunity to benefit from and contribute to economic, social, cultural and political development; enjoy socially valued resources and rewards; and realize their human rights". The G20 countries are committed to promoting 'Gender Equality' which is essential for sustainable development, which includes ensuring that women and girls have equal access to education, health care, economic opportunities, and political participation.

Women have a strong relationship with nature and pro-environmental attitudes and beliefs. They have developed a unique set of values on environmental concerns. The perspectives of women towards nature influence how they approach environmental challenges. The role of Women in Environment Protection is remarkable. In India, Women started many environment protection movements prior to Independence which are remarkably continued till today.

I hope that the findings of various studies and the suggestions offered by the authors concerned would help the researchers, policy makers and practitioners of Women and Gender Studies. On behalf of the Editorial Board, I acknowledge the support given by the contributors and readers.

Prof. D. Sai Sujatha
Director
Centre for Women's Studies

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Women Play a Crucial Role in the Preservation of Environment

Dr. K. Kiran

Ms. Dasireddygari Jyothi

Dr. E. Mahadev Reddy

Abstract

Women contribute significantly and in a variety of ways to environmental preservation. At all levels, from neighbourhood grassroots activities to global policymaking, their contributions are essential. It is essential to recognize and enhance the role of women in environmental protection to achieve sustainable development and address pressing environmental concerns. Building a more equitable and environmentally sustainable world requires adhering to the core principles of gender equality and inclusivity. In India, Women play a crucial role in the movements for sustainability and environmental conservation. Their contributions are varied and significant, addressing the nation's many environmental problems. In India, women play important responsibilities in environmental protection. Empowering women is crucial for achieving sustainable goals as they play a central role in sustainable development. Sustainable development acknowledges the interdependence of social, economic, and environmental factors and is sometimes characterized as development that satisfies present demands while not impairing the capacity of future generations to satiate their own needs. Women have important and varied roles in sustainable development.

Keywords: Women, Indian, Environmental Protection, Movements, Sustainable etc.

Introduction

Women bear the brunt of environmental degradation and are essential in overseeing the management of natural resources within households and communities. They are responsible for the management of forests,

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farmland, water, food, and fuel resources in communities globally. Women in developing countries are responsible for producing 60 to 80 percent of the food supply. However, they often face limitations in land ownership, access to loans, and obtaining insurance due to inheritance laws and cultural norms. The 1992 UN Earth Summit, the Chipko movement in India, and the Green Belt Movement in Kenya all emphasized the importance of women's voices and perspectives in sustainable development at all levels, from the top to the bottom.

Women around the world have demonstrated leadership, activism, and advocacy in tackling pressing environmental issues, and have played pivotal roles in various environmental movements. Their substantial contributions have impacted policies and practices, rallied communities, and heightened awareness.

The term "environment," originating from the French word meaning "to surround," encompasses the interactions between water, air, land, humans, other living beings, and property. In contrast, women have historically been perceived as the subordinate gender, often responsible for managing and conserving resources for their families on a global scale. Courageous women are taking the lead in various fields, such as exploring water resources worldwide and safeguarding forest reserves. Ester Boserup's book, Woman's Role in Economic Development, published in the early 1970s, played a pivotal role in sparking interest in the relationship between women and the environment. It wasn't until the 1980s that governments and policymakers began to give more attention to this connection.

Women's direct interaction with the environment has led to a deep understanding of it, resulting in significant roles as agriculturalists, water resource managers, and traditional scientists. Not only are women knowledgeable about the environment, but they are also protective and nurturing, as highlighted by Shettima (1996). Due to their primary

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Opinion of the Farmers towards YSR Rythu Bharosa and PM Kisan Scheme - A Study

Dr. E. Mahadev Reddy

Abstract

YSR Rythu Bharosa is one of the Navaratnalu assistance schemes of Andhra Pradesh. The Andhra Pradesh Government is instigating "YSR Rythu Bharosa" from October 15th 2019 for affording financial assistance to the farmer families, including tenant farmers @ Rs.13,500/- per farmer family, per annum, to support the cultivators in meeting the investment during the crop season with a view to enable them to timely sourcing of quality inputs and services for higher crop productivity.

Under the YSR Rythu Bharosa-PM Kisan Scheme, the Andhra Pradesh State government gives financial assistance of Rs.13,500/- per year to eligible farmers in three different installments (May @ Rs. 7500/- + Sept./ Oct. @ Rs. 4000/- + & January @Rs.2000/- = total @ Rs.13,500/-). The entire amount of Rs. 13,500/- does not come via YSR Rythu Bharosa scheme alone, and as the name suggests, the direct cash transfer (Direct Benefit Transfer) includes Rs. 6000/- annually assured to eligible farmers under PM KISAN Samman Nidhi Scheme (PM-KISAN). In other words, while Rs. 7,500/- comes from the state government and another Rs. 6,000/- comes via PM KISAN scheme.

Keywords: Cultivators, Quality Inputs, Higher crop Produciton.

Introduction

YSR Rythu Bharosa was launched by Chief Minister of Andhra Pradesh Sri. Y.S. Jagan Mohan Reddy on 15th October, 2019 releasing Rs.3785 crore benefiting 38 lakh farmers in the A.P. State. Rythu Bharosa Kendras were later launched on 30th May 2020 to supply seedlings, fertilizers and seeds to horticulture, aquaculture and agriculture sectors. A total amount of Rs. 6,173 crores was spent on the scheme for the year

2019-20 and Rs. 6,928 crore for 2020- Rythu Bharosa Scheme. As you all know that the beneficiary list prepared by real-time government society (RTGS). The concerned authorities have identified around 66,54,891 landowner farmers who will get benefits under this scheme till date. The scheme has been implementing successfully even though in the pandemic period.

The Rythu Bharosa Scheme also called as the YSR Rythu Bharosa Scheme, is one of the welfare schemes for farmers launched by the Andhra Pradesh government in June 2019. It was implemented effectively from 15th October, 2019.

Online Application Process for Rythu Bharosa Scheme

To apply online, all you have to do is follow the steps given below:

1. Visit the official website of the scheme: https://ysrrythubharosa.ap.gov.in/RBApp/index.html
2. Click on the "Login" button on the right upper corner of the page.
3. Create your username, password, and enter the captcha given to log into the new account.

How to check beneficiary list

The beneficiary list will be prepared by the government on a district-wise level. This will be updated on the official website. To check if your name is on the list, follow the steps given below:

1. Visit the official website of the scheme: https://ysrrythubharosa.ap.gov.in/RBApp/index.html
2. Click on the "Login" button on the right upper corner of the page.
3. Log in using your username and password.
4. The beneficiary list will be displayed on the page with details such as

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RIGHTS of WOMEN

Dr. V. Jagadeeswari

Curiosity Press

Rights of Women

Dr. V. Jagadeeswari

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About the Book

Despite great strides made by the international women's rights movement over many years, women and girls around the world are still married as children or trafficked into forced labor and sex slavery. They are refused access to education and political participation, and some are trapped in conflicts where rape is perpetrated as a weapon of war. Around the world, deaths related to pregnancy and childbirth are needlessly high, and women are prevented from making deeply personal choices in their private lives. Human Rights Watch is working towards the realization of women's empowerment and gender equality—protecting the rights and improving the lives of women and girls on the ground. With this backdrop the work of ***'Rights of Women'*** *was executed.*

This book provides women's human rights and then explains the critique voiced concerning the national and international system in this esteem. Further, the chapters included in the book discuss about the violation of human rights with gender lens at home as well as in work place. Authors contributed the studies based on primary as well as secondary data. The authors focussed different domains of women rights both sense i.e., violation and protection. Hence the book chapters cover economic, education, legal and Social aspects which are crucial for empowerment of Women and Children in India. I thank the authors for contributing valuable information to carry out the book. The book is useful to the students and researchers of law, sociology, social work, rural development, extension studies, women and gender studies, etc.

V. Jagadeeswari

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Influence of Literacy Programmes on Women and Development

Dr. E. Mahadev Reddy

Abstract

"Literacy empowers women, enabling their mobility, enhancing decision making and ensuring better command over their own lives..."

Literacy is the key element for the development of any nation. It leads to better health, employability skills, and better employment opportunities and safeguard the more stable societies. The role of literacy and the development of aspects like social, economic and cultural development. Helping someone able to read and write effectively and to solve some mathematical elements or acquire basic skills of literacy take for granted, improves the future of everyone in the society. When learners have higher literacy levels the economic development is enhanced as well as individual and community well-being. Two-thirds of the world's adult illiterates are women. This situation has not changed in the last 20 years and the latest projection indicates that this ratio will remain at this level by 2015 (UNESCO Institute of Statistics). That means that

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WOMEN ROLE IN ENVIRONMENTAL PROTECTION: A CASE STUDY IN GANGUDUPALLI VILLAGE, CHANDRAGIRI MANDAL, SRI BALAJI DISTRICT, ANDHRA PRADESH, INDIA.

Dr.K.Kiran[a], Ms. Dasireddygari Jyothi[b], Dr. E.Mahadevareddy[c]

a : Academic Consultant, Department of Environmental Science, b: Student, Department of Rural Development, c: Academic Consultant, Department of Adult & Continuing education, Sri Venkateswara University, Tirupati-517502.

Abstract: The natural environment refers to all living and non-living components that exist without human interference. This word is frequently used to describe the Earth or specific areas of it. It includes all living organisms, weather patterns, climate, and natural resources that influence human survival and economic endeavours. In developing countries like India, women bear the primary responsibility for managing and conserving resources within their families. They dedicate significant amounts of time to tasks such as gathering and storing water, ensuring access to fuel, food, and fodder, as well as overseeing the management of various types of land, including forests, marshes, and agricultural areas. This paper discusses about how a women play a key role in protecting the natural environment by studying the practices and daily activities of Gangudupalli village women towards environmental protection.

Index Terms: **Women, India, Gangudupalli village, Environmental Protection, Sustainability, etc.**

I. INTRODUCTION

The term "environment," which means "to surround,". The word "environment" refers to the interaction of water, air, and land, as well as their interactions with one another, humans, other living things, and property. According to Schultz et al., [1] the women, environment and development (WED) -debate is based on a critical perspective of development policies, emphasizing the connection between modernization/industrialization, technology, and environmental degradation. Women, on the other hand, have long been considered the lower sex. On a worldwide scale, women are often in charge of managing and saving resources for their families. Women are breaking new ground in a range of sectors, including the investigation of the world's water resources and the conservation of forest resources.

Women play a vital role in the management of natural resources, including land, water, forests, and energy. Women in underdeveloped regions of the world are regarded as the primary consumers of natural resources such as land, forests, and water, as they are accountable for collecting food, fuel, and fodder [2]. They possess both traditional and modern knowledge about the natural environment surrounding them. In the past, women were often overlooked or disregarded, but there is now a growing recognition of the significant impact they have on the environment. Additionally, there is an increasing understanding of how the environment affects the health and well-being of women. This shift in perspective is evident in events such as the 1992 UN Earth Summit, the Chipko movement in India, and the Green Belt Movement in Kenya. These initiatives highlighted the importance of women's voices and perspectives in promoting sustainable development at all levels, from the highest decision-making bodies to local communities. In recent decades, environmental movements have increased as the movements for women's rights have also increased. Today's union of nature preservation with women's rights and liberation has stemmed from invasion of their rights in the past [3,4].

In the Asian and Pacific Island regions, the majority of women involved in the economy are engaged in the agriculture sector, which encompasses various activities such as work in own-account farms, labor in small enterprises for processing fruits, vegetables and fish, paid and unpaid work on other people's land, and collecting forest products. However, only a small percentage of these women, ranging from 10-20%, have been able to secure tenure to the land they work on due to economic and legal barriers. One such barrier is the gender disparity in access to loans, which results in women receiving fewer and less favorable loans to acquire land compared to men [5].

Women's direct involvement with the environment has resulted in a deep grasp of it. As a result, Women act as agriculturalists, water resource managers, traditional scientists, etc among others. Women interact with the natural and man-made environments more extensively than males, owing to their major duty for domestic and home administration. As a result, individuals are more vulnerable to the negative consequences of degraded home, neighbourhood, and city environments, and they incur a greater cost associated with living in substandard homes and communities with inadequate residential and health infrastructure. Women are predominantly responsible for farm work and domestic food production across the globe [6,7,8,9]. Although there is a growing trend of women taking on more agricultural tasks and expanding their involvement, the gender-based division of labour remains unchanged in terms of reproductive work.

It is imperative to comprehend the diverse methods through which women have actively engaged in the preservation and administration of the environment, with the intention of incorporating them into environmental management initiatives. The purpose of this manuscript is to evaluate the participation of women in environmental management, specifically focusing on a small village.

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Status of Tribals in Professional Education: A Study in Ananthapuramu District

Mr. G. Gangadhara
Prof. R.B. Sathyavathi

Abstract

Tribal's are the group of people who live in forests or backward areas. They are completely dependent on forests for their livelihood and survival. Indian constitutional assembly members notified the facts that certain communities in India were suffering from extreme social, educational and economical backwardness. These communities were notified as Scheduled Caste and Scheduled Tribes as per the provisions contained in clause 1 of article 341 and 342 of the Constitution respectively.The criterion used to specify a community, as scheduled tribes are indications of primitive traits, distinctive culture, geographical isolation, shyness of contact with the community at large, and backwardness. This criterion was not spelt out in our constitution, but it has become more popular. Advisees were the most marginalized people in India. Their traditional life has been intrinsically permitted to the forest areas of India. Historically these communities have been the subject of stage inflicted oppression, trapping them in a vicious cycle of violence and poverty. The present paper is highlighted that the tribal community in professional education in Ananthapuramu district of Andhra Pradesh.

Key words: Tribals, education, development, professional

Introduction

The term Tribe generally referred as human social group which mainly live in a forest region and survive by hunting animals and by carrying out shifting cultivation. They have their own culture, religious beliefs and traditions which are completely different from main stream practices.

Tribals are the group of people who live in forests or backward areas. They are completely depended on forests for their livelihood and survival.

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Indian constitutional assembly members notified the facts that certain communities in India were suffering from extreme social, educational and economical backwardness. These communities were notified as Scheduled Caste and Scheduled Tribes as per the provisions contained in clause 1 of article 341 and 342 of the Constitution respectively.

After the Africa, India has the largest tribal community in the world. Among the marginalized people, Tribals had a long history. In ancient times people were segregated as Tribals on various reasons. India is one of the diversified and largest tribal populated countries in the world. According to the 2011 census tribal population in India is 104 million or 8.6 percent of the total population.

In India Tribal communities have been recognized by the Indian constitution under the 'Schedule 5'. Hence the reorganization of the tribes in the constitution is known as "Scheduled Tribes". Article 366 (25) defines about Scheduled Tribes as "Such tribes or tribal communities or part of or groups within such tribes or tribal communities as we deemed under Article 342 to be Scheduled Tribes for the purpose of this constitution"

The criterion used to specify a community, as scheduled tribes are indications of primitive traits, distinctive culture, geographical isolation, shyness of contact with the community at large, and backwardness. This criteriawas not spelt out in our constitution but it has become more popular. Adivasisare the most marginalized people in India. Their traditional life has been intrinsically permitted to the forest areas of India. Historically these communities have been the subject of stage inflicted oppression, trapping them in a vicious cycle of violence and poverty.

India is the place of 705 ethnic groups which are notified as Scheduled tribes. According 2011 census 10.42 crore Indians (8.6%) areScheduled tribes. Since ancient period in India there has been discriminatory section. In this schedule tribes also one such kind facing the untouchability and discrimination. Although there has been constitutional safeguards in the Indian Constitution there has been practice of untouchability, prejudice and violence.

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government policy and its implementation, to hold public office and perform all public functions at all levels of government, and the right to participate in non-governmental organizations (NGOs) or associations concerned with the public and political life of the country. Article 8 requires State parties to "take all appropriate measures to ensure to women, on equal terms with men and without any discrimination, the opportunity to represent their Governments at the international level and to participate in the work of international organizations."

Although women's right to vote has been secured in nearly every country of the world, in practice, the right to vote can sometimes be meaningless

Conclusion

VET plays a crucial role in the social and economic development of a nation and is subjected to the rapidly changing needs of education, society, rural sector, industry and the environment.The politics and practices of a state-initiated, feminist conceived empowerment program for rural women in India seek to challenge. There is a need for policy measures to improve the technological level of women for higher productivity in employment. Microcredit has become one of several possible platforms from which rural women articulate their concerns about caste, poverty and the burden of raising daughters as successful individuals. Women are increasingly being recognized as equal partners in development.

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WOMEN ROLE IN ENVIRONMENTAL PROTECTION: A CASE STUDY IN GANGUDUPALLI VILLAGE, CHANDRAGIRI MANDAL, SRI BALAJI DISTRICT, ANDHRA PRADESH, INDIA.

Dr.K.Kiran[a], Ms. Dasireddygari Jyothi[b], Dr. E.Mahadevareddy[c]

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Women play a vital role in the management of natural resources, including land, water, forests, and energy. Women in underdeveloped regions of the world are regarded as the primary consumers of natural resources such as land, forests, and water, as they are accountable for collecting food, fuel, and fodder [2]. They possess both traditional and modern knowledge about the natural environment surrounding them. In the past, women were often overlooked or disregarded, but there is now a growing recognition of the significant impact they have on the environment. Additionally, there is an increasing understanding of how the environment affects the health and well-being of women. This shift in perspective is evident in events such as the 1992 UN Earth Summit, the Chipko movement in India, and the Green Belt Movement in Kenya. These initiatives highlighted the importance of women's voices and perspectives in promoting sustainable development at all levels, from the highest decision-making bodies to local communities. In recent decades, environmental movements have increased as the movements for women's rights have also increased. Today's union of nature preservation with women's rights and liberation has stemmed from invasion of their rights in the past [3,4].

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It is imperative to comprehend the diverse methods through which women have actively engaged in the preservation and administration of the environment, with the intention of incorporating them into environmental management initiatives. The purpose of this manuscript is to evaluate the participation of women in environmental management, specifically focusing on a small village.

II. STUDY AREA

Gangudupalli is a Village in Chandragiri Mandal in Chittoor District of Andhra Pradesh State, India. It belongs to Rayalaseema region. It is located 6 KM from Chandragiri town and 21 KM towards West from District headquarters Sri Balaji. According to 2011 census, Gangudupalli Village Local Language is Telugu. Gangudupalli Village Total population is 1080 and number of houses are approximately 250. Female Population is 53.3%. Village literacy rate is 61.6% and the Female Literacy rate is 33.0%. Their major occupation is Agriculture, Cattle maintenance, Silkworm cocoon cultivation. Apart from that, few of them doing Jobs and businesses at various sectors located in and around Tirupati.

In this paper, we employ two different categories of data. The initial category consists of secondary source materials, acquired from prior research on women's participation in environmental preservation and control. These materials encompass books, journal publications, and articles obtained from online sources. The second category of data was procured from primary sources, specifically through the distribution of questionnaires to the women residing in the rural area of Gangudupalli Village.

III. REVIEW

3.1. Water Resource Management

Etta [10] conducted a survey in Mariko Lower-income settlement in Lagos, which revealed that women hold a pivotal role in managing communal water resources and fulfilling household water requirements. Women are primarily responsible for regulating and supervising communal taps or water points, and they often secure these sources to prevent damage by children. At the household level, women and girls are burdened with the task of fetching water for various domestic activities such as cooking and washing. Conversely, men tend to dominate the water trade. Unfortunately, these sources are susceptible to pollution, especially from untreated sewage, which poses significant health risks [11,10]. In rural areas, women are solely responsible for procuring water for their domestic needs. However, the methods and practices employed in obtaining water, particularly from riverbanks, contribute to water pollution [12].

3.2. Women in Agriculture

Women's contributions to agricultural production have been significant worldwide, with the Food and Agriculture Organization reporting that they are responsible for producing more than half of all food grown in 1996. In certain regions, such as sub-Saharan Africa and the Caribbean, women produce an astonishing 80% of basic foodstuffs. Adebayo et al [13] found that in Asia, women provide between fifty and ninety percent of the labour force for rice cultivation, while in Adamawa State, Nigeria, 60% of women are involved in farming. Jayasheela [14] outlines the various roles that women play in Indian agriculture, including production and distribution, planting and cultivation, weeding, hoeing, harvesting, and storage.

Women in Gangudupalli Village play a significant role in the agricultural sector by contributing to the production of rice, groundnuts, and sugarcane. Additionally, they are actively involved in cultivating livestock crops for their cows, buffalos, goats, and other animals. This highlights the close interaction between women and the environment, particularly the land. As victims of soil degradation, women have actively participated in initiatives aimed at conserving soil. A notable example of their involvement is the Agro-forestia project in Yatenga, Burkina Faso. Moreover, Igbo women have taken on traditional male agricultural responsibilities, in addition to their existing roles within the female sphere [15, 16].

3.3. Solid waste disposal

In the specified research domain, the rate of solid waste accumulation surpasses the pace of population expansion. The disposal of solid wastes commonly occurs at designated dumping sites or undeveloped areas. Women, owing to their proximity to the environment, actively engage in environmental stewardship by undertaking responsibilities such as cleaning and upholding cleanliness, particularly in relation to garbage disposal. Acknowledging the health hazards linked to waste, women assume the responsibility of ensuring its consistent removal at the communal level.

IV. RESULTS

The present section presents the outcomes of the questionnaire survey carried out to examine the extent of women's involvement in environmental management within the specified study area, namely Gangudupalli Village. The demographic characteristics, specifically age and marital status, of the women are presented in Table 1. It is worth mentioning that a mere 17.6% of the women surveyed are below the age of 22 years. The majority, accounting for 66.4%, belong to the middle age group (23-50 years), while only 16.0% are aged above 50 years. This distribution of age indicates that a significant proportion of the women are still in their prime years and possess the necessary Vigor to actively engage in environmental management activities.

Table 1. Age and marital status of survey women

S.No	Age Group	Number	Percentage
1	Below 22 years	18	17.6
2	Middle age (23-50) Years	65	66.4
3	Above 50 years (51-75)	17	16

Table 2 displays that a significant majority of female participants, specifically 66.4%, are involved in agricultural activities in the study area. Organic farming is the most used method of soil conservation by women. Planting trees is recognized as an effective approach to safeguarding the environment and mitigating hazards such as windstorms and erosion. The survey results indicate that almost 76.2% of women in the study area have planted trees or flowers within the past five years, further supporting the notion that women actively engage in tree planting. Fruit trees, such as mango, sapota, papaya, and various fruit plants, are frequently planted by women, serving the dual purpose of environmental protection and providing fruits for household consumption.

Table 2 Women involvement in Environmental Management

Involvement in Farming	Percentage(%)
Yes No	66.4 33.6
Planting trees (Farming/Around the house)	Percentage (%)
Yes No	76.2 23.8
Conserving methods	Percentage (%)

Organic farming planting	55.7 44.3
Major activities in Environmental Cleaning	Percentage (%)
Weeding Sweeping Drainage	22 63 15

The challenges faced by women in environmental management within the study region were identified by the participants as follows: firstly, there is a lack of environmental consciousness among the general population; secondly, there is a shortage of waste disposal facilities; and finally, there is an insufficiency in drainage systems.

V. RECOMMENDATIONS

To achieve sustainable development, it is recommended that active involvement of women in environmental management be promoted, while considering the obstacles they currently face. To bring about a transformation in the mindset of the populace and equip them with relevant knowledge, it is crucial that environmental education becomes mandatory for the majority of women. This will address the issue of individuals carelessly discarding paper scraps, fruit peels, plastic cans, and polythene bags on the streets for mere amusement.

Additionally, prioritizing women's education and ensuring access to education for girls should be considered a policy imperative. Educated women will play a significant role in bridging the gap between the environment and development. It is important to duly acknowledge and support the empowerment of women in sustainable human development, as well as their role in safeguarding the environment.

VI. CONCLUSION

In conclusion, it is evident that both married and single women have actively engaged in the preservation of the environment. However, a noteworthy proportion of women involved in this endeavour are married. This substantial presence of married women within the study area implies that they are more inclined to assume responsibility for the conservation and cleanliness of the environment due to their roles as homemakers. Consequently, this study has examined the diverse ways in which women have actively contributed to the protection of the environment and the management of natural resources, aiming to ensure the sustainable utilization of environmental resources.

Based on the findings, recommendations are proposed, particularly those that can facilitate the empowerment of women. The crucial role of women as managers of resources, advocates for the environment, and activists within their communities must be acknowledged when devising strategies for environmental protection. It is imperative to provide women with the opportunity to participate in environmental matters at the local, regional, national, and international levels. For women to have a substantial influence on decision-making processes, their representation should be equal to that of men. As resource managers, women should be consulted and supported in their ongoing efforts to safeguard the environment. Specifically, a greater inclusion of women in decision-making processes concerning environmental policies, programs, and funding is essential.

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An Informal Economy of Women in Asmara (Eritrea): A Case Study

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This case study focuses on the participation of women street vendors in the central business area of Asmara, Eritrea, particularly around the chicken market and outlying streets. Women who fail to find jobs in the formal sector engage in alternative work in the informal economy (street vending). Today, many street vendors depend on their illicit business to earn them and rescue themselves from different poverty levels. This case study seeks to examine the involvement of women in street vending activities. Therefore, this study aims to contribute to the apparent literature gaps by utilizing qualitative and ethnographic analysis of the cause of their participation and the problems they encounter. This study applied anthropological ethnographic fieldwork methodology. Furthermore, the study involved participant observation, semi-structured and in-depth interviews and photographs as a leading data collection method among the women vendors. Implementing these research methods examined the overall daily routine and livelihood of the street vending women. Additionally, focused on the reasons why they engaged and what practical problems they faced, both during the work in the street and other socio-cultural problems in their home, were examined and described in this literature.

Keywords: women, street vendor, informal economy, anthropology, ethnography

Economic sectors are broadly classified as formal and informal, i.e. dual economic systems. The formal sector is characterized by wage earning, licensed, and officially recognized by governmental institutions. On the other hand, the informal economy means self-employed, tax-free, and most diminutive or not recognized officially (ILO, 1993). The concept of the "informal sector" was initially claimed by the International Labor Organization (ILO) in a study on urban labour markets in Ghana by anthropologist Keith Hart (Plattner, 1989). However, it was mainly realized in developing countries after Second World War. The present study focuses on the participation of women in informal sector business in Asmara.

Informal economy (also termed "underground economy", "black market", & "moonlighting") (Plattner, 1989) refers to economic activities outside the state-regulated employment activities. It involves engagement in labour, circulation, and consumption of goods and services, mainly outside the Ken of the government (ibid). For example, a job held by an employee is considered informal if there is no social security contribution or respect for the employer's primary or minimum labour conditions, and the employee is not entitled to pay sick leave and paid annual leave. In other words, the working condition in the informal economy is not subject to the state's labour law. Hearle et al. (2019) found two billion informal workers in the global economy.

The labour law in Eritrea, for instance, defines informal economy for economic activities involving workers below 14 years of age and all unregistered private business enterprises that did not keep a written record of accounts, size of employee less or equal to three, not entitled of paid sick leave and paid annual leave, no social security coverage, and all contributing family workers (MLHW, 2018). Excluding the agriculture sector, about 451,636 workers (out of 1,435,886 employees) engage in the informal economy, about 31.5% of the total working force. In total, the percentage in the informal economy was higher for women (35.5%) than for men (27.3%) (MLHW, 2018).

The types of activities widely observed in the informal economy include agro-pastoral, manufacturing, workshops, street vending, housemaid, etc. and the present study deals with one of the different types of the informal economy, i.e., street vending. Street vendors often are self-employed, and there is no registration or tax cost; they work as a means of income in poor working conditions and without security. Municipal response to informal trade activities varies from city/town to city/town. Still, in principle, municipal offices try to stop these illegal commercial activities due to sanitation, traffic, crimes and revenue problems associated with this type of business. It is an easily understandable feature that the State neglects the intervention in informal activities. The study defined the purpose of this case study as street vending is one form of the informal sector which is not recognized by the law and regulations of any instruction and the workers do it without any protection. Moreover, street vendors are called invisible entrepreneurs working as part of the urban landscapes and closely analyzing the activity of their street businesses (Sekhani et al., 2019).

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Research Paper

Can Life in Senior Care Homes Affects Psychological Well-Being of Older Widows

Madhavi B.M.[1]*, Jamuna D.[2], Srikanth Reddy V.[3]

ABSTRACT

In the era of modernization, with the transmission of values and morality, widows face several societal challenges. Illiteracy and economic dependency intensify the situation of these widows as they grow older. Widows their psychological, emotional and physical health has been affected due to chronic psychological distress. The objective of this present study is to examine the life experiences of older widows living in senior care homes and its impact on psychological wellbeing. The study was carried out on 160 older widows who are residing in pay and stay homes in the age group of 65-75 years, who are cognitively intact and communicative were enrolled in the study. The findings revealed that age, no education, lower income and joint family are the sources of psychological distress in older widows. Poor health appears to be an important factor among the institutionalized aged to effectively determine whether the individual can cope with major stresses.

Keywords: *Psychological health, Older Widows, Senior care homes.*

Aging is a series of process that begins with life and continue throughout the life cycle, ending with death. (Singh, Misra 2009). Population aging has become a universal phenomenon and is the result of a process known as "demographic transition" in which there is a shift from high mortality and fertility to low, leading to an increase in the proportion of elderly people in the total population. India, the second largest country in the world, is presently undergoing such a demographic transition (Seby, et al., 2011) with 72 million elderly persons above 60 years of age, which is expected to increase to 179 million in 2031 and further to 301 million in 2051 (Pracheth, 2013). Widowhood may be a tense life transition that a huge part of the overall population eventually ought to face. In this connection, the social relationships can account for variation in reaction and adaptation to the current vital event. Social links are possible to change after the loss of a spouse; these social links stored before may be distinguished from those after widowhood (Lundorff et al. 2019). The idea of well-being has been utilized moderately in the form of various terms like quality of life, life fulfillment, financial safety, individual satisfaction, social well-being, and mental well-being. More specifically, mental well-being is related to depression, anxiety, and stress, while social

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wellbeing is related to social participation, social support, home attachment, and so on (Sharifian and Gruhn 2019). Trends are changing in modern urbanized societies in developing countries such as Pakistan which affected the mental and social well-being negatively among the older adults due to the changing trends of life. Education is always considered a good quality of foundation for widows' well-being. Older adult widows required proper knowledge to prevent sickness for their productive and healthy lives. Widowhood ratio is evident statistically over the globe especially among the older adults who crossed 65 years of age. The data showed that around 65% of women are widowed, and this number is higher than the men's counterpart which shows the life expectancy is higher among the women as compared with that of men (Ayuso, 2019).

Few studies carried out in 1980's on older widows. Ramamurti, (1989) assessed the contemporary psychosocial status of elderly widows belonging to forward and backward communities. The findings supported most of the common observations pertaining to the problems of widows in India. The widows had more problems of adjustment than non-widows in almost all the age groups. A variety of demographic, social, economic and personal factors influence the nutritional status of the elderly. Marital status, caste, locality, age and physiological needs were the most important predictors of mental health. Various intervention strategies were suggested to remove the negative self-attitudes and improve the psychological well - being of the elderly widows. Psychological health includes freedom from some qualities such as feelings of helplessness, worthlessness, feelings of depression, etc. To that extent, they contribute a positive evaluation of oneself which in turn may influence memory performance favorably, just as the case concerning good self-esteem (Ramamurti, 1997).

Health and physical status is probably an important concern and has a significant impact on intellectual functioning. Physical health is predictive of the maintenance of cognitive function (Schaie & Hertzog, 1986).

Maintenance of good mental health is one of the key indicators of successful aging. In psychosomatic medicine, theorists argue that certain patterns of psychological responding are damaging to or promoting physical health. It is often assumed that people who are sociable, upbeat, undemanding and easygoing are proved to be health related and to longevity (Friedman 1997).

Most of the studies of Successful Aging established the physiological and psychological benefits of education on cognition in older adults (Kubzansky et al., 1998). Empirical evidence for the effectiveness of cognitive–behavioral interventions with older adults has grown over the past 3 decades. Research apart from the age and memory performance the role of other variables also plays a critical role on memory performance which includes education, health, and individual differences are source variation in the memory performance (Zelinski et al, 2001). It was also noticed that the effect of socioeconomic status and prior life experiences on cognitive performance in older adults (Kramer et al., 2004).

Studies on elder care in Indian community settings and studies on old age homes indicate that more than 85% of the elderly stay in families (either with spouse or with adult children). It involves care giving interactions between family caregiver and the elderly care receiver. Jamuna, and Babu Rao, (2015) examined the factors that mediate care needs and care adequacy of men and women over the age of 60 years. The psychological care needs were examined in relation to socio familial, demographic and psychological variables viz., physical and psychological health status, social supports and cognitive status. The findings highlight

the implications in national policy on care and to evolve culturally suitable care models. The outcome of study would become important inputs to the existing care concerns of elderly in NPOP.

Li. et al., (2013) examined the relationship between transitions in volunteering activity and physical and psychological health outcomes among older adults in Taiwan. Approximately, 3% of older volunteers kept volunteering and 7% stopped or started their volunteering over time. Engaging in any volunteering, including continuous volunteering, discrete volunteering, active-to-inactive volunteering, and inactive-to-active volunteering, was significantly associated with better self-rated health and higher life satisfaction when compared with the non-volunteering group.

Social participation stages decline with the death of a partner, mostly owing to the bad spousal conditions which consequently raise the chances of loneliness among older adult widows (Jones et al. 2019). Despite the Article-25 of the Universal Declaration of Human Right which focuses on the quality of living standard, health, and well-being of oneself and of his family, as well as foodstuff, outfit, accommodation and treatment, vital societal facilities, and security for widows, the older adults have the variant level of social well-being due to diverse cultural values of the different societies (Ashiq and Asad 2017; Cardenas et al. 2019).

In view of these lacunae, the current study is contemplated with the following objectives.

- To examine the life experiences of older widows living in the senior care homes and its impact on psychological wellbeing.
- To assess the salient determinants of psychological wellbeing among older widow residents of senior care homes.

MATERIALS & METHODS

The present study included 160 older widows who stays in pay & stay senior care home and were aged 65 to 75 years (Mean age=70years). The study group included people who were willing to participate, had normal cognitive ability with the capacity to comprehend the instructions. The study excluded older widows who had trouble communicating and had been diagnosed with serious health issues, depression or anxiety problems (clinical cases). The widow participants were told about the nature, purpose, and voluntariness of their involvement, and was obtained signed informed consent following the Declaration of Helsinki principles (2003) and later amendments. All the participants in this study were residents of senior care homes. The personal data form used to know the socio-demographic categories of the older widows. The psychological health status was assessed through the Indian version of Cornell Medical Index (CMI) Health Questionnaire which was adopted and standardized for an ICSSR project on older widows. (Ramamurti et. al (1989). The older widows from senior care homes were divided into small groups with 10 in each and they were encouraged to open for focused group discussion on broad themes (provided by the researcher) on sources of anxiety. Inputs of each group discussion were shared by the group leader and the same data has been used in identifying the psychosocial issues in older widows.

RESULTS AND DISCUSSION

Table – 1 shows the sample characteristics of the older widows in senior care homes. 55% of the women are educated and 45% were uneducated. 58% of the sample are belongs to 65-70 years age group. 53.1% of the older widows coming from nuclear families and 46.9% were from joint families. Most of the older widows (54.4%) related to rural areas and 45.6% were from urban areas. 72.5% of older widows source of income is pension and 48.1% of women

are belongs to below middle-class group and 35.6% of women are from middle class economic status.

Table 1: Sample Characteristics of Older Widows of Senior Care Homes (N=160)

S.No.	Sub-groups	N	Percentage (%)
1.	**Age**		
	65-70	93	58.1
	71-75	67	41.9
2.	**Education**		
	No Education	72	45.0
	Education	88	55.0
3.	**Type of Family**		
	Nuclear	85	53.1
	Joint	75	46.9
4.	**Locality**		
	Rural	87	54.4
	Urban	73	45.6
5.	**Source of Income**		
	Pension	116	72.5
	Property	34	21.3
	Others	10	6.3
6.	**Economic Status**		
	Below Middle class	77	48.1
	Middle Class	57	35.6
	Upper Middle Class	26	16.3

Table-2: Psychological Health in Different Socio-Demographic Subgroups among Older Widows of Senior Care Homes

S.No.	Sub-groups	N	Mean (SD)	t value
1.	**Age**			
	65-70	93	32.10(5.86)	2.606**
	71-75	67	34.28(4.20)	
2.	**Education**			
	No Education	72	35.33(4.90)	5.405**
	Education	88	31.11(4.91)	
3.	**Type of Family**			
	Nuclear	85	34.14(5.91)	1.971*
	Joint	75	32.44(4.86)	
4.	**Economic Status**			
	Below Middle class	77	35.56(4.88)	2.624**
	Middle Class	57	33.00(6.40)	
5.	**Locality**			
	Rural	87	33.92(5.86)	1.973*
	Urban	73	35.48(3.65)	
****P<0.01; * P<0.05; @ Not Significant**				

A cursory glance of results on psychological health status (Table-2) indicate that the mean differences are statistically significant in term of their age, education, economic status. Older widows in 65-70 years, with basic education from middle class, from rural background and from joint family reported poor psychological well – being compared to their counterparts.

A few studies that look specifically at widows 'psychological wellbeing over duration of widowhood. Wilcox et al (2003) using data from the Women's Health Initiative compare married and widowed women, with the later distinguished by time since widowhood. They find that widowed women report more mental health problems than married women. This may reflect the effects on mental health of spousal care both for recent widows and comparable married women. An indication of the immediate mental health consequences of widowhood is the elevated risk of suicide reported by Luoma and Pearson (2002) among young widows and widowers.

There is little literature that relates the psychological well-being for widows and widowers to their economic resources. While Carr et al. (2000) argue that the emotional consequences of widowhood are affected by the quality of the marriage and dependence – financial and emotional – on the deceased partner, they do not examine how financial dependence separately contributes to emotional dependence. Earlier studies of widowhood noted the additional stress on bereaved widows who were financially dependent on deceased husbands (Morgan, 1981, Lopata, 1973). This pre- widowhood dependence may have been what Lee and DeMaris (2007) were attempting to capture by including pre-widowhood resources in their study of post-widowhood depression. That they found no effect may be because it is post-widowhood resources (or those resources relative to pre- widowhood resources) that are the appropriate explanatory variable.

Fig.1: Levels of Psychological health in Different Socio-Demographic Subgroups among Older Widows of senior care Homes

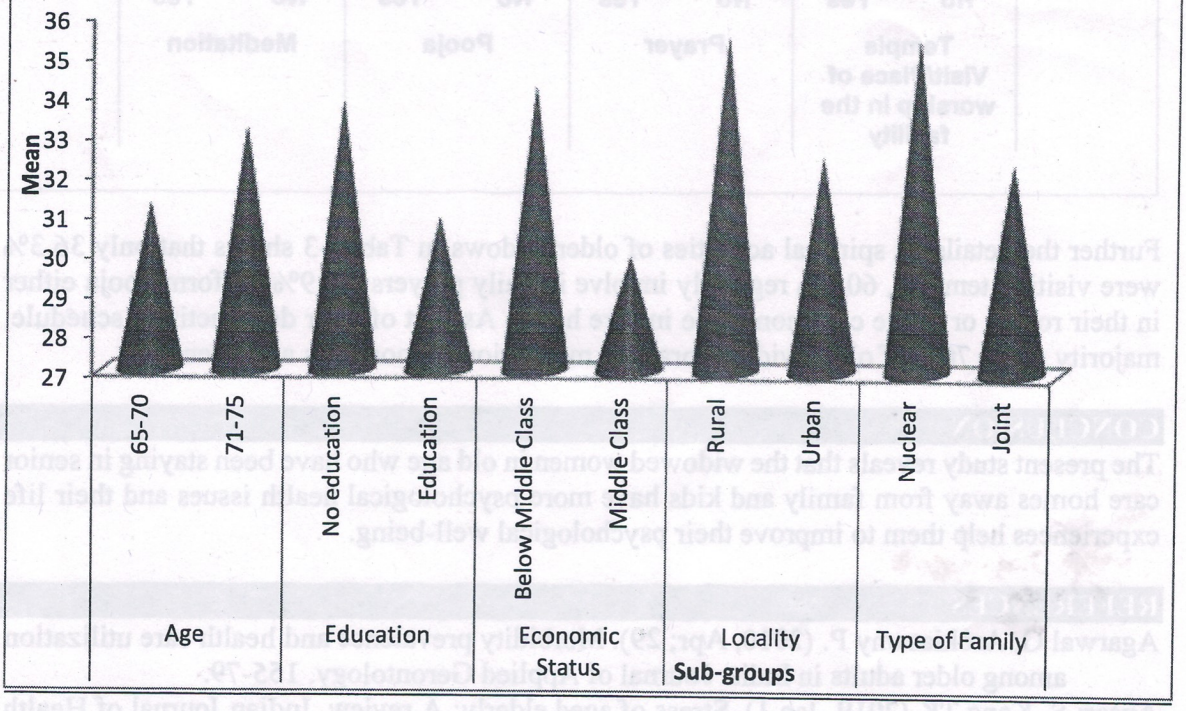
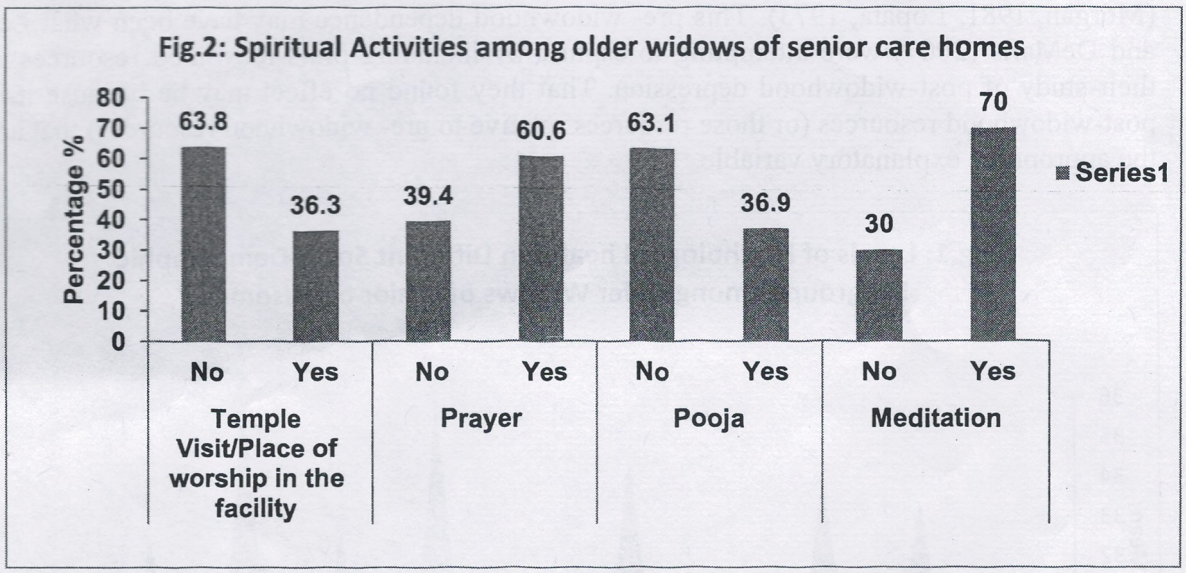


Table 3: Spiritual Activities Among Older Widows of Senior Care Homes

S.No.	Spiritual Activities	N	Percentage (%)
1.	**Temple Visit/Place of worship in the facility**		
	a) No	102	63.8
	b) Yes	58	36.3
2.	**Prayer**		
	No	63	39.4
	Yes	97	60.6
3.	**Pooja**		
	a)No	101	63.1
	b)Yes	59	36.9
4.	**Meditation**		
	a)No	48	30.0
	b)Yes	112	70.0



Further the details on spiritual activities of older widows in Table -3 shows that only 36.3% were visiting temples, 60.6% regularly involve in daily prayers; 36.9% perform pooja either in their rooms or in the common place in care home. As part of their daily activity schedule, majority about 70% of older widows practice meditation in mornings and evenings.

CONCLUSION

The present study reveals that the widowed women in old age who have been staying in senior care homes away from family and kids have more psychological health issues and their life cxperiences help them to improve their psychological well-being.

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Conflict of Interest

The author(s) declared no conflict of interest.

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Social Supports and Social Adjustment among Older Widows Living in Pay and Stay Homes

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ABSTRACT

The objective of this study was to examine the impact of social support on the social adjustment of 80 older widows, in the age group of 65-75 years, cognitively intact and communicative, and living in pay-and-stay homes in Andhra Pradesh. The Social support and social adjustment of individuals were assessed by using social support inventory (Ramamurti & Jamuna, 1991), and an adjustment inventory(Ramamurthi,1969), for older persons. The findings of the study suggest the importance of maximizing social networks to facilitate social adjustment in older widows to make their living experience in senior care homes meaningful and satisfying.

Keywords: Social Supports, Social Adjustment, Older Widows, Pay and stay Homes

One of the issues that most elderly people experience is limited support from family or relatives or significant others (Sharghi, *et al.*, 2018). Elderly individuals need contact with others to ask for help when they need it as a means to satisfy their emotional needs (Theurer, *et al.*, 2015). The transformation of social structures in recent decades

and the imbalance of the traditional joint family system, the care provider in the nuclear family have led to an increase in the number of old age homes and the culture of delivery of elderly people to these homes (Roberto, and Blieszner, 2015). However, some studies point to the benefits of living in care homes such as relationships with peers, access to nursing care and health facilities, lack of loneliness, and depression. When an elderly person is in a care home, he/she is likely to be physically, psychologically, emotionally, and economically dependent (Atadokhtw, *et al.*, 2015, Theurer, *et al.*, 2015) on non-family networks. Dependency can reduce self-esteem and increase depression in a senior care home. In one of the studies Unsar, *et al.*, (2016) reported higher levels of social support and Activities of Daily Living (ADL) in every resident of senior care homes.

There is enough evidence that many elderly people prefer attending and participating in activities of daycare centers rather than staying in care homes. Daily gatherings can increase the level of physical, mental, and social health of the elderly by enriching their leisure time through implementing various programs (Fields, 2016). Social support acts as a protective shield against mental health issues. It is associated with the reduction of depression, anxiety, and other psychological problems (Patil, *et al.*, 2015). It is still unclear whether older widows living in senior care homes have personal adjustment and perceive their social supports and to what extent they adjust to their social network. Generally, personal adjustment is in demand in old age due to diminishing health, limited capacity, poor mental ability, and increased economic dependency (Shukla, and Kiron, 2013).

Widowhood is an inevitable life event. It is a catastrophic event at any stage of life for the surviving partner with serious repercussions on their physical, economic, and emotional well-being, particularly in the first year of the loss or for a longer term in some cases (Wilcox, *et al.*, 2003). However, the emotional response to spousal loss is hypothesized to be different depending on various socio-demographic characteristics such as age, gender, onset of widowhood, living arrangement, functional ability to perform activities, health status, other

factors such as community involvement and economic conditions of the survivor (Moon, *et al.*, 2011, Agrawal, and Keshri, 2014)

One of the ingradients of successful ageing is the perception of Social support. It is shaped by the social networks within an area where the individual is located, and synchrony with those significant others at times of need. Keeping the above in view, the present study was planned with the following objectives:

- To examine the socio-demographic profiles of older widows living in the pay and stay homes.
- To study the social supports and social adjustment of older widows living in pay-and-stay homes.

Method

Sample

From a sample of 240 older widows in Pay-and - stay senior care homes, located across districts of the United Andhra Pradesh, only a sample of 80 residents from these homes, ages varying from 65 to 75 years, belonging to rural and urban areas, were selected by systematic random sampling method keeping in mind the accepted inclusion and exclusion criteria.

The subjects were explained about the nature, purpose, and voluntariness of their involvement, and signed informed consent was obtained. A trial interview was conducted to assess the subjects' capacity to communicate. The subjects without chronic illness and those cognitively intact were included in the study. The subjects in the study were individually administered the tests.

Tools used **:** The participants were administered Personal Data Form (PDF) to seek information on relevant socio-demographic characteristics, and Adjustment Inventory (Ramamurthi, (1969), to assess adjustment in older widows. A short form of perception of the Social Supports Inventory was used to measure social support in older widows.

And tools we again field tested on a sample of 5 widows to examine relevance. The test-retest reliability was 0.91. (after 15 days).

Results and Discussion

The analyses used a variety of descriptive techniques to describe the patterns of social participation following the loss of a spouse. Some analyses compared widows with controls to differentiate the effects of widowhood from aging, whereas additional analyses compared subgroups within the widowed sample to assess the differential responses to widowhood.

Table 1

Sample Characteristics of Older Widows of Pay & Stay Homes (N=80)

S.No.	Sub-groups	N	Percentage (%)
1.	Age		
	65-70	45	56.3
	71-75	35	43.7
2.	**Education**		
	No education	23	28.8
	Education	57	71.2
3.	**Type of Family**		
	Nuclear	29	36.3
	Joint	51	63.7
5.	**Locality**		
	Rural	35	43.8
	Urban	45	56.2
6.	**Source of Income**		
	Pension	50	62.5
	Property	20	25.0
	Others	10	12.5
7.	**Economic Status**		
	Below Middle class	21	26.2
	Middle Class	33	41.3
	Upper middle class	26	32.5
8.	**No. of members in the family**		
	2-4	48	60.0
	4-8	32	40.0

The sample characteristics of older widows in pay & stay homes were compiled to understand their details (Table -1). Age distribution of older widows shows that 56.3 per cent were in the 65-70 years and 43.7 per cent were in the 71-75 years age group. The educational status of older widows shows that about 28.8 per cent had no education, and 71.2 per cent were educated. All belong to the Hindu religion only. Distribution of older widows across family type (before their relocation) indicates that 36.3 per cent were with the nuclear family and 63.7 per cent were in a joint family setting. Older widows about 43.8 per cent were basically from semi-urban areas and 56.2 per cent were from urban areas. The source of income distribution shows that the majority of them (62.5%) receive pensions, 25 per cent have a property and only 12.5 per cent have other help. The details on economic status show that 26.2 per cent were from below the middle, 41.3 per cent were from the middle income group and 32.5 per cent were from the upper middle class. The number of children in the family shows that 60 per cent had 2 to 4 children, 40 per cent had 4 to 8 children.

Table 2

Level of Social Supports in Different Socio-Demographic Subgroups

S.No.	Sub-groups	N	Mean (SD)	t value
1.	**Age**			
	65-70	48	37.24(8.38)	2.637**
	71-75	32	41.51(5.22)	
2.	**Education**			
	No education	49	43.35(8.20)	3.634**
	Education	31	37.02(6.54)	
3.	**Economic Status**			
	Below Middle class	21	43.43(7.09)	2.659**
	Middle Class	33	37.09(9.32)	2.000*
	Upper middle class	26	41.12(4.78)	1.331@

4.	**Locality**			
	Rural	35	36.57(8.45)	1.991*
	Urban	45	41.13(6.92)	
5.	**Type of Family**			
	Nuclear	29	34.59(7.05)	2.635**
	Joint	51	39.39(8.24)	
****P<0.01; * P<0.05; @ Not Significant**				

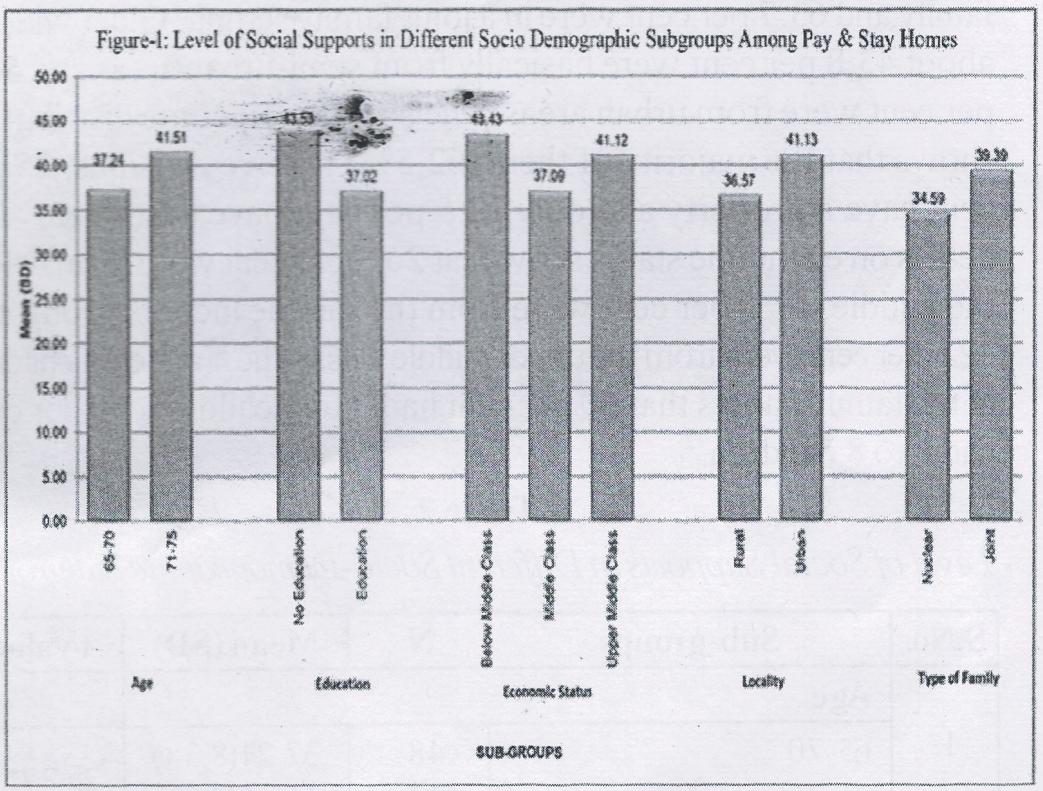
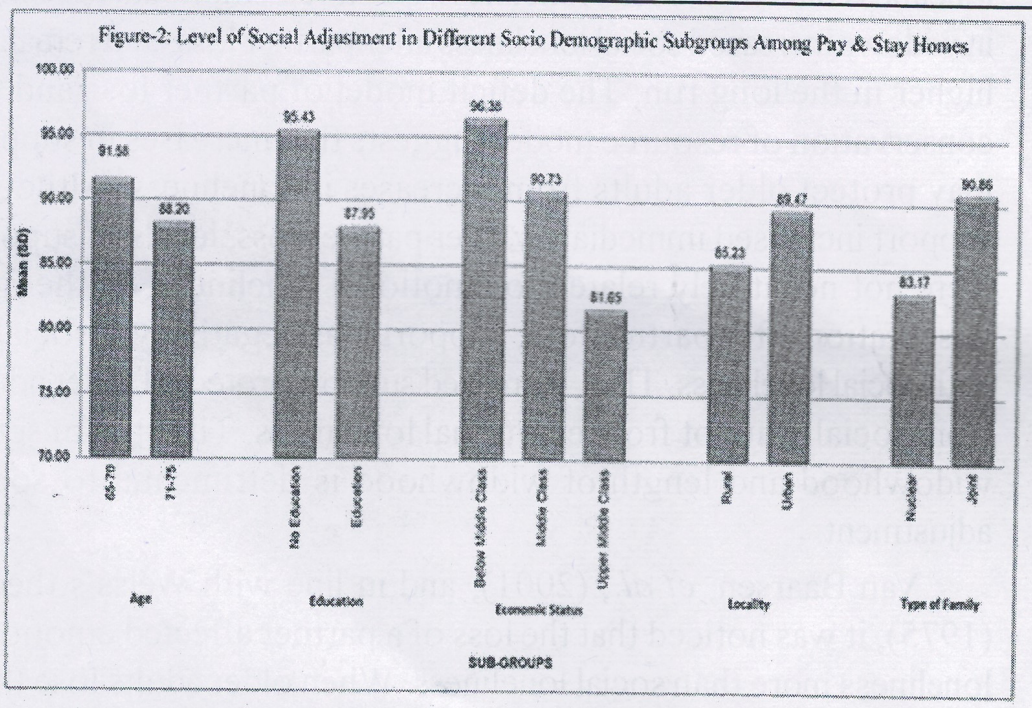


Table 3

Levels of Adjustment in Different Socio-Demographic Subgroups

S.No.	Sub-groups	N	Mean (SD)	t value
1.	**Age**			
	65-70	48	91.58(7.92)	1.990*
	71-75	32	88.20(6.98)	
2.	**Education**			
	No education	23	95.43(4.93)	4.384**
	Education	57	87.95(7.55)	

3.	**Economic Status**			
	Below Middle class	21	96.38(3.91)	2.677**
	Middle Class	33	90.73(9.13)	4.296**
	Upper Middle Class	26	81.65(6.41)	9.209**
4.	**Locality**			
	Rural	52	85.23(10.34)	1.991*
	Urban	28	89.47(8.68)	
5.	**Type of Family**			
	Nuclear	29	83.17(10.61)	3.717**
	Joint	51	90.86(7.76)	
	****P<0.01; * P<0.05; @ Not Significant**			



A cursory glance at results on social supports (Table 2) indicates that the mean differences are statistically significant in terms of their age, education levels, economic status, and type of family subgroups. Older widows in the 65–70 years age group, with education, except in upper-middle-class widows from joint families reported higher social support than their other counterparts in the sub-group (Figure 2).

Social adjustment in older widows living in senior care homes of different socio-demographic subgroups (Table 3) shows that there

are subgroup variations in social adjustment. Results on Social adjustment in subgroups of age, education, economic status, and type of family differed significantly (Table 3). Older widows in 71-75 years, with no education, from the lower middle class, from a rural background, and from nuclear family reported higher levels of social adjustment.

The present study sought to understand that decreased support from the significant would aggravate loneliness after partner loss. In line with the theory of loneliness (Weiss, 1975), as emotional and social loneliness in widows. Results showed that older adults were affected much more by partner loss regarding their emotional loneliness than their social loneliness. As stated emotional loneliness in widows increased social loneliness after partner loss, and remained higher in the long run. The deficit model of partner loss and the conservation of resource model suggests that increases in support may protect older adults from increases in loneliness. Although support increased immediately after partner loss, levels of support were not negatively related to emotional loneliness. In the final observation after partner loss, support was negatively associated with social loneliness. Thus, increased support protected older adults from social, but not from emotional loneliness. Thus the onset of widowhood and length of widowhood is detrimental to social adjustment.

Van Baarsen, *et al.*, (2001), and in line with Weiss's theory (1975), it was noticed that the loss of a partner affected emotional loneliness more than social loneliness. When older adults lose their partner, their emotional loneliness increases sharply; but their social loneliness increases only slightly. In the long run, emotional loneliness remains high. With their partner loss, older adults lose a major source of attachment of security, but not necessarily social integration. In sum, the loss of a partner is associated more with emotional loneliness than with social loneliness. Similar to the outcome of the present study marital status and its link with mental health has been explored previously, concluding that unmarried and widowed individuals show

higher rates of loneliness, lower life satisfaction, physical ailments, and higher mortality with advancing age (Zebhauser, *et al.*, 2014).

Further, an in-depth analysis of the case study of older widows in senior care homes and the social adjustment (Golden, *et al.*, 2009) determined that social networks independently affect mood and well-being in the elderly, and the risk of depression increases with the severity of loneliness. Another study found that older adults who had poorer social networks had also a worse quality of life (Kahn, *et al.*, 2003; Isabelli, C., 2006).) found that relationships between perceived social support and psychological well-being (depression, loneliness, and life satisfaction) were quite strong. Garousi, *et al.*, (2013) emphasized that supportive family behaviors are important sources of social support and could be in negative relation to depression and anxiety of diabetic patients.

In conclusion, this study shows how important changes in the social resources of older widows are for their social adjustment. The poor social adjustment and negative life expectancy of widows benefit from the broad range of social resources available in their networks of personal relationships and social adjustment in the community rather than in pay-and-stay homes. Moreover, widows experience additional benefits from their social resources when their instrumental support increases after a partner loss. More generally, it suggests that older widows derive benefits from their social resources, as a substitute for their partner loss. This would suggest that policy initiatives to enhance social resources in care homes are to be planned.

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EVALUATION OF *IN-VITRO* ANTIFUNGAL POTENTIALITIES AND GC/MS SPECTROSCOPIC APPROACH OF *CLEISTANTHUS COLLINUS* (ROXB.) BENTH. EX. HOOK. F.

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Keywords:

Agar well-diffusion method, Antifungal activity, *Cleistanthus collinus*, GC-MS, Phytochemical profile

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ABSTRACT: India is the home to the familiar plant *Cleistanthus collinus* (Roxb.) Benth. ex Hook. F (Euphorbiaceae) has great ethnomedicinal and therapeutic applications. The present study was designed to assess the phytochemical profile and investigate the antifungal effectiveness of leaf, bark and fruit extracts by using the agar well diffusion method. All crude extracts from leaf, bark, fruit and fractions derived also demonstrated significant antifungal activity (20-80%), but the methanol extracts showed a remarkable antifungal spectrum; as a result, GC-MS analysis was performed on it. From this GC-MS analysis, 14 chemicals, including alkanes, glycosides, phenols, flavonoids and steroids were identified, while leaf methanol extract has high phytochemical diversity with 9 compounds than bark with 6 compounds and fruit with 5 compounds. 1, 2, 3-Benzenetriol, 3-O-Methyl-d-glucose and Undecane are a few significant molecules with larger area percentages that demonstrated biological value. These compounds have been linked to anti-cancer, anti-inflammatory, anti-microbial and antioxidant properties. The current results collectively highlight the appreciable antimicrobial potential of *C. collinus* and its numerous chemical compounds that are physiologically active and offer a thorough understanding of the phytochemical profile, which could be exploited to create plant-based medications.

INTRODUCTION: Rising antibiotic resistance has emerged as a serious hazard to human well-being worldwide [1]. The rising prevalence of drug-resistant diseases necessitates identifying and isolating novel bioactive components from medicinal plant species utilizing standardized contemporary scientific techniques. Medicinal compounds obtained from plants might provide innovative and accessible techniques to pathogenic organisms.

QUICK RESPONSE CODE

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According to the World Health Organisation (WHO), conventional drugs produced from plants with medicinal properties continue to assist 80% of poor countries. WHO has also documented a list of over 20,000 therapeutic plant species and identified these plants as a possible driver of new medications [2].

The antibiotic era, which has lasted barely 80 years, has recently entered a time of gradual and extensive appearance of drug-resist microbes, threatening to end this era. Microbial diseases, especially fungus, have quick reproductive rates, malleable genes, and the capacity to adapt to environmental conditions containing a high concentration of possible hazardous substances that apply significant selective stresses.

Fungi's eukaryotic chemistry makes them particularly dangerous infections due to a smaller range of selective therapeutic targets over which inhibitors not hazardous to human, animal, and plant hosts may be created. Moreover, there do not exist medicinal vaccination or supplementary immune-mediated therapies present to assist people in their health care, necessitating dependence on a restricted arsenal of antifungal medication classes to combat an increasing wave of fungal diseases [3]. The worldwide stress of fungus-related infections is escalating. Over 150 million severe instances concerning fungal illnesses occur each year worldwide, leading to nearly 1.7 million fatalities. The aforementioned numbers are rapidly increasing, owing to a variety of societal and medical advances in recent decades that have aided the proliferation of fungal diseases [4]. To settle this problem, novel antifungal drugs are required and plants are the main wellsprings of novel drugs.

Due to their vast and varied organic components, which may have an important physiological influence on the human body, medicinal plants have been used to treat human ailments for centuries. Natural assets, such as plants with medicinal properties, which possess a wide range of phytocompounds potential as traditional medicine for treating chronic and infectious illnesses, have long been seen as safer and more efficient options with fewer adverse effects than synthetic drugs [5]. Owing due to their diverse pharmaceutical qualities, plants high in bioactive phytomedicine components such as alkaloids, flavonoids, tannins, and polyphenols have been utilised to treat diseases [6].

Around 25% of the active ingredients of medicinal plants that have been used as legal drugs have been discovered [7]. *Cleistanthus collinus* is an essential medicinal tree that has piqued the interest of researchers owing to its potential for medication development. *C. collinus*, a member of the Euphorbiaceae family, is a small tree featuring ellipse foliage and its silken villous spike. It tends to occur in South Indian deciduous dry highland forests, Sri Lanka and Malaysia [8]. Cleistanthus A and Cleistanthus B, diphyllin glycosides, are cytotoxic to a variety of cancerous cell lines [9]. Because of its unique pharmacological active principles, the isolation of independent bioactive chemicals of *C. collinus* might be widely exploited in the pharmaceutical industry. Despite being a toxic plant, its active constituents have been investigated for medicinal qualities such as antihypertensive, diuretic, and anticancer properties. Active compounds in *C. collinus* that show ability will have a good probability of being developed into drug use [10]. The plant's stem bark can be used as an antiseptic in skin illnesses and to treat bovine hoof sores [11]. A detailed examination of the literature reveals that two have been discovered in the assay of anti-bacterial activity reports [12, 13] and one in antifungal activity [14] from this plant. The primary goal of this study was to appraise the GC-MS analysis study and examine the antifungal potentiality of diverse plant solvent extracts.

MATERIALS AND METHODS:

Sample Collection: The plant *C. collinus* was handpicked from the vicinity of Gopavaram village, Andhra Pradesh, India (17˚22’09.16” N 81˚47’48.42” E), in January 2022 and authenticated by Prof. N. Savithramma, Sri Venkateswara University, Botany Department, Tirupati, Andhra Pradesh, India, with accession number SVUH: 1226.

Extraction of Plant Material: Plant parts were harvested, dried in the shade at 32^{o}C and ground into a fine powder. The powder was then sieved through a 0.5 mm sieve to maintain consistent molecule size and stored in sterile containers until usage. For the extractions of leaves, bark and fruit, the following solvents were selected: methanol, ethyl acetate and chloroform in the ascending order of polarity. Using a soxhlet extractor, the phytochemicals from the plant material were isolated using the aforementioned solvents, which were then stored for 72 hours in sealed jars. A thick concentration was generated when the extracts were collected in a rotary evaporator at 45°C under reduced pressure. The crude extracts were kept in a 4°C refrigerator for future usage.

Collection of Test Pathogens: Four test fungal species; two non-filamentous human pathogens *Saccharomyces cerevisiae* (MTCC 4742), *Candida albicans* (MTCC 227) and two filamentous plant pathogens *Aspergillus niger* (MTCC 282) and *Aspergillus flavus* (MTCC 277) were utilized in

this work; they were acquired from the Microbial Type Culture Collection (MTCC), IMTECH, Chandigarh, India.

Preparation of Test Sample: The methanol, ethyl acetate and chloroform extracts were dissolved in 10% aqueous DMSO (Himedia) to get different concentrations (10 mg, 5 mg and 2.5 mg per 20µL). 10% aqueous DMSO was utilized as the negative control (solvent control). As positive reference standards, Fluconazole (Central Drug House P. Ltd., India) was employed for fungal strains at a dosage of 30µg/mL.

Antifungal Activity Assay: The agar well diffusion method was used to assess the antifungal potentialities of plant extracts in a Potato Dextrose Agar (PDA) medium. A sterilized L-shaped bent rod was used to disperse the 100 µL fungal inoculums evenly and allowed it to harden in the Petri plates.

With the aid of a sterile cork borer, 5mm-diameter wells were made on the plates and filled with various solvent extracts (10 mg, 5 mg and 2.5 mg per 20µL in 10% aqueous DMSO) positive and negative controls of 20 µL each.

After a 48-hour incubation period at 26°C, the inhibitory zone's diameter was determined. The usual positive and negative controls were fluconazole 30 µg/mL and DMSO (10%) and the results of each test were averaged after being repeated three times. A strict aseptic environment was maintained during the entire microbiological experiment.

GC-MS Analysis: The extracts were examined using the Agilent Technologies GC-MS (GC-8890, GC/MS 5977 MSD). With an 18 mL/min split flow and a 3 mL/min purge flow in the injection mode. The temperature of the oven was programmed to range from 75°C to a maximum of 360°C.

The column was a Polar Columns (DB-WAX) & HP-5 MS UI with a 1.21 mL/min flow rate and helium gas (99.99%) as the carrier gas. A temperature range of 60°C to 325^{o}C was set for the column. The GC-MS lasts for a total of 53.5 minutes. The sample pieces were ionized using the EI mode (70 eV). The spectra of the unknown components were compared to the spectrum of the known components using the Spectral Library and Database (licensed NIST 2017 Library; Software: Open Lab CDS 2.5 version).

RESULTS AND DISCUSSION:

Anti-fungal Activity: The antifungal bioassay findings against pathogens using crude extracts of the *C. collinus* plant (10 mg, 5 mg, and 2.5 mg of each) were described regarding the zone of inhibition's diameter. According to the observed inhibitory zones, which were also correlated with their tested doses, the entire extract and various fractions of *C. collinus* displayed strong antifungal activity against *C. albicans*, considerable anti-yeast ability against *S. cerevisiae* and moderate activity against *A. flavus* and *A. niger* **Table 1**.

The majority of the studied substances had strong inhibitory effects on *C. albicans*, among them fruit methanol crude extract showing the highest activity (25mm), followed by leaf methanol extract (21mm), bark ethyl acetate (19mm) and bark methanol (17.3mm). Methanol and ethyl acetate extracts showed high to moderate activity against test fungal pathogens while chloroform extracts had the lowest activity.

Here, *A. flavus* shows the strongest resistance to crude extracts of *C. collinus*, whereas *C. albicans* is the most vulnerable. It was discovered that the fractions containing the highest secondary metabolites concentration had higher levels of antifungal activity.

Moreover, the highest inhibitory properties against *A. flavus* were exhibited by the fruit methanol extract (12.3mm) followed by bark ethyl acetate (10.3mm) and bark methanol (10mm) extracts.

Whereas both ethylacetate and chloroform extracts of leaf and fruit did not show any activity. Contrary to *A. flavus*, *A. niger* was more susceptible to bark methanol extract (14mm) followed by fruit methanol extract (11.3mm).

The effectiveness of fluconazole has consistently outperformed that of plant solvent extracts, which has made it a recognized measure for comparing their effects. The DMSO containing well (negative control) exhibited no bioactivity.

TABLE 1: ANTIFUNGAL ACTIVITY OF DIFFERENT EXTRACTS (ME, EA &CH) AT THE DOSAGES OF 10mg, 5mg, AND 2.5mg

Plant part	Extract	*S. cerevisiae*			*C. albicans*			*A. flavus*			*A. niger*		
		10mg	5mg	2.5mg	10mg	5mg	2.5mg	10mg	5mg	2.5mg	10mg	5mg	2.5mg
Leaf	ME	8.6± 0.5	8±0	8±1	21±1	13.6± 0.5	12±1	6.6±. 0.57	6±0	-	7.6± 0.57	6.5± 0.7	-
	EA	8±1	-	-	15±1	12±1	10.3± 0.5	-	-	-	-	-	-
	CH	10±1	-	-	17±1	13±1	8±0	-	-	-	-	-	-
Bark	ME	13±1	9 ±1	8±1	17.3± 0.5	15±1	11.6± 0.5	10±1	8±1	6.6±.0 .57	14.3± 0.57	12± 1	9±1
	EA	8.3±0.5	7.3± 0.5	-	19.3± 0.5	14±1	10±1	10.3± .0.57	9.6± .0.5 7	7.6±.0 .57	9±1	7.6± 0.57	6.3±0. 57
	CH	7.6± 0.5	7.6±0 .5	-	11±1	9±1	8±1	-	-	-	-	-	-
Fruit	ME	10.6± 0.5	7.6± 0.5	7.6±0.5	25±1	22±1	21±1	12.3 ±.0.5 7	10± 1	6±0	11.3± 0.57	10± 1	7±1
	EA	8±1	7±0	-	13±1	11.3± 0.5	8±0	-	-	-	-	-	-
	CH	11±1	8.6±0 .5	7.6±0.5	16±1	12±1	8.6±0. 5	-	-	-	-	-	-

Values represent mean ± standard deviations; ME stands for methanol extract, EA for ethyl acetate, CH for chloroform, and "-" for no zone of inhibition. A zone of inhibition with a diameter of less than 6 mm was considered inactive. Source: authors.

Furthermore, the antifungal activities of higher concentration (10mg) plant extracts were compared to the positive control fluconazole's inhibition capacity **Fig. 1**.

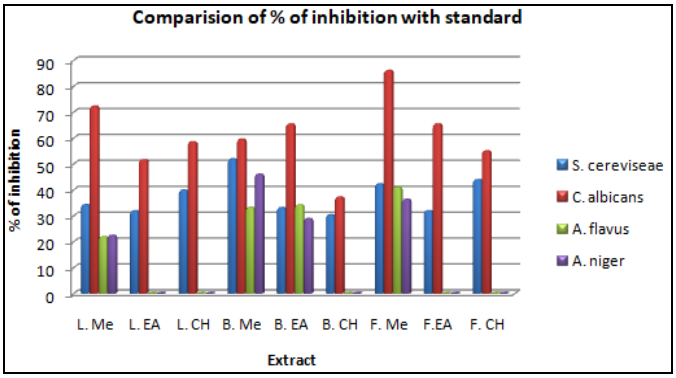


FIG 1: ANTIFUNGAL ACTIVITY (% OF INHIBITION) WITH RESPECT TO +' VE CONTROL

The highest percentage of inhibition (86.2%) against *C. albicans* was found in the fruit methanol extract *of C. collinus*, followed by leaf methanol (72.4%) and bark ethyl acetate (65.5%). The remaining eight plant extracts, except bark chloroform extract, demonstrated more than 50% inhibitory effect against *C. albicans* compared to the standard. All plant extracts inhibited *S. cerevisiae* growth in a medium-to-high range (30-55%). *S. cerevisiae* and *C. albicans* were more susceptible and all plant extracts tested inhibited their growth, whereas *A. flavus* and *A. niger* were more resistant and only methanol extracts with moderate activity, i.e., 20-45% when compared to standard, inhibited their growth. The antifungal activity of leaf acetone, water and benzene extracts from *C. collinus* studied by Majiet al., 2010 against *C.albicans* ranged from 13 to 8 mm[12] however in my study Methanol, Ethyl acetate and chloroform extracts of leaves showed higher activity ranged from 21 to 15 mm. Previous research employed aqueous and ethyl acetate solvent-based *C. collinus* leaf extracts against *C. albicans*, *C. tropicalis*, and *C. glabrata*, in which the ethyl acetate extract only showing action against *C. albicans* and other species being resistant [15]. In addition to previous data, the current investigation demonstrates that *C. collinus* methanol and ethyl acetate extracts are more efficacious than the chloroform extract. This might be because the kind of solvent utilized in the extraction technique substantially influences the subsequent characterization of phytochemicals. 1,2,3 Benzenetriole has strong antimicrobial properties [25, 26] and GC-MS analysis revealed that it was found in higher concentrations in all leaf, bark, and fruit methanol extracts; this may be a reason behind the results obtained in antifungal assays.

The antifungal screening supports *C. collinus* potentiality as a traditional cure for several fungal illnesses, including its usage as an antiseptic.

GC-MS Chemical Profiling: Methanol extracts were chosen for gas chromatography and mass spectrometry (GC-MS) analysis to examine the phytochemical composition because they displayed the highest antifungal efficacy compared to the other solvent extracts. This study demonstrates that a variety of physiologically active compounds are present in leaf, bark and fruit methanol extracts at various concentrations and also offers a thorough understanding of the phytochemical profile that may be exploited to create plant-based therapeutics.

GC/MS spectrum data of the methanol extracts showed several peaks **Fig. 2, 3** & **4** that indicated the presence of 14 different chemicals (9 from leaf, 6 from bark and 5 from fruit). Each of these chemicals was recognized and described using the mass fragmentation patterns and retention indices from the Spectral Library and Database (NIST 2017 Library). In **Table 1**, the active ingredients are listed in chronological order of retention durations, their peak area percentage, molecular formula, molecular weight, structural features and biological activities. To look at the biological effects of important substances, a review of the literature was conducted.

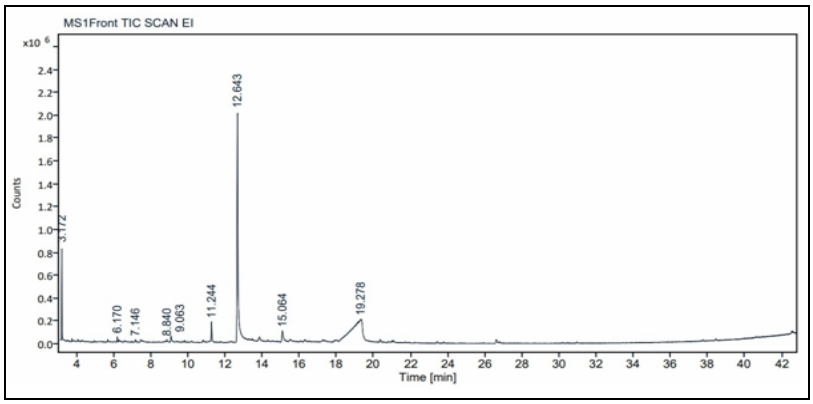


FIG. 2: GC-MS CHROMATOGRAM OF *C. COLLINUS* LEAF METHANOL EXTRACT

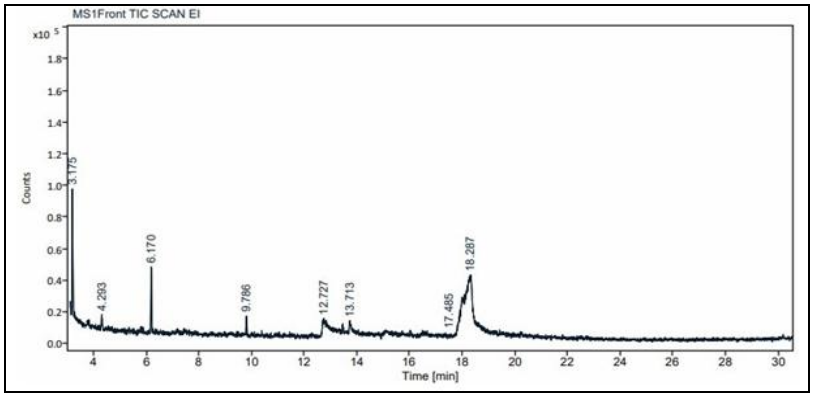


FIG. 3: GC-MS CHROMATOGRAM OF *C. COLLINUS* BARK METHANOL EXTRACT

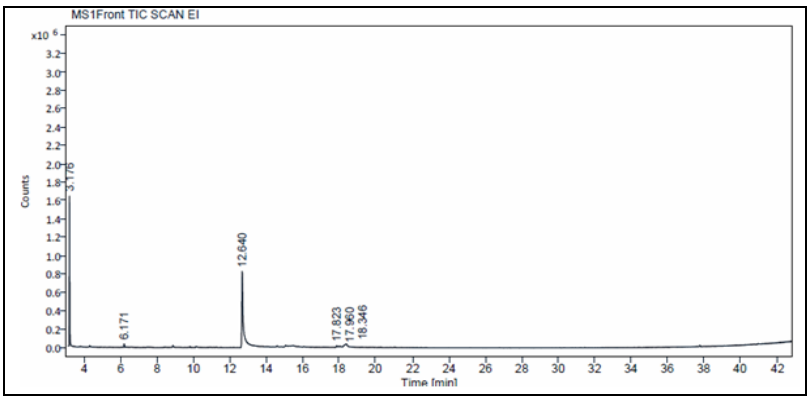


FIG. 4: GC-MS CHROMATOGRAM OF *C. COLLINUS* FRUIT METHANOL EXTRACT

We discovered that most of the constituents in the *C. collinus* leaf methanol extract exhibit a variety of advantageous pharmacological and therapeutic activities. The leaf methanol extract provides a rich source of significant bioactive molecules. Ten different chemicals, including hydrocarbons, phenols, terpenes and glucose derivatives, were found to be present. Undecane, 1, 2, 3-Benzenetriol and 3-O-Methyl-d-glucose were discovered in all three plant sections, whereas fruit and bark extracts contained N-[3-[N-Aziridyl] propylidene] hexylamine. A little amount of the following compounds were detected only in the leaf methanol extract: 4H-Pyran-4-one, 2, 3-dihydro - 3, 5 – dihydroxy – 6 - methyl, 6-Methyl-enebicyclo [3.2.0] hept-3-en-2-one, 5-Hydroxymethylfurfural, Phenol, 5-ethenyl-2-methoxy and D-Allose. Only bark extracts included decane, 4(3H)-Pteridinone, 2-amino-7, 8-dihydro-8-methyl-6, 7-diphenyl and fruit extracts had trace amounts of phthalic acid, 5-methylhex-2-yl heptadecyl ester.

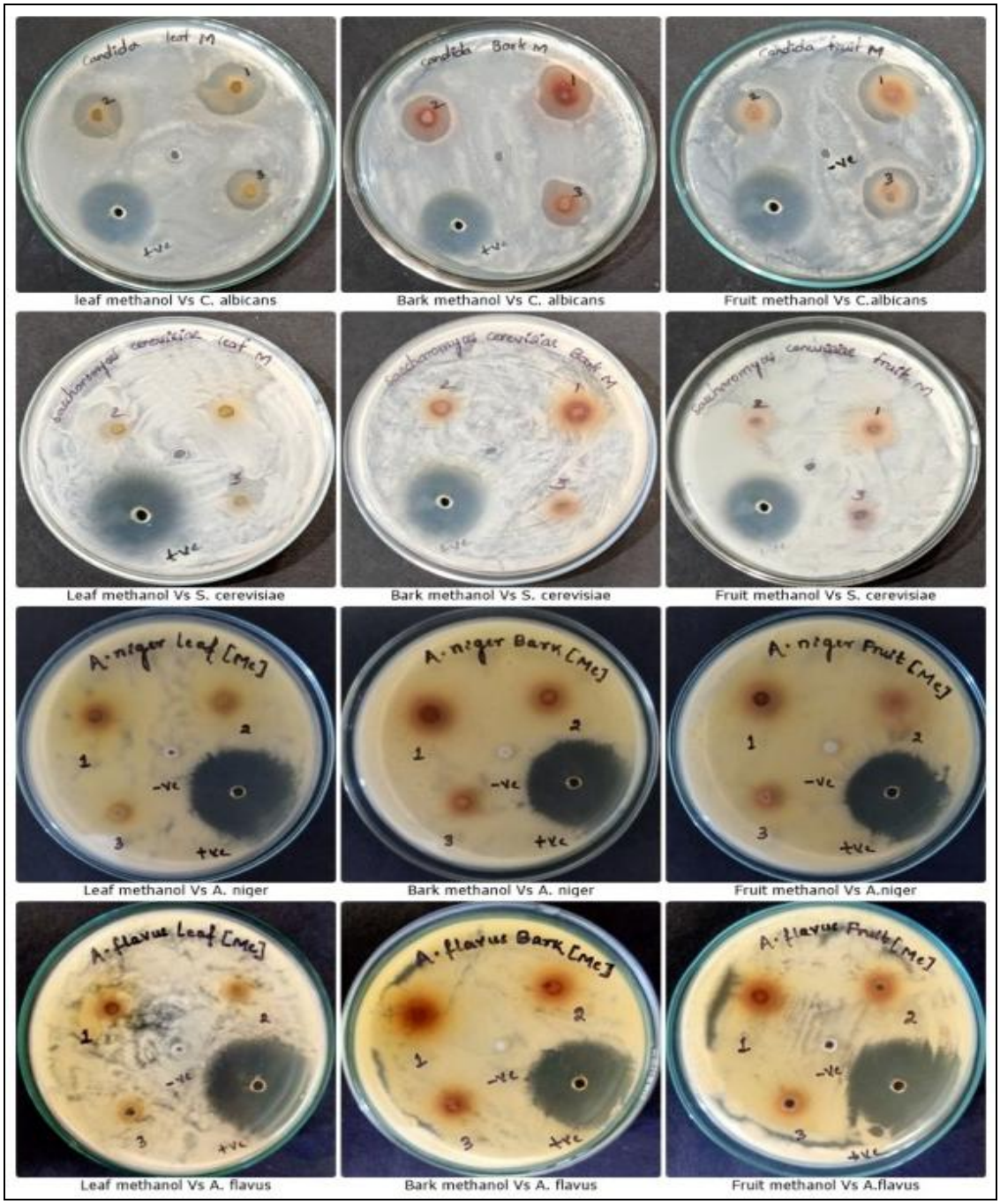
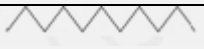
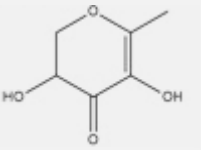
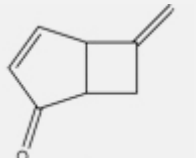
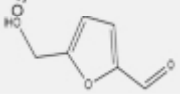
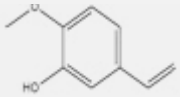
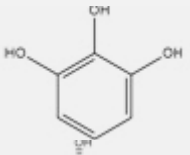
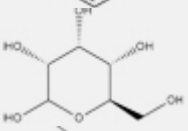
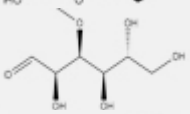
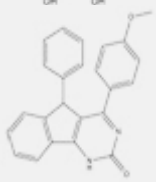
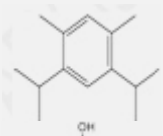
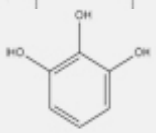
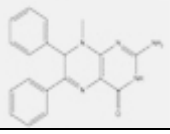
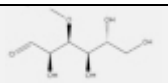
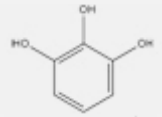
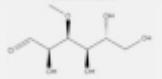


FIG 5: PICTORIAL DATA OF ANTIFUNGAL ACTIVITY OF *C. COLLINUS* (LEAF, BARK & FRUIT) METHANOL EXTRACTS

TABLE 2: BIOACTIVE CHEMICAL PROFILE OF *C. COLLINUS* THROUGH GC-MS

S. no.	Name of the compound	RT minutes	Mol. weight	Mol. formula	Area %	Structure	Importance
				Leaf			
1	Undecane	6.169	156.31	$C_{11}H_{24}$	0.55		Mild sex attractant[20]anti-inflammatory and antioxidant effects[21]
2	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	7.144	144.12	$C_6H_8O_4$	0.35		Antimicrobial, anti-inflammatory, Anti-proliferative[22]
3	6-Methylenebicyclo[3.2.0]hept-3-en-2-one	8.838	120.15	C_8H_8O	0.19		Bacteriostatic, fungistatic, anti-parasitic activity[23]
4	5-Hydroxymethylfurfural	9.063	126.11	$C_6H_6O_3$	0.43		Anti-oxidant activity[24]
5	Phenol, 5-ethenyl-2-methoxy-	11.245	150.17	$C_9H_{10}O_2$	2.00		Aromatic, flavoring, cytotoxic, anti-inflammatory, germination inhibitor, insect repellent[19]
6	1,2,3-Benzenetriol	12.645	126.1100	$C_6H_6O_3$	35.95		Anti-microbial, Antibiofilm and Antivirulence activity[25,26]
7	D-Allose	15.064	180.16	$C_6H_{12}O_6$	1.72		Anti-oxidant, Anti-tumour activity[27,28]
8	3-O-Methyl-d-glucose	19.277	194.18	$C_7H_{14}O_6$	25.33		Anti-tumor activity[29]
9	2-Oxo-5-phenyl-4-(4-methoxyphenyl)-1,2-dihydro-5H-indeno[1,2-d]pyrimidine	49.245	366.4	$C_{24}H_{18}N_2O_2$	27.54		-
				Bark			
1	Decane	4.294	142.28	$C_{10}H_{22}$	2.09		cocarcinogenic and tumor-promoting activities[30]
2	Undecane	6.169	156.31	$C_{11}H_{24}$	7.42		Mild sex attractant[20]anti-oxidant and anti-inflammatory activities [21]
3	Benzene, 1,5-dimethyl-2,4-bis(1-methylethyl)-	9.788	190.32	$C_{14}H_{22}$	2.89		-
4	1,2,3-Benzenetriol	12.726	126.1100	$C_6H_6O_3$	5.10		Anti-microbial, Apoptosis, Antibiofilm and Antivirulence activity[25, 26]
5	4(3H)-Pteridinone, 2-amino-7,8-dihydro-8-methyl-6,7-diphenyl-	13.714	331.4	$C_{19}H_{17}N_5O$	1.84		-

6	3-O-Methyl-d-glucose	18.290	194.18	$C_7H_{14}O_6$	67.88		Anti-tumor activity[29]
				Fruit			
1	Undecane	6.169	156.31	$C_{11}H_{24}$	0.95		Mild sex attractant[20]anti-oxidant and anti-inflammatory activities[21]
2	1,2,3-Benzenetriol	12.639	126.1100	$C_6H_6O_3$	63.09		Anti-microbial, Apoptosis, Antibiofilm and Antivirulence activity[25,26]
3	N-[3-[N-Aziridyl]propylidene] hexylamine	17.821	182.31	$C_{11}H_{22}N_2$	0.69		Anti-viral activity[31]
4	Phthalic acid, 5-methylhex-2-yl heptadecyl ester	17.959	502.8	$C_{32}H_{54}O_4$	0.17		Aminoglycoside antibiotic, Neuroprotective[32]
5	3-O-Methyl-d-glucose	18.346	194.18	$C_7H_{14}O_6$	4.03		Anti-tumor activity[29]

The chemicals found in this study were mostly stated to have anti-cancer, antibacterial, anti-virulence, anti-inflammatory, neuro-protecting, and antioxidant effects according to the reported biological activities. 1, 2, 3-Benzenetriol is a phenolic molecule that is most abundantly present in fruit extracts (63.09%), leaf extracts (35.95%) and bark extracts (5.1%). It is an effective anti-microbial and antiviral agent and leads to the death of cancer cells by apoptosis. The highest concentration of 3-O-Methyl-d-Glucose, a glucose derivative with good anti-cancer capabilities, was identified in the bark extract (67.88), followed by the leaf (25.33) and the fruit extract (4.03). Undecane is a hydrocarbon compound that is present in fruit and bark extracts in low amounts and high concentrations in bark extract (7.42).

It possesses anti-inflammatory and antioxidant activities. Decane contains co-carcinogenic and tumor-promoting properties but is reported only in bark extract. 2-Oxo-5-phenyl-4-(4-methoxyphenyl)-1, 2-dihydro-5H-indeno [1, 2-d] pyrimidine reported in leaf extract in high concentration (27.54), although its bioactivities have not been studied. Earlier work by Pratheepa M. *et al.,* 2012 revealed the GC-MS analysis of the plant leaf acetone extract which showed 8 different bioactive compounds from which the novel chemical dioctyl phthalate observed at a peak area of 95.23% which may operate as a very promising medicinal agent for persons suffering from cancer or afflicted with fatal diseases, *etc* [16]. Arulmanickam P. and Chitra T. *et al.,* 2020 studied leaf powder ethanolic extract and revealed 13 different types of bioactive compounds, but only six of them can carry out specific biological functions. These include alpha-methyl mannofuranoside (36.25%) for its antibacterial and antifungal activity, undecanoic acid (1.88%) for its cytotoxic, anticancer, and anti-microbe properties, 5-O-methyl-D-gluconic acid dimethylamide (4.86%) for its antioxidant and anti-microbial properties, Cyclopropanetetradecanoic acid, 2-Octyl-, Methyl ester (3.20) for its anti-microbial activity and Pentanoic acid, 2 (Aminooxy) (3.59%) for its Anti-oxidant and lubricantproperties [17].

Suman *et al.,* 2013 found four bioactive compounds in the leaf's aqueous, hot extracts, with 4-OMethylmannose (70.12%) having antibacterial activity and 1,2,3-Benzenetriol (21.76%) having antioxidant, antibacterial, antiseptic, fungicide, antimutagenic, antidermatitic, pesticide, dye and candidicide properties. In contrast, the methanol extract contained significant amounts of thiophene (antimicrobial action), tetrahydro-2-methyl-myo-inositol (48.54%), 1,2,3-benzenetriol (7.51%) and Vitamin E (d -α-tocopherol) (6.52%). Higher concentrations of 4-O-methylmannose (Secondary messenger) and 5-Methyl-2-trimethylsilyloxy-aceto phenone (7.35%) were found in the ethanol extract. In the ethyl acetate extract, there were 15 compounds detected, the main ones being silane (Coupling Agent) and trimethyl [5-methyl-2-(1-methyl ethyl) phenoxy] anthracene (7.06%) [9].

Parasuraman *et al.*, 2009 reported 17 compounds, of which 14 are from fresh leaves and 5 are from dry leaves. 3-Omethyl-d-glucose (32.88%), Benzenetriol (22.43%), 1.6- Anhydro - â - Dglucopyranose (15.66%), Heptacosane (8.99%), 2-Hydroxy-7methoxy-4,5 diphenyl-5 Hindeno [1.2-d] pyrimidine (7.45%) and Eicosane (3.76%) were found in fresh leaves, whereas 3-O-methyl-d-glucose (41.61%), Benzenetriol (Pyrogallic acid, Pyrogallol) (25.06%), n- Hexadecanoic acid (10.60%), Heptacosane (4.41%) and 1,2-Benzenedicarboxylic acid, diisooctyl ester (3.54%) were present in dried leaves aqueous extracts [18]. Kazi M. and Gude A. *et al.*, 2022 summarized the phytoconstituents and discussed 46 compounds and their biological properties [19]. Only 1,2,3-Benzenetriole (35.95) and 3-O-methyl-d-glucose (25.33) were previously reported of the 9 compounds we found in leaf methanol extract; the other compounds were discovered for the first time. To the best of my knowledge, no studies on the GC-MS analysis of methanol extracts of *C. collinus* fruit and bark have been published yet. In contrast to earlier findings, we present the most recent analysis of the GC-MS profile of the methanolic extracts of leaves, bark and fruits in our investigations.

CONCLUSION: These findings have established a solid scientific foundation for the use of the plant *Cleistanthus collinus* in traditional medicine to treat fungal infections. Compared to chloroform extracts, methanol and ethyl acetate extracts showed high antifungal activity. In particular, *C. albicans* and *S. cerevisiae*, which displayed the strongest antifungal activity, excelled over other fungal strains examined. GC-MS study revealed 15 phytochemical components with antifungal, antibacterial, antioxidant, anti-inflammatory and anti-cancer properties. As far as I am aware, very little work has been done on the antifungal activity of *C. collinus*, as there is very little literature accessible on the antifungal activity of this plant species. We believe that more studies in this area will aid in developing novel antifungal and anticancer drugs.

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Author Contributions: S. Prathamanjali assisted and conducted the experiment, calculations, and literature analysis and prepared the manuscript. Prof. T. Vijaya guided the co-authors and prepared the final version of the manuscript. Y.T. Rajesh Babu helped in conducting the experiments and preparation of the manuscript. All authors read the final version of the manuscript and accepted it.

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Green Synthesis of Silver Nanoparticles using Endostemon viscosus (Roth) aqueous leaf extract; Characterization; Evaluation of Antibacterial, DPPH and Anticancer efficacy

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A B S T R A C T

Nanoparticles are being constantly exploited through scientific community because of their multifaceted properties and applications. Production of biogenic silver nanoparticles (AgNPs) with plant material is extremely cost effective and environmentally non-hazardous. Plant extracts are wealth of various phytochemicals such as secondary metabolites and frequently act as reducing and capping agents in the synthesis of nanoparticles. The present study deals with the synthesis of silver nanoparticles by the aqueous leaf extract of *Endostemon viscosus (Roth)*. Synthesized silver nanoparticles characterized by different recent spectroscopic tools such as UV-Visible spectrophotometer, DLS-Zeta potential, FT-IR, TEM with EDS, and XRD (X-ray diffraction). UV-Vis showed that the peak at 414 nm. DLS-Zeta potential analysis revealed about stability and even size of the particles. FT-IR was studied to know what phyto-constituents are actually acting as capping and stabilization of the nanoparticles. TEM is used to find shape, size and agglomeration pattern of the nanoparticles. TEM image exhibited size range from 11.03 to 37.87 nm and average size of the EvL-AgNPs are 16.77 nm. Eventually green synthesized nanoparticles are evaluated for their efficacy on anti-bacterial, DPPH, and anti-cancer activities. Biologically synthesized EvL-AgNPs expressed excellent anti-bacterial, anti-oxidants, and anti-cancer activities. Hence, the bio-synthesized AgNPs could be considered as auspicious therapeutic option against infectious pathological situations.

Introduction

Nanomaterial improvement, especially of high quality, is a hot topic in nanoscience and technology these days. Metal techniques have sparked renewed attention due to its fascinating physical, thermodynamic and chemical properties, make great candidates for various applications such as optical electronics, catalysis, and biomedical applications (Azizi *et al.,* 2017; Mani *et al.,* 2021; Parasuraman *et al.,* 2019; Sathiyaraj *et al.,* 2021; Anju *et al.,* 2019). Nanoparticles are normally considered as particles with a maximum size of 100 nm and are produced from numerous non-metal and metal elements with exceptional topographies and widespread uses in

science and medicine due to their unique properties (Matei, 2008). Similarity in size of nanoparticles with biomolecules, i.e., proteins and poly-nucleic acids, makes them useful to interact and reduce in size during the synthesis of these nanoparticles' effects of unique physical and chemical properties of biomolecules (Yeo, 2003). Among the metal nanoparticles, silver nanoparticles (Ag-NPs) are one of the best, frequently used nanoparticles having features of very small size, high surface area and high dispersion (Mathew, 2013). They are known to have potent antioxidant and antibacterial activities (AbouEl-nour, 2010). Silver metal is highly toxic to the bacterial cells but nontoxic to animal cells in small concentration (Marambio-Jones, 2010). Nowadays, the Ag-NPs are broadly used as an active antibacterial tool against a broad spectrum of bacteria, including antibiotic-resistant strains (Percival, 2007).

Silver has various biological activities such as antimicrobial (Yugandhar and Savithramma, 2015) antihelmintic and wound healing activity (Garg *et al.,* 2014) anti-larvicidic (Sundaravadivelan *et al.,* 2013) antioxidant (Kumara *et al.,* 2015) anticancer (Vasanth *et al.,* 2014) anti-inflammatory (El-Rafie *et al.,* 2014) hepatoprotective (Bhuvaneswari *et al.,* 2014). Earlier the nanoparticles can be synthesized by using physical and chemical methods. However, the physical and chemical approaches are the most high-priced, time consuming, energy consumption, and more chemicals are needed for the production of nanoparticles and they cause threat to the environment and also inappropriateness for biological applications. Instead of these two Physical and chemical methods, researchers needed to develop another alternative method. The researchers developed the substitute biological method to reduce the abovementioned disadvantages and environmentally benign than the physical and biological methods.

This method overcame most of the problems through the synthesis of silver nanoparticles (AgNPs) by employing various biological agents like algae, bacteria, enzymes, fungi, oligosaccharides, polysaccharides, DNA, and human cell lines (Corciova *et al.,* 2018). In addition to different kinds of NPs have been prepared successfully i.e. Cadmium oxide nanoparticles through *Achillea wilhemsii* (Karimi Andeani, 2013) calcium nanoparticles from *Boswellia ovalifoliata* (Yugandhar and Savithramma, 2013). Copper Nanoparticles by the using *Magnolia Kobus* plant material (Lee, 2013) Gold nanoparticles from *Walsura trifoliata* (Venkata Subbaiah and Savithramma, 2022) Palladium nanoparticles from *Cinnamomum camphora* (Yang, 2010). Zinc oxide nanoparticles from *Catharanthus roseus* (Bhumi, 2014). Silver nanoparticles from *Adansonia digitata* (Kumar *et al.,* 2015).

Endostemon viscosus (Roth) M.R.Ashby also called as *Orthosiphon diffuses*; commonly called as Sticky Wild Basil (E) belongs to the family Lamiaceae, which is distribute in South Asian countries such as India, Thailand etc. This is a traditional medicinal plant perennial herb that is distributed in many of India especially Western and Eastern Ghats in South India. The plant is a subshrub, growing from a woody base. Branch lets are finely velvet-hairy, 4-angled, Leaves are decussate, elliptic to nearly round, up to 2 x 1.5 cm, base flat, leaf-stalk to 1 cm. Flowers are borne in whorls of 6, on a 3-chotomous raceme, flower-cluster-stalk are up to 9 cm, bracts ovate; flower-stalk 0.5 cm. Flowers are pinkish, hairy along throat. Stamens 4, didynamous, filaments 2 mm; anthers 2-celled. Disk anteriorly developed. Nut-lets are erect, enclosed in a crescent calyx (Okaiyeto *et al.,* 2018). The plant is used as treating hypertension, hepatitis/jaundice and fever by folk fore practitioners. The activity of the plant claimed by the tribal peoples in western and Eastern Ghats and was proven by different researchers too (Chin *et al.,* 2008).

Materials and Methods

Collection of Plant Material

The healthy leaves were gathered from Tirumala hills, Tirupati, Andhrapradesh, India. The collected material was cleaned thrice using with running tap water, as well as with distilled water for one time for the removal of admixtures on leaves surface and shade dried for 10-15 days and ground to a fine powder with the help of electrical blender.

Plant Extract Preparation

25 g of weighed plant material was taken into 250 ml conical flask 100 ml of milli-Q water added to this shaken well for 5 min. Then this is kept on water bath for 20 min at 100 ^{0} C and this was cooled at room temperature. Later extraction is done by the using Whatman No 1 filter paper. The extraction is stored in amber colour bottle until the synthesis at room temperature.

Preparation of Ag $(No_3)_2$ Solution

10 gram of silver nitrate purchased from Sigma Aldrich and prepared 1 mM silver nitrate solution with using 100 ml of milli-Q water in sterile Erlenmeyer conical flask. Then the solution was stored in amber colour bottle.

Synthesis of Silver Nanoparticles (AgNPs)

The leaves aqueous extract was added to prepare 1 mM AgNo3 solution. It was heated on water bath at 60-80^{0}C. The colour change of the solution from light yellow to thick brown indicated the silver nanoparticles were synthesized from the leaf extract, and then this is further used for the characterization and antibacterial, antioxidant and anticancer efficacy.

UV- Vis Spectra Analysis

The bio-reduction of silver ions was analysed by UV-Vis spectrophotometer Nano drop range from190-750 nm. The absorbance peak was recorded before 24 hours. It is the primary method to confirm the formation of bio-synthesized AgNPs in the prepared reaction mixture.

FT-IR Spectral analysis

Fourier Transform Infrared (FTIR) spectral analysis was carried out by using dried powder of silver nanoparticles (AgNPs). For the getting dry powder of AgNPs following protocol was applied. When mixing the plant extract to the 1 mM AgNo3 solution 1:9 ratio kept on water bath at 80^0 C for 15 minutes, the solution is changed into brown coloured AgNPs formed.

It was centrifuged at 20000 rpm for 15 minutes. Formed pellets were dispersed in distilled water. Again it was centrifuged and this process was repeated thrice. Then the pellet of AgNPs was dried and this was utilised for FTIR analysis.

DLS Particle Size and Zeta Potential

To determine the size of the particle and size distribution in aqueous AgNPs solution performed by the advanced equipment Dynamic Light Scattering (DLS) Malvern-Zeta analyzer. This is an advanced tool; it depends on the interaction of Brownian motion of spherical particles with the light passing by a colloidal solution (Saxena *et al.,* 2010).

Transmission Electron Microscopy (TEM)

TEM analysis is done by the using HF-3300 advanced 300 kV TEM from Hitachi. It is the valuable, frequently used and important technique for the characterization of nanoparticles, used to procure particle quantitative measure and /grain size, size distribution and morphology of nanoparticles. TEM has two advantages than SEM: it can be provide better spatial resolution and the capability for additional analytical measurements. The images were taken by coating the suspension of AgNPs on carbon- coated copper grid. The average size of the Bio-synthesized AgNPs was calculated with the help of Image J software through TEM images.

XRD Studies

X-ray diffraction (Shimazdu XRD-6000) was analysed to confirm the crystalline nature and average size, and measure the degree of crystallinity of the PmL-AgNPs. XRD is the powerful characterization tool for both qualitative and quantitative analysis of nanoparticles. Diffraction intensities were compared with the standard JCPDS files. The average crystalline size of the AgNPs was calculated by the Debye-Scherer equation.

$$D=k\,\lambda/\beta\cos\theta$$

Where D is diameter of NPs, k is the Scherrer constant, λ is the wave length of X-ray radiation source, β is full width half maximum value of XRD diffraction lines and θ is the half diffraction angle-Bragg angle.

X-ray diffraction patterns of EV-AgNPs peaks shows at

Anti-Bacterial Studies of Fm-F AgNPs

The anti- bacterial activity analysed by the bio-synthesized Ev-L AgNPs against two gram positive bacteria like *Bacillus subtilis* (MTCC-441), *Staphylococcus aureus* (MTCC-731) and two gram negative bacteria species like *Escheria coli* (MTCC-443), *Klebsiella pneumonia* (MTCC-741). Disc diffusion method was executed by using standard protocol Anonymous (1996). 20 µl of $Ag(No_3)_2$, plant extract, AgNPs and Streptomycin was applied on separated sterile filter paper discs (Whatman No. 1 filter paper discs with 6 mm diameter), and allowed to dry before being placed on nutrient agar medium. The activity is examined by triplicate of each solution of above

mentioned and incubated at 37^0 C for 24 h in inoculation chamber. Diameter of zone of inhibition (ZOI) was measured with the help of scale and the results were tabulated.

Antioxidants Activity

Antioxidant activity of Ev-L -AgNPs was assessed by DPPH- (2, 2-Diphenyl-1-picry Hydrazyl radical Scavenging activity). For the assay, 1mM DPPH stock solution was prepared by adding 4 mg DPPH in 100 mL of methanol. 2 mL of DPPH stock solution was added to 1 mL of methanolic solution of Ev-L -AgNPs consisting vary concentrations of Ev-L -AgNPs (25, 50, 75 and 100 µg). The reaction solution was incubated for 45 min in the dark room at room temperature. Later incubation absorbance values were recorded at 518 nm. DPPH activity of the Ev-L -AgNPs was calculated using with the following formula % of inhibition= ((Absorbance of control- Absorbance sample)/ Absorbance of control) X 100. And the concentration of inhibition of 50% free radicals (IC_{50}) was calculated by regression coefficient (R_2=0.9).

Anticancer Studies (Cell proliferation Assay using SRB (Sulforhodomine-B)

Different human cancer Cell lines (MDA-MB-231,SK-OV-3,PC3,PANC-1, and HeLa) purchased from the American Type Culture Collection. For this SRB assay is a quantitative colorimetric method used for determination of cell survival and proliferation based on the measurement of cellular protein content. Cell were grown in Dulbecco's modified Eagle's medium (containing non-essential amino acids and 10% FBS). PC-3 was grown in RPMI with glutamine containing non-essential amino acids. Cell lines were maintained in humidified atmosphere of 5% CO_2 at 37°C.Cells were trypsinized when sub-confluent from 90mm dishes and seeded in 96 well plates at a concentration of 1×10^4 cells/mL in complete medium a day before treatments. Cells were incubated with different concentrations of Ag NPs (12.5-100µg/ml) for 48h for potent compounds; entire process was executed in triplicates.

Results and Discussion

The reduction biologically synthesized silver nanoparticles (AgNPs) was primarily observed by visualization method of colour change pattern of the reaction mixture and it was changed brown into deep brown colour, after process of synthesis; then this solution was performed by the using of UV-Vis Spectroscopy range from 190 to 750 nm Nano drop. The absorbance peak was recorded at 414 nm which was further confirmation the reduction nanoparticles are silver (AgNPs) (Fig.1). This respective peak shown because of the Surface Plasmon Resonance (SPR) of electrons present on the surface of the synthesized nanoparticles. Similar type of results was observed in the AgNPs synthesized from the leaf source aqueous extract of *Odontonema strictum* (Luhata *et al.,* 2022). For this Fourier transform infra-red (FT-IR) spectral analysis with scan range of 4000-500 cm^{-1}(ALPHA interfero meter ECO-ATR, Bruker Ettlingen, Karlsruhe Germany) was used. Here the FT-IR revealed broad peaks 3300.20 assigned for O-H bond phenols, 1587.42 belongs to the strong C=O amide, 1382.96 assigned for medium stretch CH3 bend aliphatic group, 1261.45 indicates strong stretching C-O alkyl aryl ether, 1114.86 assigned strong C-O starching ester, 1047.35 belongs to strong broad CO-O-CO stretching anhydride, 810.10 assigned for strong C-H bending 1, 4-disubstituted, 597.93 and 520.78 assigned to strong C-I stretching halo compound.

All these constituents interacting with silver nanoparticles (AgNPs) as reducing agents (Fig.2). The DLS method revealed average size 5.3 nm and the zeta potential negatively charged with -3.5 mV, which proved that the particles are dispersed in the reaction mixture (Fig.3a & b). A higher magnification analysis was carried out through TEM to find out the size, shape and agglomeration pattern of AgNPs. TEM analysis shows higher magnification due to these green synthesized nanoparticles and exhibited interface between two lattice fringes with small-sized nanoparticles belonging to attachment of AgNPs between the surface sheets of the TEM micrographs. TEM micrographs disclosed about size range between 11.03- 37.87 nm at 50 nm scale bar, Average size of the AgNPs 16.77 nm.

At 5 nm scale bar revealed 0.24 nm as well as no seen any agglomeration between the particles (Fig.4). Such type of results observed in synthesized AgNPs by the using Leaf extract of the *Uvaria narum* (Ajaykumar *et al.,* 2023). The peaks obtained at 2θ of X-axis 38.11^0,44.27^0, 64.42^0, 77.47^0 and 81.53^0corresponds to 222,111, 200, 220 and 311 Bragg reflections of Y- axis respectively which may be indexed based on the end-centred monocrystalline structure of AgNPs. Based on the X-ray diffraction reports clearly indicates that the formed particles are AgNPs (Fig.5).

Table.1 Antimicrobial activity of *Endostemon viscous* aqueous leaf extract biologically synthesized EvL-AgNPs, Ag $(No_3)_2$ solution and antibiotic Streptomycin.

Bacteria	Extract	$AgNo_3$	EVAgNP	Streptomycin
Bacillus subtilis	8.71±0.21	8.19±0.44	18.28±0.47	25.14±0.36
Staphylococcus aureus	8.24±0.17	7.90±0.40	18.22±0.23	25.40±0.39
Klebsiella pneumoniae	9.5414±0.64	9.85±0.18	19.12±0.38	24.31±0.19
Escherchia coli	9.69±0.51	9.92±0.42	19.53±0.65	23.72±0.78

Figure.1 UV-Vis spectra analysis spectrum using aqueous leaf extract of *Endostemon viscous* AgNPs

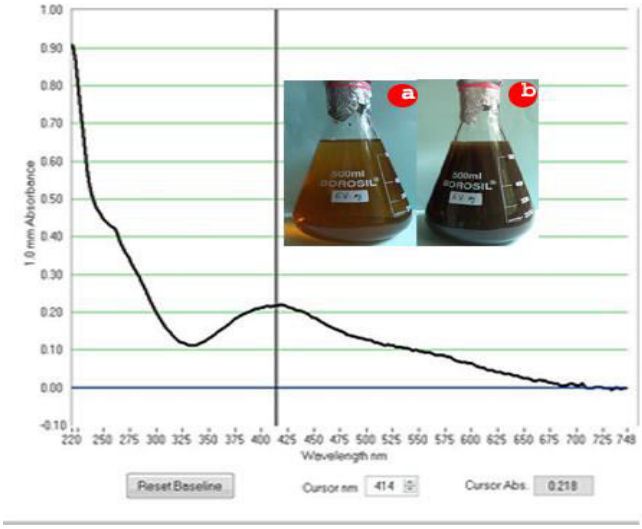


Figure.2 Fourier- Transform Infra-Red (FT-IR) spectra of bio-synthesized AgNPs from *Endostemon viscous*

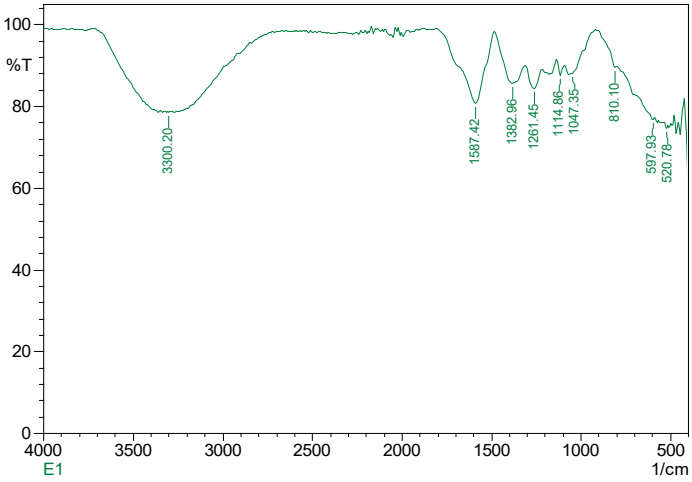


Figure.3 a). Particle sizeand b). Zetapotential *studies of Endostemon viscous* AgNPs

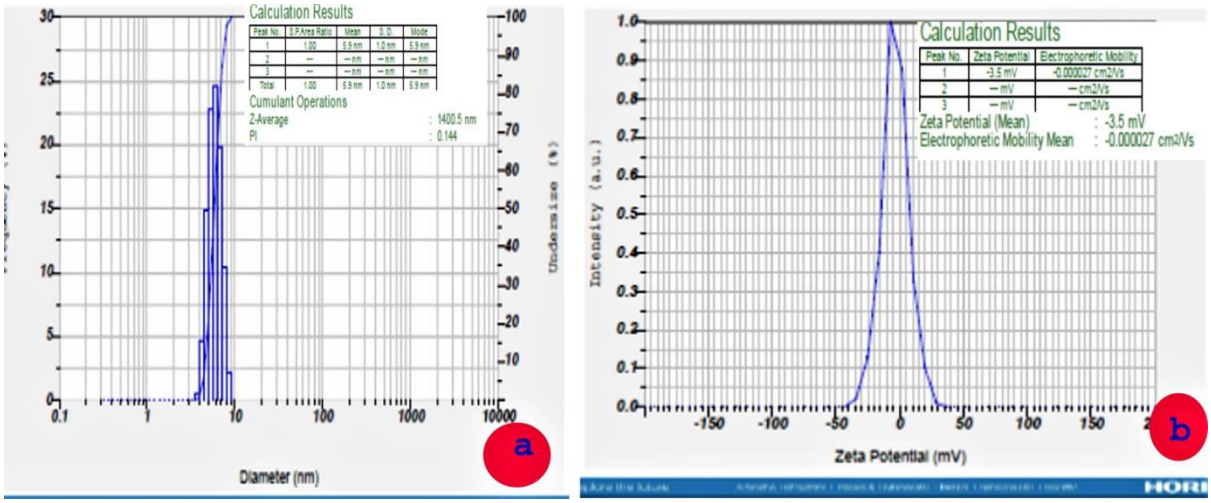


Figure.4 TEM images of *Endostemon viscous AgNPs* a). At 5 nm 0.24 nm, b). At 50 nm AgNPs are spherical in shape and Average size of the AgNPs 16.77 nm. c). At 51 nm beam of TEM d). EDAX analysis

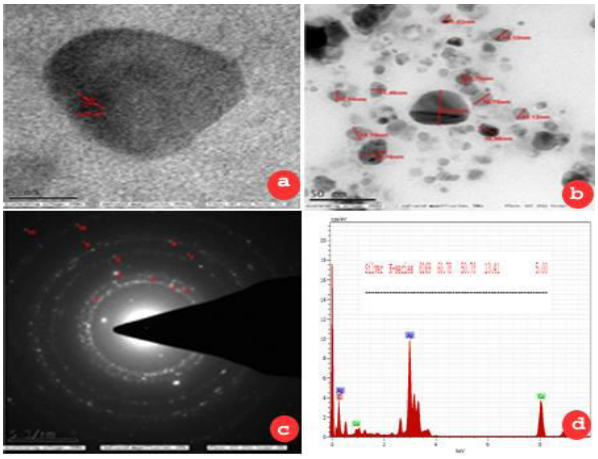


Figure.5 XRD pattern analysis of leaf sourced biologically synthesized AgNPs of *Endostemon viscous*

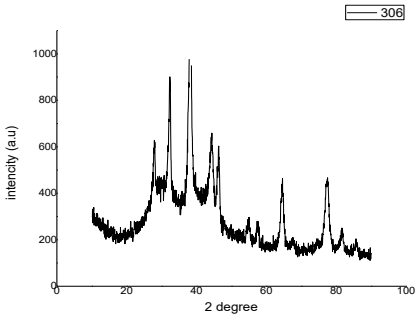


Figure.6 Antimicrobial activity of biologically synthesized EvL-Ag NPs against Two gram gram positive and two negative bacteria. 1. Plant extract 2. Ag $(No_3)_2$ solution 3.ZnO NPs 4.Streptomycin.

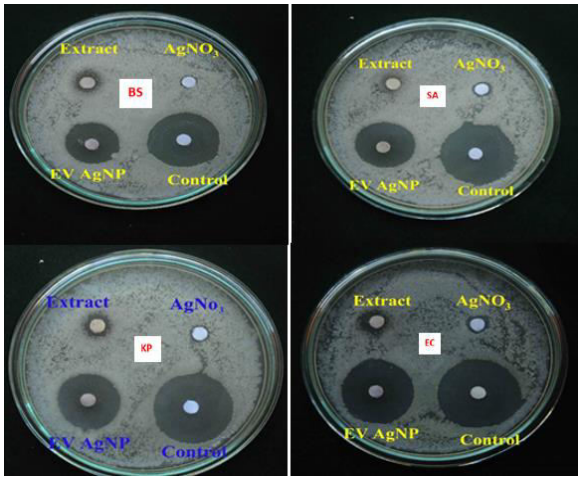


Figure.7 Graphical representation of anti-bacterial activity using bio-synthesized EvL-AgNPs

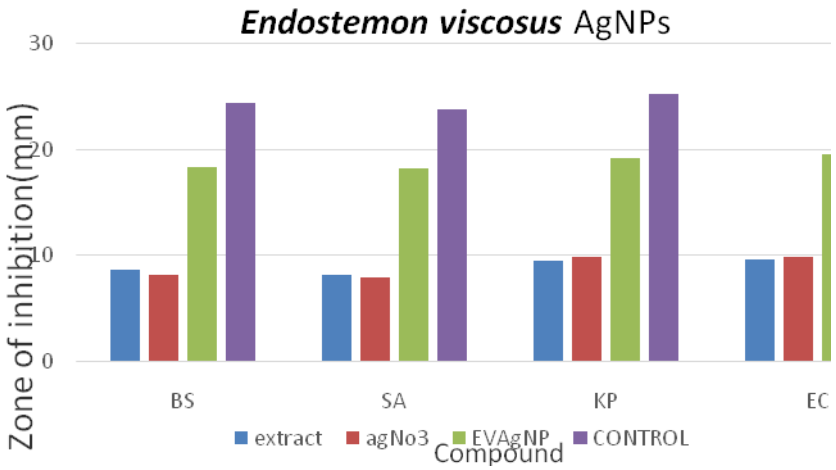


Figure.8 Graphical representation of anti-oxidants activity by synthesized EvL-AgNPs

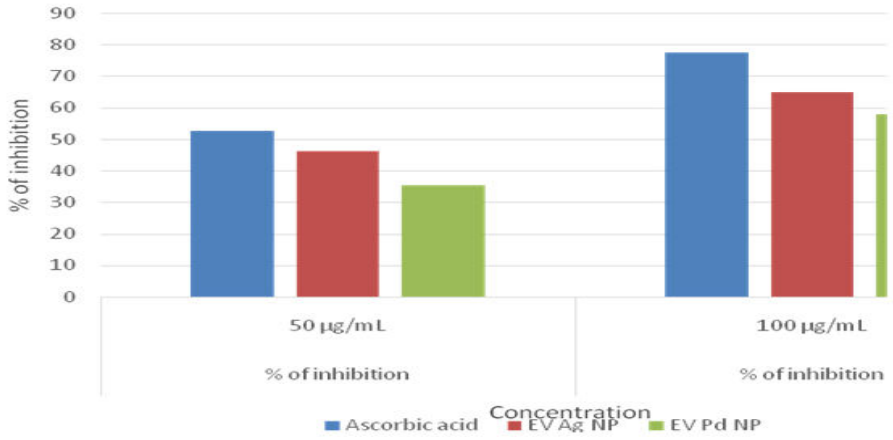


Figure.9 Anti-cancer activity on selected human cancer cell lines by synthesized EvL-AgNPs 1). PC-3 2). MDA-MB-231 3). SK-OV-3 4). PANC-1 5). HeLa
a) Cell control b). Standard control c). 12.5 µg/ml d). 25 µg/ml e). 500 µg/ml and f). 100 µg/ml

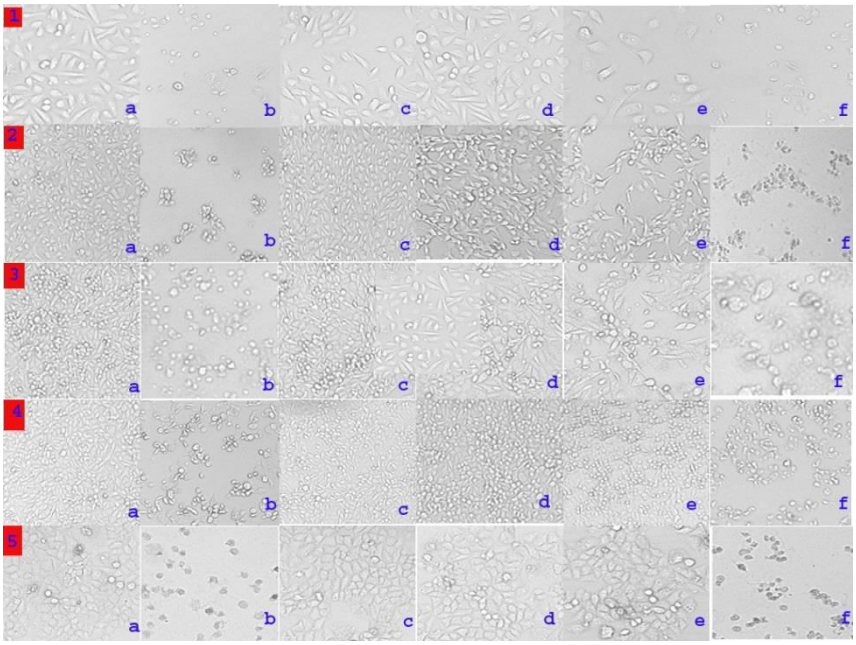
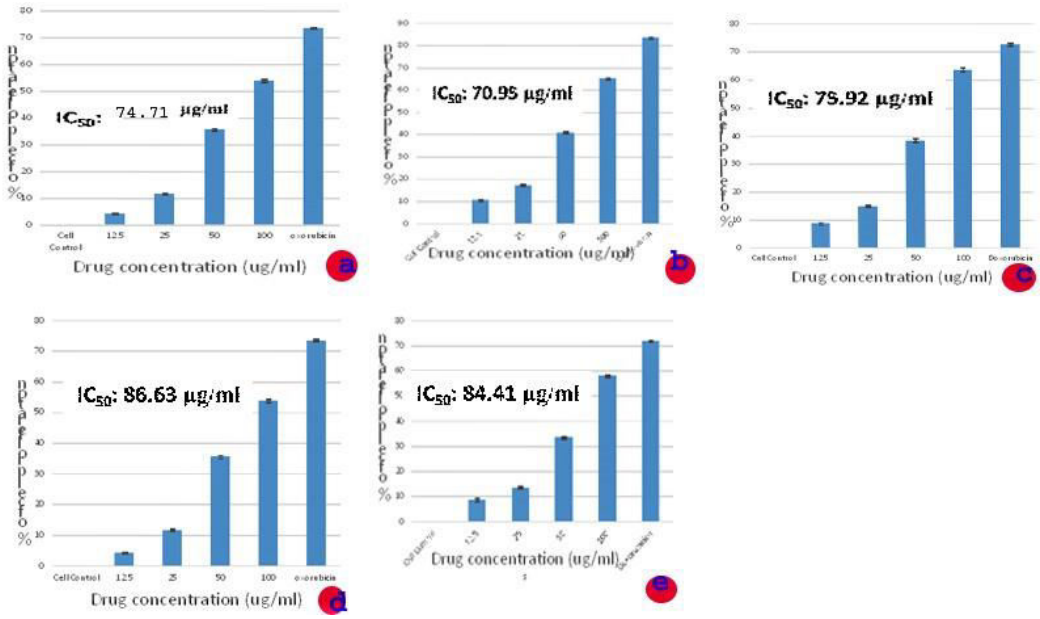


Figure.10 Graphical representation of anticancer activity by using EvL-AgNPs against five selected human cancer cell lines a). PC-3 b). MDA-MB-231 c). SK-OV-3 d). PANC-1 e). HeLa



Biologically synthesized AgNPs showed excellent bacterial activity on selected two gram positive (*B. subtilis* and *S. aureus*) and two gram negative (*K.pneumoniae* and *E.coli*). Synthesized EvL- AgNPs exhibited a maximum zone of inhibition on two gram negative bacteria than positive bacteria. This is due to Gram positive bacteria contain a thick layer that is made up of peptidoglycan when compared to Gram negative

bacteria and penetration of AgNPs by the cell membrane is easy in case of Gram negative bacteria but also inhibition of growth is possible. Among the activity suggesting that the clearly highest activity was seen on *E.coli* (Fig.6 & 7 Graph; Table.1). These types results find in bio-fabrication of AgNPs with leaf aqueous source of *Walsura trifoliolata* (Venkata Subbaiah and Savithramma, 2022). Biosynthesized EvL- AgNPs were tested with DPPH method. The activity depends on the reduction of DPPH radical from DPPH to DPPH-H, where anti-oxidant donated by hydrogen. Among the activity exhibited concentration depends on the dependant scavenging activity against DPPH scavenging. In which concentration of EvL- AgNPs is increased from 50 µg/ml -100 µg/ml. Therefore, the activity was exhibited by increased from 46.07 ± 0.34µg/ml - 64.83±0.31 µg/ml. IC_{50} values 77.54 ± 0.4 clearly suggested that EvL- AgNPs are magnificently showed anti-oxidants activity at 100 µg/ml. The DPPH activity showed excellent activity with WT-AgNPs than a plant extract and 1mM Ag $(NO_3)_2$ solution. (Fig. 8 Table). These kind of results observed in AgNPs synthesized from leaves extract of *Sauropus androgynous* (L.) Merr (Anu Abhimannue and Ashwathi Menon, 2021). Green synthesized EvL-AgNPs furtherly evaluated on various selected five human cancer cell lines such as MDA-MB-231, SK-OV-3, PC3, PANC-1, and HeLa. Experiment was carried out as cell proliferation assessment using SRB (Sulforhodomine-B) colorimetric method.

Diverse concentrations of EvL- AgNPs (12.5 µg/ml, 25.0 µg/ml, 50 µg/ml, and 100 µg/ml) and Doxorubicin as standard control applied to the growing cell lines like dose dependant process. The cytotoxic results demonstrated that the small sized nanoparticles were easily penetrates the cell membrane damaging the DNA, ultimately causing cell death with the reactive oxygen species (ROS) mechanism in cell (Alvur *et al.,* 2022; Ko *et al.,* 2022). EvL-AgNPs exhibited excellent activity on five selected human cancer cell lines. The activity was manifested magnificently on five selected human cancer cell lines, highest activity was seen in PANC-1 73.43 percent at 100 µg/ml, and higher IC50 was seen in PANC-1 (86.63 percent) when comparing the remaining selected human cell lines (Fig. 9 & 10). These kinds of results accordance with *Cucumis prophetarum* leaf extract AgNPs evaluated on different human cancer cell lines (Hemalata *et al.,* 2020).

The present work on synthesis of EvL-NPs leaf aqueous extract of *Endostemon viscous* was utilised as a capping agent for thr stabilization of the biological synthesized nanoparticles. For the preparation of the AgNPs we followed facile, cost-effective, eco-friendly method. Here, less chemicals were used and environmentally safer approach. This is a most effective way of synthesis which involves non-toxic and very conventional method which leads to find out for further directions of environmentally amiable nanoparticles. UV-Vis (scan range from 190 to 750 nm.) spectra analysis is an initial technique to notice of formation of EvL-AgNPs in the synthesized solution, through this instrument at 414 nm we found peak. FT-IR results suggested about phenols, amide, aliphatic group, alkyl aryl ether, ester, anhydride, and halo compound were interfered to form of nanoparticles and these compounds act as capping and stabilization agents to prevent agglomeration in the reaction mixture.

The crystallinity of the synthesized nanoparticles was proven from XRD analysis. The morphology, shape, size and agglomeration pattern of the EvL-AgNPs was performed by HR-TEM. The average size of the bio-synthesized AgNPs was 16.77 nm, sherical shaped, without any agglometation was observed and EDAX was results exhibited about 60.78 % weight percentage in the reaction mixture. The green synthesized EvL-Ag NPs was showed remarkable antimicrobial activity against both gram negative (*K.pneumoniae and E.coli*) and gram positive bacteria (*Bacillus subtilis*, *Staphylococcus aureus*). Hence the highest bacterial growth zone of inhibition (ZOI) was recorded towards gram negative bacteria when compare the gram positive bacteria by the small sized bio-synthesized nanoparticles. Different concentrations of aqueous leaf extract of EvL-AgNPs exhibited strong anti-oxidant activity. Anti-cancer activity was expressed notable with the using diverse human cell lines such as MDA-MB-231, SK-OV-3, PC3, PANC-1, and HeLa. The bio-synthesized AgNPs showed promising Anti-bacterial, anti-oxidants and anti-cancer activities, suggesting their capability utilize in different bio-medical applications.

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Abbreviation

mM - Milli molar, nm - Nano meter, AgNPs - Silver nanoparticles, Ev - *Endostemon viscous*

Author Contribution

Jayachandra Nagadasari: Investigation, formal analysis, writing—original draft. T. Vijaya: Validation, methodology, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval: Not applicable.

Consent to Participate: Not applicable.

Consent to Publish: Not applicable.

Conflict of Interest: The authors declare no competing interests.

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Metallic Nanoparticles Applications in Medicine

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Keywords: Metallic nanoparticles, Treatment

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Chat 1

Abstract

Metallic na
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Chat 1

Research Lake

Phytochemistry and invitro anti-microbial activity of *Achyranthes aspera* against Human pathogens

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ABSTRACT

The present work was focused on the anti-bacterial and anti-fungal activity of various solvent extracts of *Achyranthes aspera* Linn. The acetone, chloroform, methanol and diethyl ether solvent extracts of plants leaves were screened for anti-microbial activity. The screening was done by disc diffusion method against *Bacillus Subtilis, Escherichia coli, Klebsiella pnemoniae, Pseudomonas vulgaris, salmonella typhi* and *Streptococcus aureus*. The present study revealed that diethyl ether extracts showed significant antibacterial activity against *B.subtilis*, methanol extract showed significant anti-bacterial activity against *K.pnemoniae, E.coli, and S.typhi*. All extracts of *Achyranthus aspera* showed significant anti fungal activity towards *A.niger, A.flavus, and R.stolinifer*.

Key words: Phytochemical analysis, *Achyranthus aspera,* Anti-bacterial activity, Anti-fungal activity, Different solvent extracts.

INTRODUCTION

Achyranthes aspera common name chaff – flower the plant is used for medicinal purposes.It can be found in many places growing as an introduced species and a common weed it is an invasive species in some areas, including many pacific island environments[1]. It is an erect, branched herb under shrubs up to 15 cm high it was waste land herb everywhere .Leaves are opposite or rounded at apex. Its seeds rich in protein, these are cooked and eaten. *Achyranthes aspera* is one of the powerful ayurvedic herb, it is used to prepare to special medicine called kshara, used extensively in surgical procedures to treat fistula and as oral medicine for obesity.Medicinal plants have been used for human diseases because they contain components of therapeutic value. Some of them are also used for prophylactic purposes[2]. An increasing interest in herbal remedies has been observed in several parts of the world and many of the herbal remedies have been incorporated into orthodox medicinal plant practice[3]. Diseases that have been managed traditionally using medicinal plant include malaria, epilepsy, infantile convulsion, diarrhea, and dysentery, fungal and bacterial infections[4]. Medicinal herb is considered to be a chemical factor as it contains multiple of chemical compounds like alkaloids, glycosides, saponins, resins, oleoresins, sesquiterpene, lactones and oils[4]. India has one of the oldest, richest and most diverse cultural traditions associated with the use of medicinal plants. According to an estimate, 120 or plant-based drugs prescribed for use through the world come from just 95 plant species. Natural anti microbials can be derived from plants, animal tissues and microorganisms. The short comings of the drugs available today for the discovery of new pharmaco therapeutic agents from medicinal plant research[5]. The amount of phytochemical substances varies considerably from

species to species and even from plant to plant, depending on the age and various ecological and climatic factors. Most of the natural products are secondary metabolites and about 12,000 of such products have been isolated so far. These products serve as plant defense mechanisms against predation by microorganisms, insects and herbivorous plant (leaves, flowers, stems, roots, seeds, bark etc.) may be used as herbal drugs in particular or in combinations of each other. Today there is growing interest in chemical composition of plant-based medicines[6]. Several bioactive constituents have been isolated and studied for pharmacological activity. During the last two decades, the pharmaceutical industry has made massive investment in pharmacological and chemical researches all over the world in an effort to discover much more potent drugs, rather a few new drugs. Plants have successfully passed the tests of commercial screenings. Phytochemicals can be classified into two groups. Primary and secondary according to their functions in the plant body[7]. Primary metabolites (sugars, amino acids, proteins, lipids, chlorophyll….) are required for growth while secondary metabolites (alkaloids, essential oils, flavonoids, tannins, terpenoids, saponins, phenolic compounds, cardiac glycosides.).Plants have limit less ability to synthesize aromatic substances, mostly phenols or their oxygen-substituted derivatives.



Materials & Methods

Collection of Plant materials:

The leaves of the plant species were collected from the local areas of Sri Padmavathi Mahila University, Tirupati, Chittoor district, the collected plants were identified at the department of botany, Sri Padmavathi MahilaUniversity, Tirupati, India.

Preparation of extracts:

First, the plant material was collected (which is free from disease) in which the leaves are disease free,then the leaves were washed thoroughly with running water for about 2-3 times. After washing with running water, wash once with distilled water, Air dried the given material for 5 days on sterile blotter under shade (the given leaves were powdered with blender for about 25 grams dried powder was filled in the thimble and extract successively with methanol solvent in soxhlet apparatus for 48 hrs). 5 grams of dried powdered was mixed with 50ml of methanol solvent and allow it to stand for 3 days, then above solvent was filtered with the help of filter paper. The solvent extract was concentrated under reduced pressure and preserved at 5°C in air tight bottle for further use.

Microorganisms used:

The invitro antimicrobial activity was examined for Acetone, Chloroform, Methanol and Diethyl ether extracts of the medicinal plants against bacterial cultures of *Escherichia coli, Pseudomonas vulgaris, Klebsiella pneumonia, Salmonella typhi, Streptococcus aureus,* and Fungal cultures of *Aspergillus niger, Aspergillus flavus, Rhizopus stolonifer*. The cultures were collected from the department of microbiology were used for antimicrobial test organisms. The bacteria were maintained on nutrient broth (NB) at 37ºC and fungal were maintained on potato dextrose agar (PDA) at 28ºC.

Anti- bacterial activity:

Acetone, Chloroform, Methanol and Diethyl ether extract was tested by disc diffusion method[8]with 100 µg concentrations. The test organism was seeded into respective medium by spread plate method with the 24hrs bacterial culture growth in nutrient broth. After solidification the filter paper discs (5mm in diameter) impregnated with the extracts were placed on test organism seeded plates. Gentamycin used as positive control and DMSO solvent used as negative control. The anti-bacterial assay plates were incubated at 37°C for 24hrs .The diameter of the inhibition zone was measured in mm.

Antifungal activity:

The anti-fungal activity was tested by disc diffusion method[9]. Inoculation with each fungal culture in PDA plates by point inoculation. The filter paper discs (5mm in diameter) impregnated with 100 µg concentration of the extracts were placed on test organisms seeded plates. DMSO was used to dissolve the extract and was completely evaporated before application on test organism seeded plate followed by impregnated blank disk by drying was used as negative blank. Nystatin act as antifungal agent (10 mg) used as positive control. The activity was determined after 72 hrs of incubation at 28°C. The diameter of the inhibition zone was measured in mm.

PHYTOCHEMICAL SCREENING FOR DIFFERENT COMPOUNDS:

The Plant extracts obtained by using different solvent extraction process and it is subjected to different phytochemical tests to identify the plant constituents by using following standard methods[10].

Test for Flavonoids: 0.5 g of various extract was shaken with petroleum ether to remove the fatty materials (lipid layer). The defatted residue was dissolved in 20 ml of 80% ethanol and filtered. The filtrate was used for the following tests: (a) 3 ml of the filtrate was mixed with 4 ml of 1% aluminium chloride in methanol in a test tube and the colour was observed. Formation of yellow colour indicated the presence of flavonols, flavones and chalcones. (b) 3 ml of the filtrate was mixed with 4 ml of 1% potassium hydroxide in a test tube and the colour was observed. A dark yellow colour indicated the presence of Flavonoids. (c) 5 ml of the dilute ammonia solution was added to the portion of the aqueous filtrate of each plant

extract followed by the addition of concentrated H2SO4. The appearance of the yellow colouration indicated the presence of flavonoids.

Test for alkaloids: 0.5 to 0.6 g of various extract was mixed in 8 ml of 1% HCl, warmed and filtered. 2 ml of the filtrate were treated separately with both reagents (Mayer's and Dragendorff's), after which it was observed whether the alkaloids were present or absent in the turbidity or precipitate formation.

Test for Glycosides: Five ml each of various extract were hydrolysed separately with 5 ml each of conc. HCl and boiled for few hours on a water bath and hydrolysates were subjected to the following test. A small amount of alcoholic extract of samples was dissolved in 1ml water and then aqueous 10% sodium hydroxide was added. Formation of a yellow colour indicated the presence of glycosides.

Test for steroids: 0.5 g of the various solvent extract fraction of each plant was mixed with 2 ml of acetic anhydride followed by 2 ml of sulphuric acid. The colour changed from violet to blue or green in some samples indicated the presence of steroids.

Test for Phenols: To 1ml of various solvent extracts of sample, 2ml of distilled water followed by a few drops of 10% aqueous ferric chloride solution were added. Formation of blue or green colour indicated the presence of phenols.

Test for Terpenoids (Salkowski test): 5 ml of various solvent extract was mixed in 2 ml of chloroform followed by the careful addition of 3 ml concentrated (H2SO4). A layer of the reddish brown colouration was formed at the interface thus indicating a positive result for the presence of terpenoids.

Test for Saponins: 0.5 g of various solvent extract was dissolved in boiling water in a test tube. Test cooling aqueous extracts were mixed vigorously to froth and the height of the froth was measured to determine the saponin contents in the sample. 2.0 g of the powdered plant material was boiled in distilled water in a test tube in boiling water bath and filtered. 10 ml of the filtrate was mixed with 5 ml of distilled water and was shaken vigorously to the formation of stable persistent froth. The frothing was mixed with 3 drops of olive oil and shaken vigorously for the formation of emulsion thus a characteristic of saponins.

Test for Resins: One ml of various solvent extract were treated with few drops of acetic anhydride solution followed by one ml of conc. H2SO4. Resins give colouration ranging from orange to yellow.

Test for Tannins:0.25 g of various solvent extract was dissolved in 10 ml distilled water and filtered. 1% aqueous Iron chloride (FeCl3) solution was added to the filtrate. The appearance of intense green, purple, blue or black colour indicated the presence of tannins in the test samples.

Test for Cardiac glycosides (Keller-Killani test): 5 ml of various solvent extract was mixed with 2 ml of glacial acetic acid containing one drop of ferric chloride (FeCl3) solution, followed by the addition of 1 ml concentrated sulphuric acid. Brown ring was formed at the interface which indicated the presence of deoxysugar of cardenoloides. A violet ring may appear beneath the brown ring, while in the acetic acid layer, a greenish ring may also form just gradually throughout the layer.

Test for Carboxylic acid: One ml of the various extracts was separately treated with a few ml of sodium bicarbonate solution. Effervescence (due to liberation of carbon dioxide) indicates the presence of carboxylic acid.

Test for Coumarins: 0.5 g of the moistened various extracts was taken in a test tube. The mouth of the tube was covered with filter paper treated with 1 N NaOH solution. Test tube was placed for few minutes in boiling water and then the filter paper was removed and examined under the UV light for yellow fluorescence indicated the presence of coumarins.

Test for Quinones: One ml of each of the various extracts was treated separately with alcoholic potassium hydroxide solution. Quinines give coloration ranging from red to blue.

Test for Xanthoproteins: One ml each of the various extracts were treated separately with few drops of conc. HNO3 and NH3 solution. Formation of reddish orange precipitate indicates the presence of xanthoproteins.

Results&Discussion

The phytochemical analysis of different extracts of *Achyranthus aspera* was shown in Table 1. Among all the tested plant extracts methanol extract was found to be most effective. All the solvent extracts were inactive compared to methanolic extract.

Phytochemical constituents	Acetone	Chloroform	Methanol	Di ethyl ether
Flavonoids	+	-	++	-
alkaloids	+	-	+	+
Glycosides	-	+	+	-
steroids	+	-	+	-
Phenols	-	-	++	++
Terpenoids	-	-	-	-
Saponins	+	-	+	+
Resins	-	-	+	-
Tannins	-	+	+	-

Cardiac glycosides	-	+	+	-
Carboxylic acid	+	+	+	+
Coumarins	-	-	-	+
Quinones	-	+	+	+
Xanthoproteins	-	-	+	+

- : absent +: present

Table1: Phytochemical analysis of *Achyranthus aspera* leaves

Solvents (plant material extracted)	**Zone of inhibition measured in mm 30µg/disc**					
	E.coli	***B.subtilis***	***K.pneumonia***	***S.typhi***	***P.vulgaris***	***S.aureus***
Acetone	12	10	0.7	0.9	0.7	0.8
Chloroform	16	10	16	17	16	10
Methanol	13	0.9	10	12	10	11
Diethyl ether	11	16	13	10	0.7	0.9
Standard(Gentamycin)	20	19	22	20	25	20

Table 2: Anti-bacterial activity of *Achyranthus aspera* Linn.

Anti-bacterial activity of *Achyranthes aspera* by disc diffusion method

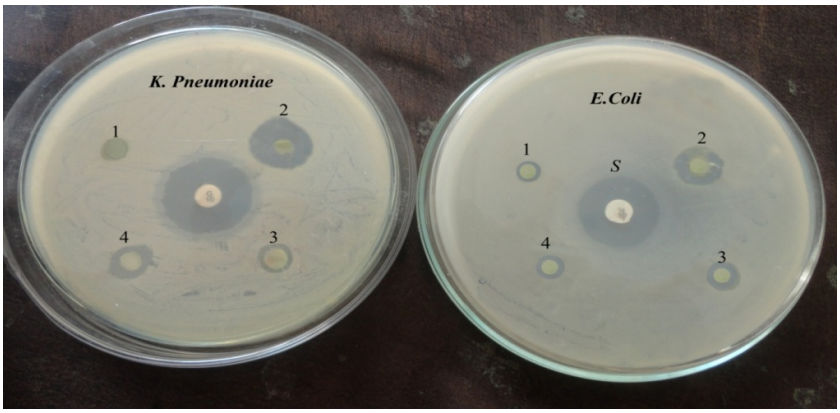


Fig1: Anti-bacterial activity of *Achyranthus aspera* Linn. against *K.pneumoniae* and *E.coli*

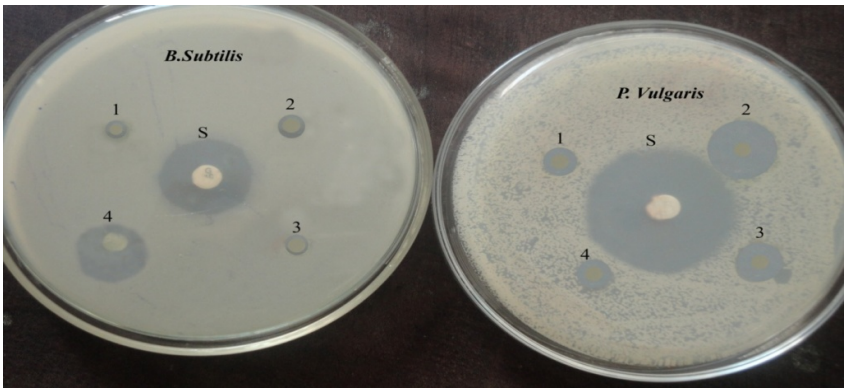


Fig2: Anti microbial activity of *Achyranthes aspera* against *B.subtilis* and *P.vulgaris*

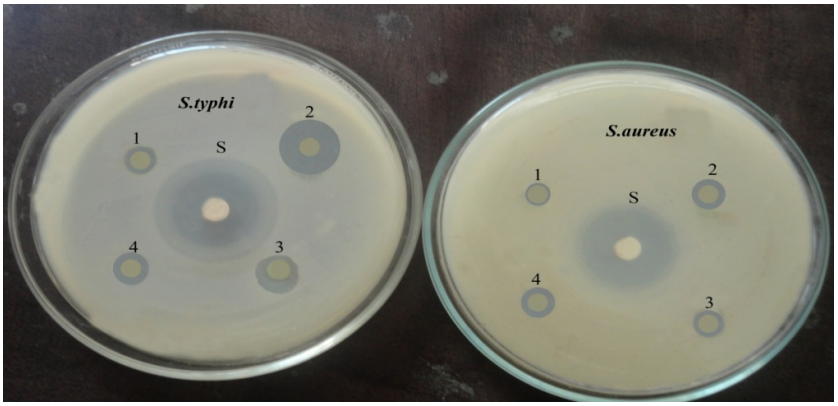


Fig3: Anti microbial activity of *Achyranthes aspera* against *S.typhi* and *S.aureus*

1. Acetone 2. Methanol 3.Chloroform 4.Diethyl ether S - Standard

Solvent (plant material extracted)	Zone of inhibition measured in mm 30µg/disc		
	A. niger	*A.flavus*	*R.stolonifer*
Acetone	15	14	11
Chloroform	18	14	13
Methanol	10	16	15
Diethyl ether	12	15	10
Standard(Gentamycin)	22	23	19

Table 3: Anti-fungal activity of *Achyranthus aspera* Linn.

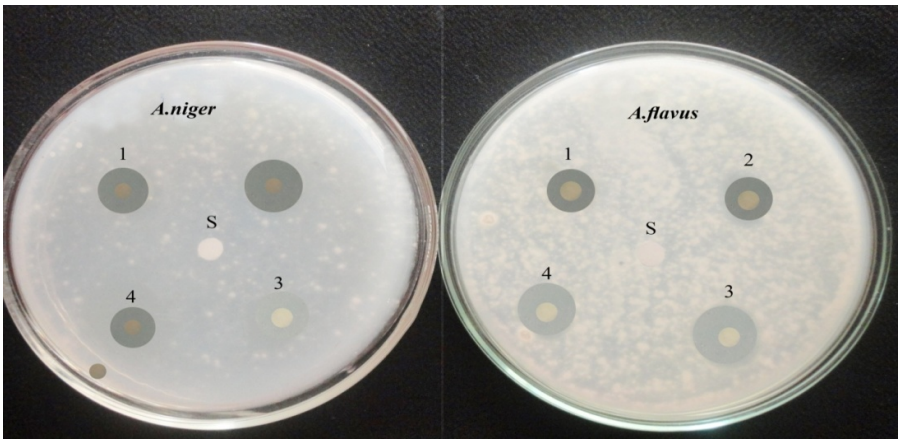


Fig4: Antifungal activity of *Achyranthes aspera* Linn.against *Aspergillus niger* and *Aspergillus flavus*

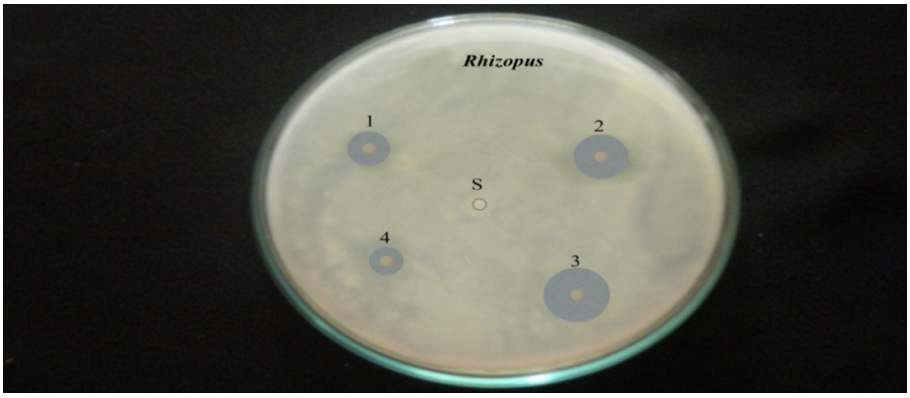


Fig5: Antifungal activity of *Achyranthes aspera* against *Rhizopus stolonifer.*

1. Acetone 2. Methanol 3.Chloroform 4.Diethyl ether S - Standard

CONCLUSION

The result showed potent in-vitro anti-bacterial and anti-fungal activity of various solvent extracts of *Achyranthus aspera* Linn.leaves. This study would lead to the establishment of bioactive compound that has to be used to formulate more potent anti microbial drugs of plant origin and further used in pharmalogical formulations to combat the various human diseases.

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PRODUCTION OF BIO-FABRICATED SILVER NANOPARTICLES; CHARACTERIZATION AND EVALUATION OF BIOLOGICAL APPLICATIONS EFFICACY USING AQUEOUS LEAF EXTRACT OF *POGOSTEMON MYOSUROIDES (ROTH) KUNTZE*

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ABSTRACT: The huge demand for metallic nanoparticles synthesized by green protocols has increased because of their therapeutic clinical and different applications. The present work, aimed to synthesize and evaluate the potential of AgNPs synthesized from Pogostemon myosuroides (Roth) kuntze by a cost-effective way. Synthesized AgNPs with the leaf aqueous extract further characterization was done by recent spectroscopic tools like UV-Vis Spectrophotometer, DLS-Zeta potential, FT-IR (Fourier transform infra-red) spectra, Transmission Electron Microscopy, and X-ray Diffraction. The AgNPs formation was primarily confirmed through UV-Vis scan range from 190 to 750 nm acquired intensive peak at 445 nm. The DLS particle size and zeta potential analysis revealed the size and stability of the nanoparticle around 8.5 nm and -4.4 mV zeta potential values. The FT-IR was used to validate the presence of different functional groups accountable for stabilization and capping agents. TEM was used to find the morphology, size, and agglomeration pattern of the nanoparticles. TEM images exhibited an average size of the nanoparticles of about 22.16 nm size ranging between 10 to 38 nm. XRD was used to crystalline nature and size of the synthesized nanoparticles. Biologically synthesized nanoparticles from leaf extract of the Pogostemon myosuroides (Roth) kuntze had shown significant anti-bacterial activity on selected two gram-positive Bacillus subtilis (MTTC-441) and Staphylococcus aureus (MTTC -731); two gram-negative bacteria Klebsiella pneumonae (MTTC-741) and Escherichia coli (MTTC-443) bacteria; and anti-oxidants activities. PmL-AgNPs also evaluated on five selected human cancer cell lines (MDA-MB-231, SK-OV-3, PC3, PANC- 1, and HeLa); exhibited magnificent activity.

Keywords: Characterization, AgNPs, anti-bacterial activity, anti-oxidants, and human cancer cell lines.

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1. INTRODUCTION

The revolution in nanotechnology has marked a magnificent turning point in history. Nanotechnology involves the manufacturing, manipulation, and imaging of nanostructures with sizes ranging from 1 to 100 nm [1]. Nanoparticles have a plethora of applications in the fields of health care and cosmetics, food and feed, environmental health, mechanics, space industries, energy science, and photo-electrochemical field [2]. Metallic nanoparticles mainly consist of gold, silver, copper, magnetic (cobalt, nickel), and semiconducting materials. In contrast, non-metallic nanoparticles are primarily composed of carbon-based materials. Intensive research has been conducted on metallic nanoparticles because they possess distinctive electrical, optical, and catalytic properties [3]. Silver nanoparticles (AgNPs), among other nanoparticles; have received extensive attention because of their unique properties s [4-7]. AgNPs are essential nanomaterials studied extensively because of their electrical, optical, and biological properties. Consequently, these nanoparticles have been used for numerous applications, including bio-sensing, drug delivery, Nano device fabrication, and medicine [8]. Silver nanoparticles have different natural applications significantly antimicrobial, antimalarial, anti-inflammatory, wound recuperating, chemo preventive agent, and so on [9-10]. Silver-NPs and silver-based materials are exceptionally harmful to microorganisms. Silver is known for inhibiting a wide range of bacterial strains and pathogens commonly seen in clinical and mechanical settings [11]. Since Silver NPs have antibacterial and antifungal characteristics, they have a wide range of uses in medication development, burn infection prevention, and disinfection [12]. For the amalgamation of Silver-NPs, a variety of approaches are available, including chemical, physical, and bio-reduction procedures [13-14]. Physical and chemical techniques are rather hazardous and expensive, while biological techniques are eco-friendly, secure, and less difficult for nanoparticle synthesis [15]. Synthesizing of nanoparticles using plant extracts offers several advantages compared with other green synthesis methods because plants are eco-friendly and easy to handle [16]. Moreover, it offers energy efficiency, low toxicity, high yield, time-, cost-effectiveness, and availability. Further, plants are a good and easily available source of bioactive plant secondary metabolites such as polysaccharides, proteins, polyphenols, flavonoids, terpenoids, tannins, alkaloids, amines, ketones, and aldehydes, which act as reducing, stabilizing, and capping agents in the conversion of metal ions to metal nanoparticles, leading to the production of desirable nanoparticles with predefined characteristics [17]. In recent years different types of nanoparticles have been synthesized successfully by the greener approach using plant materials like Indium oxide nanoparticles from Aloe vera [18], Iron oxide nanoparticles from Medicago sativa [19], Palladium nanoparticles from Cinnamomum camphora [20], Copper nanoparticles from Magnolia kobus [21], Cadmium Oxide Nanoparticles from Achillea wilhelmsii [22]. Calcium nanoparticles from Boswellia ovalifoliolata [23], Zinc oxide nanoparticles from Vitex negundo [24], Silver nanoparticles from Flemingia wightiana [25]. Pogostemon myosuroides (Roth) kuntze is an herb, that belongs to the Lamiaceae family. The plant species contains the following synonyms i.e. Dysophylla myosuroides (Roth) Benth.exWall., Dysophylla myosuroides (Roth) Benth., Dysophylla myosuroides Benth., Eusteralis myosuroides (Benth.) M.R. Almeida, Mentha myosuroides Roth, Pogostemon myosurodes Kuntze, Pogostemon myosuroides (Roth) El Gazzar & L. Watson. Rootstock woody, stem terete, pale tawny or white silky tomentose. Leaves are thick and wrinkled. Flowers are very small, whorls close and compact. Calyx minute is 1.2 to 1.5 mm and the corolla 1.5 mm long. Pogostemon myosuroides (Roth) kuntze is common to open rocky crevices on hill slopes of Tirumala [26], the local healers and tribal peoples use to cure ailments of leaf extract is used to relieve anxiety and stimulation of brain [27].

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2. MATERIALS AND METHODS

Pogostemon myosuroides (Roth) kuntze Plant leaves were collected from Japaliteertham, Tirumala Hills of the Eastern Ghats, Chittoor district, A.P., INDIA. Healthy and mature leaves were cleaned by running tap water and followed by distilled water. Then all leaves were wiped with tissue paper, later cut into 1.0x1.0 cm pieces, and dried up for 10 to 14 days under shade dried to evaporate moisture content and made ground fine powder with an electric blender and it was stored in the amber colour bottle until further work.

Preparation of plant extract

25 g. of powder was taken into 500 ml sterile Erlenmeyer conical flask and 250 ml of sterile Milli-Q water was added and boiled for 15 min at 100oC. After that the leaf extract was collected in a separate sterile conical flask through a standard filtration procedure, this filtrate was utilized for the characterization, antibacterial, anti-oxidants, and anti-cancer activities.

Chemicals and preparation of the 1 mM Ag $(No_3)_2$ solution

10 grams of Silver nitrate was purchased by Hi-media Company, and then 1 mM silver nitrate solution was prepared by sterile double distilled water, later this was taken into the amber-coloured bottle until the process of synthesis.

Synthesis of silver nanoparticles (AgNPs)

Synthesis of AgNPs was performed by the leaf aqueous extract of Pogostemon myosuroides (Roth) kuntze was added to 1 mM of Ag (No3)2. 20 ml of leaf aqueous extract were taken into a 250 ml sterile conical flask and it was titrated by 200 ml of 1 mM of Ag (No3)2 solution with heating at 600C to 800C for 30 min. Later it was centrifuged at 20,000 rpm for 15 min to remove the presence of biological admixture, and this was utilized for characterization and evaluation of its antimicrobial antioxidant, and anti-cancer activities.

Characterization of the Nanoparticles

Synthesized silver nanoparticles (PmL-AgNPs) were analyzed by the advanced tools. AgNPs of Pogostemon myosuroides (Roth) kuntze were performed by the UV-Vis spectrophotometer Nanodrop scan range from 190 to 750 nm to know which nanoparticles interfered in decreasing the nanoparticles by Surface Plasmon Resonance (SPR) Mechanism. To determine the size of the particle and size distribution in aqueous AgNPs solution carried out by the advanced tool Dynamic Light Scattering (DLS) Malvern-Zeta analyzer. To comprehend which phyto-constituents interacted in the capping and stabilization of the nanoparticles was analyzed by the Fourier Transform Infra-Red (FT-IR, EC ART), Bruker, Ettlingen, Karlsruhe, Germany by KBr pellet procedure. The crystalline nature and to calculation of the average size of nanoparticles was done by the XRD (Shimadzu, XRD-6000). To find out the nanoparticle's shape and size was performed with the Hr-TEM H-3300 advanced 300 kV from Hitachi.

Antibacterial activity

The antibacterial study was evaluated by using standard protocol followed by the disc diffusion assay [28]. Clinically isolated bacterial strains were acquired from the Department of Microbiology, Sri Venkateswara University, Tirupati. Biologically synthesized PmL-AgNPs were experimented for antibacterial activity against selected two gram-positive (Bacillus subtilis and Staphylococcus aureus) and two gram-negative bacteria (Klebsiella pneumonae and Escherichia coli). For this 20 µl of plant extract, Ag (No3)2, AgNPs, and streptomycin were applied on separate sterile Whatman No.1 filter paper discs (7 mm diameter) and allowed to dry before being put on nutrient agar medium. The total process was done in triplicates and incubated at 370C for 24 hours. The results were tabulated after measuring the zone diameter in centimetres.

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DPPH activity of (PmL-AgNPs)

The antioxidant activity of PmL-AgNPs was tested by DPPH- (2, 2-Diphenyl-1-picry Hydrazyl radical Scavenging activity) [29]. For this, 1mM DPPH stock solution was prepared by adding 4 mg DPPH in 100 mL of methanol. 2 mL of DPPH stock solution was added to 1 mL of methanolic solution of PmL-AgNPs consisting of two different concentrations of PmL- AgNPs (50and 100 µg/ml). Following 30 minutes of incubation time at room temperature, we recognize the absorbance (RSA) against blank at 517 nm. The DPPH assay expressed IC50 values. The assay was performed in triplicates. DPPH activity of the PmL-AgNPs was calculated by the following bellow mentioned formula.

% of formula = [(Absorbance of control - Absorbance of sample)/ Absorbance of control] X100.

Anticancer studies (Cell proliferation assay using SRB (Sulforhodomine-B)

Different human cancer Cell lines (MDA-MB-231, SK-OV-3, PC3, PANC- 1, and HeLa) were purchased from the American Type Culture Collection. SRB assay is a quantitative colorimetric method used for the determination of cell survival and proliferation based on the measurement of cellular protein content. Cells were grown in Dulbecco's modified Eagle's medium (containing non-essential amino acids and 10%FBS). PC-3 was grown in RPMI with glutamine containing non-essential amino acids. Cell lines were maintained in a humidified atmosphere of 5% CO2 at 37°C. Cells were trypsinized when sub-confluent from T75 flasks/90mm dishes and seeded in 96 well plates at a concentration of 1×104 cells/mL in complete medium a day before treatments. Cells were incubated with different concentrations of Ag NPs (12.5-100µg/ml) in triplicates for 48h for potent compounds.

3. RESULTS AND DISCUSSIONS

Ultraviolet- Vissible (UV-Vis) Spectroscopy analysis PmL-AgNPs

The aqueous leaf extract of P. myosuroides mixed with the 1 mMof Ag(No3)2 solution, the color turned into deep brown from transparent yellow, which is the primary and valuable technique to confirm that the synthesized nanoparticles are silver. UV spectra analysis revealed that the broad peak at 445 nm (Fig.1), was due to the SPR Surface Plasmon Resonance mechanism of the AgNPs in the prepared samples. SPR is a collection of oscillations in the conduction of electrons on the material's surface. Obtained UV-Vis spectroscopic results indicate that the stability of the green synthesized AgNPs can be maintained for several months [30]. These types of results were in accordance with the previous reports. [31].

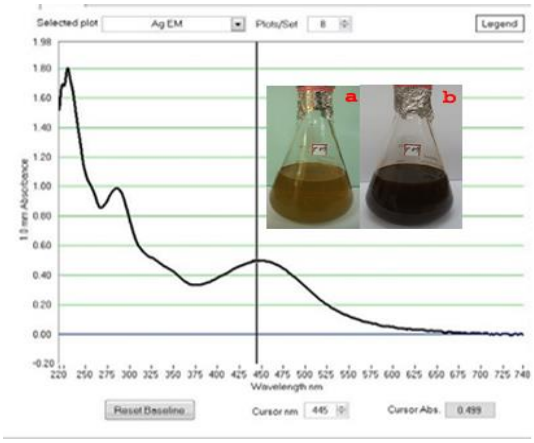


Figure.1 UV-Vis spectra analysis spectrum using aqueous leaf extract of *Pogostemon myosuroides* AgNPs

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DLS and Zeta potential

DLS (Dynamic Light Scattering) can be used to scrutinize the surface charge, size, and size distribution of the nanoparticles. This is an advanced tool; it depends on the interaction of the Brownian motion of spherical particles with the light passing by a colloidal solution [32]. The Zeta potential is utilized to estimate the stability, dissemination, and aggregation levels of biologically synthesized nanoparticles through repulsion effects around through fluctuations in charge densities. The PmL-AgNPs in this work expressed about average size is 8.5 nm and negatively charged zeta potential value of -4.4 mV, and 0.165 of the polydispersity index. The results PmL-AgNPs are elucidated in the figure (Fig.2 a &b). This type of result was monitored in the Biosynthesis of silver nanoparticles of Syzigium cumini leaves extract [33].

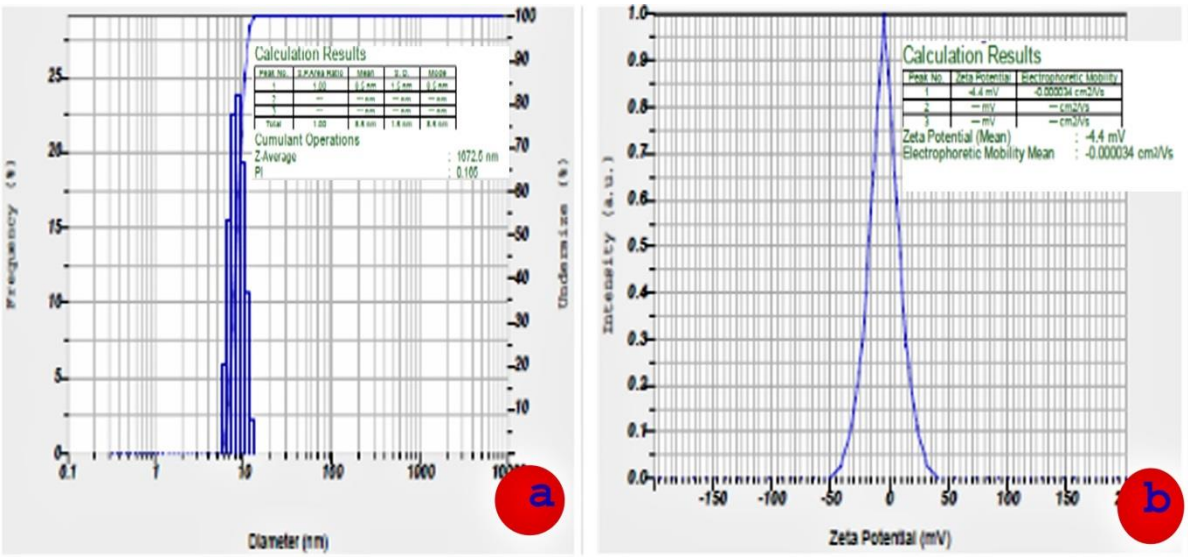


Figure.2 a). Particle size and b). Zeta potential *studies of Pogostemon myosuroides* AgNPs

FT-IR

Green synthesized nanoparticles were analyzed by FT-IR (Fourier transform infra-red) spectra with a scan range of 4000-500 cm-1 (ALPHA interfero meter ECO-ATR, Bruker Ettlingen, Karlsruhe Germany) was used to find the expedient phytochemicals responsible for capping and stabilization. By the FT-IR spectrum broad peaks obtained from leaf aqueous extract of PmL-AgNPs exhibited at 3282 – corresponds to O-H Stretch H Bonded Alcohol, Phenol, 1635 – assigned for N-C Stretch Alkenes and 514 – belongs to C-Br Stretch Alkyl halides (Fig.3). Based on these results cleared that the phytochemicals in the plant extract were essentially accountable for capping and stabilization of pmL-AgNPs. Therefore, FT-IR spectroscopy is a valuable and economical tool to determine the role of biomolecules in the synthesis and stabilization of biosynthesized AgNPs. These results accordance with previous results [34].

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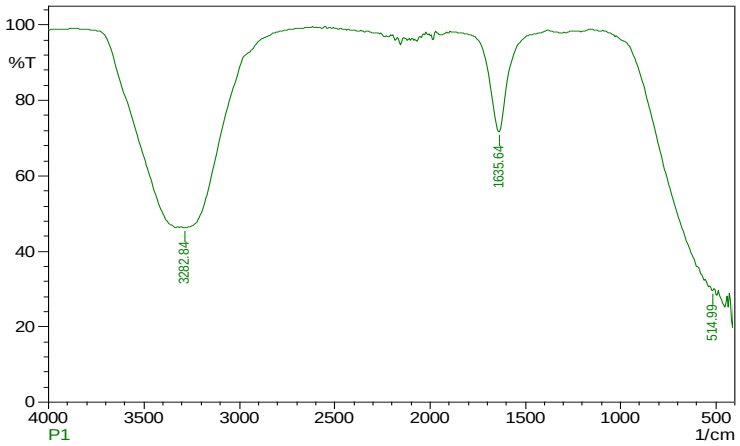


Figure.3 Frourier- Transform Infra-Red (FT-IR) spectra of bio-synthesized AgNPs from *Pogostemon myosuroides*

XRD

X-ray diffraction (Shimazdu XRD-6000) was analyzed to confirm the crystalline nature and average size, and measure the degree of crystallinity of the PmL-AgNPs. XRD is a powerful characterization technique for both qualitative and quantitative analysis of nanoparticles. The peaks obtained at 2θ of X-axis 27.500, 37.890, 46.50, 63.770, and 76.270corresponds to 222,111, 200, 220, and 311 Bragg reflections of Y- axis respectively which may be indexed based on the end- centred monocrystalline structure of AgNPs (Fig. 4). Based on the X-ray diffraction reports indicates that the formed particles are AgNPs. The highest Bragg reflection was obtained at 2θ of 37.89 to predict FWHM (Full Width Half Maxima) value, i.e. 10 and 38 nm average sizes of the nanoparticles by using the Debye-Scherrer equation:

1.1. $D=k\,\lambda/\beta\cos\theta$

Where D is the diameter of NPs, k is the Scherrer constant, λ is the wavelength of X-ray radiation source, β is full-width half maximum value of XRD diffraction lines and θ is the half diffraction angle-Bragg angle.

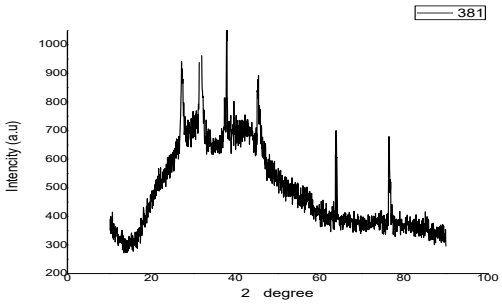


Figure.4 XRD pattern analysis of leaf sourced biologically synthesized AgNPs *Pogostemon myosuroides*

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TEM

Nanoparticles can also be characterized by TEM (Transmission Electron Microscope). Quantitative measurements of the synthesized nanoparticles i.e. size of the particle, size distribution, and morphology of the nanoparticles can be acquired by TEM. TEM conducts imaging by passing an electron beam by a sample and the carbon copper grids must coat a single drop of the reaction mixture. TEM is an advanced tool and provides improved special resolution when compared with SEM and enables a much more in-depth analysis of nanoparticles. HR-TEM showed at 50 nm scale micrograph very small sized, spherical in shape and size range from 10 to 38 nm; Average size of the AgNPs 22.16 nm. These tiny-sized nanoparticles showed no physical contact and did not see any agglomeration between them (fig.5). Such type of results were seen in silver nanoparticles synthesized from plant extracts of Wrightia tinctoria and Acacia chundra [35].

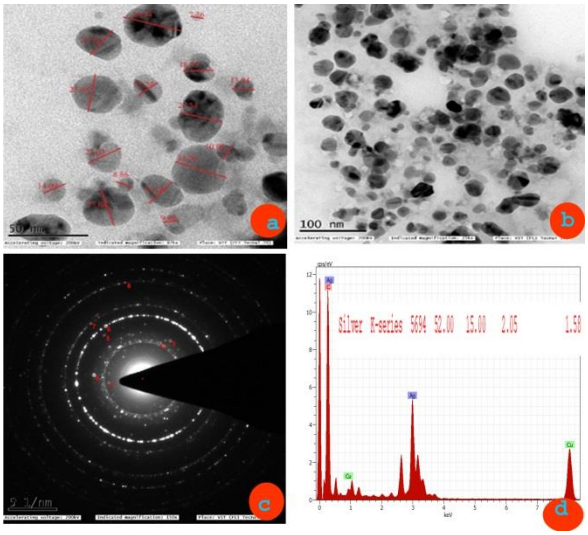


Figure.5 TEM images of *Pogostemon myosuroides AgNPs*

a). At 50 nm 0.24 nm, b). At 50 nm AgNPs are spherical in shape AgNPs. c). At 51 nm beam of TEM d). EDAX analysis

Antibacterial studies

The bio-fabricated PmL-AgNPs efficacy was evaluated against two selected two-gram-positive Bacillus subtilis MTTC-441 and Staphylococcus aureus MTTC -731; two-gram negative bacteria Klebsiella pneumonae MTTC-741 and Escherichia coli MTTC-443. To do this Streptomycin standard drug was used as a positive control, Ag solution as a negative control, and plant extract served as a control for comparison. The results showed significant anti-bacterial activity against gram-negative bacteria; sufficient activity was seen against gram-positive bacteria. The zone of inhibition was exhibited in the table (Figure 6). The activity revealed that the highest zone of inhibition was observed with PmL-AgNPs in Escherichia coli (Fig. 6 & 7). These kinds of results were found in synthesized AgNPs with leaf aqueous extract of Walsura trifoliata [36].

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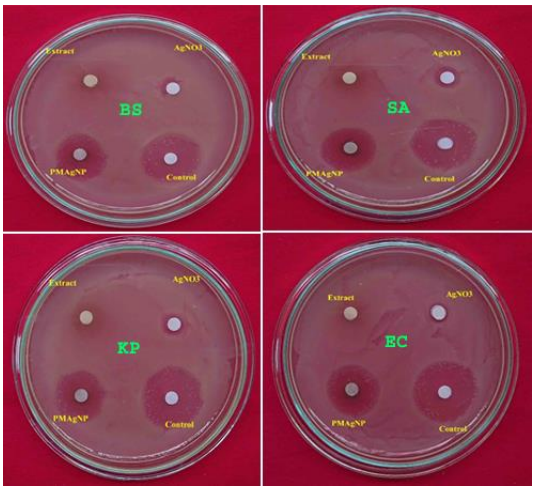


Figure.6 Antimicrobial activity of *Pogostemon myosuroides* aqueous leaf extract biologically synthesized PmL- AgNPs, Ag $(No_3)_2$ solution and antibiotic Streptomycin.

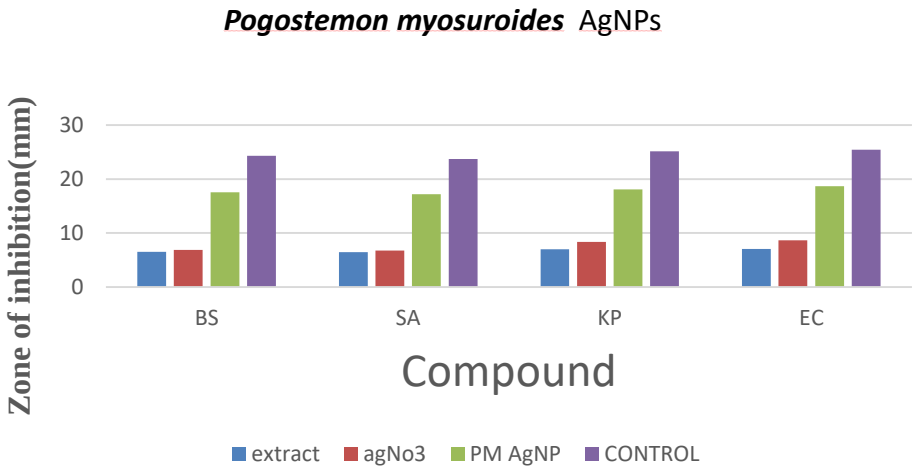


Figure.7 Graphical representation of anti-bacterial activity using bio-synthesized PmL-AgNPs

Antioxidant activity (DPPH)

reduction of DPPH radical from DPPH-H, a hydrogen-donating anti-oxidant. The IC 50 values of in-vitro Pogostemon myosuroides leaf aqueous extract, sourced biosynthesized AgNPs anti-oxidant activity described in the table.The results divulged that the DPPH anti-oxidant activity was done by the increased concentrations of the test samples. Plants possess a wealth of bio-active compounds i.e. Flavonoids, tannins belong to the phenolic compounds along with other polyphenols, which are a significant group of phytochemicals that act as primary anti-oxidants of free radical scavengers [37-38]. The maximum free radical scavenging activity was monitored in the PmL- AgNPs with 58.78 % at 100 µg/mL concentrations and the lowest activity was seen 41.04 % at 50 µg/mL respectively (Fig.8; Table.1). Similar results were seen in earlier work AgNPs synthesized from Plantago lanceolata leaf extract [39].

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Table.1 DPPH anti-oxidants activity comparison table

S.no	Compound	% of inhibition 50 µg/mL	% of inhibition 100 µg/mL
1	Ascorbic acid	52.48 ±0.44	77.54 ±0.54
2	PM Ag NP	41.04 ±0.48	58.78 ±0.52
3	PM EXTRACT	25.34 ±0.20	43.30 ±0.30

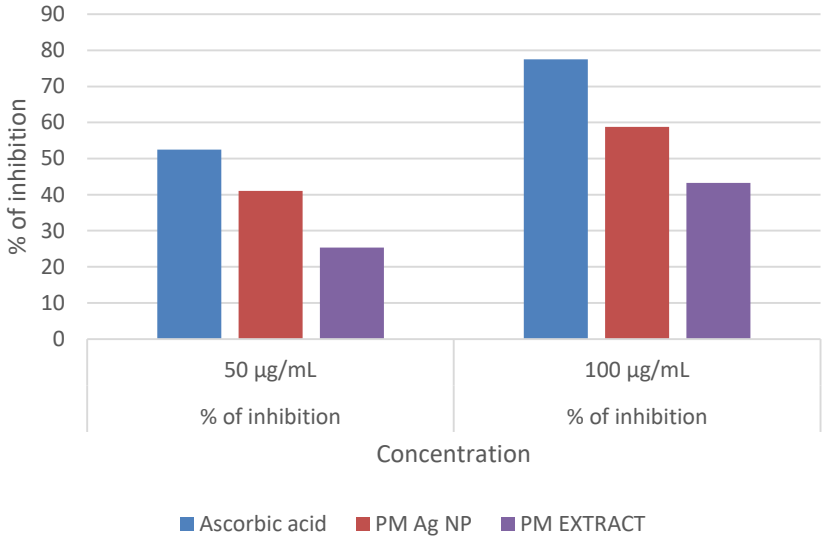


Figure.8 Graphical representation of anti-oxidants activity by synthesized PmL-AgNPs

Anti-cancer studies

Biologically synthesized PmL-AgNPs were screened out against diverse selected human cancer cell lines i.e. MDA-MB-231 an epithelial, human breast cancer cell line, SK-OV-3 -is an ovarian cancer, PC3 -human prostate cancer, PANC-1 -human pancreatic cancer, and HeLa -human epithelial cervical cancer cell lines. The experiment was done as a cell proliferation assay using SRB (Sulforhodomine-B) colorimetric method. Here served cell control, standard control Doxorubicin, and different concentrations of plant-mediated nanoparticles (i.e. 12.5 µg/ml, 25 µg/ml, 50 µg/ml, and 100 µg/ml) to the growing cell lines, in the dose dependant manner. The cytotoxic results suggested the improvement of the aqueous leaves extract AgNPs of Pogostemon myosuroides (Roth) kuntze. Above mentioned assay clearly explained that the tiny-sized nanoparticles allow them to enter cells more easily through endocytosis. Not only do they enter cells, but also they interact with the functioning of cellular proteins, causing changes in cellular structure and chemistry. However, due to these nanoparticles are small and non-aggregated, they are also efficient in producing reactive oxygen species (ROS) in cells. Moreover, ROS can cause stress by damaging DN and causing morphological changes in cells, ultimately leading to cell death [37-38]. Among the activity on five selected human cancer cell lines (MDA-MB-231, SK-OV-3, PC3, PANC- 1, and HeLa) significant activity was noticed in all, lesser activity was seen 4.8 µg/ml in PANC- 1 and PC3 exhibited 4.83 µg/ml at lower concentration (12.5 µg/ml); whereas highest activity was observed in MDA-MB-231 (64.46 µg/ml) and SK-OV-3 (59 µg/ml) at 100 µg/ml than remaining cell lines. The highest IC50 values were monitored PANC- 1 (87.08 µg/ml) and HeLa (85.61 µg/ml) (Fig. 9 & 10). Similar types of results were observed in the Anti-cancer

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potential of biologically synthesized AgNPs using Lantana camera leaf extract [40] and also by Cucumis prophetarum leaf-mediated synthesized AgNPs evaluated on different human cancer cell lines [41].

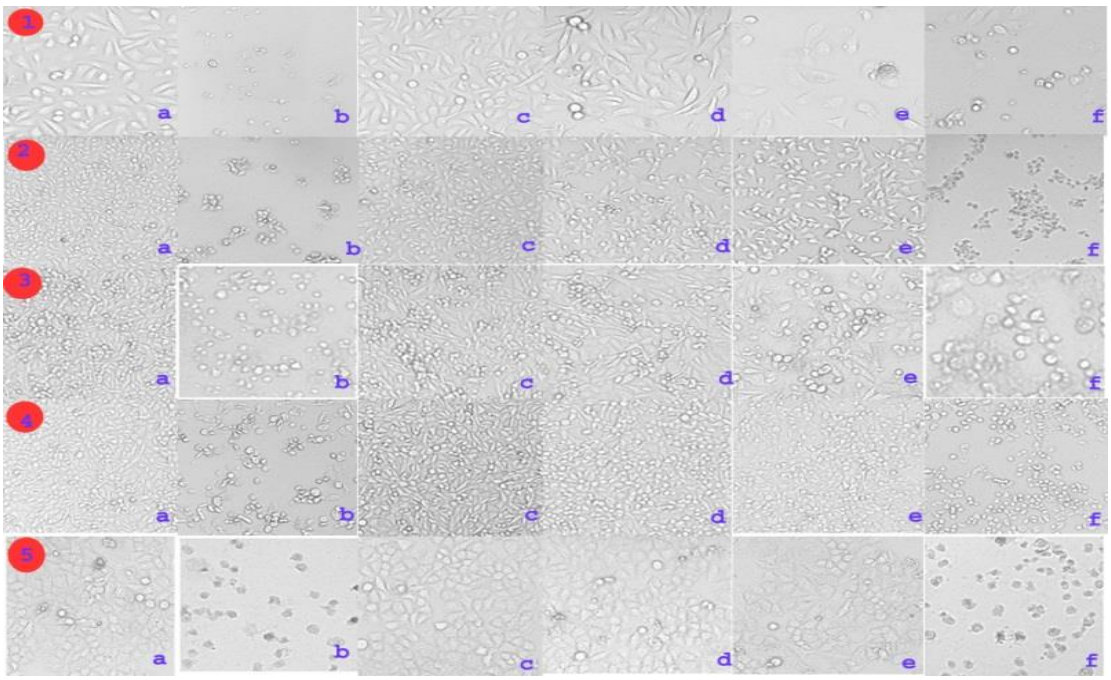


Figure. 9 Anti-cancer activity on selected human cancer cell lines by synthesized PmL-AgNPs
1). PC-3 2). MDA-MB-231 3). SK-OV-3 4). PANC-1 5). HeLa
a). Cell control b). Standard control c). 12.5 µg/ml d). 25 µg/ml e). 500 µg/ml and f). 100 µg/ml

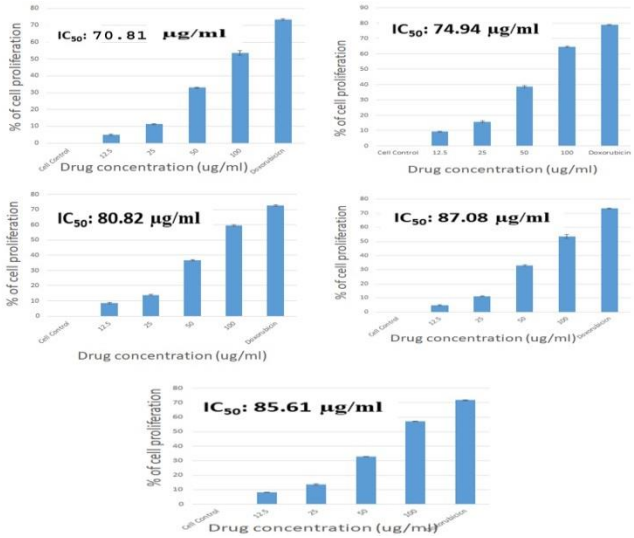


Figure. 10 Graphical representation of anticancer activity by using PmL-AgNPs against five selected human cancer cell lines
a). PC-3 b). MDA-MB-231 c). SK-OV-3 d). PANC-1 e). HeLa

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4. CONCLUSION

The greener way is adapted rather than the heavy toxic synthesizing methods of synthesis of nanoparticles. This is a novel method to form nanoparticles in the reaction mixture. Our present work is intended for the easy synthesis of nanoparticles using a very small amount of chemicals and a small volume of aqueous plant leaves extract of Pogostemon myosuroides (Roth) kuntze by the green method. The synthesized PmL-AgNPs were characterized by advanced techniques i.e. UV-Visible spectroscopy, FT-IR, DLS: Zeta potential, TEM and XRD. Primarily, colorless Ag (No3)2 solution added to the aqueous leaf sourced extract got the deep brown color from transparent yellow; this indicates the formation of nanoparticles. Then these were observed through the UV-visible spectroscopy, acquired peak at 445 nm, this confirmed that the formed nanoparticles are silver in the solution. The DLS zeta potential study revealed about stability, dissemination, and aggregation levels of bio-synthesized nanoparticles and the size of the nanoparticles around 8.5 nm evenly distributed and -4.4 mV zeta potential values. The FT-IR analysis results expressed that the phyto-constituents in the plant extract help in the oxidation of silver nitrate solution into silver nanoparticles. TEM micrographs confirmed that the shape of the nanoparticle is spherical, and the average size of the particle was 22.16 nm size ranging from 10 to 38 nm in the reaction mixture. The EDS study done along with the TEM revealed that silver is a major element in the nanoparticles. X-ray diffraction suggests the crystalline nature and average size of the PmL-AgNPs. All the above studies regarding the synthesized nanoparticles are spherical with small size. The anti-bacterial studies of the PmL-AgNPs on selected two gram-positive Bacillus subtilis (MTTC-441) and Staphylococcus aureus (MTTC -731); two gram-negative bacteria Klebsiella pneumonae (MTTC-741) and Escherichia coli (MTTC-443) showed significant activity, PmL-AgNPs also expressed effective DPPH activity with dose dependant manner. Anti-cancer activity was evaluated on five selected human cancer cell lines (MDA-MB-231, SK-OV-3, PC3, PANC- 1, and HeLa), showing remarkable activity through increasing concentration levels. Above mentioned biological properties were evaluated, and AgNPs were found to have potent anti-bacterial, anti-oxidant, and anti-cancer action. The advantages of this method to synthesis from plant extracts are a clean working environment, a healthy, and non-hazardous atmosphere, lesser wastage, and most stable products. The work suggests that the plant-assisted nanoparticles can be employed in the forthcoming days for the treatment of diseases. The green synthesized nanoparticles from PmL-AgNPs will help to develop into efficacious drug delivery systems as they are smaller in size. The nanoparticles exhibited their correct capability as a pharmaceutical drug.

ABBREVIATIONS

PmL- *Pogostemon myosuroides* leaf material

AgNPs- Silver nanoparticles

XRD- X-ray diffraction

FT-IR- Fourier transform infra-red spectra

DLS-Dynamic Light Scattering

TEM_ Transmission Electron Microscope

EDAS- Energy-Dispersive X-ray Analysis

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mM- Millimolar

ml- Milli litre

mg- Milligram

mm- Millimetre

nm- Nano metre

µg- Micrograms

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are base of this research.

CONSENT FOR PUBLICATION

Not applicable.

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None.

CONFLICT OF INTEREST

The authors declared that they have no interest of conflicts

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Biological Activity of Silver Nanoparticle (AgNps) Synthesized from *Hemidesmus indicus* and *Carica Papaya* to identify and to develop novel drugs

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ABSTRACT

The amazing papaya fruit contains enzymes and compounds that can prevent cancer, ageing and can promote healthier heart. The collected two different plant leaf materials were used to prepare an extract. silver nanoparticles were synthesized and within 30 min of incubation period nanoparticles were rapidly synthesized, the aqueous silver nitrate solution was turned to brown color by the addition of plant extract. The intensity of brown color increased with direct proportion to the incubation period. It may be due to the excitation of Surface Plasmon resonance (SPR) effect and reduction of AgNO3.FTIR analysis of *H.indicus* extract having peaks at 3423, 2425, 1629, 1077 and 664cm-1. The wave numbers due to the presence of phenols at high concentration, alkynes (C=C) and alcohol.The wave numbers due to the presence of phenols at high concentration, alkynes (C=C) andalcohol,and also indicates the high contents of flavonoids in *Carica papaya*.Zeta potential of AgNps of *H.indicus* leaf extract was done (fig 9) and observed that Zeta potential of synthesized nanoparticle shows the stability of the compound having low stability of 3.4mV.Zeta potential of AgNps of *C.papaya* leaf extract was done and observed that Zeta potential of synthesized nanoparticle of *C.papaya* shows the stability of the compound having low stability of 3.4mV.Antibacterial activity of green synthesized water extract of *H.indicus*and *Carica papaya* leaf extract at different concentrations were taken and observed that they are active against *Staphylococcus aureus* and *Bacillussubtilis*.

KEY WORDS

Silver Nanoparticles,FTIR, Zeta Potential,and Bioactivity

INTRODUCTION

Disease causing microbial organisms such as virus, bacteria and fungi cause disease and lead to decrease the quality of human life. Identification of effective, safe and natural drug can help in protects from dreadful diseases. Medicinal plants are the natural resources and are used to treat various diseases caused by bacteria, fungi and viruses. Medicinal plants have secondary metabolites such as alkaloids, carbohydrates, flavonoids, glycosides, sterols, saponins, terpenoids, coumarins, quinones and tannins (Cowan, 1999). Only one third of the infectious diseases have been treated by these synthetic products (Manish Kumar et.al., 2014). Usage of natural drugs are more efficient then chemical drugs and no side effects. There is an increasing need to search for new compounds with antibacterial and antifungal activity to microbial infections. Nowadays, an increasing number of infectious agents are becoming more resistant to commercial antimicrobial (Ranjani Ramakrishnan, 2013; 2018).

Medicinal plants have served as the starting point for more number of drugs on the market today. These plant-based traditional medicine systems continue to play an essential role in health care, about 80% of the world's inhabitants relying mainly on traditional medicines for their primary health care. World's plant species have been examined for the presence of bioactive compounds (Myers 1984). Researchers generally say that natural products from plants and other organisms have been the source for ideas for new drugs (Mukesh R. Jangra*et al*.,2018, NagarajanArumugam *et al* ., 2107, Reshma S. Konjari*et al*.,2015,Gayathri. M. and K. Kannabiran. 2009, (RanjaniRamakrishnan, 2013; 2018).

The advancement of green syntheses of nanoparticles is progressing as a key branch of nanotechnology; where the use of biological entities like microorganisms, plant extract or plant biomass for the production of nanoparticles could be an alternative to chemical and physical methods in an eco-friendlymanner (Reddy et al., 2012). Silver is commonly used in cooking procedure to prevent contamination, to prevent water contamination, food spoilage, and also used in the development of antibiotics, and prophylaxis against gonocaccal infection. For gonococcal infection it is used as standard care in many countries in 20th century (Hoyme 1993).

Plant profile: Hemidesmus indicus:



The botanical name of the plant is *Hemidesmusindicus*. It belongs to the family Apocyanaceae. *Hemidesmusindicus* or Anantmool is a semi-erect and sometimes prostrate shrub with woody aromatic roots. The slender, numerous stem is thick nodes. The leaves are very variable, opposite, and short-petioled. They are oblong-elliptic to linear lanceolate. The flowers are green on the outside and purplish inside.

The stem and branches of the plant twine anticlockwise and the roots have a camphor-like smell. Flowers may be greenish-yellow to greenish purple on the outside and yellow to light purple on the inside. It has fused corolla that numbers twice that of the calyx. Pistil is bicarpellary with free ovaries many ovuled and having distinct styles.

Carica papaya



Papaya enjoys a rich history, and has been used since very long for medicinal uses in day to day life. The Mayans used to worship papaya trees and called it the “Tree of Life”.Papaya (*Carica papaya*) is an evergreen flowering tree that is valued for its buttery fruit that is believed to offer many health benefits. The amazing papaya fruit contains enzymes and compounds that can prevent cancer, ageing and can promote healthier heart.

MATERIALS AND METHODS

Collection of plant Material:

Two medicinal plants *Hemidesmus indicus*(*H.indicus*)and*Carica papaya*(*C.papaya*)were collected during the growing season of January to March from different places of surroundings of Tirupathi and Tirumala hills in Chittoor district, Andhra Pradesh. Collected plants were identified with plant taxonomist, Dept. of Botany, S V University, Tirupathi, Andhra Pradesh, India. Among all, thetwo important plants were identified and selected for further studies (Annapoorna and Ranjani 2013).

Preparation of plant extract:

Preparation of extractions prepared according to the method of AlamSher (2009). The collected two different plant leaf materials were used to prepare an extract. Leaf materials and water were used to prepare extracts with selected plant materials. The samples were prepared and tested in triplicate.

Synthesis of silver nanoparticle (AgNPs) from leaf aqueous extract - of *Hemidesmus indicus* (*H. indicus*) and *Carica papaya* (*C.papaya*)and their characterization:

Silver nanoparticles were synthesized by using aerial parts extraction of *H.indicus*and*C.papaya*. Within 30 min of incubation period silver nanoparticles were rapidly synthesized, the aqueous silver nitrate,(AgNO3) solution was turned to brown color by the addition of plant extract. The intensity of brown color increased with direct proportion to the incubation period (Annapoorna and Ranjani 2013, Venkatasubbaiah *et al*., 2013).

Characterization of nanoparticles:

Zeta potential:

Particle size and Zeta potential measurement experiments were carried out using a Nanopartical SZ-100 (HORIBA) according to Kotakadi*et al*.,(2014).Higher zeta potential indicates greater stability of the synthesized silver nanoparticles.

Fourier Transform Infrared Spectroscopy (FTIR) analysis:

The FTIR spectrum was obtained in the range of 500–4000 cm-1 with the resolution of 2 cm-1 by employing alpha interferometer FTIR to detect the functional groups were determined by the method Bozanic *et al.,* (2010).Solid samples can be milled with potassium bromide (KBr) to and then compressed into a thin pellet which can be analyzed(Annapoornaand Ranjani (2016).

Test microorganisms (Microbial pathogens):

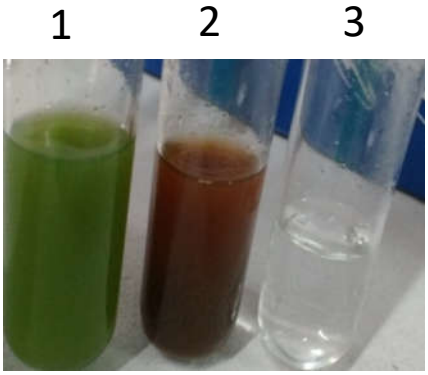
Bacterial species like: *Staphylococcus aureus, Bacillus subtilis*cultures were obtained from SVIMS,Tirupati.

Antibacterial activity:

Antibacterial activities are tested nutrient agar well diffusion method (Annapoornaand Ranjani, 2013). The nutrient agar was taken for culturing of bacteria. Minimum Bacterial concentrations (MBC) and Minimum inhibitory Concentrations (MIC) are determined. The different concentrations of plant samples are added in to the wells then the plates were incubated zone of inhibition is calculated by subtracting control zone with test sample zone of inhibition. Resultant zone is taken as final as zone of inhibition of test sample (Annapoorna and Ranjani 2013, Venkatasubbaiah*et al*., 2013).

Results and Discussion

Green synthesis of silver nanoparticles (AgNps) was carriedout using of *H.indicus* and *Carica papaya* leaf material of *H.indicus.* In the present study silver nanoparticles were synthesized and within 30 min of incubation period silver nanoparticles are rapidly synthesized, the aqueous silver nitrate solution was turned to brown color by the addition of plant extract. The intensity of brown color increased with direct proportion to the incubation period. It may be due to the excitation of Surface Plasmon resonance (SPR) effect and reduction of AgNO3. (Ranjani, 201, 2018, Venkatasubbaiah *et al*., 2013,Annapoorna and Ranjani,2013, Mukesh R. Jangra *et al*.,2018, Nagarajan Arumugam *et al* ., 2107, Reshma S. Konjari*et al.*,2015,Gayathri. M. and K. Kannabiran. 2009).



1.*H.Indicus* leaf extract
2.*H.Indicus* leaf extract/$AgNO_3$
3.H_2O - $AgNO_3$

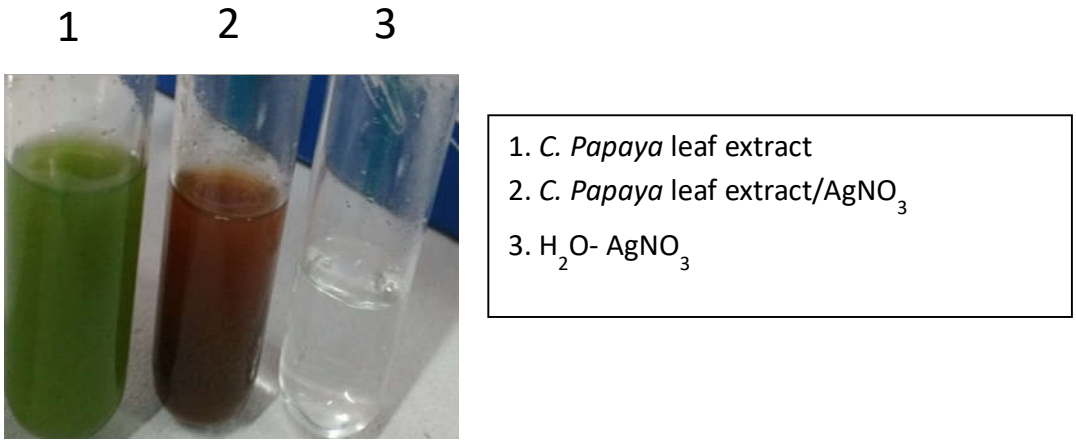


Fig3: Green synthesis of silver nanoparticles (AgNps)

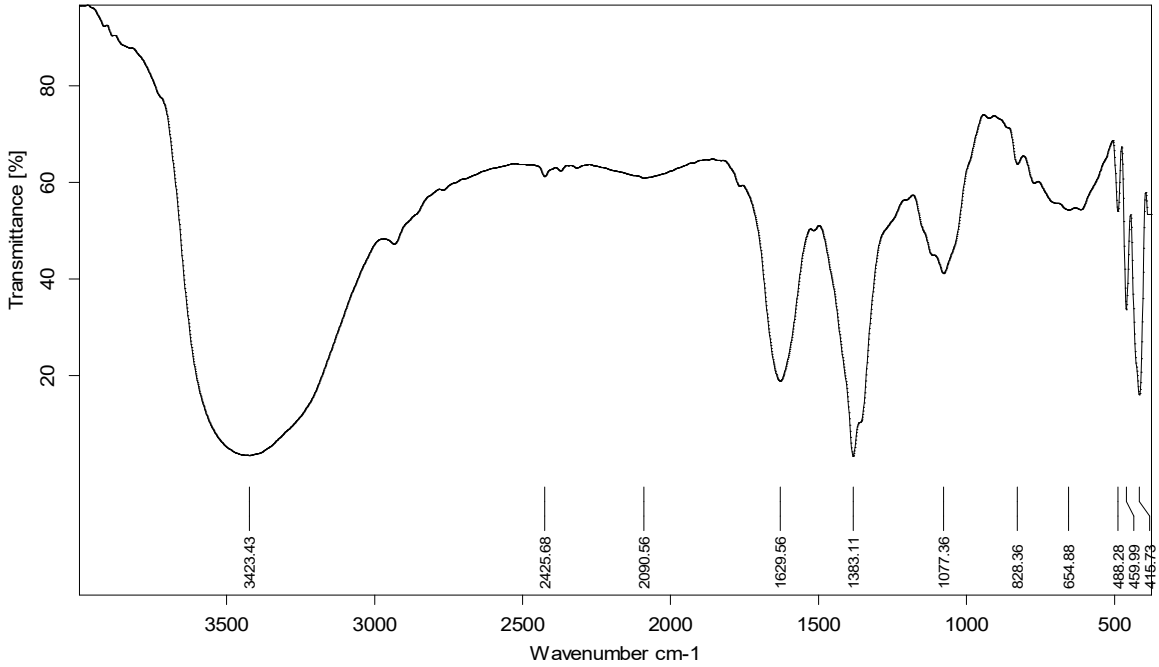


Fig 4: FTIR spectra of *H.indicus*leaf extractAgNps

FTIR spectra of *H.indicus*leaf extract AgNps were taken (fig 4).FTIR analysis of plant extract having peaks at 3423, 2425, 1629, 1077 and 664cm-1. The wave numbers due to the presence of phenols at high concentration, alkynes (C=C) and alcohol(Ranjani, 2013,

2018.Venkatasubbaiah*et al*., 2013Annapoorna and Ranjani,2013, Mukesh R. Jangra*et al*.,2018, NagarajanArumugam*et al* ., 2107, Reshma S. Konjari*et al.,*2015,Gayathri. M. and K. Kannabiran. 2009).

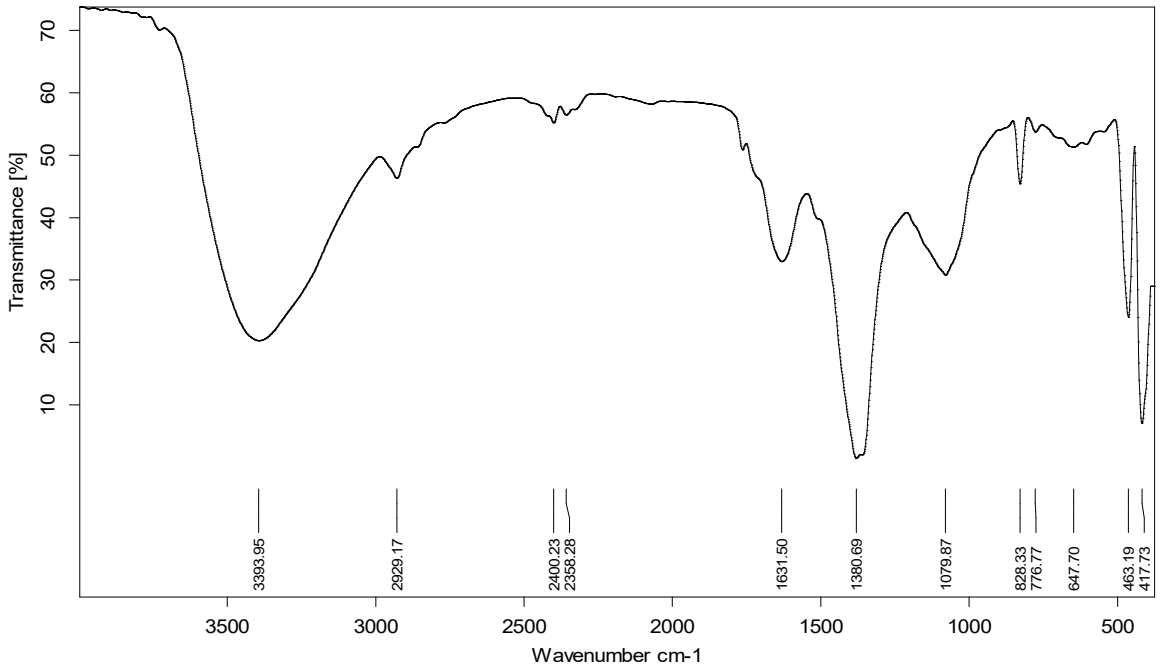


Fig 5: FTIR Spectra of *C.papaya*leaf extractAgNps.

FTIR spectra of leaf extract AgNpsof*C.papaya* were taken (fig 5).FTIR analysis of plant extract having peaks at 3393, 2995, 1631, 1079 and 647cm-1. The wave numbers due to the presence of phenols at high concentration, alkynes (C=C) andalcohol, also indicates the high contents of flavonoids in *Carica papaya*.(Ranjani, 2013, 2018.Annapoorna and Ranjani,2013, Mukesh R. Jangra*et al*.,2018, NagarajanArumugam*et al* ., 2107, Reshma S. Konjari*et al.*,2015,Gayathri. M. and K. Kannabiran. 2009).

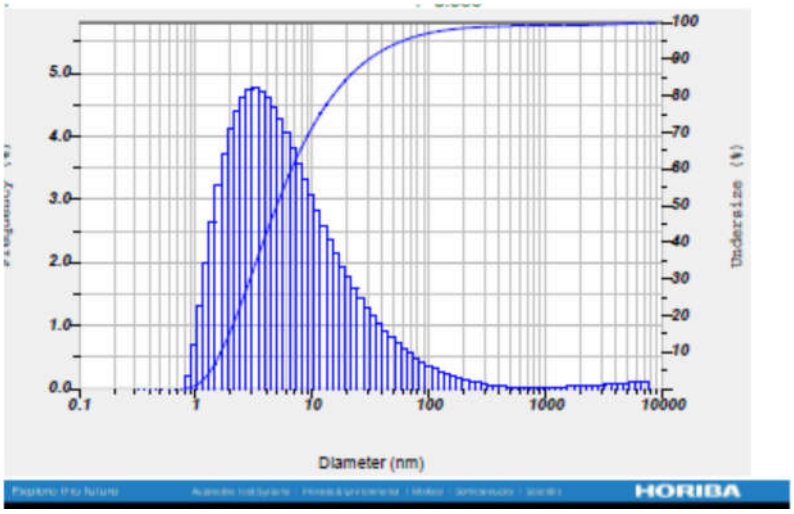


Fig 8: Size of the AgNps of *H.indicus* leaf extract.

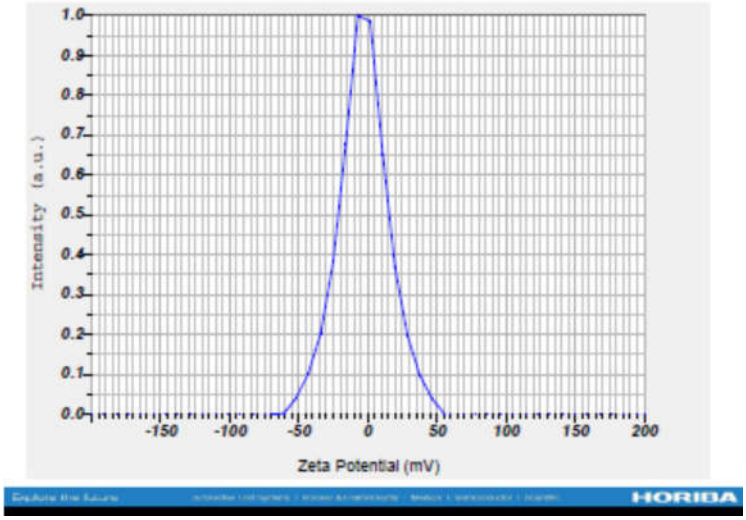


Fig 9: Zeta potential of AgNps of *H.indicus* leaf extract.

It shows that particles size is the ~ 10nm diameter .Zeta potential of AgNps of *H.indicus* leaf extract was done (fig 9) and observed that Zeta potential of synthesized nanoparticle shows the stability of the compound having low stability of 3.4mV(Ranjani, 2013, 2018. Annapoorna and Ranjani,2013, Mukesh R. Jangra*et al*.,2018, NagarajanArumugam et al ., 2107, Reshma S. Konjari*et al*.,2015,Gayathri. M. and K. Kannabiran. 2009).

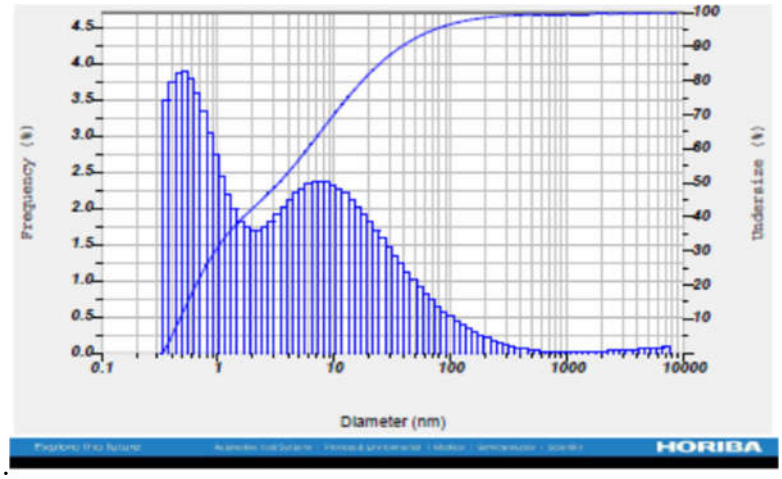


Fig 10: Size of the AgNpsof leaf extract of *C.papaya*

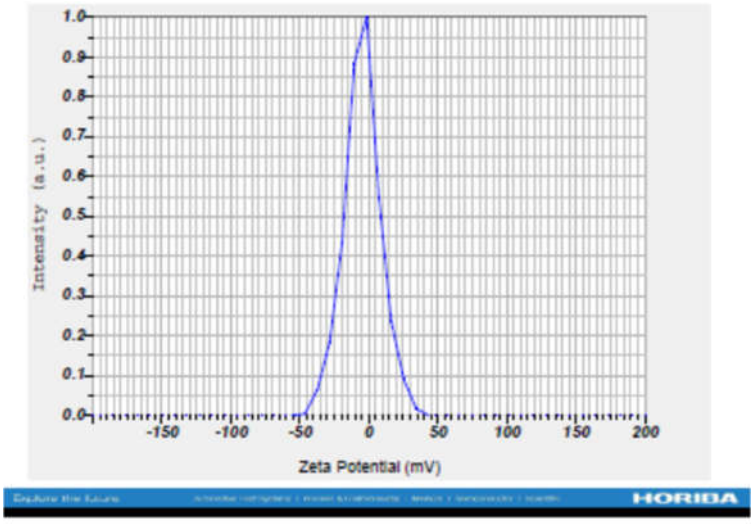


Fig 11: Zeta potential of the AgNpsof *C.papaya*leaf extract.

It shows that particles size is the ~20nm diameter Zeta potential of AgNps of *C.papaya*leaf extract was done (fig 11) and observed that Zeta potential of synthesized nanoparticle of *C.papaya*shows the stability of the compound having low stability of 3.4mV(Ranjani, 2013, 2018. Annapoorna and Ranjani,2013, Mukesh R. Jangra*et al*.,2018, NagarajanArumugam*et al* ., 2107, Reshma S. Konjari*et al.*,2015,Gayathri. M. and K. Kannabiran. 2009)..



b). *Staphylococcus aureus* c). *Bacillussubtilis*

Fig 12: Antibacterial activity of AgNps of *H.indicus*leaf extract.



b). *Staphylococcus aureus* c). *Bacillus subtilis*

Fig 13: Antibacterial activity of AgNps of *Carica papaya*leaf extract.

Antibacterial activity of green synthesized water extract of *H.indicus*and*Carica*papayaleaf extractat different concentrations were taken and observed that they are active against a) *Streptococcus*and b) *Bacillus*and a). control also maintained. Concentration of AgNps(50, 100, 150 µl) of *H.indicus*leaf extract*Streptococcus*.(2.6, 0.6,1.8 cm ;fig 14) and *Bacillus*(2,2.1,2.1 cm; fig 14) respectively (Table 1; chart 1).

Antibacterial activity of green synthesized water extract of *Carica papaya* leaf extract at different concentrations were taken and observed that they are active against a) *Streptococcus* and b) *Bacillus*and a). control also maintained. *Staphylococcus*and *Bacillus*. Concentration of

AgNps (50, 100, 150 µl) of *H.indicus*and*Carica papaya*leaf extractwere used against Streptococcus. And observed inhibition zone in(1.7, 1.8, 2.1 cm ;fig 15) and *Bacillus*(0,6,0.7, 0.7 cm) respectively. (Ranjani, 2013, 2018.Venkatasubbaiah*et al.,* 2013Annapoorna and Ranjani,2013, Mukesh R. Jangra*et al.,*2018, NagarajanArumugam*et al .,* 2107, Reshma S. Konjari*et al*.,2015,Gayathri. M. and K. Kannabiran. 2009).

Conclusion:

With the help of obtained results following conclusions are made the preliminarily study made with AgNPs synthesized from*Hemidesmusindicus* (*H.indicus*) and *Carica papaya* (*C.papaya*)water extracts were used to check, the biological activity like antibacterial activity with different concentrations (50, 100, 150 µl).Nanoparticle is synthesized from the *H.indicus* and *C.papaya*, characterized by particle size, zeta potential, FTIR, and tested for antimicrobial activity and exhibited the antibacterial activity. In the present study, conclude that AgNPs are more effective than some of the antibioticdrug compound.

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ADVANCES IN BIOSCIENCES

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A TREASURE TROVE OF NOVEL ANTICANCER COMPOUNDS: ENDOPHYTIC FUNGI

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Abstract

Endophytic fungi are microorganisms that exist almost ubiquitously inside the various tissues of living plants where they act as an important reservoir of diverse bioactive compounds. Recently, endophytic fungi have drawn incredible attention from researchers; their isolation, culture, purification, and characterization have revealed the presence of around 200 important and diverse compounds including anticancer agents, antibiotics, antifungals, antivirals, immunosuppressants, and antimycotics. Many of these anticancer compounds, such as paclitaxel, camptothecin, vinblastine, vincristine, podophyllotoxin, and their derivatives, are currently being used clinically for the treatment of various cancers (e.g., ovarian, breast, prostate, lung cancers, and leukemias). By increasing the yield of specific compounds with genetic engineering and other biotechnologies, endophytic fungi could be a promising, creative source of anticancer drugs. In the future, compounds derived from endophytic fungi could increase treatment availability and cost effectiveness. This chapter will assist readers in better comprehending bioactive chemicals and the beneficial interaction between the fungal endophytes and medicinal plants.

Keywords: Natural products, Antitumor activity, Fungal Endophytes, Secondary Metabolites.

Introduction

Cancer, which is the combined name for a variety of related diseases, is the cells whose division and growth are uncontrolled after mutation. Cancer cells can attack and destroy adjacent tissues and organs. Moreover, it can pass through the tumor and enter the blood, lymphatic system or other organs to form new tumors. In 2012, The WHO's GLOBOCAN estimated approximately 14.1 million new cancer cases and 8.2 million deaths worldwide, which are expected to rise to 22 million in the next two decades [1]. Current methods for treating cancer including chemotherapy, g-radiation, immunotherapy or suicide gene therapy, which mainly mediated through triggering apoptosis [2]. Among them, chemotherapy is the most effective method for treating metastatic tumors. However, the multidrug resistance characteristics of cancer cells and the side effects of drugs are still major obstacles to successful treatment duringa the process of chemotherapy [3,4]. Thus, research on the sources of new drugs indicates that natural products continue to play an vital role in drug discovery and development for the treatment of some human diseases [5].

BIOSYNTHESIS OF NANOPARTICLES AND THEIR APPLICATIONS AND FUTURE PROSPECTS

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Abstract:

Green nanoparticle (NP) synthesis is a new field of nanotechnology that stands out in physical and chemical applications based on cost- effectiveness, biocompatibility, environmental friendliness and scalability. Nanotechnology plays an important role in our daily life, from biomedicine to energy. There are many physicochemical and biological methods to synthesize nanoparticles for various applications. This review explores the biosynthetic processes of nanoparticles processed by organisms such as bacteria, fungi and algae and their applications. The possibility of controlling the size and shape of nanoparticles by changing the antibody has been demonstrated in many studies. Traditionally, nanoparticles are produced by chemical and physicochemical methods using various chemicals that cause many dangers later due to their chemical properties, thus referring to the intended use. Chemicals have emerged to fill these gaps. The plant-mediated synthesis process goes through a very controlled approach, which makes it suitable for metal nanoparticle synthesis. In addition, biosynthesis of metal nanoparticles is an inexpensive, one-step and environmentally friendly method. Due to their biosynthetic process, they can reduce the salt into corresponding nanoparticles. This review covers some of the biological fields that scientists use to synthesize nanoparticles and their applications.

Introduction

Nanoparticles - one or more small particles 100 nanometers or smaller - have attracted attention for their unusual and attractive properties as well as applications that have the advantage of big things (Daniel and Astruc, 2004). There are many methods for the combination of physical, chemical, biological and different types of nanoparticles (Liu et al., 2011). Although physical and chemical methods are more popular in the synthesis of nanoparticles, the use of chemicals greatly limits their biomedical use, especially in the field of medicine.

Therefore, the development of reliable, non-toxic and environmentally friendly methods for the synthesis of nanoparticles is essential to expand their biomedical applications. One option to achieve this goal is to use bacteria to synthesize nanoparticles. In addition to the traditional, physical and chemical methods of nanoparticle synthesis, nanoparticle biogenesis has also attracted researchers due to some advantages of using biological materials to produce NPs. Physics (Ayyub et al., 2001; Kalishwaralal et al., 2010) nd chemical methods (Murray et al., 2002), which are expensive and involve the use of hemical products and reagents, such as gel-sol synthesis, chemical reduction, aerosol chnology, photolithography, laser ablation, will harm the environment. Use them to talk out big things. Nature has created many methods for the synthesis of nano- and micro-

THERAPEUTIC APPLICATIONS OF *BOSWELLIA SERRATA* - AN IMPORTANT MEDICINAL PLANT OF ANDHRA PRADESH

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Abstract

One of Ayurveda's oldest and most prized herbs is Boswellia serrata. Pharmacological, aesthetic, and nutritive businesses all rely heavily on medicinal plants. B. serrata is one such plant that is utilised for a multitude of purposes in the medicament and cosmetic sector. This therapeutic tree is part of the family Burseraceae and is also referred in english as Indian Olibanum and in telugu as Guggilamu. The plant's unique characteristic is its oleo-gum resin, a complex mixture of various medicinally important phytoconstituents like boswellic acids. This plant possesses anti-viral, anti-microbial, anti-oxidant, anti-inflammatory, anti-cancer, anti-diabetic, anti-obesity, anti-arthritic nephroprotective, hepatoprotective, immuno-modulatory, analgesic, diuretic, and other beneficial properties. B. serrata has traditionally been used to treat juvenile, soft tissue fibrosis, rheumatoid arthritis, osteoarthritis, and spondilytis with no negative effects. Present review focuses on various therapeutic activities and medicinal worth of B. serrata Roxb.

Keywords: Boswellia serrata, ayurveda, therapeutic, anti-inflammatory, anti-cancer

Introduction

Since the Vedic era, plants that have therapeutic properties have been used. For thousands of years, they have been used to treat and prevent a wide range of ailments and outbreaks. Certain medical herbs are employed as tasty seasoning, to flavour, to colour, to preserve food, and so on. Almost each and every portion of the plant has therapeutic benefits by itself. Secondary metabolic products discovered in medicinal plants that have a crucial part in many illnesses and are also employed in the manufacture of medications. Many of the plants are also known to have anti-parasitic, anti-oxidant, antibiotic, anti-inflammatory, anti-hemolytic and anti-insecticidal effects and are frequently utilised by tribal individuals all over the entire globe. There are around 4.5 million species of plants in India, but only an approximated 250,000-500,000 species have been examined phytochemically for biological or pharmacological activity (1). While it is hard to assign a single definition to the vast range of qualities and elements of folk medicine, the World Health Organization (WHO) believes that a practical concept seems to be necessary. As a result, it concludes that therapeutic agents include "multiple health strategies, methods, ideals and facts assimilating plant-based, animal-based, and/or mineral-based medicinal products, transcendental treatments, manual approaches and workouts used singly or else in amalgamation to sustain wellbeing, also to treat, detect or else boost immunity". In accord with WHO, a therapeutic plant is "a plant that contains chemical that can be administered for treatment reasons or that is a precursor for cytotoxic drugs semi-

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Breaking the Seed Dormancy by Scarification and Quantitative Analysis of Seed Germination Parameters in *Rhynchosia Suaveolens* (L.f.) D.C.

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ABSTRACT
Seed dormancy is a common problem in most of the perennial herbs for the population size increase, though it is needed in the case of most of the drought escaping plants as a part of ecological adaptability. *Rhynchosia suaveolens* (L.f.) D.C. is a perennial herbaceous plant of ethnobotanical and medicinal importance. Due to hard seed coats the plants are exhibiting seed dormancy and the scarification treatments are showing better results in the breaking of dormancy. Before performing different scarification treatments, the seeds are chemically tested for seed viability with TTC and good viability is noticed. Various seed germination parameters are calculated for each scarification treatment. Studies may help in the field of conservation biology of the species as the propagation by means of seed is a method to increase the population size.

Key words: Seed dormancy, *Rhynchosia suaveolens* (L.f.) D.C., scarification, seed viability.

INTRODUCTION

The genus *Rhynchosia* belongs to Fabaceae is having a species diversity of 22 species in our India. Some plant species of the genus are found to have bacterial nodules that enrich the soil denotes the ecological significance of these plants (Allen et al. 1981). Phytochemical studies on the members of the species revealing that these are rich in flavones, specifically glycosyl flavones (Rao et al. 1991). According to ILDIS (International Legume Database and Information Service), *Rhynchosia suaveolens* (L.f.) D.C. is the native of India and reported an extinct species in Sri Lanka. *R. suaveolens* is ethnobotanically used for treating general weakness in Seshachalam hill range of Andhra Pradesh (Sudhakar Reddy et al. 2009).

The seed is a vital stage in the life cycle of higher plant with respect to its survival as an established species. One of the most significant aspects deciding the rise of a progeny in their respective habitats is most presumably changes in dormancy levels of the seeds. The connection between the dormancy of seeds and the accomplishment of a plant as a widely propagated species is extensively established (Ali et al. 2011). The seeds differ broadly as for degree, span, and reason for dormancy. Endurance of a huge number of seeds with fluctuating dormancy degrees is the fundamental driving factor for some plant population issues each year (Ali et al. 2012). It was reported that among 260 examined *Leguminoseae* seeds, about 85% had tegument or seed coat impermeable to water. It is noted that, seed coat impermeability is associated with the presence of palisade cells. So, this kind of primary dormancy could be overcome by weakening the seed coat by allowing water to pass and that triggers germination (Cavalheiro et al. 2007). This process can also occur through the action of acids during seed digestion by zoochorous animals (Goddard et al. 2009).

Seed dormancy inferable from the existence of impenetrable layers of the seed wall cells could be discharged by debilitating the covering, along these lines permitting water to go through the layers and empower the germination of the seeds (Cavalheiro et al. 2007). Under natural conditions, the arrival of dormancy forced by the seed coat layers require the methodologies of breaking of various biological and physiological dormancy (Kelly et al. 1992).

As per the classification system for seed dormancy, there are five classes of seed dormancy were noticed viz. physiological (PD), morphological (MD), morphophysiological (MPD), physical (PY), and combinational (PY + PD). PD is expected to be caused by a physiological state of the embryo and possibly a decreased gas permeability of seed

covering structures. MD is observed in seeds with embryos that are underdeveloped, especially in terms of size, but differentiated. MPD is also evident in seeds with underdeveloped embryos, but in addition they have a physiological component to their dormancy. PY is caused by water impermeable layers of palisade cells in the seed or fruit coat that control water movement. This form of dormancy is common in the members of Fabaceae family. PY + PD is evident in seeds with water-impermeable coats combined with physiological embryo dormancy (Baskin et al. 2004).

Dormant seeds which unable to grow under favourable ecological circumstances stay hard and ungerminated for a while (Koornneef et al. 2002). The coat-forced seed torpidity (hard seededness) is because of either the impermeability of the coat to water and gases, the mechanical counteraction of radicle augmentation, or the seed coat keeping inhibitory substances leaving from the undeveloped embryo or by providing inhibitors to the incipient embryo (Baskin et. al. 2000). The presence of a hard and impermeable seed coat is viewed as a boundless reason for seed dormancy in a few significant legume groups, such as, lentil, faba bean, normal bean, soybean, cowpea, Lupinus and Trifolium and that can be eradicated by scarification methods (Tiryaki et al. 2014).

Different types of mineral acids like Conc. HCl, HNO_3, and H_2SO_4 have been in use widely for eradicating seed dormancy of many species with hard seed coat, such as the species of *Astragalus* and *Medicago* (Patane et al. 2006).

The seed dormancy characteristics of *R. suaveolens*, with its hard seed coat is not known. Hence, the present study was conducted to assess the effects of mechanical (non-chemical) and chemical scarification on the release of dormancy in *R. suaveolens* seeds. Various seed germination parameters are calculated for analysis to each scarification treatment.

MATERIALS AND METHODS

Pods of *R. suaveolens* are collected‘ from the forest area of Seshachalam hill range of Tirumala and separated seeds. The seeds are stored in sealed bags for further use. Healthy and similar type of seeds are selected for the experimentation. The mature and dry pods of *R. suaveolens* exhibiting explosive dehiscence to eject the seed with bi-valvate configuration. The seeds are shiny, striate, reniform and pigmented with greyish brown or black appearance and measures 4.3 ± 0.3 mm long, 3.2 ± 0.3 mm wide strophiolate.

Chemical seed viability testing

The TTC Test (Tetrazolium test) originally developed by Lakon (1949) used to assess seed viability, prior to scarification treatments performed with the application of TTC (2,3,5-tryphenyl tetrazolium chloride) on cut single seeds as a rapid method. The test relies on the reduction of the colourless and water soluble TTC to an insoluble red Formazan compound. This reduction occurs as a result of hydrogen ions donated to the TTC upon dehydrogenase activity in metabolically active embryonic tissues.

Consequently, seed viability is usually determined by a visual observation of finding the characteristic pattern and intensity of formazan staining pattern for individual seed embryos. 1% aqueous solution of TTC is prepared and the soaked seeds are placed after removing the seed coats and making the seeds into two parts along the cleavage of the cotyledons (Verma et al. 2013). The total set up is left for the incubation of time period about 24 hrs. in the dark condition so as to prohibit the photooxidation.

Scarification treatments

Seeds are taken in 25 number in total and 5 seeds for each petri plate to perform each scarification test. Scarification treatments include the physical scarification with the sand paper and chemical scarification, includes the treatment of seeds with Concentrated acids H_2SO_4, HCl and HNO_3. The chemical scarification methods are adopted for a standard time period of 25 minutes. Seeds are kept in hot water of 70^0 C and left the container at the room temperature allowing it for cooling. It is one of the non-chemical alternatives used for scarification of seeds.

After the treatments, the seeds are placed on wetted filter papers in petri plates and kept for observation for 15 days in the laboratory at room temperature and humidity conditions. The results are

noted every day and the data is analyzed for various germination parameters statistically by One-way ANOVA of SSS online package.

Seed germination parameters

Six different parameters related to seed germination were assessed according to the standard formulae. Final germination percentage (G), mean germination time (MGT), coefficient of velocity of germination (CVG) and germination rate index (GRI) were estimated as suggested by Al Mudaris (1998) and mean germination rate (MGR) following the method suggested by Ranal et al. (2009). Timson's germination index was calculated using the formula reported by Khan et al. (1984).

RESULTS AND DISCUSSION

Seed viability test turned the cotyledons into frozen red colouration after the incubation period, giving the inference that the selected seeds are 98% (±2.739) viable. This indicates that the seeds are viable and having the capacity to germinate but the problem is seed dormancy conferred by the impermeable seed coat.

Many species of the Fabaceae, such as *Lupinus* species seeds exhibit dormancy that is primarily due to water impermeability of the outer seed coat. Seed dormancy, an apparently inert or resting state of the seed, stops seed germination of plant species over a prolonged stretch of time periods. Seeds with dormancy permit the plants to overcome the unfavorable conditions (Ali et al. 2011). Scarification of *L. texensis* seeds with conc. Sulfuric acid for 30 to 60 min improved seedling emergence. It was reported that the acid scarification did not reduce thickness or strength of the seed coat, but created several small pores in the seed coat which likely facilitated imbibition. The experimental results showing that seed exhibits Physical dormancy conferred by the impermeability of seed coat, that is making the seed to be remain in dormant condition. The values of G% and T50 denoting that, the conc. H_2SO_4 treatment is found to be the best method out of all treatments for the eradication of the dormancy of seeds in *R. suaveolens*. Similar value of G% is attained in the physical scarification method also but T50 is high denoting the delayed response for the treatment. Hot water treatment is also promoting seed germination but it is not as much as the Conc. H_2SO_4 treatment and Physical scarification. The scarification with HCl and HNO_3 are found to be negative effect in the results showing no effect on the seed coat permeability (Table 1).

Seed germination is the main process that triggers the growth of the seedlings that are responsible for the increase in the population of the species. *Rhynchosia suaveolens* seeds are hard and impermeable, scarification is suggestable method for the removal of dormancy as the process increases the permeability by weakening the seed wall layers. Mechanical scarification and treatment with Conc. H_2SO_4 are found to be the best methods. There are certain inferences we can made from the measured seed germination parameters. With the increase of the FGP values increase in the seed germination can be observed (Scott et al. 1984). The lower values of MGT indicate the faster germination (Orchard 1977). The CVG indicates the speedy germination of the seeds. If the value increases the required time for

Table 1. Germination of *R. suaveolens* seeds under various scarification treatments

Treatment	G%FGP	T50 Days	MGT Days	MGR	CV	GRI	TGI
H_2SO_4	98.4±2.19	2.6±0.22	3.68±0.1	0.27±0.007	27.18±0.79	27.59±1.01	24.6±0.54
HCl	0	0	0	0	0	0	0
HNO_3	0	0	0	0	0	0	0
HOT WATER	81.6±2.19	3.2±0.27	4.85±0.13	0.20±0.005	20.63±0.27	20.63±0.57	16.93±0.54
PHYSICAL	98.4±219	3.7±0.27	4.68±0.1	0.21±0.004	21.37±0.49	21.37±0.49	16.39±0.36

G% : Final Germination Percentage (FGP); MGT: Mean Germination Time; MGR: Mean Germination Rate; CV: Coefficient of Velocity of Germination; GRI: Germination Rate Index; TGI: Timson's Germination Index

the germination process decreases. The highest possible value of CVG is 100 which can be attained if the total germination of the selected sample takes place on the first day itself (Jones et al. 1987). The GRI value stands for the germination percentage on each day during the germination span. High GRI indicates the high and fast germination. Probable natural release of physical dormancy is seeds to be exposed to the specific environmental conditions. For some species of Fabaceae, moist conditions in the environment are required for the breaking of Physical dormancy (Rodrigues-Junior et al. 2018).

Abrasing with sandpaper is reported as a very effective method in breaking seed dormancy in *Rhynchosia capitata*, and germination to 100% as compared to HCl treatments. The probable mechanism of increase in seed germination influenced by Conc. H_2SO_4 is due to its capability to weakening the seed coat that leads to water intake and seed imbibition (Ali et al. 2011). As per the reports available, in case of forage legume tree species, the most efficient seed dormancy eradication method was immersion in Conc. H_2SO_4, while in the case of forage herbaceous legumes, the most efficient seed dormancy eradication treatments were immersion in concentrated sulfuric acid, sandpapering (physical or mechanical method) and hot water. In general, the scarification methods signified with the positive results in dormancy eradication resulted in significantly higher total germination percentages. As in the case of present study, the other relevant works associated with the some of the examples are, the use of immersion of seeds in H_2SO_4 for five minutes of *Neonotonia wightii* and *Pueraria phaseoloides* was reported as the most suitable method of dormancy removal and scarification with sandpaper stands good with the dormancy removal of the seeds of *Calopogonium mucunoides* (Morais et al. 2014). Sulfuric acid scarification generates many cracks and cavities in the seed coat that may help in water absorption and O_2 diffusion required for the embryo. Increased water absorption is known to overcome seed dormancy in many tree species (Tanaka-Oda et al. 2009). Similarly, the results of the experiments conducted on *R. capitata* seeds showed that Mechanical scarification was the best method to overcome this coat-imposed dormancy, apart from softening of the seed coat by soaking in conc. H_2SO_4, HCl, and HNO_3 that significantly increased seed germination (Ali et al. 2011).

Considering the results of the present study, it is possible that the mechanical forces of seeds and sand may be weakening of seed coat. Better results of scarification with HCl and HNO_3 in *R. capitata* (Morais et al. 2014) might be due to the prolonged leaching treatment and the varied composition of seed coat material when compared to *R. suaveolens*. No remarkable results are observed in the present study for the scarification treatments with HCl and HNO_3 may be due to the scarification for short time period.

CONCLUSIONS

In general, the results of these experiments showed that seeds of *R. suaveolens* exhibited hard seed coat dormancy. Softening the seed coat by soaking the seeds in H_2SO_4 significantly increased seed germination. Mechanical scarification was found to be the best nonchemical treatment to overcome this coat-imposed dormancy in the seeds of this species. It can be concluded that the seed coat was the major barrier to *R. suaveolens* seed germination that imparts dormancy to seed.

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EVALUATION OF *IN-VITRO* ANTIFUNGAL POTENTIALITIES AND GC/MS SPECTROSCOPIC APPROACH OF *CLEISTANTHUS COLLINUS* (ROXB.) BENTH. EX. HOOK. F.

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Agar well-diffusion method, Antifungal activity, *Cleistanthus collinus*, GC-MS, Phytochemical profile

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ABSTRACT: India is the home to the familiar plant *Cleistanthus collinus* (Roxb.) Benth. ex Hook. F (Euphorbiaceae) has great ethnomedicinal and therapeutic applications. The present study was designed to assess the phytochemical profile and investigate the antifungal effectiveness of leaf, bark and fruit extracts by using the agar well diffusion method. All crude extracts from leaf, bark, fruit and fractions derived also demonstrated significant antifungal activity (20-80%), but the methanol extracts showed a remarkable antifungal spectrum; as a result, GC-MS analysis was performed on it. From this GC-MS analysis, 14 chemicals, including alkanes, glycosides, phenols, flavonoids and steroids were identified, while leaf methanol extract has high phytochemical diversity with 9 compounds than bark with 6 compounds and fruit with 5 compounds. 1, 2, 3-Benzenetriol, 3-O-Methyl-d-glucose and Undecane are a few significant molecules with larger area percentages that demonstrated biological value. These compounds have been linked to anti-cancer, anti-inflammatory, anti-microbial and antioxidant properties. The current results collectively highlight the appreciable antimicrobial potential of *C. collinus* and its numerous chemical compounds that are physiologically active and offer a thorough understanding of the phytochemical profile, which could be exploited to create plant-based medications.

INTRODUCTION: Rising antibiotic resistance has emerged as a serious hazard to human well-being worldwide [1]. The rising prevalence of drug-resistant diseases necessitates identifying and isolating novel bioactive components from medicinal plant species utilizing standardized contemporary scientific techniques. Medicinal compounds obtained from plants might provide innovative and accessible techniques to pathogenic organisms.

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According to the World Health Organisation (WHO), conventional drugs produced from plants with medicinal properties continue to assist 80% of poor countries. WHO has also documented a list of over 20,000 therapeutic plant species and identified these plants as a possible driver of new medications [2].

The antibiotic era, which has lasted barely 80 years, has recently entered a time of gradual and extensive appearance of drug-resist microbes, threatening to end this era. Microbial diseases, especially fungus, have quick reproductive rates, malleable genes, and the capacity to adapt to environmental conditions containing a high concentration of possible hazardous substances that apply significant selective stresses.

Fungi's eukaryotic chemistry makes them particularly dangerous infections due to a smaller range of selective therapeutic targets over which inhibitors not hazardous to human, animal, and plant hosts may be created. Moreover, there do not exist medicinal vaccination or supplementary immune-mediated therapies present to assist people in their health care, necessitating dependence on a restricted arsenal of antifungal medication classes to combat an increasing wave of fungal diseases [3]. The worldwide stress of fungus-related infections is escalating. Over 150 million severe instances concerning fungal illnesses occur each year worldwide, leading to nearly 1.7 million fatalities. The aforementioned numbers are rapidly increasing, owing to a variety of societal and medical advances in recent decades that have aided the proliferation of fungal diseases [4]. To settle this problem, novel antifungal drugs are required and plants are the main wellsprings of novel drugs.

Due to their vast and varied organic components, which may have an important physiological influence on the human body, medicinal plants have been used to treat human ailments for centuries. Natural assets, such as plants with medicinal properties, which possess a wide range of phytocompounds potential as traditional medicine for treating chronic and infectious illnesses, have long been seen as safer and more efficient options with fewer adverse effects than synthetic drugs [5]. Owing due to their diverse pharmaceutical qualities, plants high in bioactive phytomedicine components such as alkaloids, flavonoids, tannins, and polyphenols have been utilised to treat diseases [6].

Around 25% of the active ingredients of medicinal plants that have been used as legal drugs have been discovered [7]. *Cleistanthus collinus* is an essential medicinal tree that has piqued the interest of researchers owing to its potential for medication development. *C. collinus*, a member of the Euphorbiaceae family, is a small tree featuring ellipse foliage and its silken villous spike. It tends to occur in South Indian deciduous dry highland forests, Sri Lanka and Malaysia [8]. Cleistanthus A and Cleistanthus B, diphyllin glycosides, are cytotoxic to a variety of cancerous cell lines [9]. Because of its unique pharmacological active principles, the isolation of independent bioactive chemicals of *C. collinus* might be widely exploited in the pharmaceutical industry. Despite being a toxic plant, its active constituents have been investigated for medicinal qualities such as antihypertensive, diuretic, and anticancer properties. Active compounds in *C. collinus* that show ability will have a good probability of being developed into drug use [10]. The plant's stem bark can be used as an antiseptic in skin illnesses and to treat bovine hoof sores [11]. A detailed examination of the literature reveals that two have been discovered in the assay of anti-bacterial activity reports [12, 13] and one in antifungal activity [14] from this plant. The primary goal of this study was to appraise the GC-MS analysis study and examine the antifungal potentiality of diverse plant solvent extracts.

MATERIALS AND METHODS:

Sample Collection: The plant *C. collinus* was handpicked from the vicinity of Gopavaram village, Andhra Pradesh, India (17˚22’09.16” N 81˚47’48.42” E), in January 2022 and authenticated by Prof. N. Savithramma, Sri Venkateswara University, Botany Department, Tirupati, Andhra Pradesh, India, with accession number SVUH: 1226.

Extraction of Plant Material: Plant parts were harvested, dried in the shade at 32^{o}C and ground into a fine powder. The powder was then sieved through a 0.5 mm sieve to maintain consistent molecule size and stored in sterile containers until usage. For the extractions of leaves, bark and fruit, the following solvents were selected: methanol, ethyl acetate and chloroform in the ascending order of polarity. Using a soxhlet extractor, the phytochemicals from the plant material were isolated using the aforementioned solvents, which were then stored for 72 hours in sealed jars. A thick concentration was generated when the extracts were collected in a rotary evaporator at 45°C under reduced pressure. The crude extracts were kept in a 4°C refrigerator for future usage.

Collection of Test Pathogens: Four test fungal species; two non-filamentous human pathogens *Saccharomyces cerevisiae* (MTCC 4742), *Candida albicans* (MTCC 227) and two filamentous plant pathogens *Aspergillus niger* (MTCC 282) and *Aspergillus flavus* (MTCC 277) were utilized in

this work; they were acquired from the Microbial Type Culture Collection (MTCC), IMTECH, Chandigarh, India.

Preparation of Test Sample: The methanol, ethyl acetate and chloroform extracts were dissolved in 10% aqueous DMSO (Himedia) to get different concentrations (10 mg, 5 mg and 2.5 mg per 20µL). 10% aqueous DMSO was utilized as the negative control (solvent control). As positive reference standards, Fluconazole (Central Drug House P. Ltd., India) was employed for fungal strains at a dosage of 30µg/mL.

Antifungal Activity Assay: The agar well diffusion method was used to assess the antifungal potentialities of plant extracts in a Potato Dextrose Agar (PDA) medium. A sterilized L-shaped bent rod was used to disperse the 100 µL fungal inoculums evenly and allowed it to harden in the Petri plates.

With the aid of a sterile cork borer, 5mm-diameter wells were made on the plates and filled with various solvent extracts (10 mg, 5 mg and 2.5 mg per 20µL in 10% aqueous DMSO) positive and negative controls of 20 µL each.

After a 48-hour incubation period at 26°C, the inhibitory zone's diameter was determined. The usual positive and negative controls were fluconazole 30 µg/mL and DMSO (10%) and the results of each test were averaged after being repeated three times. A strict aseptic environment was maintained during the entire microbiological experiment.

GC-MS Analysis: The extracts were examined using the Agilent Technologies GC-MS (GC-8890, GC/MS 5977 MSD). With an 18 mL/min split flow and a 3 mL/min purge flow in the injection mode. The temperature of the oven was programmed to range from 75°C to a maximum of 360°C.

The column was a Polar Columns (DB-WAX) & HP-5 MS UI with a 1.21 mL/min flow rate and helium gas (99.99%) as the carrier gas. A temperature range of 60°C to 325^{o}C was set for the column. The GC-MS lasts for a total of 53.5 minutes. The sample pieces were ionized using the EI mode (70 eV). The spectra of the unknown components were compared to the spectrum of the known components using the Spectral Library and Database (licensed NIST 2017 Library; Software: Open Lab CDS 2.5 version).

RESULTS AND DISCUSSION:

Anti-fungal Activity: The antifungal bioassay findings against pathogens using crude extracts of the *C. collinus* plant (10 mg, 5 mg, and 2.5 mg of each) were described regarding the zone of inhibition's diameter. According to the observed inhibitory zones, which were also correlated with their tested doses, the entire extract and various fractions of *C. collinus* displayed strong antifungal activity against *C. albicans*, considerable anti-yeast ability against *S. cerevisiae* and moderate activity against *A. flavus* and *A. niger* **Table 1**.

The majority of the studied substances had strong inhibitory effects on *C. albicans*, among them fruit methanol crude extract showing the highest activity (25mm), followed by leaf methanol extract (21mm), bark ethyl acetate (19mm) and bark methanol (17.3mm). Methanol and ethyl acetate extracts showed high to moderate activity against test fungal pathogens while chloroform extracts had the lowest activity.

Here, *A. flavus* shows the strongest resistance to crude extracts of *C. collinus*, whereas *C. albicans* is the most vulnerable. It was discovered that the fractions containing the highest secondary metabolites concentration had higher levels of antifungal activity.

Moreover, the highest inhibitory properties against *A. flavus* were exhibited by the fruit methanol extract (12.3mm) followed by bark ethyl acetate (10.3mm) and bark methanol (10mm) extracts.

Whereas both ethylacetate and chloroform extracts of leaf and fruit did not show any activity. Contrary to *A. flavus*, *A. niger* was more susceptible to bark methanol extract (14mm) followed by fruit methanol extract (11.3mm).

The effectiveness of fluconazole has consistently outperformed that of plant solvent extracts, which has made it a recognized measure for comparing their effects. The DMSO containing well (negative control) exhibited no bioactivity.

TABLE 1: ANTIFUNGAL ACTIVITY OF DIFFERENT EXTRACTS (ME, EA &CH) AT THE DOSAGES OF 10mg, 5mg, AND 2.5mg

Plant part	Extract	*S. cerevisiae*			*C. albicans*			*A. flavus*			*A. niger*		
		10mg	5mg	2.5mg	10mg	5mg	2.5mg	10mg	5mg	2.5mg	10mg	5mg	2.5mg
Leaf	ME	8.6± 0.5	8±0	8±1	21±1	13.6± 0.5	12±1	6.6±. 0.57	6±0	-	7.6± 0.57	6.5± 0.7	-
	EA	8±1	-	-	15±1	12±1	10.3± 0.5	-	-	-	-	-	-
	CH	10±1	-	-	17±1	13±1	8±0	-	-	-	-	-	-
Bark	ME	13±1	9 ±1	8±1	17.3± 0.5	15±1	11.6± 0.5	10±1	8±1	6.6±.0 .57	14.3± 0.57	12± 1	9±1
	EA	8.3±0.5	7.3± 0.5	-	19.3± 0.5	14±1	10±1	10.3± .0.57	9.6± .0.5 7	7.6±.0 .57	9±1	7.6± 0.57	6.3±0. 57
	CH	7.6± 0.5	7.6±0 .5	-	11±1	9±1	8±1	-	-	-	-	-	-
Fruit	ME	10.6± 0.5	7.6± 0.5	7.6±0.5	25±1	22±1	21±1	12.3 ±.0.5 7	10± 1	6±0	11.3± 0.57	10± 1	7±1
	EA	8±1	7±0	-	13±1	11.3± 0.5	8±0	-	-	-	-	-	-
	CH	11±1	8.6±0 .5	7.6±0.5	16±1	12±1	8.6±0. 5	-	-	-	-	-	-

Values represent mean ± standard deviations; ME stands for methanol extract, EA for ethyl acetate, CH for chloroform, and "-" for no zone of inhibition. A zone of inhibition with a diameter of less than 6 mm was considered inactive. Source: authors.

Furthermore, the antifungal activities of higher concentration (10mg) plant extracts were compared to the positive control fluconazole's inhibition capacity **Fig. 1**.

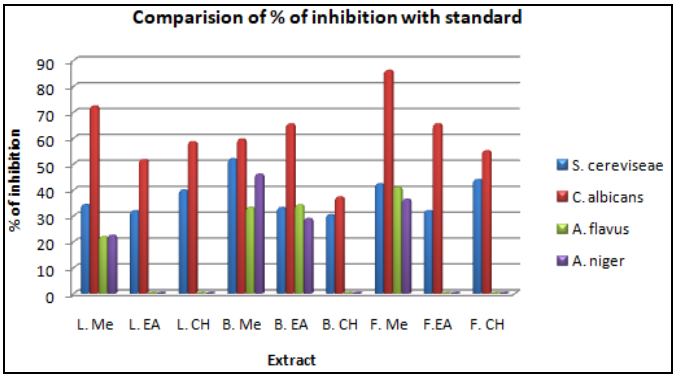


FIG 1: ANTIFUNGAL ACTIVITY (% OF INHIBITION) WITH RESPECT TO +' VE CONTROL

The highest percentage of inhibition (86.2%) against *C. albicans* was found in the fruit methanol extract *of C. collinus*, followed by leaf methanol (72.4%) and bark ethyl acetate (65.5%). The remaining eight plant extracts, except bark chloroform extract, demonstrated more than 50% inhibitory effect against *C. albicans* compared to the standard. All plant extracts inhibited *S. cerevisiae* growth in a medium-to-high range (30-55%). *S. cerevisiae* and *C. albicans* were more susceptible and all plant extracts tested inhibited their growth, whereas *A. flavus* and *A. niger* were more resistant and only methanol extracts with moderate activity, i.e., 20-45% when compared to standard, inhibited their growth. The antifungal activity of leaf acetone, water and benzene extracts from *C. collinus* studied by Majiet al., 2010 against *C.albicans* ranged from 13 to 8 mm[12] however in my study Methanol, Ethyl acetate and chloroform extracts of leaves showed higher activity ranged from 21 to 15 mm. Previous research employed aqueous and ethyl acetate solvent-based *C. collinus* leaf extracts against *C. albicans*, *C. tropicalis*, and *C. glabrata*, in which the ethyl acetate extract only showing action against *C. albicans* and other species being resistant [15]. In addition to previous data, the current investigation demonstrates that *C. collinus* methanol and ethyl acetate extracts are more efficacious than the chloroform extract. This might be because the kind of solvent utilized in the extraction technique substantially influences the subsequent characterization of phytochemicals. 1,2,3 Benzenetriole has strong antimicrobial properties [25, 26] and GC-MS analysis revealed that it was found in higher concentrations in all leaf, bark, and fruit methanol extracts; this may be a reason behind the results obtained in antifungal assays.

The antifungal screening supports *C. collinus* potentiality as a traditional cure for several fungal illnesses, including its usage as an antiseptic.

GC-MS Chemical Profiling: Methanol extracts were chosen for gas chromatography and mass spectrometry (GC-MS) analysis to examine the phytochemical composition because they displayed the highest antifungal efficacy compared to the other solvent extracts. This study demonstrates that a variety of physiologically active compounds are present in leaf, bark and fruit methanol extracts at various concentrations and also offers a thorough understanding of the phytochemical profile that may be exploited to create plant-based therapeutics.

GC/MS spectrum data of the methanol extracts showed several peaks **Fig. 2, 3** & **4** that indicated the presence of 14 different chemicals (9 from leaf, 6 from bark and 5 from fruit). Each of these chemicals was recognized and described using the mass fragmentation patterns and retention indices from the Spectral Library and Database (NIST 2017 Library). In **Table 1**, the active ingredients are listed in chronological order of retention durations, their peak area percentage, molecular formula, molecular weight, structural features and biological activities. To look at the biological effects of important substances, a review of the literature was conducted.

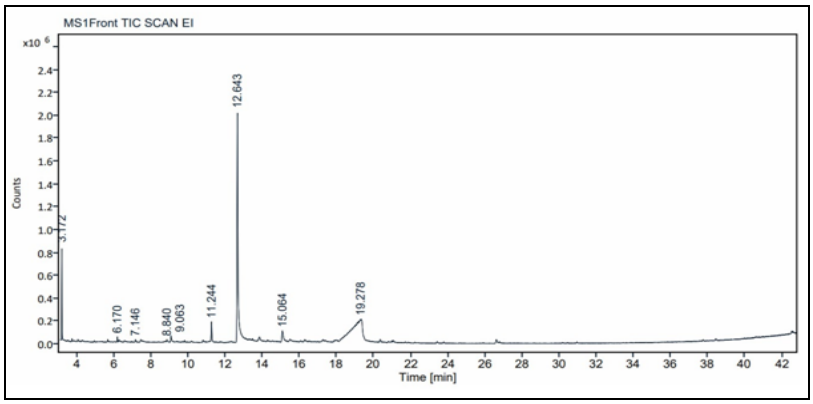


FIG. 2: GC-MS CHROMATOGRAM OF *C. COLLINUS* LEAF METHANOL EXTRACT

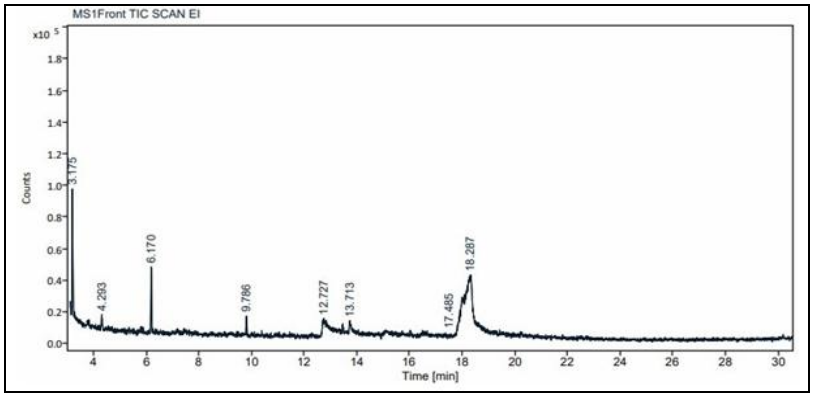


FIG. 3: GC-MS CHROMATOGRAM OF *C. COLLINUS* BARK METHANOL EXTRACT

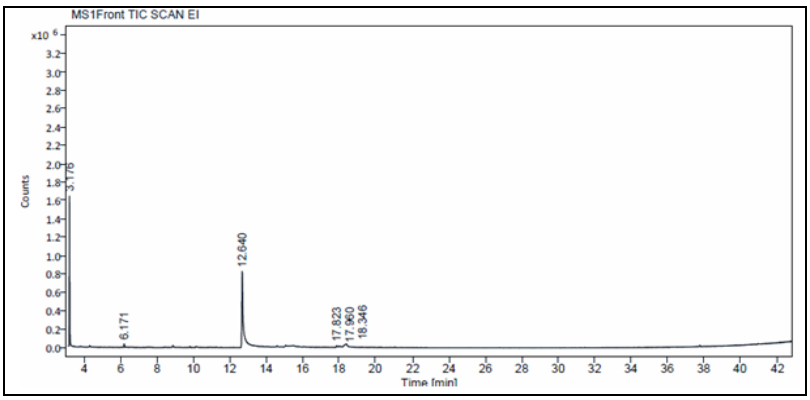


FIG. 4: GC-MS CHROMATOGRAM OF *C. COLLINUS* FRUIT METHANOL EXTRACT

We discovered that most of the constituents in the *C. collinus* leaf methanol extract exhibit a variety of advantageous pharmacological and therapeutic activities. The leaf methanol extract provides a rich source of significant bioactive molecules. Ten different chemicals, including hydrocarbons, phenols, terpenes and glucose derivatives, were found to be present. Undecane, 1, 2, 3-Benzenetriol and 3-O-Methyl-d-glucose were discovered in all three plant sections, whereas fruit and bark extracts contained N-[3-[N-Aziridyl] propylidene] hexylamine. A little amount of the following compounds were detected only in the leaf methanol extract: 4H-Pyran-4-one, 2, 3-dihydro - 3, 5 – dihydroxy – 6 - methyl, 6-Methyl-enebicyclo [3.2.0] hept-3-en-2-one, 5-Hydroxymethylfurfural, Phenol, 5-ethenyl-2-methoxy and D-Allose. Only bark extracts included decane, 4(3H)-Pteridinone, 2-amino-7, 8-dihydro-8-methyl-6, 7-diphenyl and fruit extracts had trace amounts of phthalic acid, 5-methylhex-2-yl heptadecyl ester.

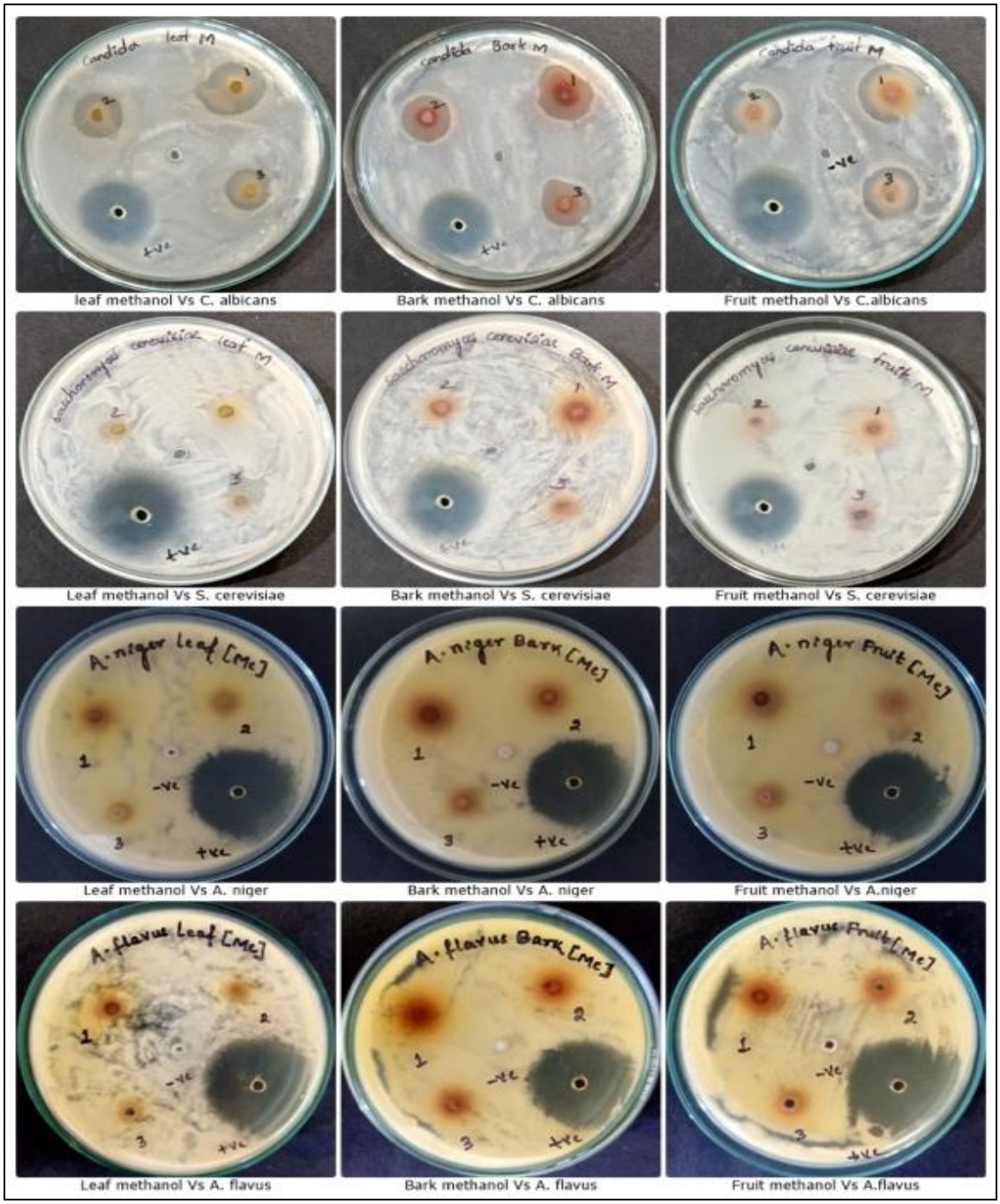
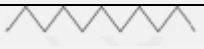
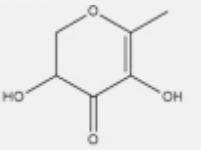
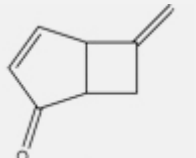
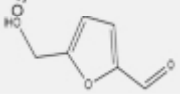
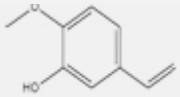
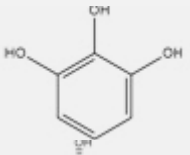
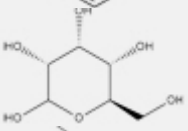
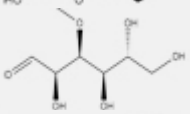
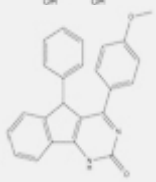
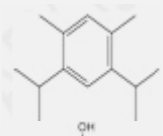
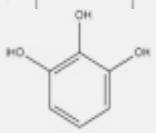
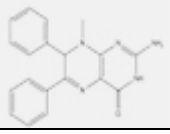
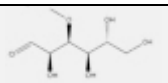
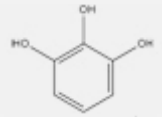
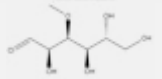


FIG 5: PICTORIAL DATA OF ANTIFUNGAL ACTIVITY OF *C. COLLINUS* (LEAF, BARK & FRUIT) METHANOL EXTRACTS

TABLE 2: BIOACTIVE CHEMICAL PROFILE OF *C. COLLINUS* THROUGH GC-MS

S. no.	Name of the compound	RT minutes	Mol. weight	Mol. formula	Area %	Structure	Importance
				Leaf			
1	Undecane	6.169	156.31	$C_{11}H_{24}$	0.55		Mild sex attractant[20]anti-inflammatory and antioxidant effects[21]
2	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	7.144	144.12	$C_6H_8O_4$	0.35		Antimicrobial, anti-inflammatory, Anti-proliferative[22]
3	6-Methylenebicyclo[3.2.0]hept-3-en-2-one	8.838	120.15	C_8H_8O	0.19		Bacteriostatic, fungistatic, anti-parasitic activity[23]
4	5-Hydroxymethylfurfural	9.063	126.11	$C_6H_6O_3$	0.43		Anti-oxidant activity[24]
5	Phenol, 5-ethenyl-2-methoxy-	11.245	150.17	$C_9H_{10}O_2$	2.00		Aromatic, flavoring, cytotoxic, anti-inflammatory, germination inhibitor, insect repellent[19]
6	1,2,3-Benzenetriol	12.645	126.1100	$C_6H_6O_3$	35.95		Anti-microbial, Antibiofilm and Antivirulence activity[25,26]
7	D-Allose	15.064	180.16	$C_6H_{12}O_6$	1.72		Anti-oxidant, Anti-tumour activity[27,28]
8	3-O-Methyl-d-glucose	19.277	194.18	$C_7H_{14}O_6$	25.33		Anti-tumor activity[29]
9	2-Oxo-5-phenyl-4-(4-methoxyphenyl)-1,2-dihydro-5H-indeno[1,2-d]pyrimidine	49.245	366.4	$C_{24}H_{18}N_2O_2$	27.54		-
				Bark			
1	Decane	4.294	142.28	$C_{10}H_{22}$	2.09		cocarcinogenic and tumor-promoting activities[30]
2	Undecane	6.169	156.31	$C_{11}H_{24}$	7.42		Mild sex attractant[20]anti-oxidant and anti-inflammatory activities [21]
3	Benzene, 1,5-dimethyl-2,4-bis(1-methylethyl)-	9.788	190.32	$C_{14}H_{22}$	2.89		-
4	1,2,3-Benzenetriol	12.726	126.1100	$C_6H_6O_3$	5.10		Anti-microbial, Apoptosis, Antibiofilm and Antivirulence activity[25, 26]
5	4(3H)-Pteridinone, 2-amino-7,8-dihydro-8-methyl-6,7-diphenyl-	13.714	331.4	$C_{19}H_{17}N_5O$	1.84		-

6	3-O-Methyl-d-glucose	18.290	194.18	$C_7H_{14}O_6$	67.88		Anti-tumor activity[29]
				Fruit			
1	Undecane	6.169	156.31	$C_{11}H_{24}$	0.95		Mild sex attractant[20]anti-oxidant and anti-inflammatory activities[21]
2	1,2,3-Benzenetriol	12.639	126.1100	$C_6H_6O_3$	63.09		Anti-microbial, Apoptosis, Antibiofilm and Antivirulence activity[25,26]
3	N-[3-[N-Aziridyl]propylidene] hexylamine	17.821	182.31	$C_{11}H_{22}N_2$	0.69		Anti-viral activity[31]
4	Phthalic acid, 5-methylhex-2-yl heptadecyl ester	17.959	502.8	$C_{32}H_{54}O_4$	0.17		Aminoglycoside antibiotic, Neuroprotective[32]
5	3-O-Methyl-d-glucose	18.346	194.18	$C_7H_{14}O_6$	4.03		Anti-tumor activity[29]

The chemicals found in this study were mostly stated to have anti-cancer, antibacterial, anti-virulence, anti-inflammatory, neuro-protecting, and antioxidant effects according to the reported biological activities. 1, 2, 3-Benzenetriol is a phenolic molecule that is most abundantly present in fruit extracts (63.09%), leaf extracts (35.95%) and bark extracts (5.1%). It is an effective anti-microbial and antiviral agent and leads to the death of cancer cells by apoptosis. The highest concentration of 3-O-Methyl-d-Glucose, a glucose derivative with good anti-cancer capabilities, was identified in the bark extract (67.88), followed by the leaf (25.33) and the fruit extract (4.03). Undecane is a hydrocarbon compound that is present in fruit and bark extracts in low amounts and high concentrations in bark extract (7.42).

It possesses anti-inflammatory and antioxidant activities. Decane contains co-carcinogenic and tumor-promoting properties but is reported only in bark extract. 2-Oxo-5-phenyl-4-(4-methoxyphenyl)-1, 2-dihydro-5H-indeno [1, 2-d] pyrimidine reported in leaf extract in high concentration (27.54), although its bioactivities have not been studied. Earlier work by Pratheepa M. *et al.,* 2012 revealed the GC-MS analysis of the plant leaf acetone extract which showed 8 different bioactive compounds from which the novel chemical dioctyl phthalate observed at a peak area of 95.23% which may operate as a very promising medicinal agent for persons suffering from cancer or afflicted with fatal diseases, *etc* [16]. Arulmanickam P. and Chitra T. *et al.,* 2020 studied leaf powder ethanolic extract and revealed 13 different types of bioactive compounds, but only six of them can carry out specific biological functions. These include alpha-methyl mannofuranoside (36.25%) for its antibacterial and antifungal activity, undecanoic acid (1.88%) for its cytotoxic, anticancer, and anti-microbe properties, 5-O-methyl-D-gluconic acid dimethylamide (4.86%) for its antioxidant and anti-microbial properties, Cyclopropanetetradecanoic acid, 2-Octyl-, Methyl ester (3.20) for its anti-microbial activity and Pentanoic acid, 2 (Aminooxy) (3.59%) for its Anti-oxidant and lubricantproperties [17].

Suman *et al.,* 2013 found four bioactive compounds in the leaf's aqueous, hot extracts, with 4-OMethylmannose (70.12%) having antibacterial activity and 1,2,3-Benzenetriol (21.76%) having antioxidant, antibacterial, antiseptic, fungicide, antimutagenic, antidermatitic, pesticide, dye and candidicide properties. In contrast, the methanol extract contained significant amounts of thiophene (antimicrobial action), tetrahydro-2-methyl-myo-inositol (48.54%), 1,2,3-benzenetriol (7.51%) and Vitamin E (d -α-tocopherol) (6.52%). Higher concentrations of 4-O-methylmannose (Secondary messenger) and 5-Methyl-2-trimethylsilyloxy-aceto phenone (7.35%) were found in the ethanol extract. In the ethyl acetate extract, there were 15 compounds detected, the main ones being silane (Coupling Agent) and trimethyl [5-methyl-2-(1-methyl ethyl) phenoxy] anthracene (7.06%) [9].

Parasuraman *et al.*, 2009 reported 17 compounds, of which 14 are from fresh leaves and 5 are from dry leaves. 3-Omethyl-d-glucose (32.88%), Benzenetriol (22.43%), 1.6- Anhydro - â - Dglucopyranose (15.66%), Heptacosane (8.99%), 2-Hydroxy-7methoxy-4,5 diphenyl-5 Hindeno [1.2-d] pyrimidine (7.45%) and Eicosane (3.76%) were found in fresh leaves, whereas 3-O-methyl-d-glucose (41.61%), Benzenetriol (Pyrogallic acid, Pyrogallol) (25.06%), n- Hexadecanoic acid (10.60%), Heptacosane (4.41%) and 1,2-Benzenedicarboxylic acid, diisooctyl ester (3.54%) were present in dried leaves aqueous extracts [18]. Kazi M. and Gude A. *et al.*, 2022 summarized the phytoconstituents and discussed 46 compounds and their biological properties [19]. Only 1,2,3-Benzenetriole (35.95) and 3-O-methyl-d-glucose (25.33) were previously reported of the 9 compounds we found in leaf methanol extract; the other compounds were discovered for the first time. To the best of my knowledge, no studies on the GC-MS analysis of methanol extracts of *C. collinus* fruit and bark have been published yet. In contrast to earlier findings, we present the most recent analysis of the GC-MS profile of the methanolic extracts of leaves, bark and fruits in our investigations.

CONCLUSION: These findings have established a solid scientific foundation for the use of the plant *Cleistanthus collinus* in traditional medicine to treat fungal infections. Compared to chloroform extracts, methanol and ethyl acetate extracts showed high antifungal activity. In particular, *C. albicans* and *S. cerevisiae*, which displayed the strongest antifungal activity, excelled over other fungal strains examined. GC-MS study revealed 15 phytochemical components with antifungal, antibacterial, antioxidant, anti-inflammatory and anti-cancer properties. As far as I am aware, very little work has been done on the antifungal activity of *C. collinus*, as there is very little literature accessible on the antifungal activity of this plant species. We believe that more studies in this area will aid in developing novel antifungal and anticancer drugs.

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Author Contributions: S. Prathamanjali assisted and conducted the experiment, calculations, and literature analysis and prepared the manuscript. Prof. T. Vijaya guided the co-authors and prepared the final version of the manuscript. Y.T. Rajesh Babu helped in conducting the experiments and preparation of the manuscript. All authors read the final version of the manuscript and accepted it.

CONFLICTS OF INTEREST: The authors declare that they hold no competing interests.

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3.4.8

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Original Research Paper

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Virology

PHYTOCHEMICAL ANALYSIS AND ANTIMICROBIAL ACTIVITY OF PLUMBAGO ZEYLANICA LEAF EXTRACT

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ABSTRACT In India, *Plumbago zeylanica* is a beneficial medicinal herb. The current study examines the antibacterial, and antifungal properties and phytochemical analysis of *Plumbago zeylanica* leaf extract. Using the well diffusion technique, the antibacterial activity was evaluated against gram-positive and gram-negative microorganisms. the antifungal activity was carried on *Aspergillus niger*. The study's findings imply that the plant leaf extract possesses an inhibitory effect on both gram-positive and gram-negative bacteria and fungi and it could be used as phytomedicine for bacterial and fungal diseases

KEYWORDS :

INTRODUCTION:

Plumbago zeylanica is an herbaceous plant with ascending, prostrate, or erect glabrous stems. Additionally, the ovate petiolate or sessile leaves have leaves. It belongs to the *Plumbago* genus and the family *Plumbaginaceae*. Tropical and subtropical areas across the world support the growth of the native *Plumbago zeylanica* plant. Deciduous woodland in (Australia, and India). The herb has a variety of therapeutic benefits [1-4]. Chitrak, chitramoolam, plumbago, Ceylon leadwort, doctor bush, or wild leadwort are some of the native names for the plant. Chitra is the name in Hindi, while Chitramoolam is the name in Tamil [5,6]. Molubda scandens (L.) Raf., Plumbagidium scandens (L.) Spach, Plumbago scandens L., and Plumbago zeylanica var. glaucescens Boiss are some synonyms for the plant [7,8].

The *P. zeylanica* plant grows to a height of 0.5-2 meters. The leaves are simple, alternating, elliptic, or oblong, 0.5–12 cm long, with a tapering base, and sometimes have a hairy edge. They can also be ovate or ovate-lanceolate. Young leaves lack stipules and have a thin petiole with tiny auricles. The inflorescence has numerous flowers and is of the terminal raceme type, measuring 6 to 30 cm in length [4-7]. White flowers are produced in terminal and axillary elongated spikes. They are pentamerous, pedicellate, bisexual, regular, and sweet-scented. Free and included are the stamens. The ovary is superior and single-celled, and the style is filiform with five elongated stigma lobes. The flowers also have a tubular calyx with glandular trichomes (hairs) that secrete gooey mucilage, which is another distinguishing feature [3]. The plant blooms all year round, and insects are the main pollinators. The mucilaginous glands facilitate animal fruit distribution and insect capture. The plant's fruit is a single-seeded, oblong capsule with five ridges. Each seed has an oblong shape, is 5–6 mm long, and ranges in color from reddish-brown to dark brown. Roots are at least 30 cm long, smooth, branching, or unbranched, with or without secondary roots, and 6 cm in diameter. When they are young, they are light yellow, and as they dry, they turn reddish-brown. The roots taste caustic and bitter and have a potent, distinctive smell [7].

Description:

The generic name comes from the Latin words plumbum, which means lead since this plant was thought to be able to treat lead poisoning and eye illness. The particular plant comes from Sri Lanka and is known as Ceylon. In India, the plant *Plumbago zeylanica* is also known as Chitrak, and it has several conventional and effective medical applications. The plant's blossoms may be eaten and are used to adorn salads, desserts, and cold beverages. The plant thrives in West Bengal, Madhya Pradesh, and Chhattisgarh. It also grows in a variety of soil types, including deep soil, deep black soil, and red literate soil. It may be quickly propagated via stem cuttings [8].

including cardiotoxicity, atherogenicity prevention, and cardiotonic neuroprotection. It may also be used to lower blood cholesterol levels and improve the poor density of lipoproteins. Diabetes, cancer, skin infections, rheumatoid arthritis, constipation, asthma, and muscle discomfort are all treated with this herb [9].

Growth and Development:

The plant *Plumbago zeylanica* is a wild species that grows in many locations and has a variety of medicinal uses. The plants are cultivated in tropical and subtropical areas where it rains throughout the rainy season [10]. To identify the numerous bioactive substances that are significant from a pharmacological standpoint, including alkaloids, steroids, flavonoids, phenolic compounds, and many more, a phytochemical examination was carried out. The plant's bioactive components are a source for making medicines [11]. The bioactive substances are known to behave as microbial inhibitors [12]. The hunt for novel structural medications to replace synthetic antioxidants that are reportedly harmful has led researchers to explore plants in the present [13].

MATERIALS AND METHODS:

Collection of plant material:

The plant *Plumbago zeylanica* was harvested from the Nallamala forest in the Kurnool district, Andhra Pradesh, India. The gathered plant leaves are divided into bits, let to air dry for 10 days, and then ground into a fine powder for use in further research.

Preparation of plant leaf extract:

Up to 10 gms of the dried leaf powder were used, and 100 ml of distilled water was used to dissolve it. The leaf extract that had been dissolved was utilized to analyze phytochemicals and test the antibacterial and antifungal activities.

Phytochemical analysis of leaf extract of *Plumbago zeylanica*:

The phytochemical examination of the *Plumbago zeylanica* leaf extract was used to identify the bioactive components, such as alkaloids, flavonoids, tannins, phenolic compounds, and saponins [14].

Test for carbohydrates:

Molisch's test:

Plant leaf extract (2ml) was mixed with 1ml of Molisch's reagent and a few drops of concentrated H_2SO_4: the production of a violet color at the intersection of the two layers shows the presence of carbohydrates.

Test for reducing sugars:

Benedict's test:

Journal of Advanced Zoology

3.4.8

Ecofriendly Dyes: Extraction, Characterization and Potential Applications

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Keywords: Natural Dyes, Extraction, Characterization, Dyeing, Synthetic chemical dyes

Abstract

Indians were thought to be forerunners in the technique of natural dyeing. Although indigenous knowledge systems have been practiced for many years, the usage of natural dyes has declined over generations owing to a lack of documentation and accurate understanding of the extraction and dyeing processes. As a result, natural dyes aren't commercially viable. Currently, all ecologically hazardous synthetic chemical dyes are utilized to colour textile fabrics. They are nonbiodegradable, carcinogenic, and cause water contamination and waste disposal issues. Natural colours provide a viable answer to these issues. Natural dyes are used to colour textiles, meals, medicines, and cosmetics. Dyes are also used in small amounts to colour paper, leather, shoe polish, wood, cane, candles, and other materials. Historically, dyes were obtained only from natural sources. Natural dyes, on the other hand, suffer from the inherent limitations of uniform application and dye standardization, since dyes obtained from comparable plants or natural sources are impacted and exposed to the vagaries of climate, soil, cultivation practices, and so on. As a result, standardization procedures play a critical and essential role for natural dyes to be ir[illegible]ialized and compete with synthetic dyes. This study is all about natural dyes, their extraction, characterization, applications, and their uses.

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3.4.8

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ADMET DMPK. 2023 Jul 1;11(4):573-585. doi: 10.5599/admet.1793. eCollection 2023.

Green synthesis, characterization and biological activities of silver nanoparticles synthesized from *Neolamarkia cadamba*

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PMID: 37937248 PMCID: PMC10626518 DOI: 10.5599/admet.1793

Abstract

Background and purpose: Metal nanoparticles are essential due to their unique catalytic, electrical, magnetic, and optical characteristics, as well as their prospective use in sensing, catalysis, and biological research. In recent years, researchers have focused on developing cost-effective and eco-friendly biogenic practices using the green synthesis of metal nanoparticles (AgNP).

Experimental approach: In the present study, the aqueous extracts prepared from the leaf, stem, bark, and flower of *Neolamarkia cadamba* were used for the synthesis of silver nanoparticles. Synthesized silver nanoparticles were characterized using UV-Visible spectroscopy, zeta potential, dynamic light scattering, scanning electron microscope (SEM), and EDAX.

Key results: The current study showed absorption of synthesized AgNPs at 425, 423, 410, and 400 nm. Dynamic light scattering of AgNPs Showed size distribution of AgNPs synthesized from leaf, stem, and flower aqueous extracts ranges from 80-200 nm and AgNPs prepared from bark extract ranges from 100-700 nm. Zeta-potential of the biosynthesized AgNPs was found as a sharp peak at -23.1 mV for the leaf, -27.0 mV for the stem, -34.1 mV for the bark, and -20.2 mV for the flower. Silver nanoparticles and crude extracts of *Neolamarkia cadamba* showed effective antibacterial, antifungal, and antioxidant activities.

Conclusion: Silver nanoparticles have substantial antibacterial activity against Gram-positive bacteria and also exhibit the utmost antifungal activity against *Aspergillus niger*. The study concludes that the green synthesis of silver nanoparticles from *N. cadamba* leaf, stem, bark, and flower extract is a reliable and eco-friendly technique.

Keywords: Antibacterial activity; antifungal activity; antioxidant activity; electron microscopy.

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Figures

International Journal of Cultural Studies and Social Sciences

EXPLORING AI TOOL AWARENESS AMONG LIBRARY AND INFORMATION SCIENCE PROFESSIONALS IN ANDHRA PRADESH: A STUDY

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Abstract

This paper discusses on the exploration of AI tool awareness among LIS Professionals in selected districts of Andhra Pradesh. An online questionnaire was designed for this purpose and circulated to 182 LIS professionals working in academic libraries. 164 responses received out of 182 total. The overall user response rate 90.10.%. The results revealed that majority of the respondents are strongly agreed with their awareness on AI tools, all the areas of AI applications in libraries, advantages and motivating factors, whereas some of the respondents are disagreed with the same factors. However, LIS professionals should understand their user needs and also the importance of Artificial Intelligence by learning and updating their knowledge with the latest technological developments.

Keywords:

Artificial Intelligence (AI), LIS, Andhra Pradesh, Areas of AI, Challenges of AI

Introduction

Artificial intelligence (AI) is a branch of computational science focused on solving complex problems in a manner similar to human thought processes. It involves integrating human cognitive traits into algorithms that computers can understand and process to generate outputs. AI functions as a neural network, resembling the organization of human neural activities, and has evolved since the 1950s, with applications in various sectors including libraries since the 1990s. In libraries, AI encompasses a range of techniques enabling machines to detect, understand, learn, and perform administrative tasks, thereby providing libraries with advanced technologies. This integration of AI represents a significant advancement for information-driven fields such as law, healthcare, commerce, and automotive industries. In libraries, AI applications span various functions including acquisition, cataloging, management, circulation of serials, information retrieval and dissemination, inter-library loan services, cooperative acquisition, and forming library consortiums.

Review of the Literature

Huang (2022)[1] discovered the diverse artificial intelligence (AI) applications used in academic libraries and the key factors and obstacles related to their implementation. The author adopted quantitative research methods in the form of a questionnaire, using both open and closed questions. A total of 472 questionnaires were received from academic librarians. The author found that the librarians recognized that AI applications are predictable, but showed that that the problems of in execution have hindered the adoption of AI. This study found that the two most important elements affecting the implementation of AI applications were finance and implementation costs. A number of the obstacles to the adoption of AI applications are related to technical issues. Instead of initially decreasing and cutting down on human resources, a number of librarians recommended that managers invest additional resources early on.

Cox (2023)[2] stated that the application of artificial intelligence to knowledge discovery is the paper's primary topic. Eleven alternative strategies that libraries might use for these AI applications are examined, and their chances are assessed. The impact of various internal and external factors on the adoption of AI is then examined. The study offers a new perspective of librarians as hybrids in addition to discussing the potential effects of AI on librarianship and how to integrate the research on competences with professional philosophy.

Subaveerapandiyan(2023)[3] examined the understanding and impression of artificial intelligence among library and information science workers in Zambia. The findings indicate that although library and information science professionals had a positive and upbeat view of AI, they were also concerned about AI taking over the role of librarians and about the obstacles to AI technology adoption in Zambian libraries. Before deploying artificial intelligence, the article recommends libraries take into

BUILDING INFORMATION MODELLING OF AN EARTHQUAKE RESISTANT STRUCTURE

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ABSTRACT

Constructing a structure that minimizes earthquake damage can be challenging due to the unpredictable nature of seismic events, making it seem impractical. However, this study focuses on developing earthquake-resistant structure by incorporating Building Information Modelling (BIM) in the design and detailing process. The primary focus is on a G+5 apartment building designed to withstand seismic forces and prioritize occupant safety during earthquakes. BIM technology, using software such as Revit, ETABS, SAFE, SketchUp, AutoCAD, etc., is employed to enhance the structural design. Starting with creating a detailed architectural plan for the G+5 structure and rendered different architectural 3d views by creating models in Blender software. Then the detailed seismic analysis and design is done in ETABS & SAFE as per seismic design code (IS:1893-2016). BIM tools generate a dynamic 3D model, facilitating the visualization and simulation of seismic responses. The project encompasses comprehensive Structural, Architectural, and MEP (Mechanical-Electrical-Plumbing) BIM. The BIM model serves as a central information repository, allowing for precise quantity take-offs and cost assessments. The study's outcomes contribute significantly to the advancement of earthquake-resistant building design, highlighting the efficiency of BIM in optimizing structural performance and cost-effectiveness. These findings hold relevance for professionals in structural engineering, architecture, and construction management, underscoring the pivotal role of integrating BIM in earthquake-resistant designs. Furthermore, the detailed cost estimation for the entire G+5 building is also included.

Keywords: Building Information Modelling (BIM), seismic resilience, G+5 apartment building, earthquake-resistant structure, cost estimation, architectural, MEP BIM.

I. INTRODUCTION

1.1 General

Designing earthquake-resistant structures is crucial in civil engineering, particularly in earthquake-prone areas. Building design must consider hindrances to earthquake forces and ensure adequate support to prevent collapse. In this G+5 project, advanced BIM tools like AutoCAD, ETABS, Revit, and SAFE are employed. These tools help as digital assistants, enhance the design process, provide detailed information, and optimize the building's resilience to both routine and seismic challenges.

In India the earthquake prone area is divided into 4 zones based upon their vulnerability to earthquakes. So, for designing any type of structure in these zones, there are some design codes (see in 1.2). Following these codes will ensure that our constructions are not only safe but also capable of withstanding earthquakes.

Design Guidelines: Structural designers must adhere to key standards for earthquake-resistant design:

- IS 1893: 2016: Criteria for Earthquake Resistant Design.
- IS 13920: 1993: Ductile Detailing of Reinforced Concrete Structures subjected to seismic forces.
- IS: 456-2000: Indian Standard Plain Reinforced Concrete Code of Practice (Fourth Revision).
- IS 875 (Part 1-5): 1987: Code of Practice for Design Loads (excluding earthquake) for Buildings and Structures (Second Revision), encompassing dead loads, live loads, wind loads, snow loads, and special loads.

These streamlined guidelines ensure structures are resilient to seismic challenges in their respective zones, promoting safety and structural integrity.

1.2 Building Information Modelling (BIM)

'BIM' stands for 'Building Information Modeling,' a dynamic process that encompasses the creation and management of construction project information across its entire life cycle. BIM includes the development of detailed 3D models, each representing a distinct construction phase. This project specifically focuses on 5D BIM within the broader spectrum of eight dimensions.

Key Dimensions in BIM:

- 1D: Process and Brief Preparation
- 2D: + 2-Dimensional Views
- 3D: + 3-Dimensional Model
- 4D: + Time Schedule
- 5D: + Budget (Cost)
- 6D: + Facilities Management (Maintenance)
- 7D: + Sustainability (Life Cycle)
- 8D: + Occupational Safety and Health

BIM plays a pivotal role in simplifying difficult construction tasks through advanced 3D modeling software, reducing costs, and expediting project completion.

Essential Requirements for Successful BIM Implementation:

- Powerful PC with Required Software: Necessary for effective BIM execution.
- Coordination and Collaborations: Imperative for seamless project stakeholder interaction.
- Sound Subject Knowledge: Essential for leveraging BIM's potential in construction.
- 3D Modeling Experience: Prerequisite for navigating BIM intricacies.
- Literature Study and Exploration: Critical for staying current with evolving BIM methodologies.

Software Used in BIM:

- Autodesk AutoCAD
- Google SketchUp
- Bentley Staad-Pro
- CSI ETABS, SAFE, Detail
- Autodesk Revit
- Autodesk Navisworks, etc.

Advantages of BIM Implementation:

- Improve Onsite Collaboration and Communication.
- Model-Based Cost Estimation.
- Visualize Projects in Preconstruction.
- Better Coordination and Clash Detection.
- Mitigate Risk and Reduce Cost.
- Improved Scheduling/Sequencing.
- Increase Productivity with Prefabrication.

While offering substantial benefits, BIM necessitates significant investment in robust hardware and ongoing staff training and education to fully harness its potential. BIM integration represents a strategic approach to enhance efficiency, reduce costs, and ensure project success in construction endeavors.

1.3 Objectives

- Analysis and Design of a G+5 Apartment building to resist earthquake forces.
- Architectural, Structural and MEP Building Information Modelling.
- Arriving cost estimation of the G+5 Apartment building.

II. LITERATURE REVIEW

Syed Usam Ali, Nazeer Ahmed, Mohammed Khaja Zaheruddin (2021): Their study explores the comprehensive process of constructing a G+4 residential building in Aramgarh, Hyderabad. Employing AutoCAD and STAAD Pro, it covers layout, design, analysis, planning, and cost estimation. The 150' x 90' plot includes a ground floor for parking and 4 residential floors, each with 8 apartments. AutoCAD drawings, serving as the foundation for structural analysis, offer insights into forces, schedules, concrete take-off, and reinforcement weights. Foundation design utilizes STAAD

Foundation's isolated footings. Primavera P6 aids in project planning, and cost estimation is facilitated by the Centre Line Method in Microsoft Excel.

Arti, Sanjay Kumar Sharma (2020): This study employs STAAD Pro. software to analyze a multi-storied (G+5) building in accordance with IS1893:2002 part 1. Parameters such as seismic zone (IV), response reduction factor (R), and importance factor (I) are considered, along with properties like soil type, structure type, and damping ratio. STAAD Pro. provides detailed results, including joint displacements, support reactions, member forces, base shear, and lateral load, facilitating an economic analysis and design approach for the structure. The paper illustrates this methodology using a practical example of a multi-story building, showcasing detailed numerical results in the generated output file.

Mr. Saurabh N. Ugale, Mr. Sachin U. Pagar (2023): The study delves into the intricate art of planning and designing an eight-storey (G+8) apartment building, emphasizing safety, serviceability, durability, and economy. Utilizing AutoCAD for plan and elevation and E-Tabs for analysis, the research follows building by-laws and design codes like IS: 456-2000 and IS: 875. The focus remains on the balance between aesthetics, addressed by architects, and technical considerations, overseen by structural engineers.

III. METHODOLOGY

3.1 Problem Statement

An earthquake resistant analysis & design of a G+5 apartment building consisting of 4 No. of 3BHK (2400 sft.) flats in each floor is carried out first and then all the architectural, structural and MEP building information modelling is done. Finally, the total cost estimation of this G+5 apartment building is carried out.

3.2 Methodology adopted for this project:

- First, a G+5 3BHK APARTMENT Plan was prepared. (Using AutoCAD).
- Then Architectural 3D model of the building was prepared. (Using REVIT & Blender).
- Next, Structural Modeling and Design has been done. (Using ETABS & SAFE).
- Then, Structural Detailing was done (Using Revit & CSI Detail).
- Then, MEP Detailing was done showing Plumbing & Electrical layouts (Using Revit & AutoCAD).
- Finally, Complete cost estimation was done (Using Revit & other sources).

IV. ARCHITECTURAL BIM

The Architectural Building Information Modeling generated in this project is provided below:

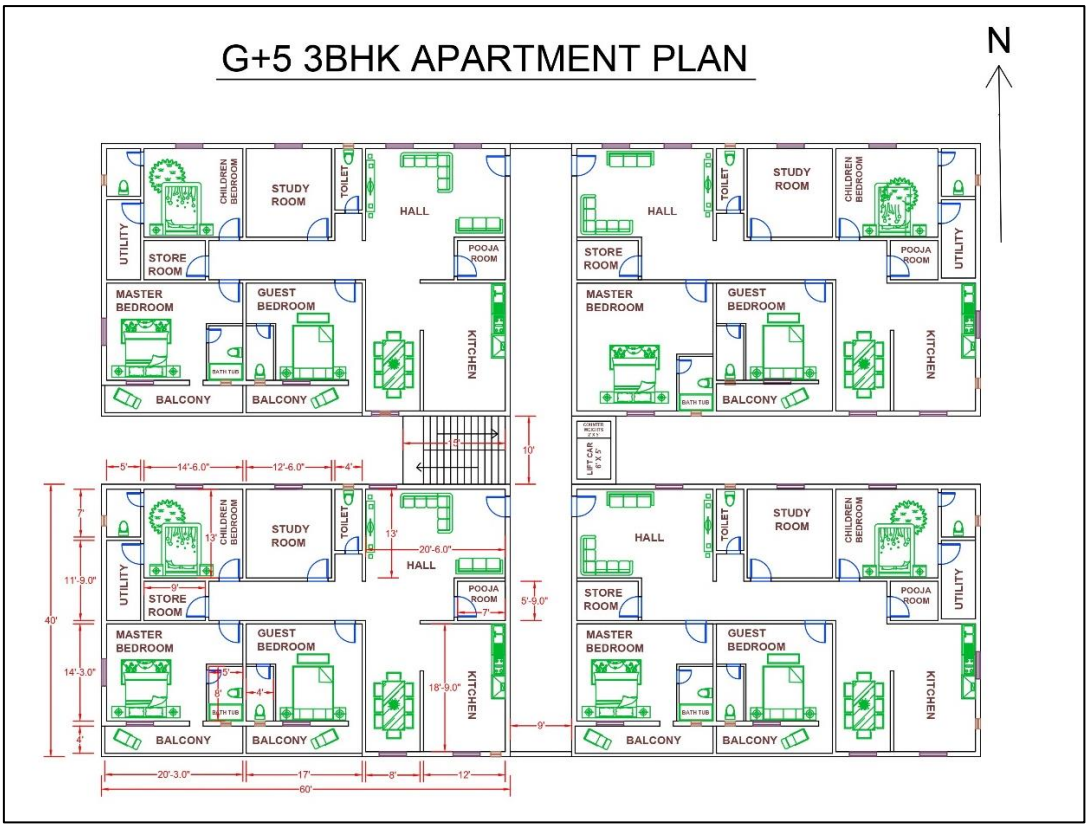


Figure 1: Full Plan of G+5 Apartment building.



Figure 2: Interior architectural renderings of Living room & kitchen.

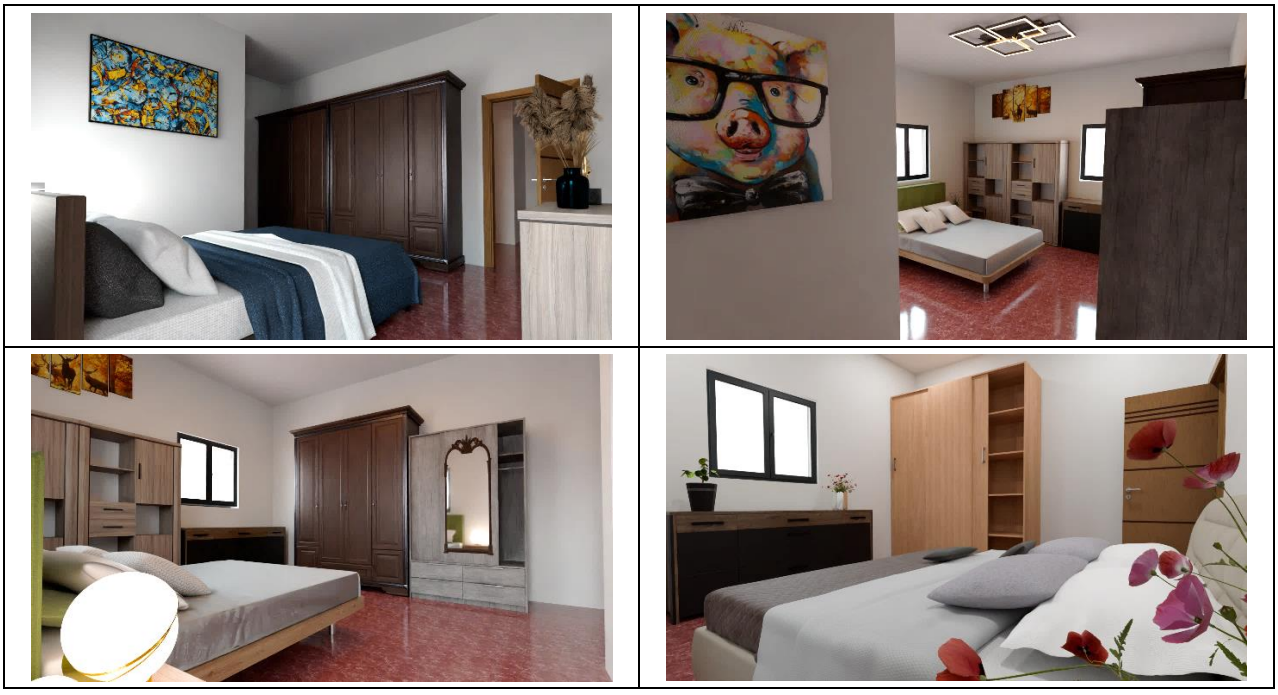


Figure 3: Interior architectural renderings of all 3 bedrooms.



Figure 4: Architectural renderings of toilets, balcony & utility rooms.



Figure 5: Exterior renderings of G+5 apartment building.

V. STRUCTURAL BIM

Structural Data of G+5 Apartment building:

No. of storeys	G+5
No. of flats	4 on each floor = 4x5 = 20
Ground Floor	Left for parking
Flat details	3BHK – 2400 sft. area
Slab thickness	150 mm
Storey height	3200 mm
Walls thickness	External – 230 mm Internal – 150 mm
Lift & Staircase	Provided
No. of columns on each floor	92 columns

Size of flat	60 ft x 40 ft (see fig.2)
No. of bays in X-Dir.	14
No. of bays in Y-Dir.	10
Support conditions	Fixed
Seismic Zone	Zone III – (0.16)
Soil type	Type – II (Medium Stiff)
Column sizes adopted	230 x 450 – 300 x 400 300 x 450 – 350 x 450
Beam sizes adopted	300 x 400 – 300 x 450 350 x 450 – 400 x 450
Materials	Concrete – M30 Grade Steel – Fe415 Grade

Analysis & Design Results:

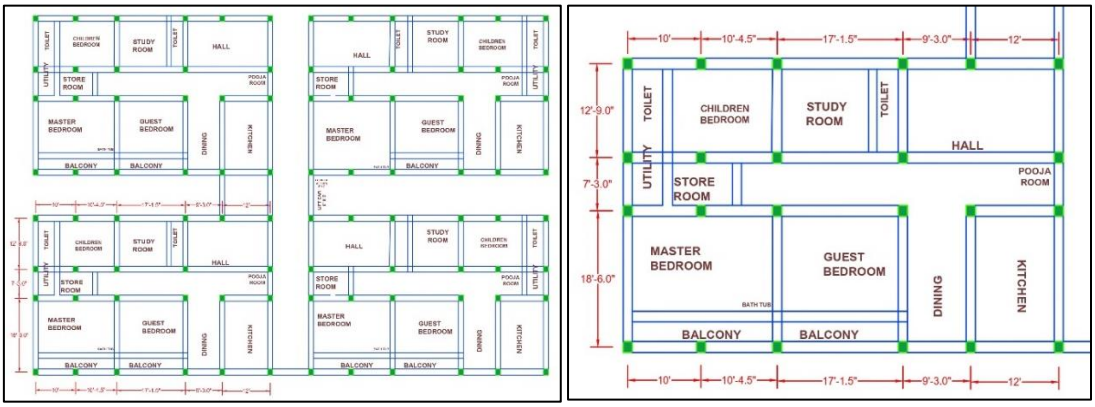


Figure 6: Beams & Columns layout plan.

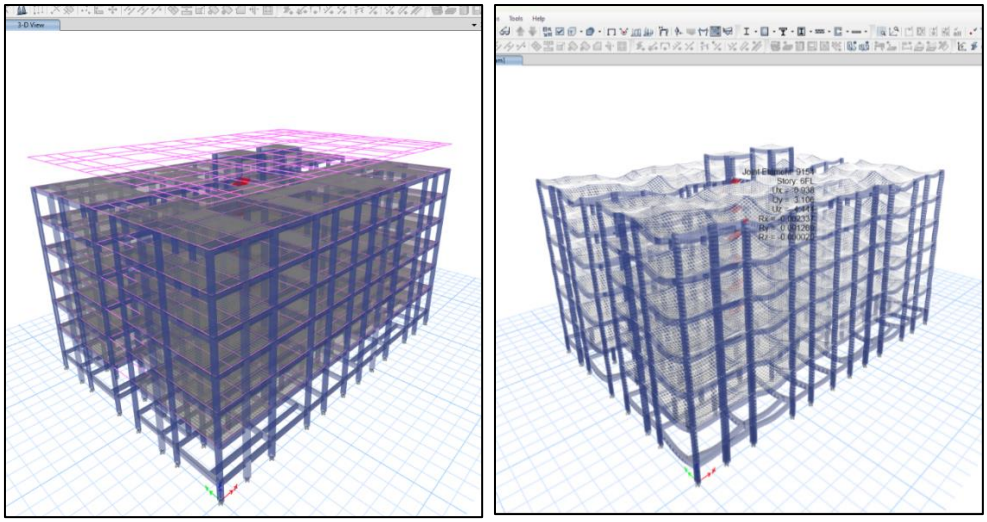


Figure 7: Structural 3D models in ETABS before and after analysis.

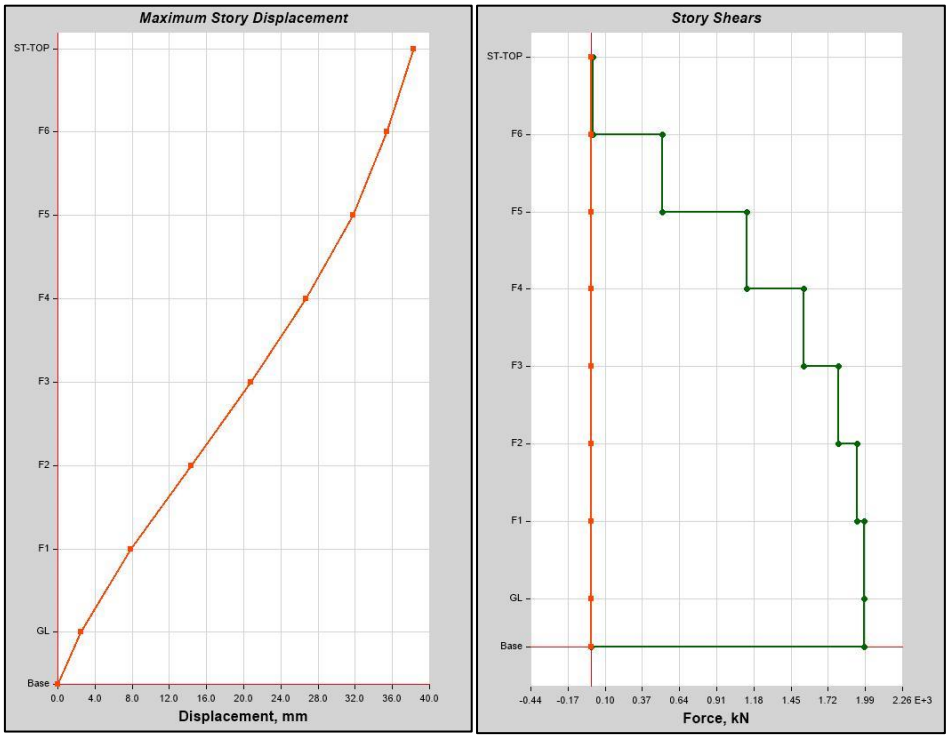


Figure 8: Maximum Story Displacements & Story Shears obtained in ETABS.

VI. MECHANICAL-ELECTRICAL-PLUMBING(MEP) BIM

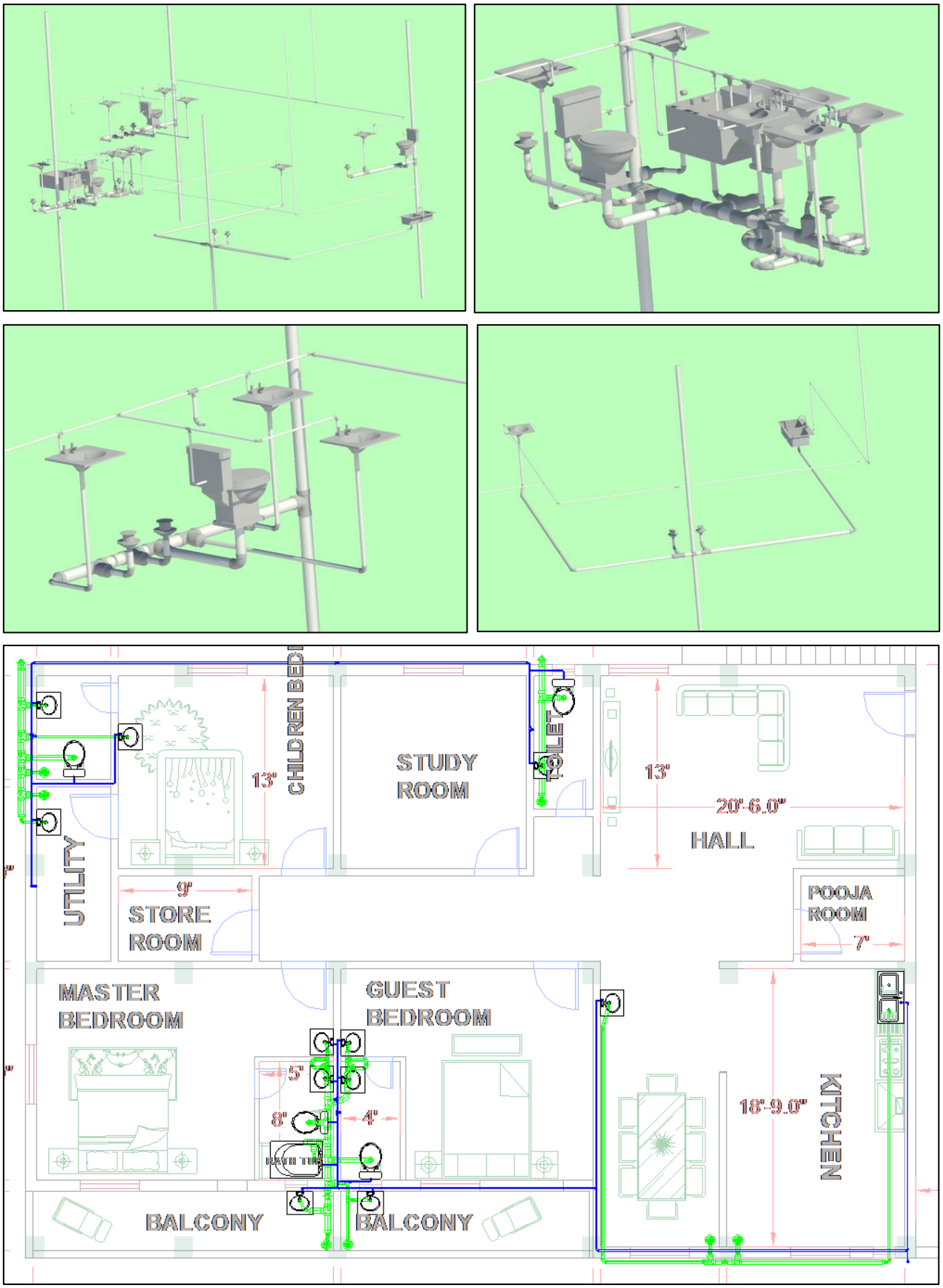


Figure 9: Plumbing Detailing of G+5 Apartment building with 3D models.

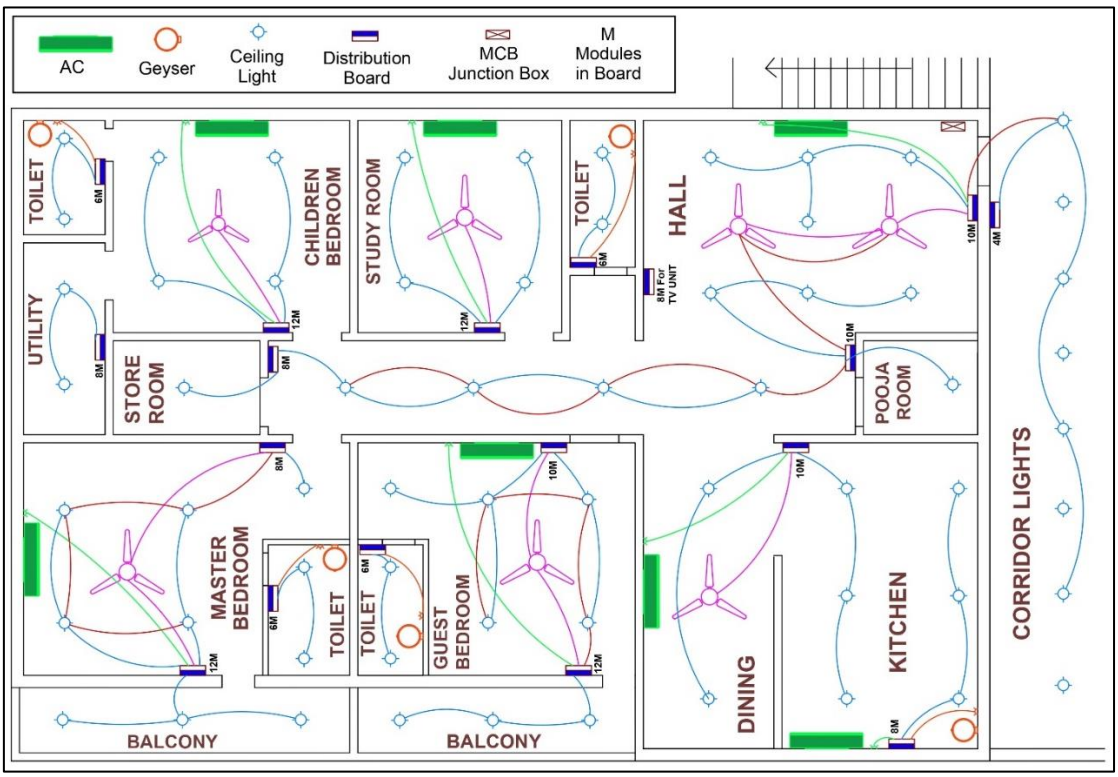


Figure 10: Electrical Detailing Layout of G+5 Apartment building.

VII. COST ESTIMATION

Table.1: Complete Cost Estimation of G+5 Apartment Building

SITE CLEARANCE CHARGES FOR JCB = 30Hr × 1000 = Rs.30000/-
DESIGN FEE = Rs.100/sft. × 11000 = Rs.1100000/-
BORE CHARGES = 150000 × 4 = Rs.600000/-
EARTHWORK CHARGES = Rs.100000/-
BASEMENT FILLING = Rs.1000000/-
ELECTRIC WORKS (M+L) = Rs.100/sft. × 10630 × 5 = Rs.5315000/-
PLUMBING WORKS (M+L) = Rs.110/sft. × 10630 × 5 = Rs.5846500/-
PAINTING COST + POP = Rs. 160/sft. × 10630 × 5 = Rs.8500000/-
FLOOR TILES = Rs.75/sft. 10630 × 5 = Rs.3986250/-
WALL TILES = Rs.65/sft. × (10630/3) × 5 = Rs.1151583/-
GRANITE = Rs. 120/sft. × (0.05 × 10630) × 5 = Rs.318900/-
TOTAL WALLS COST = 1491 m^3 × Rs.8500/m^3 = 12673500/- + (300 × 8391 m^2) = Rs.1,51,90,800/-
TOTAL COST FOR FOOTINGS = 23,92,000 + 10,50,000 + (10630 × 60) = Rs.40,79,800/-
WINDOWS COST = 6500/No. × 170 = Rs.1105000/-
MAIN DOORS = 85000/No. × 20 = Rs.1700000/-
BEDROOM DOORS = 15000/No. × 80 = Rs.1200000/-
BATHROOM DOORS = 3000/No. × 175 = Rs.525000/-
TOTAL CONCRETE VOLUME FOR SLABS = 846.863 m^3
TOTAL STEEL WEIGHT FOR SLABS = 36.239 TONNES
TOTAL BEAMS CONCRETE VOLUME = 542.168 m^3
TOTAL STEEL FOR BEAMS = 84.954 TONNES
TOTAL CONCRETE VOLUME FOR COLUMNS = 387.746 m^3
TOTAL STEEL FOR COLUMNS = 134.142 TONNES

TOTAL COST OF CONCRETE FOR SLABS, BEAMS, COLUMNS = Rs.88,83,885/-
TOTAL COST OF STEEL FOR SLABS, BEAMS, COLUMNS = Rs.2,04,26,800/-
TOTAL COST OF LABOUR FOR LAYING SLABS, BEAMS = (6 × 10630 × 130) = Rs.82,91,400/-
TOTAL COST OF LABOUR FOR LAYING COLUMNS = (96 × 3000 × 6) = Rs.17,28,000/-
WATER TANKS & PUMPS COST = Rs.15000/No. × 20 = Rs. 3,00,000/-
LIFT COST FOR G+5 BUILDING = Rs.8,50,000/-
TOTAL BUILDING COST = Rs.9,21,09,918/-
HOUSE PERMISSION CHARGES = 1-3% OF BUILDING COST = Rs.27,63,300/-
CONTRACTORS PROFIT = 10% OF BUILDING COST = Rs.92,10,990/-
FINAL COST OF G+5 APARTMENT BUILDING = **Rs. 10,40,84,208 /-**
COST PER SFT = Rs.10,40,84,208 / (10630 × 5) sft. = **Rs.1960/-** per sft.

VIII. CONCLUSION

As the design of a building to resist an earthquake force especially in earthquake prone areas is challenging, and cost of structure also will be increased compared to conventional design. So, to optimize the overall cost of structure and to maintain stability and integrity of the structure, proper methodology should be adopted in the design process. So, in this project, adopted Building Information Modelling (BIM) process for the complete design of structure using some important BIM software tools to design the selected G+5 Apartment building. And here are the conclusions:

- With the help of AutoCAD tool, it can be easily drafted any kind of building plan and architectural details.
- The interior and exterior architectural renderings based on 3D models from different views of different rooms like bedrooms, living room, kitchen, utility, etc. are prepared in Sketchup and Blender software.
- For the most important part, i.e., Analysis and Design, CSI ETABS and SAFE were used for design and all design criteria of Earthquake Design is based on IS Code – IS:1893-2016.
- The analysis and design results achieved are very optimal and cost-effective without unnecessary sections and ductile design detailing of every structural element is provided in the results and discussions section.
- Plumbing and Electrical layouts of the G+5 Building along with some typical 3D models have also prepared.
- Finally, the overall cost estimation of the structure, G+5 Apartment Building, is prepared by using Revit and some other sources manually and the results came out very optimistically and economically.

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AWARENESS AND UTILISATION OF E-PG PATHSHALA AMONG PG STUDENTS OF SRI VENKATESWARA UNIVERSITY, TIRUPATI: A STUDY

Dr. M. Prasantha Kumari, Associate Professor, Dept., of Library and Information Science, Sri Venkateswara University, Tirupathi, Andhra Pradesh

Abstract

This study discusses about the awareness and utilisation of e-PG Pathshala among students of Sri Venketeswara University, Tirupati. Online questionnaire was prepared in Google Forms and distributed to 182 students and received responses from 178 students of Arts. Findings revealed that students were aware of e-PG Pathshala and utilised the e-content to the maximum extent. Moreover, awareness and utilisation need to be increased among the students of university.

Keywords:

e-PG Pathshala, UGC, INFLIBNET, ICT, SVU

INTRODUCTION

The development and impact of technology has transformed people's lives in different ways, as technology is impacting every aspect of our lives. Technological advancements such as computers, the internet etc. have fundamentally altered the way we work with, access, retrieve, share and process data or information. This has made information processing easier, faster and more efficient, and has taken information processing to a whole new level, making it an essential part of ICT.

INFLIBNET AS LEARNING RESOURCE

INFLIBNET is an Information and Library Network (IUC) centre of the UGC in India. It is a fully funded autonomous body of the UGC. It was set up by UGC under MHRD to develop higher education in India. It started as a project of IUCAA in 1991 and became an independent IUC centre in 1996. Its main objective is to modernize and promote infrastructure to connect different university libraries through high-speed data for the sharing of information resources between different academic or research institutions. It is based in the city of Gandhinagar in Gujarat. Technology is the driving force in modern education system. The UGC has taken many initiatives for the betterment of the academic community in the universities under its jurisdiction. These initiatives include Shodhganga, Shodhgangotri, OJAS, INFLIBNET, Open-Source Software Research and Development, Infoportal e-PG Pathshala is one of the initiatives projects under INFLIBNET.

e-PG Pathshala

e PG Pathshala (e-PG) is an online platform which is hosted and managed by the Institute of Postgraduate Education (INFLIBNET). The primary purpose of this platform is to meet and deliver course content according to the NME-ICT curriculum for each postgraduate learner. All the resources have been developed by the selected experts from various Institutions and Universities. The aim is to provide e-content to the students and peers through various delivery modes for formal and non-formal education, to complement and enhance the teaching and learning process in higher education, and to encourage the usage of e-content among students and peers. This e-content is available in open access and it is being accessed across the globe. The total no of visitors was 21639248 as on February 22nd 2024. Even on YouTube the videos are being viewed in large numbers with students, teachers, researchers and other stakeholders providing constant feedback. HRD Minister Pokhriyal on the Twitter urged all Post Graduate students in the country to take benefit of the superior content available on this platform during the lockdown.

REVIEW OF THE LITERATURE

Subhajit (2020)[1] conducted a study to observe the usage pattern of e-PG Pathshala in respect to topographical coverage and subject areas. Data was collected from 20 countries, states and cities in

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A study on the effect of NaOH molarity on flyash based self compacting geopolymer concrete

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ABSTRACT

The concrete industry has consistently pushed for sustainable development. This investigation aims to examine the characteristics of flyash-based self-compacting geopolymer concrete (SCGPC) made with varying NaOH molarities both while it is fresh and when it has hardened. The NaOH molarity is varied from 8 M to 16 M at an interval of 2 M. Sodium silicate (Na_2SiO_3) to sodium Hydroxide (NaOH) is kept at a constant ratio of 2. For the geopolymer process, the alkaline solution to Binder ratio (L/B) was kept at 0.45. Fresh properties like Slump flow, T_{50cm} slump flow, L-Box and V-funnel have been done to assess the fresh properties of flyash based SCGPC confirming to EFNARC guidelines. Mechanical Strength properties such as Compressive, split-tensile, and flexural strength of the flyash based SCGPC were also determined at various ages. Prior to testing, all specimens are cured under ambient curing. Results indicate that the hardened properties of flyash based SCGPC are enhanced by the increase in molarity from 8 M to 16 M. Furthermore, as the molarity tends to rise, it is shown that the fresh properties slightly decrease.
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1. Introduction

Concrete is one of the most widely utilised building materials in the globe. It is the next commonest used resource in communities worldwide after water [1]. It is normally produced using ordinary Portland cement (OPC), that consumes a lot of energy and releases an equal amount of carbon dioxide (CO_2) into the atmosphere [2]. As a result of this carbon dioxide emission, the greenhouse effect increases, causing global warming. Davidovits developed geopolymer concrete, which totally replaces cement with industrial by-products [3]. Industrial waste materials possessing a high alumina and silica content, such as flyash, metakaolin, GGBS, etc., are polymerized to manufacture geopolymer concrete. Through polycondensation, these aluminosilicate compounds become a dimensionally stable structure at low temperatures [4 5]. Fresh concrete must be compacted and placed in the formwork by skilled workers. To achieve a uniform mix with no voids (honey-comb), this compaction principally attempts to reduce the entrapped air within freshly laid concrete. Normal vibrating concrete might not be able to display the necessary fresh and hardened qualities once the concrete is being poured and compacted at the construction area. Skilled work is necessary to achieve proper compaction in freshly mixed concrete. Introducing self-compacting concrete (SCC) stands one way to solve this issue [6 7]. Modern concrete that could compact under its own weight in deep, narrow segments that are heavily reinforced to fill the formwork is known as self-compacting concrete (SCC)[8]. This study examines how the properties of flyash-based SCGPC are influenced by the molarity of sodium hydroxide in both the fresh and hardening states.

2. Materials

2.1. Flyash

In the present investigation, Class – F flyash is used which is collected from Rayalaseema Thermal Power Plant (RTTP), Kadapa, India. Flyash is confirming to IS: 3812:2003 [9]. The flyash has a specific gravity of 2.24. It has Blaine's fineness about 310 m^2/kg. Table 1 provides information on the chemical composition of fly ash.

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Table 1
Chemical Composition of Flyash.

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	SO_3	L.O. I	K_2O	Na_2O
Flyash (%)	65.60	20.86	4.98	1.0	0.55	0.5	0.2	0.16	0.82	0.20

2.2. Alkaline activation solution

In the current investigation, sodium hydroxide and sodium silicate solutions are employed to produce alkaline activators. While the ratios of sodium silicate to sodium hydroxide (Na_2SiO_3/NaOH) was kept at 2, the sodium hydroxide solution molarity (NaOH) is altered from 8 M to 16 M. To reduce the amount of heat created during the mixing procedure, the prepared alkaline solution is given 24 h to cool and mature.

2.3. Aggregates

In the current study, all of these flyash-based SCGPC mixtures contained fine aggregate made of natural river sand from the Tungabhadra River bed and a coarse aggregate of 12.5 mm downsize. Both the jelly and river sand are available locally. The used fine aggregate and coarse aggregate had specific gravities of 2.60 and 2.64, respectively. In accordance with the results of the sieve analysis, the fine and coarse aggregates utilised in this work both meet the requirements of IS: 383–1970 [10 11].

2.4. Superplasticizer

The Master Glenium series superplasticizer was utilised in the current investigation. It is a modified polycarboxilic ether-based admixture. It was created to improve the qualities of newly-poured and hardened high performance concrete. Given that it is free of chlorides and alkalis, it is suitable with all types of cement. Since it is devoid of chlorides and alkali, it can be used with any type of cement. Its relative density is approximately 1.09, in accordance with IS 9103:1999 [12].

3. Mix design of flyash based self compacting geopolymer concrete

Flyash based SCGPC mix design is solely distinct from cement concrete. The trial-and-error process was employed to produce flyash based SCGPC mix. Five flyash based SCGPC mixes were made by raising the molarity of Sodium Hydroxide (NaOH) solution from 8 M until16M. The total binder content was fixed at 496.55 kg/m^3, and the Liquid-to-binder (L/B) mass ratio was kept at 0.45. In line with the binder's molarities by mass, as stated in Table 2, a superplasticizer (S.P.) content of 1.5% and additional water content were used.

3.1. Mixing, casting and curing

In the pan mixer, the dry components of flyash based SCGPC i.e., fine aggregate, coarse aggregate and flyash were mixed about 2–3 mins. Then the liquid portion of the mixture i.e., The NaOH along with Na_2SiO_3 solution is mixed in the proportion of 1:2 (by weight) to produce alkali activator fluid. Super Plasticizer and Water are added at last for the perfect blending of flyash based SCGPC[5]. These all materials are allowed to mix for another 2–3 min. The newly mixed fresh concrete was examined for fresh flowability properties before being placed into the moulds. Prior to testing, all specimens are stored at room temperature (27 ± 2 °C).

3.2. Testing methods

3.2.1. Fresh properties

The fresh properties of flyash-based SCGPC mixes are assessed using slump flow, T_{50cm} slump flow, L-box, and V-funnel tests. The filling capacity of new concrete was determined by using slump flow test. The T_{50cm} slump flow test was used to determine a mixture's filling capacity by measuring how long it took for the mixture to expand to a diameter of 50 cm. The L-box test was used to determine whether concrete could withstand the reinforcement. The concrete heights at the horizontal component's (H_2) and the vertical section's (H_1) leading ends are measured for the L-box test. The viscosity and filling capacity of the concrete were evaluated using the V-funnel test. Each test was performed in compliance with the recommendations of the EFNARC [13].

3.2.2. Mechanical properties

Using the IS 516 (1959), IS 5816 (1999), and IS 516 (1959) standards, the compressive strength, split tensile strength, and flexure strength were assessed [14 15]. The cube compression, flexural strength and splitting tensile strengths of the flyash-based SCGPC were evaluated using three 150 mm × 150 mm cubes, three 500 mm × 150 mm prisms and three 150 mm × 300 mm cylinders.

4. Results and discussion

4.1. Slump flow and T_{50cm} slump flow test

Table 3, Fig. 1 and Fig. 2 clearly show the values for the rheological properties (slump flow values and T_{50cm} slump flow) of flyash based SCGPC mixes. The slump flow values and T_{50cm} slump flow for flyash based SCGPC mixes were in the ranging of 690 to 720 mm and 2.3 to 3.51 sec, respectively. At 8 M the maximum slump was measured, and the lowest slump was measured at 16 M. When the level of NaOH concentration was increased from

Table 2
Mix proportions for flyash based self compacting geopolymer concrete.

Mix designation	Molarity	Fly Ash (Kg/m^3)	F.A (Kg/m^3)	C.A (Kg/m^3)	NaOH Pellets (Kg)	Water (lit)	NaOH (Kg/m^3)	Na_2SiO_3 (Kg/m^3)	SP (%)	Extra Water Added (%)
M1	8 M	496.55	756	924	19.52	54.98	74.5	148.9	1.5	12
M2	10 M	496.55	756	924	22.12	52.06	74.5	148.9	1.5	12
M3	12 M	496.55	756	924	26.89	47.6	74.5	148.9	1.5	12
M4	14 M	496.55	756	924	29.87	44.62	74.5	148.9	1.5	12
M5	16 M	496.55	756	924	33.07	41.45	74.5	148.9	1.5	12

Table 3
Fresh Properties of flyash based SCGPC mixes.

S.No.	Mix Designation	Molarity	Slump Flow	T_{50} cm Slump flow	V-funnel	L-box
1	M1	8 M	720	2.3	7.5	0.95
2	M2	10 M	715	2.49	7.8	0.91
3	M3	12 M	710	3.06	7.9	0.89
4	M4	14 M	695	3.2	8.2	0.86
5	M5	16 M	690	3.51	8.4	0.84

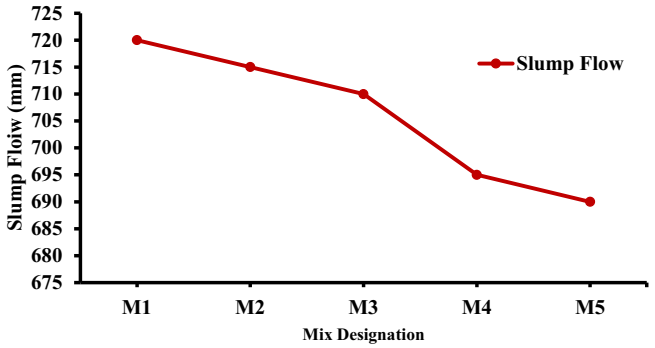


Fig. 1. Variation of Slump flow with different Sodium Hydroxide solution molarities.

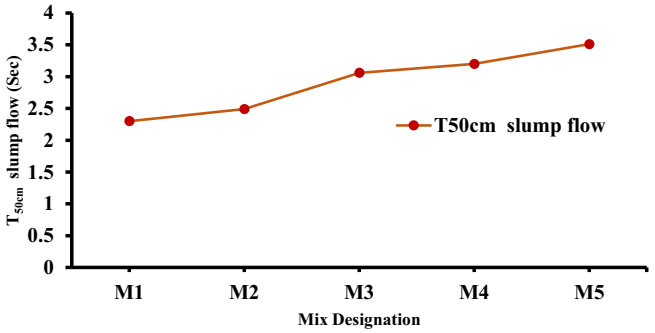


Fig. 2. Variation of T_{50cm} slump flow with different Sodium Hydroxide solution molarities.

8 M to 16 M, the slump flow was found to be reduced. All of the mixes constituted with higher molarity concentrations had lower slump flows. High T_{50cm} slump flow readings were also a result of a higher NaOH molar content. It has been observed that as the NaOH concentration rises, the slump value gradually decreases. This might be caused by the alkaline activator solution's high viscosity [16 17]. All mixes, however, conformed with the EFNARC, 2002[13].

4.2. V-funnel test

Table 3 tabulates the time taken for the V-funnel test and presented in Fig. 3, which shows that the time rose from 7.5 to 8.4 sec. As the concentration of NaOH rose from 8 M to 16 M, All V-funnel values were found to be less than 12 s and within the range of EFNARC, 2002.[13].As the amount of sodium hydroxide in the solution rises, so does its viscosity. Flyash-based self-compacting geopolymer concrete's flowability reduced as sodium concentration rose. As a result, the flow period of the V-funnel was extended.

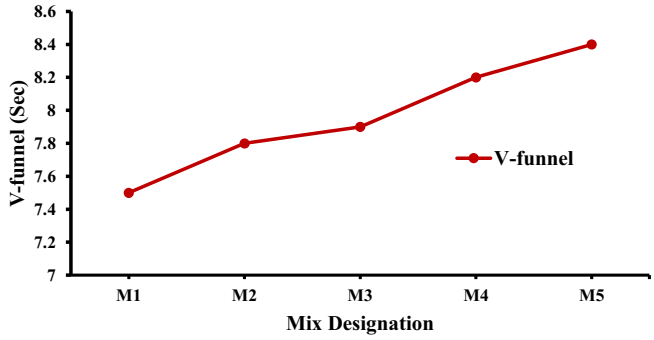


Fig. 3. Variation of V-funnel with different Sodium Hydroxide solution molarities.

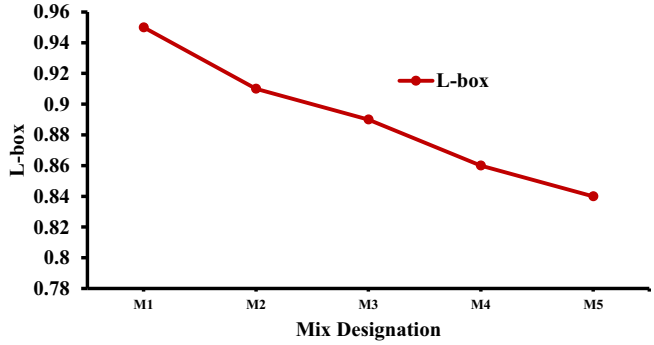


Fig. 4. Variation of L-Box with different Sodium Hydroxide solution molarities.

4.3. L-box test

The passing-ability (L-box) values are presented in Table 3 and Fig. 4. The results indicate that, regardless of the sodium hydroxide concentration, all flyash-based SCGPC mixes satisfied the L-Box ratio requirements of EFNARC [13]. The ratio of L-box dramatically declines with increased sodium hydroxide solution concentrations, as indicated in Table 3. For different concentrations of Sodium Hydroxide between 8 M and 16 M, the L-Box values varied from 0.95 to 0.84, respectively. The L-Box test results from the previous researchers' studies of three different sodium hydroxide solution concentrations (8 M, 10 M, and 12 M) in SCGPC combinations were very similar [16]. It was noticed that the L-Box values significantly decreased when sodium hydroxide concentration and molarity increased.

4.4. Compressive strength test

The results of the compressive strength test are listed in Table 4 and Fig. 5 shows how, after 7,28 days, the molarity of the NaOH solution influenced the compressive strength of the flyash-based SCGPC. The test findings demonstrated that the molarity of the sodium hydroxide solution has a significant impact on the flyash-based self-compacting geopolymer concrete. The flyash-based

Table 4
Hardened Properties of flyash based SCGPC mixes.

S.No.	Mix Designation	Molarity	Compressive Strength (MPa)		Split Tensile Strength (MPa)	Flexural Strength (MPa)
			7 days	28 days		
1	M1	8 M	17.15	25.74	2.56	3.22
2	M2	10 M	19.34	28.56	2.79	3.52
3	M3	12 M	22.34	31.94	3.12	4.05
4	M4	14 M	22.84	33.63	3.29	4.12
5	M5	16 M	23.33	34.9	3.42	4.22

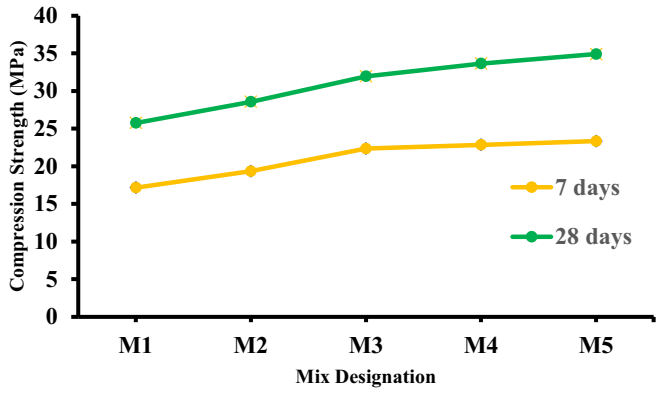


Fig. 5. Effect of NaOH solution molarity on Compressive Strength of SCGPC.

SCGPC gets harder when NaOH molar concentration rises from 8 Molarity to 16 Molarity. At 28 days, the combination with 16 M showed the highest compressive strength (34.9 MPa). When compared to flyash based SCGPC mix of 8 M, compressive strength increased by 10.95%, 24.08%, 30.65%, and 35.58%, respectively, for flyash based SCGPC mixes of 10 M, 12 M, 14 M, and 16 M. This might be the case because raising the molarity of NaOH enhances the pace at which aluminosilicate minerals dissolve, which enhances the geopolymerization process. This improvement in compressive strength characteristics is consistent with a number of previous research [18].

4.5. Split tensile strength test

Fig. 6 and Table 4 depicts the flyash-based SCGPC's split tensile strength test outcomes after 28 days. This graph clearly illustrates that as the molarity of the sodium hydroxide solution increases, the split tensile strength of the flyash-based SCGPC also increases. When compared to flyash-based SCGPC mix of 8 M, the improvement in split tensile strength is approximately 8.98%, 21.87%, 28.51%, and 33.59% for mixtures of 10 M, 12 M, 14 M, and 16 M, respectively. The split tensile test results validate the behaviour of the compressive strength test results.

4.6. Flexure strength test

At 28 days after casting, the results of the flexural strength test for the flyash-based SCGPC are displayed in Fig. 7 and Table 4. This graph unequivocally demonstrates that the flyash-based SCGPC's flexural strength increases as the molarity of the sodium hydroxide solution rises. Flyash-based SCGPC mixes of 10 M, 12 M, 14 M, and 16 M each had an increase in flexural strength of about 9.31%, 25.77%, 27.95%, and 31.05% when compared to flyash-based SCGPC mixes of 8 M. The behaviour of the compressive strength test findings is complemented by the flexural strength test results.

4.7. Effect of NaOH solution molarity

The workability of the mixture is found to be significantly reduced by a molarity rise. This is due to the alkaline activators (NaOH and Na_2SiO_3) greater viscosity in comparison to water. The viscosity of the NaOH solution increased as the molarity of NaOH increased. Additionally, the decrease in water levels caused by raising the molarity of NaOH lowers the workability of SCGPC. Increased sodium hydroxide solution concentrations hasten the polymeric reaction, which decreases workability by expediting the setting and hardening process [19]. This may also be because flyash based SCGPC that was sticky and cohesive was produced when the little fly ash particles were combined with viscous alkaline activators. Similar findings were reported by the previous researchers [20,21].

5. Conclusions

1. Flyash based SCGPC blends made by varying NaOH solution concentrations varying from 8 M to 16 M has achieved the desired fresh properties confirming to EFNARC guidelines[13].

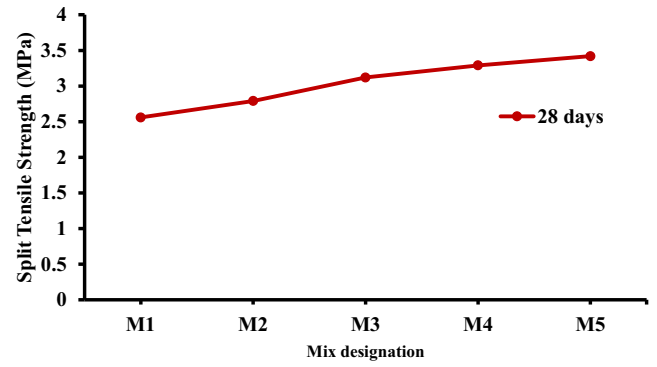


Fig. 6. Variation of Split Tensile Strength w.r.t different Molarities.

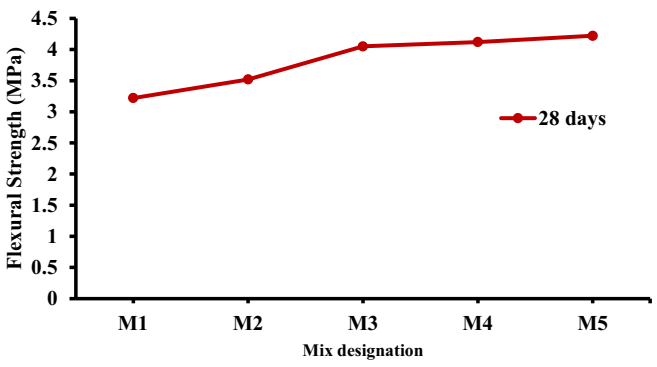


Fig. 7. Variation of Flexural Strength w.r.t different Molarities.

2. The molarity of the NaOH solution had a substantial impact on the strength of flyash-based SCGPC that was cured at room temperature.
3. The compressive strength of flyash based SCGPC increased by approximately 35.58% when the molar concentration of the NaOH was rose from 8 M to 16 M.
4. However, as the molar concentration of NaOH rose from 8 M to 16 M, the splitting tensile strength and flexural strength of flyash-based SCGPC improved by around 33.59% and 31.05%, respectively.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Role of Hard and Soft Skills in the Library Profession and Identifying Opportunities forImprovement and Growth: A Study

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Abstract

This study was conducted to explain the role of hard skills and soft skills in the Library Profession. An online questionnaire was designed for this purpose and circulated to 185 LIS professionals working in various libraries of Andhra Pradesh.165 responses received out of 185 total. The overall user response rate 89.18%. The information is presented in the form of tables and evaluated using a basic measurement process. A good number of Librarians are implementing soft skills to meet the information needs of their users as well as to satisfy them with their service. Though they are facing some challenges in implementing sift skills, they do not underestimate the value of all skills and try to practice by avoiding all challenges.

Keywords: *Hard Skills, Soft Skills, Intrapersonal Soft Skills, Interpersonal Soft Skills, Library Profession*

Introduction

The fundamental hard and soft skills that librarians need to effectively carry out their duties are known as librarian skills. Hard skills include role-specific competencies like using library software, managing digital databases for cataloguing, and other technical skills. Librarians can enhance and broaden their hard skills through webinars, online courses, and training programs. Soft skills are the actions and personal qualities that librarians employ to build positive relationships with their clients, colleagues, and other staff members.Sorting and organizing information in various formats for easy access is the art and science of librarianship.The 21st century's information and communication technology breakthroughs, along with the ever-changing information habits of library users, need library staff to provide state-of-the-art services that are customized to match user needs. These days, a highly

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Assessment Of Soil Erosion Risk Within A Small-Watershed Nandivargam, Nandyal District, India. Using Revised Universal Soil Loss Equation (RUSLE): A Remote Sensing & GIS Approach.

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Abstract
This study aims to assess soil erosion risk within the small-watershed of Nandivargam in Nandyal district, India, utilizing the Revised Universal Soil Loss Equation (RUSLE) model along with a remote sensing and Geographic Information System (GIS) approach. The RUSLE model, widely recognized for estimating soil loss and serving as the basis for global soil loss models, has undergone numerous modifications over time. The specific focus of this study is on estimating yearly soil loss in the Nandivargam small-watershed. The researchers utilized GIS and remote sensing technologies, along with the RUSLE model, to accomplish this objective. To do this, they incorporated various GIS data layers, such as rainfall erosivity (R), slope length and steepness (LS), land cover management (C), soil erodibility (K), and conservation practice (P), to analyze their respective impacts on soil loss. The findings of the study revealed an estimated annual potential soil loss of approximately 3974.7 t/yr (240.0244 km^2) within the Nandivargam small-watershed. This information provides valuable insights into the extent of soil erosion in the area and can contribute to the development of effective soil conservation strategies and land management practices to mitigate erosion impacts.

Keywords: Revised Universal Soil Loss Equation (RUSLE), Geographic Information System (GIS), remote sensing (RS), Nandivargam watershed; Soil erosion.

I. Introduction

Soil erosion is one of the major issues with land degradation in agriculture and is now recognised as a serious environmental threat [18]. Soil erosion also contributes to the degradation of land resources globally. A danger to regional water quality and sustainable agricultural output, soil erosion is typically linked to agricultural practices in tropical and semi-arid countries. It causes a reduction in soil fertility and a host of other detrimental effects on the environment. 5334 million tons of soil are reportedly removed from India each year for a variety of causes [16], [17]. In recent years, as part of the environment and land degradation assessment policy for sustainable agriculture and development, soil erosion is increasingly more being diagnosed as a threat that's more serious in mountain regions [14], [2], [1], [4], and [24]. To ensure effective management strategies, a quantitative assessment is essential for determining the scope and severity of soil erosion issues. However, the intricate nature of the variables involved makes it challenging to accurately estimate or predict erosion. Fortunately, recent advancements in spatial information technology have enhanced existing methods and provided efficient approaches for monitoring, analyzing, and managing Earth's resources. By leveraging tools such as digital elevation models (DEMs), along with remote sensing data and geographic information systems (GIS), it is possible to swiftly and comprehensively assess erosion hazards, enabling both rapid and detailed evaluations. [7], [22], [10]. Spatial and quantitative data regarding soil erosion at a small-watershed level play a significant role in the development of plans for soil conservation, erosion control, and overall management of the watershed environment. The outcomes of the estimation of soil loss in the small-watersheds had been done on an experimental foundation in lots of tropical regions the usage of unique techniques of prediction [21], [5], [27]. In this scope of study, the Revised

Universal Soil Loss Equation (RUSLE) was applied within a Geographic Information System (GIS) framework to predict potential annual soil losses in the Nandivargam small-watershed in Nandyal district, India. The utilization of remote sensing and GIS techniques has proven to be invaluable, particularly when evaluating erosion on a larger scale, due to the extensive data requirements and broader area coverage involved. For this reason use of these techniques have been widely adopted and currently there are several studies that show the potential of remote sensing techniques integrated with GIS in soil erosion mapping. The primary aim of this study was to estimate soil loss by employing the Revised Universal Soil Loss Equation (RUSLE) model, utilizing input parameters generated through remote sensing and GIS techniques. These input parameters encompassed factors such as soil erodibility, topography, land use practices, and crop management.

II. Geographical of the Study Area

The study area selected for assessing soil erosion vulnerability is the Nandivargam small-watershed shown in (Fig-01), which is part Nandyal district, India. The study area extends between latitudes 15°22' 30"N to 15°32'30"N and longitudes 78° 7' 30"E to 78°25'0"E, the covering an area of 240.72 km^2. The mean elevation of the study area is 425 meters above mean sea level. It experiences a dry climate with an annual & annual average rainfall of 1273mm and 902mm respectively. The mean minimum and maximum temperatures are 21.9 ºC and 38.5 ºC, respectively. Located in the Kundu river basin, also known as Kunderu, Kumurdruthi, it is a tributary of the Penna River in the Rayalaseema region of India. The Kundu valley, known as Renadu, is associated with the term "Renati Pourusham." The Kundu River's flood plains cover an area of around 6,000 acres (24 km^2). The study area encompasses the Kunderu river valley, situated between the Erramala and Nallamala hills, forming the western and eastern boundaries, respectively. It includes the entire Koilakuntla and parts of Nandikotkur, Nandyal, Allagadda, and Banaganapalle. The Kunderu River, a tributary of the River Penner, flows southward through the central part of the region. The Madduleru and Jurreru rivers in the west, and the Galeru and Vakkileru Rivers in the east, are the main tributaries of the Kunderu River [11]. The region has an average slope ranging between 200 and 300 meters.

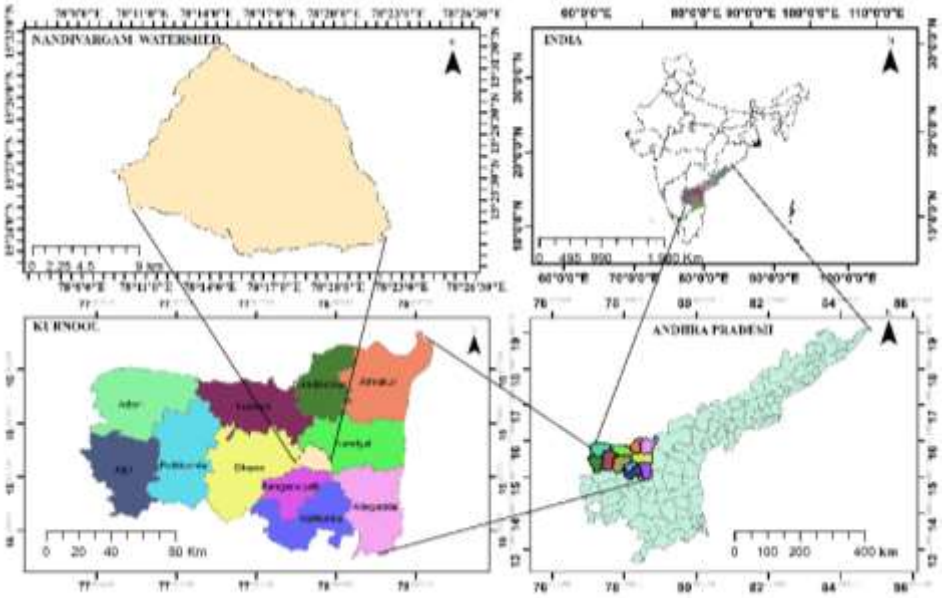


Figure 01: Location map of the study area of

The main objective of this research is to investigate the specific form of land degradation that has occurred within the designated study region. To investigate the changes in vegetation resulting from mining activities within the area, to evaluate the endeavours made by the inhabitants in restoring and reclaiming the mined areas, and to investigate additional modifications induced by mining activities on the physical environment.

III. Materials & Methodology

3.1 Annual soil loss estimation method

The source of organisation of data for study area shown in (Table -01) to estimate the soil erosion in the small- watershed

S.No.	Source	Map	Description
1	Topo-sheet / Spatial Data	Study area boundary	Watershed boundary.
2	Rainfall data (IMD) & Rainfall Erosivity of world	Rainfall data & Erosivity map GloRED	Rainfall map was used to calculate the R-factor
3	Digital soil Map of the World (DSMW)	Soil map	Soil map was used for calculation of K-factor
4	ASTER GDEM	Digital elevation model (DEM)	Digital elevation map (DEM) and LS-factor
5	Satellite imagery -10m Sentinel – 2 LA2 Thematic	Land use / land cover (LULC)	LULC map was used for calculation of P-factor and C-factor

Table 1: Data collected to estimate soil erosion using from source.

3.2. The generation of RUSLE factors through the processing of data.

Data processing and generation of Revised Universal Soil Loss Equation (RUSLE) factors (Fig-02) were carried out using a combination of high-resolution (ASTER) Global Digital Elevation Model (GDEM) data with a 30 m resolution and various techniques for extracting topographic information of hydrological interest directly from the Digital Elevation Model (DEM). These techniques, based on established studies by [8], [12], [15], [13], encompassed the extraction of slope properties, catchment areas, drainage divides, and channel networks. To calculate the soil erodibility (K-factor), the FAO Digital Soil Map of the World (DSMW) was utilized. Rainfall data from the Indian Meteorological Department (IMD) were used to determine the rainfall erosivity (R-factor). Base map delineation of the watershed boundary and processing of Landsat-8 data enabled the acquisition of land use and land cover (LULC) information. The Survey of India (SOI) topographic maps at a scale of 1:50,000 were utilized for the georeferencing of satellite data, ensuring spatial alignment of the satellite imagery. The coverage of the image corresponded to an area of 240.03 Km^2. GIS software version 10.8 was employed for generating the digital coverage of input parameters required for the erosion model. The Revised Universal Soil Loss Equation (RUSLE) was applied to determine the soil loss of the watershed. Certain modifications were made to the parameter estimation process of the RUSLE

equation to better align with Indian conditions. The Revised Universal Soil Loss Equation (1) (RUSLE) is as follows:

$$A=R\times K\times LS\times C\times P \quad \text{---------- (1)}$$

Where, A is average annual soil loss ((t ha^{-1} yr^{-1}), R is the Rainfall and Runoff erosivity factor in MJ·mm·ha^{-1} ·h^{-1} ·y^{-1}, K is the soil Erodibility factor (t h $MJ^{-1}mm^{-1}$. LS is the Slope and Length of Slope Factor; C is the dimensionless Cropping Management (range between 0 and1) Factor; P is the supporting conservation practice factor (range between 0 and1).

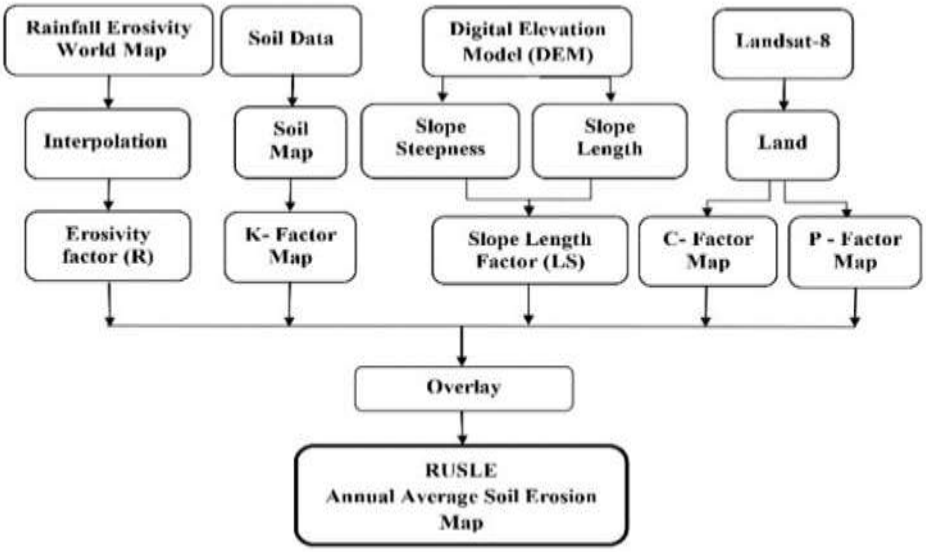


Figure 02: Factors for evaluating erosion in an incorporated integrated assessment framework.

3.2.1. Rainfall erosivity (R):

The rainfall factor, an index unit, is a measure of the erosive force of a specific rainfall. This is determined as a function of the volume, intensity and duration of rainfall and can be computed from a single storm, or a series of storms to include cumulative erosivity from any time period. Raindrop/splash erosion is the dominant type of erosion in barren soil surfaces. Rainfall data of 40 years (1982-2021) collected from Indian Meteorological Department (IMD) were used for calculating R-factor using the following relationship developed by [28] and modified by [3], this modified formula incorporates only annual and monthly precipitation data to calculate the R factor. The Global Rainfall Erosivity Database, named hereafter as GloRED a, contains erosivity values were used for calculating R-factor using the following relationship equation (2) provided below.

$$R = \sum_{i=1}^{12} 1.735 \times 10\,(1.5 \times log_{10}\left(\frac{p_i^2}{p}\right) - 0.08188\Big) \quad \text{---------- (2)}$$

Here R is the rainfall erosivity factor (MJ mm ha^{-1} h^{-1} yr^{-1}), P_i is the monthly rainfall (mm), and P is the annual rainfall (mm). For the present analysis, R-factor for the Nandivargam small-watershed was computed from available gridded rainfall data, because the watershed has no record of daily rainfall intensity. For assessing the spatial variability in rainfall, the ArcGIS software was utilized employing spatial interpolation techniques. While assessing the R-factor, it was found that, the variation of R-factor among the rain gauge stations were in the limit of ±3. To enhance the reliability of the R-factor

value, the spatial distribution of R was computed based on the available rainfall data. The average R value obtained from this calculation was then utilized for further analysis. The highest value (946.743 MJ mm ha^{-1} h^{-1} yr^{-1}) of R-factor was observed and the lowest value (758.87 MJ mm ha^{-1} h^{-1} yr^{-1}) (Fig-03). Factors for evaluating erosion in an incorporated integrated assessment framework.

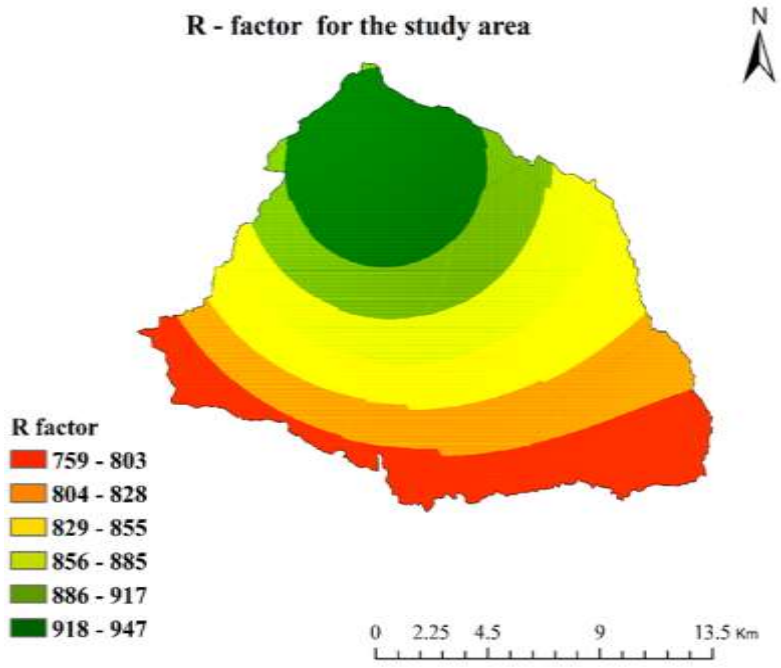


Figure 03: R - Factor for the study area (Rainfall erosivity)

3.4 Soil Erodibility Factor (K)

K is the soil erodibility factor is the average soil loss in tons/hectare for a particular soil in cultivated, continuous fallow with an arbitrarily selected slope length of 22.13 m and slope steepness of 9 %. K is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter and permeability also contribute [23]. The soil erodibility value typically falls within the range of 0 to 1, where 0 represents low sensitivity to erosion for a soil class, while 1 indicates a high susceptibility of the soil class to water erosion (Fig-04). The K factor value was derived by applying a formula adapted from existing published literature, with the FAO systematized digital soil map as follows [26]. The calculation of this factor is made as follows according to [27] equation (3–7).

$$K_{USLE} = K_W = F_{csand} \text{ X } F_{cl\text{-}si} \text{ X } F_{orgc} \text{ X } F_{hisand} \quad \text{----- (3)}$$

$$F_{csand} = \left(0.2 + 0.3 \times \exp\left[-0.256 \times m_s \times \left(1 - \frac{m_{silt}}{100}\right)\right]\right) \quad \text{----- (4)}$$

$$F_{cl-si} = \left(\frac{m_{silt}}{(m_c + m_{silt})}\right) \quad \text{----- (5)}$$

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$$F_{orgc} = \left(1 - \frac{0.25 oegC}{orgC + \exp[3.72 - 2.95 \times orgC}\right) \quad \text{----- (6)}$$

$$\mathrm{F_{hisand}} = \left(1 - \frac{0.7 \times \left(1 - \frac{m_s}{100}\right)}{\left(1 - \frac{m_s}{100}\right) + exp[\,-5.51 + 22.9\left(1 - \frac{m_s}{100}\right)}\right) \quad \text{---- (7)}$$

FAO Digital Soil Map of the World (DSMW) in ESRI shape file format was utilized to create a K factor map. The estimated K values for the different textural groups range from 0.13 t hMJ^{-1} mm^{-1} for sandy clay loam to 0.14 t hMJ^{-1} mm^{-1} sandy clay soil.

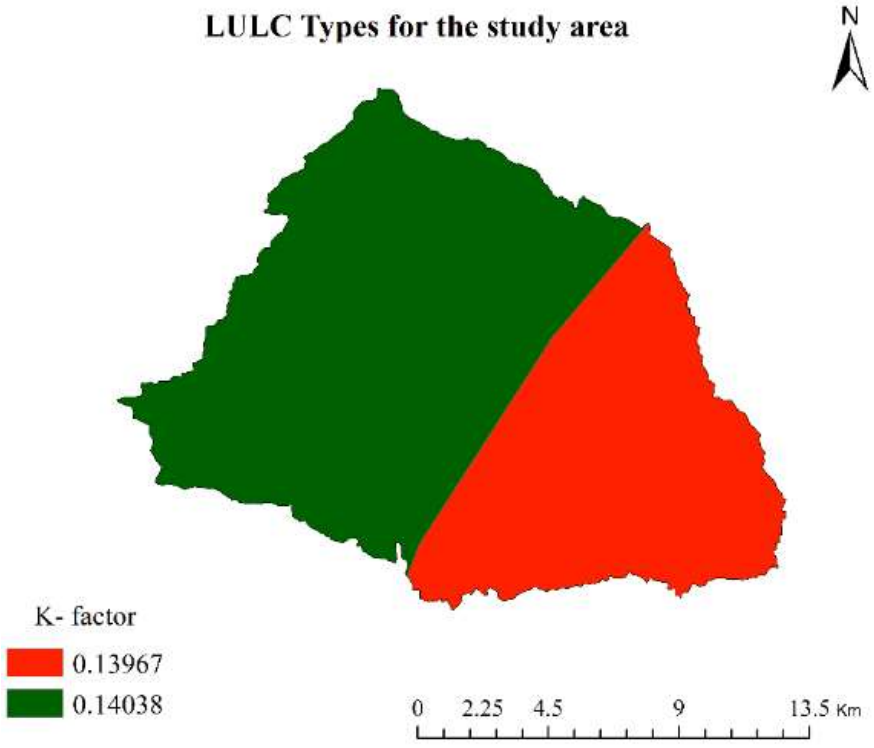


Figure 2: K – Factor for Study Area (Soil Erodibility)

3.5 Slope length and steepness factor (LS):

Slope Length and Steepness Factor (LS) LS-factor symbolizes the impact of slope length (L) and its steepness (S) on the soil erosion. The LS-factor in the Revised Universal Soil Loss Equation (RUSLE) represents the ratio of soil loss on a specific slope length and steepness to the overall soil loss [19], [25]. In this study, we used a digital elevation model (DEM) with 30 m resolution obtained from the Advanced Space borne Thermal Emission and Reflection Radiometer Global. Digital Elevation Model ASTER-GDEM was utilized within the ArcGIS 10.8, compute the LS-factor in the model maker. The LS-factor was calculated using equation (8) as follows:

$$\mathrm{LS} = \left[\frac{Flow\ accumulation \times Cell\ size}{22.13}\right]^{0.4} \times \left[\frac{(sinslope)}{0.0896}\right]^{1.3} \quad \text{----- (9)}$$

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Where flow accumulation denotes the accumulated upslope contributing area for a given cell and was derived from DEM having cell size 30 m and sin slope is nothing but sin of slope angle in degrees. LS = combined slope length and slope steepness factor, cell size = size of grid cell (for this study 30 m) and sin slope = slope degree value in sin. The LS factor value in the study area varies from 0 to 155 (Fig-05). The Majority of the study area has LS value ranges between 0 and 15.2.

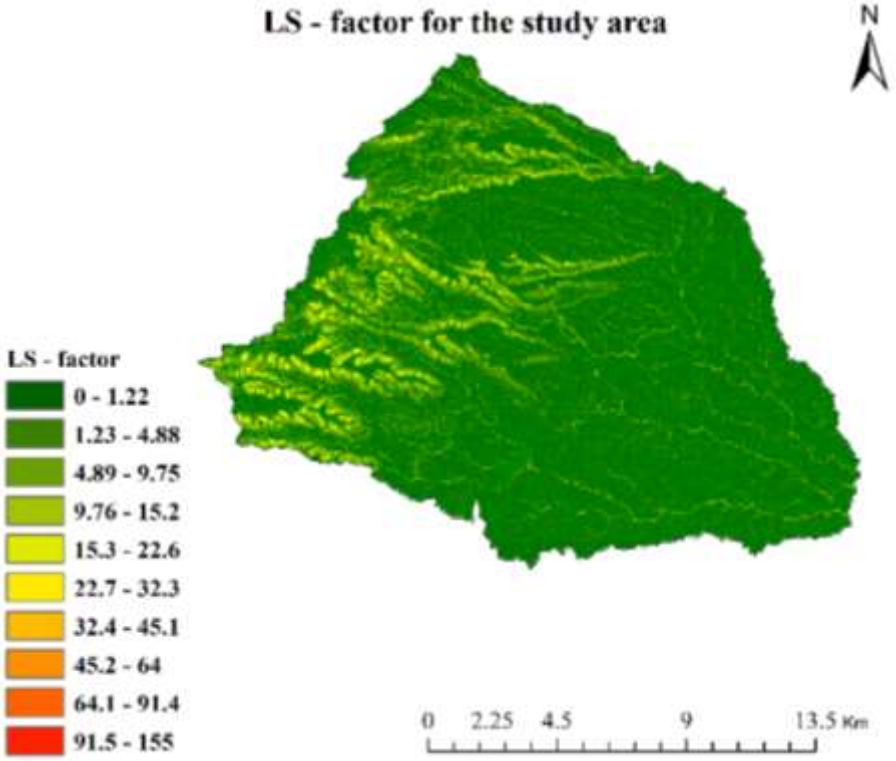


Figure 05: LS- Factor for the study area (Slope length)

3.6 Cropping Management Factor (C)

The C-factor is the most significant parameter for crop management but is not present for all Indian crops. Thus, C-factor founded [9], was used to estimate the rate of soil erosion in agricultural fields. The ground covered by vegetation canopy reduces the rate of soil erosion in the forested area. According to [6], crop cover is a potent tool for reducing the direct effect of rainfall on soil erosion, and he suggested that through the use of appropriate land reclamation techniques, bare land should be turned into agricultural land or a forest plantation. The values of the C-factor depend on seasonal changes as it varies with different parameters, such as crop types, rainfall, agriculture practice, etc. The C-factor was calculated based on the study area's LULC classification (Table-02). The overall accuracy of the classification Nandivargam watershed was classified into five LULC classes: built-up area, forest area, water body, agriculture lands, and land with and without scrubs, (Fig-06). Landsat 8 image was classified using supervised classification technique in GIS 10.8 software. The supervised classification technique requires ground truth information for each LULC.

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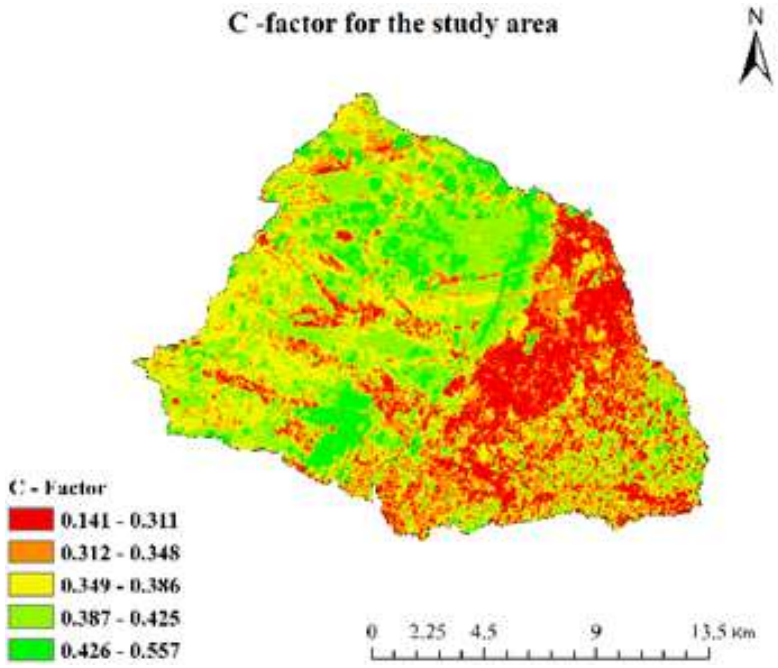


Figure 06: C- Factor for the study area

3.7 Conservation Practice Factor (P)

The P factor represents the ratio of soil loss with a specific support practice to the corresponding soil loss without support measures, specifically considering tillage practices on upslope and downslope areas [20].

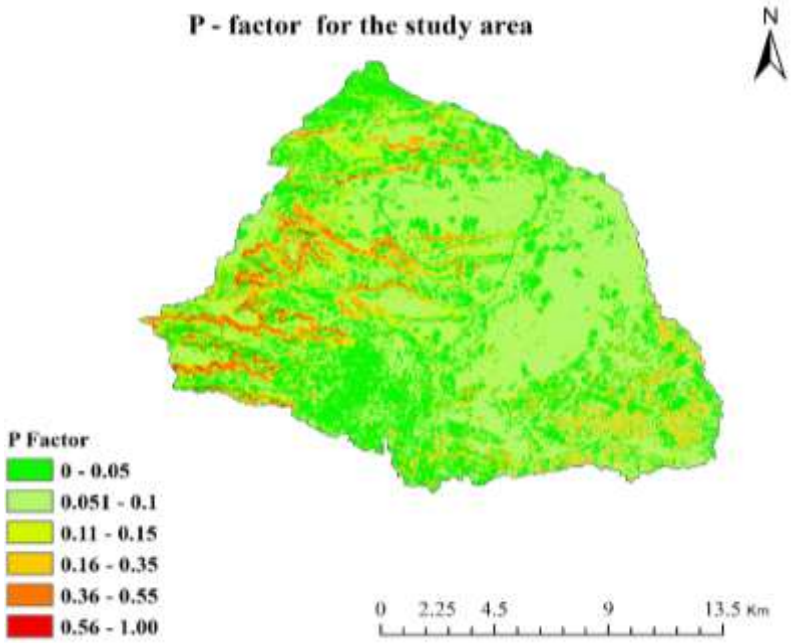


Figure 07: P- Factor for the study area (Conservation Practice)

Typically, the conservation practice factor adjusts the estimation of the Revised Universal Soil Loss Equation (RUSLE) to account for management and tillage practices that protect the soil from erosion. The P factor accounts for control practices that reduce the erosion potential of the runoff by their influence on drainage patterns, runoff concentration, runoff velocity, and hydraulic forces exerted by runoff on soil. The value of P factor ranges from 0 to 1, the value approaching to 0 indicates good conservation practice and the value approaching to 1 indicates poor conservation practice. In this study, the P factor map was generated based on land use/land cover and support factors. The values of the P factor range from 0.05 to 1, as depicted in (Fig-07). Higher values are assigned to areas where no conservation practices are implemented, while lower values correspond to built-up areas and plantations employing strip and contour cropping techniques.

4. Results and Discussion:

Average Annual Soil Loss the data layers (Maps) extracted for the R, K, LS, C, and P factors of the RUSLE model was performed using Equation (1) within the raster calculator option of the ArcGIS spatial analyst. This process allowed for the quantification, evaluation, and generation of maps depicting soil erosion risk and severity within the Nandivargam Small-watershed. The estimated (A) values obtained indicate the rate of sediment yield, with higher values representing a higher rate and lower values indicating a lower rate. Based on the analysis, the Nandivargam small-watershed was classified into five soil erosion risk categories, as shown in (Fig-08). The distribution and proportion of soil erosion risk classes are presented in (Table 3). The minimum and maximum soil losses were found to be approximately 31.17 $t \cdot ha^{-1} \cdot y^{-1}$ and 3974.7 $t \cdot ha^{-1} \cdot y^{-1}$, respectively. Approximately 94.11% (226.544 km^2) of the watershed falls within the range of 0 $t \cdot ha^{-1} \cdot y^{-1}$ and 31.17 $t \cdot ha^{-1} \cdot y^{-1}$, indicating varying degrees of soil erosion within the study area. The results presented in show that about 94.11% of the study area is classified as medium potential erosion risk (31.17t h^{-1} y^{-1}) erosion risk levels. The spatial pattern of classified soil erosion risk zones indicates that the areas with high and severe erosion risk are located (Table-04).

Table 3. Classification of soil loss of sub - watershed according to area of Nandivargam

Soil Loss ($t \cdot ha^{-1} \cdot y^{-1}$)	**Area (km^2)**	**Area (%)**
0 - 31.17	226.54	94.11
31.18 - 124.7	9.008	3.74
124.71 - 249.39	4.149	1.72
249.4 - 405.26	0.090	0.038
> 405.27	0.002	0.02
Total	**240.72**	**100**

Table 4. Classification of erosion risk

Erosion Rick Class	Soil loss ($t.ha^{-1}.y^{-1}$)
Medium	0-31.12
High	31.18-124.70
Very High	124.71 - 249.39
Very High	249.4 - 405.26
Very High	>405.27

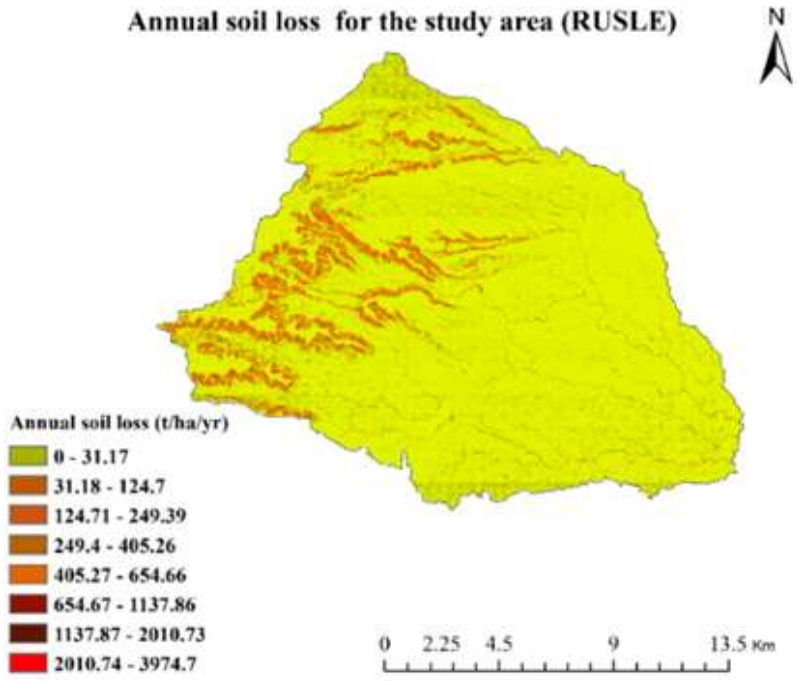


Figure 08: Soil erosion

5. Conclusion:

This study successfully utilized the Revised Universal Soil Loss Equation (RUSLE) and GIS to assess soil erosion in the Nandivargam small-watershed. Key factors driving erosion were identified as steep slopes, slope morphology, soil erodibility, and plant cover. Rainfall and runoff played significant roles in soil detachment and erosion. To mitigate soil loss and restore the watershed's functionality, comprehensive measures are required. GIS effectively managed and analyzed land degradation data, providing a comprehensive understanding of erosion processes. Medium land degradation affected 94.11% (226.54 km^2) of the study area due to rainfall, while mining activities degraded 5.89% (14.18 km^2). Mining led to land disturbance, pits, overburden dumps, altered drainage, and waterway obstruction. Deforestation, gully erosion, and drainage alteration were observed, reflecting the community's response to economic expansion and environmental challenges. This highlights the interconnectedness between human activities and soil degradation, emphasizing the importance of sustainable land management. The study demonstrates the effectiveness of GIS in simulating and mapping soil erosion, supporting decision-making and erosion control strategies. To address soil

erosion in the Nandivargam small-watershed, the following measures are recommended: prioritize soil conservation in erosion-prone areas through measures like terraces, contour plowing, and vegetative strategies such as cover crops and grass strips; improve plant cover through reforestation, afforestation, and sustainable agricultural practices; encourage responsible mining techniques that minimize land disturbance, ensure proper waste disposal, and rehabilitate mined areas; implement effective water management practices, including drainage systems, retention ponds, and sedimentation prevention measures; conduct educational programs, workshops, and outreach activities to raise awareness and involve communities in soil conservation; establish a monitoring system to assess the effectiveness of measures and track changes in soil erosion patterns; foster collaboration among government agencies, local communities, researchers, and NGOs to achieve coordinated erosion control efforts.

Abbreviations:

GIS: Geographic Information System; IMD: Indian Meteorological Department; LULC: Land use/land cover; RS: Remote Sensing; RUSLE: Revised Universal Soil Loss Equation; t.ha.h/ha.MJ.mm: ton hectare hour / hectare mega joule millimetre; GDEM: Global Digital Elevation Model.

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AN EXPERIMENTAL INVESTIGATION ON POLYPROPYLENE FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH ALCCOFINE

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ABSTRACT: *In this experimental investigation an attempt was made to study the feasibility and effectiveness of integrating Alccofine as a supplementary material in Polypropylene Fiber Reinforced Concrete of grade M25. Various concrete mixes with Alccofine substitution (5%, 10%, and 15%) were examined to determine the optimal percentage. The addition of Polypropylene fibers to concrete at 0.1%, 0.2%, 0.3%, and 0.4% by weight of concrete were prepared to determine the optimum dosage of Polypropylene fibres in concrete which is replaced with optimum Alccofine percentage. These fibers help control cracking from plastic and drying shrinkage, reduce concrete permeability, and enhance impact strength. Addition of Polypropylene fibres transforms the material from brittle to ductile. The study includes determination of compressive strength, split tensile strength, flexural strength and impact characteristics. The findings reveal that a combination of 10% Alccofine substitution along with 0.3% Polypropylene fibers leads to notable enhancement 45.3%, 35.6%, 16.67%, and 191% in compressive, split tensile, flexural, and impact strength, respectively, compared to control concrete. Based on the results it can be concluded that the combination of 10% Alccofine and 0.3% Polypropylene fibers in concrete significantly improves both the strength properties and impact strength of the concrete in comparison to control concrete.*

Keywords: ***Polypropylene Fiber Reinforced concrete, Alccofine, impact characteristics, impact strength***

1. Introduction

The modern construction constantly evolves to meet the demands of sustainable development and enhanced performance. Conventional concrete compositions often rely heavily on Portland cement, a material associated with significant carbon emissions during its production. To address environmental concerns and improve concrete properties, innovative solutions such as Alccofine as partial replacement for cement offers multifaceted benefits. By reducing the cement content, these materials help lower carbon emissions associated with concrete production, aligning with sustainability objectives. Moreover, to enhance the mechanical properties and Impact characteristics of concrete, resulting in structures that exhibit superior performance and longevity. Polypropylene fibers, derived from a thermoplastic polymer, is increasingly recognized for its ability to enhance the impact strength of concrete. When dispersed within the concrete matrix, these fibers act as reinforcement, improving tensile strength, crack resistance, and Impact characteristics. Additionally, Polypropylene fibers mitigate plastic shrinkage cracking and improve Impact strength, making them invaluable in various construction applications. Alccofine, a supplementary cementitious material, offers a sustainable alternative to conventional cement. Produced from finely ground aluminosilicate materials, Alccofine possesses pozzolanic properties that react with calcium hydroxide forming additional calcium silicate hydrate (C-S-H) gel. This reaction not only contributes to the densification of the concrete matrix but also enhances long-term strength of the concrete. Furthermore, Alccofine reduces the heat of hydration and mitigates alkali-silica reaction, thus improving the overall sustainability and performance of concrete structures. In this investigation the effects of incorporating Polypropylene fibers and Alccofine

in concrete. The research highlights the impact of these materials on concrete properties and their role in advancing sustainable construction practice.

2. Objectives

The main objective of the present experimental investigation is to obtain the influence of the combined application of Alccofine and Polypropylene fiber on various strength properties and impact characteristics of M25 grade concrete. It consists of following:

I. To find the optimum percentage of partial replacement of cement with Alccofine and.

II. To prepare Fiber Reinforced Concrete with addition of Polypropylene fibres at 0.1%, 0.2%, 0.3%, and 0.4% by weight of concrete to determine the optimum dosage of Polypropylene fibres in concrete which is replaced by optimum percentage of Alccofine.

3. Materials

The following materials were used in the experimental investigation:

3.1 Cement

The cement used in this experimental investigation is OPC 53 grade conforming to IS:269-2015. The specific gravity of the cement is 3.14.

3.2 Alccofine - 1203

Alccofine - 1203 is a specially processed product based on high glass content with high reactivity obtained through the process of controlled granulation. The raw materials are composed primary of low calcium silicates. The processing with other select ingredients results in controlled particle size distribution. Alccofine-1203 is a new generation, micro fine material of particle size much finer than materials like cement, fly ash, silica etc. Alccofine-1203 has unique characteristics to enhance performance of concrete in fresh and hardened stages due to its optimized particle size distribution. which is being manufactured in India. The chemical properties of Alccofine-1203 are shown in Table 1.

Table 1 Chemical Properties of Alccofine - 1203

S. No.	Chemical compound	Value
1	Alumina as Al_2O_3, % by mass	22.4
2	Silicon dioxide as SiO_2, % by mass	35.1
3	Magnesium Oxide as MgO, % by mass	6.1
4	Total Sulphur as SO_3, % by mass	0.15
5	CaO, % by mass	33.1

3.3 Fine Aggregate

Locally available river sand confirming to IS 383-2016 specifications was used as the fine aggregate in the concrete. Fine aggregate is an accumulation of grains of mineral matter derived from the disintegration of rocks. The physical properties of Fine aggregate are shown in Table 2.

Table 2 Physical properties of Fine aggregate

S. No.	PROPERTIES	VALUES
1	Specific gravity	2.55
2	Fineness modulus	3.79
3	Water absorption (%)	0.9
4	Dry Rodded Unit Weight(kg/m^3)	1486

3.4 Coarse Aggregate

Coarse aggregate of nominal size 20 mm, obtained from the local quarry confirming to IS 383 -2016 specifications were used. Proportion of coarse aggregate was used 20mm (60%) and 12.5mm (40%). Machine crushed granite broken stone angular in shape was used as coarse aggregate. The maximum size of coarse aggregate was 20 mm. The properties of coarse aggregate are shown in Table 3.

Table 3 Properties of coarse aggregate 20mm and 12mm

S. No.	PROPERTIES	20mm size of aggregate	12mm size of aggregate
1	Bulk density	1.50	1.45
2	Specific gravity	2.66	2.68
3	Apparent Specific gravity	2.63	2.65
4	Water Absorption	0.32%	0.35%
5	Impact value	15.51	15.57

3.5 Polypropylene Fibre

In this Project Polypropylene fibres used are available with brand name as FIBERCRETE. FIBERCRETE MF is a Synthetic monofilament fiber for concrete reinforcement that complies with standard specification for Fiber Reinforced Concrete and Shotcrete, and is specifically designed to help mitigate the formation of shrinkage cracking in concrete. The properties of Polypropylene fibers are given in Table 4.

Table 4 Properties of Polypropylene Fiber

Specification	Value
Material	100% Virgin Polypropylene
Specific gravity	0.91
Diameter / thickness	20 Microns
Fiber length	36mm
Aspect ratio	>300
Tensile strength	1000 MPa
Youngs modulus	4GPa
Water absorption	Nil

3.6 Water

In this experimental investigation tap water is used for both concrete mixing and curing purposes.

4. Experimental Program

4.1 Concrete Mix Design

Bureau of Indian standards recommended a set of procedures for design of concrete mix mainly based on the work done in national laboratories. The mix design procedures are covered in IS10262-2019. Their methods can be applied for both medium and high strength concrete.

4.2 Mix Proportioning for Concrete of M25 Grade:

Cement : 325 kg/m^3

Water : 163 liters

Fine aggregate : 699 kg

Coarse aggregate : 1179 kg

Water – cement ratio : 0.50

In the present experimental investigation, initially M25 grade controlled concrete mix was prepared using cement. Then the cement has been replaced by Alccofine at 5%, 10% and 15%. To find the optimum percentage of Alccofine as mentioned in the Table 5.

Table 5 percentage replacement of alccofine with cement

Mix ID / Materials	AL0	AL5	AL10	AL15
Cement %	100	95	90	85
Alccofine %	-	5	10	15

There after addition of Polypropylene fibers by weight of concrete in varying percentages of 0.1%, 0.2%, 0.3% and 0.4% (termed as PF0.1, PF0.2, PF0.3 and PF0.4 respectively) which is replaced by optimum percentage Alccofine.

4.3 Impact Characteristics

Impact Characteristics of concrete is assessed usually by the ability of a concrete specimen to withstand repeated blows and to absorb energy. Impact strength of Portland cement concrete (PCC) is an essential property in various applications of PCC, such as industrial floors, hydraulic structures, and explosion-proof structures.

Impact strength: Resistance to sudden shock or load.

4.3.1 Drop-Weight Impact Strength Test

This test yields the number of blows necessary to cause prescribed levels of distress in the test specimen. This number serves as a qualitative estimate of the energy absorbed by the specimen at the levels of distress specified. The test can be used to compare the relative merits of different fibre-concrete mixtures and to demonstrate the improved performance of FRC compared to conventional concrete. It can also be adapted to show the relative impact resistance of different material thicknesses.

4.3.1.1 Equipment

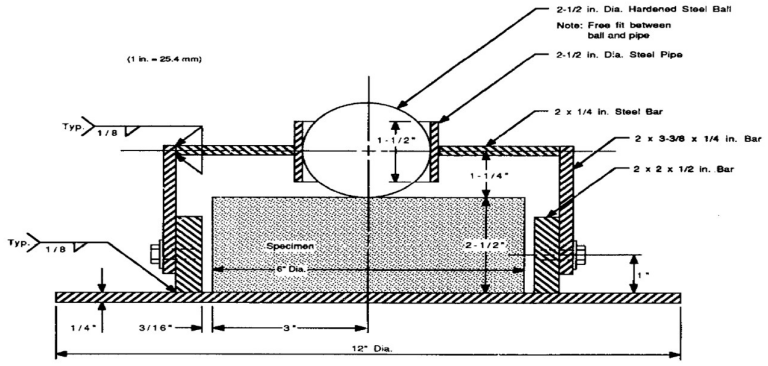


Fig.1 schematical diagram of the drop weight impact test on concrete.

Referring to Fig. 1 the equipment for the drop-weight impact test consists of:

1. A standard, manually operated 10 lb (4.54 kg) compaction hammer with an 18-in. (457-mm) drop (ASTM),
2. A 21/2 in. (63.5 mm) diameter hardened steel ball,
3. A flat baseplate with positioning bracket similar to that shown in fig.1

In addition to this equipment, a mold to cast 6 in. (152 mm) diameter by 21/2 in. (63.5 mm) thick [±1/8 in., ± (3 mm)] concrete specimens are needed. This can be accomplished by using standard ASTM C 31 or C 470 molds or the concrete test specimens can be cut of 64mm from a cylindrical mold oh height 300mm as shown in fig. 2.

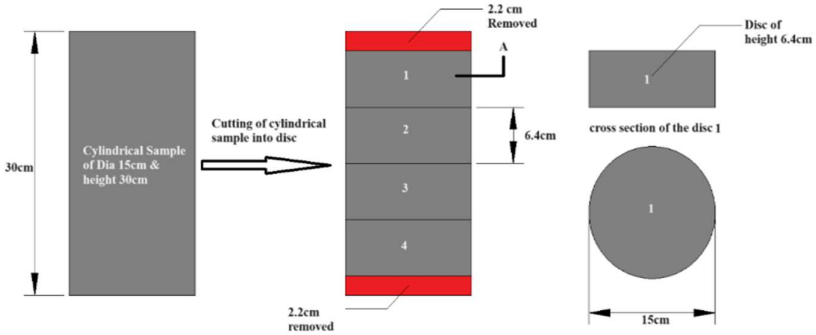


Fig.2 Cutting Process of Cylindrical Disc From Whole Cylindrical Specimen

4.3.1.2 Procedure

The 21/2 in. (63.5 mm) thick by 6 in. (152 mm) diameter concrete samples are made in molds according to procedures recommended for compressive cylinders but using only one layer. The molds can be filled partially to the 21/2 in. (63.5 mm) depth and float finished, or they can be sawn from full-size cylinders to yield a specimen size of the proper thickness. Specimens cut from full-size cylinders are preferred. If fibres longer than 0.80 in. (20 mm) are used, the test specimen should be cut from a full-size cylinder to minimize preferential fiber alignment. Specimens should be tested at 7, 28, and (if desired) 90 days of age. Curing and handling of the specimens should be similar to that used for compressive cylinders. Accelerated curing is not desirable. The thickness of the specimens should be recorded to the nearest 1/16 in. (1.5 mm).

The positioning bracket is then bolted in place, and the hardened steel ball is placed on top of the specimen within the bracket. Foamed elastomer pieces are placed between the specimen and positioning

lugs to restrict movement of the specimen during testing to the first visible crack. The drop hammer is placed with its base upon the steel ball and held there with just enough down pressure to keep it from bouncing off the ball during the test. The baseplate should be bolted to a rigid base, such as a concrete floor or cast concrete block. An automated system with a counter may also be used. The hammer is dropped repeatedly, and the number of blows required to cause the first visible crack on the top and to cause ultimate failure are both recorded.

5. Results and Discussion

5.1 Compressive Strength

The cube compressive strength of concrete at 3 days, 7 days and 28 days for different mixes are mentioned in Table 6. The development of compressive strength with their age for different mixes was plotted as shown in Fig.3 From the results obtained, the maximum cube compressive strength of 53.81 MPa was observed in AL10PF0.3 mix. Which is the optimal combination of both Alccofine and Polypropylene fibers, results in significant increases of 45.3% in compressive strength compared to control concrete.

Table 6 Compressive Strength of all mixes

Age / Concrete mix	3 days strength (MPa)	7 days strength (MPa)	28 days strength (MPa)
AL0	24.4	29.57	37.03
AL5	29.38	34.97	41.08
AL10	29.88	38.99	50.04
AL15	27.69	38.58	46.45
AL10PF0.1	31.54	39.87	51.68
AL10PF0.2	33.68	41.96	53.45
AL10PF0.3	35.92	43.71	53.81
AL10PF0.4	32.17	41.08	52.71

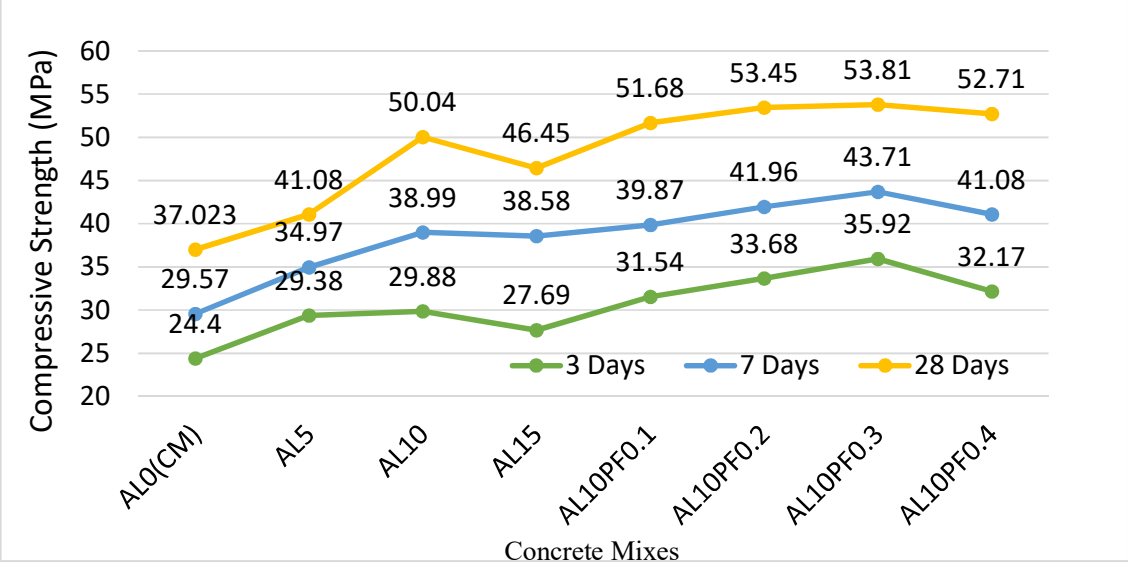


Fig. 3 Variation of Compressive Strength of Various Mix Proportions

5.2 Split Tensile Strength

The Split Tensile Strength of concrete at 28 days for different replacement and addition fibres for different mixes was plotted as shown in Fig.4. The maximum cylinder split tensile strength of 3.39 MPa was observed in AL10PF0.3 mix. Which is the optimal combination of both Alccofine and Polypropylene fibers, results in significant increases of 35.6% in split tensile strength compared to control concrete.

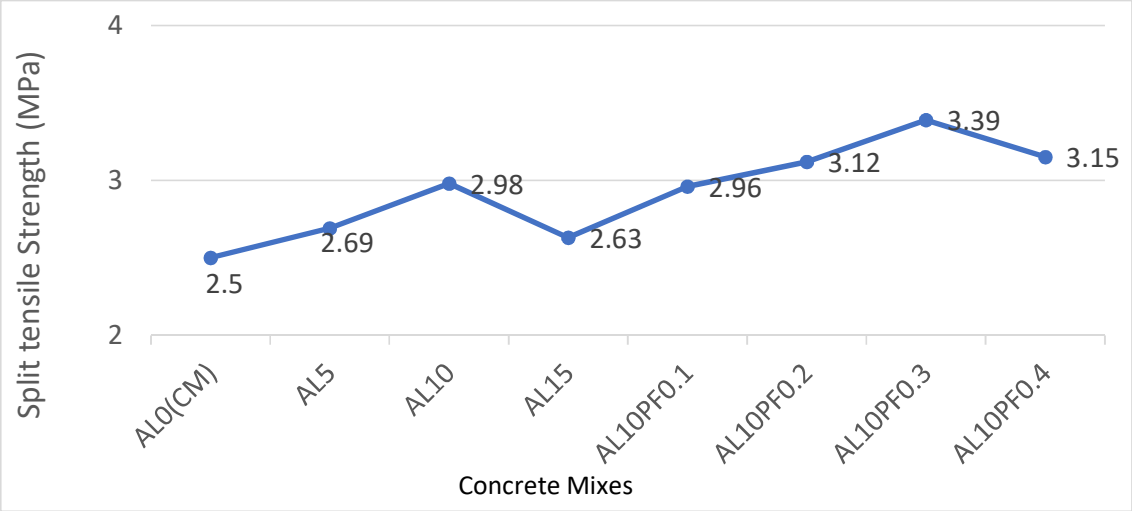


Fig.4 Variation of Split Tensile Strength of Concrete with Various Mix Proportions

5.3 Flexural Strength

The development of flexural strength at 28 days for different mixes was plotted as shown in Fig.5. The maximum flexural strength of 6.79 MPa was observed in AL10PF0.3 mix. Which is the optimal combination of both Alccofine and Polypropylene fibers, results in significant increases of 16.67% in flexural strength compared to control concrete.

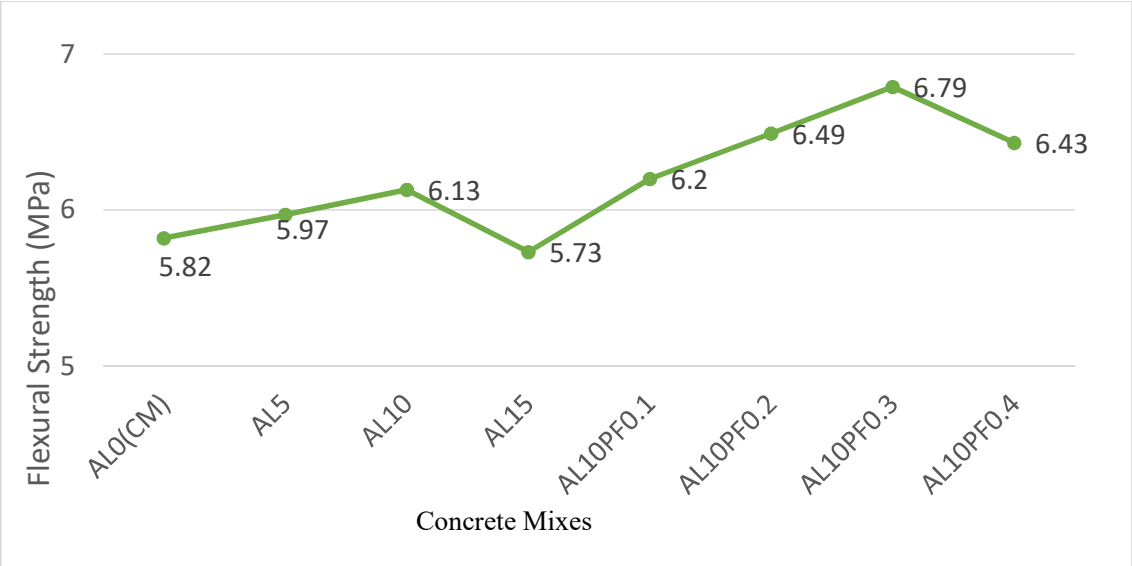


Fig. 5 Variation of Flexural Strength of Concrete with Various Mix Proportions

5.4 Impact Strength

For each mixture and 28 days curing condition, 3 discs were cut from whole cylinder and tested for the drop-weight impact load. The number of blows required for the appearance of the first crack and for the final failure was determined in the tests.

5.4.1 Impact test on control mix concrete AL0

Table 7 no. of blows taken by the concrete specimen of control mix concrete

Sample	Sample 1	Sample 2	Sample 3	Average
No. of blows	112	118	105	112

5.4.2 10% replacement of cement with Alccofine AL10

Table 8 no. of blows taken by the concrete specimen of 10% replacement of cement with Alccofine

Sample	Sample 1	Sample 2	Sample 3	Average
No. of blows	142	138	141	141

5.4.3 Impact test on concrete containing 0.3% Polypropylene fibers & 10% replacement of cement with Alccofine AL10PF0.3

Table 9 no. of blows taken by the concrete specimen containing 0.3% Polypropylene fibers & 10% replacement of cement with Alccofine

Sample	Sample 1	Sample 2	Sample 3	Average
No. of blows for 1st visible crack	290	338	274	301
No. of blows for failure of sample	311	366	306	327

5.4.4 Crack Pattren

It is very important to understand the characteristics of cracks of Polypropylene fiber reinforced concrete under impact loads for practical applications. Base on the test results, it can be concluded that the formation of a common type of radial crack pattern, initiated from the point of impact and extend toward outer periphery of the test specimens. These cracks form due to the development of tensile stress caused by the impact force. Radial cracks of brittle nature were observed in case of control concrete which possess low tensile/flexural strength. Additionally, spalling of concrete of the test specimens was also observed which indicates the detachment of fragments of concrete from the point of impact. It can also be observed that the radial cracks propagate very fast, leading to failure with very less number of blows after initiation of cracks in control concrete as shown in Fig. 6.

But, in case of Polypropylene fibre reinforced concrete specimen prepared with 0.3% Polypropylene fibers and 10% replacement of cement with Alccofines absorbs higher number of blows and absorb more impact energy before failure after the initiation of radial crack as shown in Fig. 7. This can be

attributed to the Polypropylene fibre reinforced concrete with enhanced resistance to crack propagation and failure compared to the control concrete specimen.





Fig. 6 Failure of AL0 (control concrete) specimens **Fig.7 Failure of AL10PF0.3 specimens**

5.4.5 Impact Energy (J)

The impact resistance of the specimen was determined after 28 days. The impact energy delivered to the specimen is calculated by Energy absorbed = NMgh

where,

N - number of blows
M - mass of the drop hammer (kg) = 4.5 kg
g - gravity acceleration (m/s2) = 9.81
h - height of drop hammer = 0.457 m

Table 10 impact energy absorbed by the various mixes

Type of concrete mix	Avg. No of blows for failure of specimen	Avg. Total energy absorbed by the concrete specimen Joule (KJ)
Control mix concrete	112	2.2
10% replacement of cement with Alccofine	141	2.8
Addition of 0.3% of Polypropylene fibers & 10% replacement of cement with Alccofine	327	6.6

It is observed that the addition of Polypropylene fibers significantly increases the absorption of impact energy. The optimal combination, Alccofine and Polypropylene fibers, results in significant increases of 191% in impact strength compared to control concrete.

6. Conclusions

The Conclusions from the present research work are summarized below:

1. This study explores enhancing the strength properties of M25 grade concrete with Polypropylene fibers and Alccofine as partial cement replacement.
2. Addition of Polypropylene fibers enhances its impact strength.

3. A 10% replacement of cement with Alccofine improves the compressive, split tensile, flexural, and impact strengths by 35%, 19.2%, 5.3%, and 25%, respectively, compared to the control concrete.
4. Addition of 0.3% Polypropylene fibers along with the 10% Alccofine cement concrete further improves compressive, split tensile, flexural, and impact strengths with increases of 7.5%, 13.7%, 10.7%, and 131%, respectively.
5. The optimal combination, Alccofine and Polypropylene fibers, results in significant increases of 45.3%, 35.6%, 16.67%, and 191% in compressive, split tensile, flexural, and impact strengths compared to control concrete.
6. Polypropylene fibers delay crack initiation and propagation, enhancing impact energy absorption.
7. Alccofine proves effective as a supplementary material, enhancing both mechanical properties and impact characteristics of Polypropylene fiber concrete.

Overall, this research demonstrates the potential of Alccofine as a sustainable additive in Polypropylene fiber concrete.

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An Experimental Investigation on Glass Fiber Concrete by Partial Replacement of Cement with Alccofine

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Abstract: Concrete is the most widely used construction material due to its strength, durability, and versatility. However, the production of cement, which is a key component of concrete, is a major contributor to greenhouse gas emission. The use of supplementary Cementitious materials (SCMs) can improve the properties of concrete, reduce use on natural resources and CO_2 emissions. The present study is directed to investigate the effect of Alccofine-1203 (AL) as partial replacement of cement on Glass Fibers (GF) reinforced M30 grade concrete. Different types of concrete mixes were prepared by replacing cement with Alccofine-1203 of 5%, 10% and 15%, respectively, then it is found to be the optimum percentage of replacement of cement with Alccofine-1203 is 10%. Further, the effect of Alccofine and Glass Fiber with different combinations, such as, 10%AL+0.1%GF, 10%AL+0.2%GF, and 10%AL+0.3%GF was also carried out. Based on the test results of Mechanical properties of concrete the optimum dosage is found to be 10% AL and 0.2% GF.

Keywords: Alccofine-1203, Glass fibre, Compressive strength, Split tensile strength, Flexural strength, Modulus of Elasticity .

1. INTRODUCTION

Cement is the most prevalent kind of concrete binder. At present sustainable development of the cement and concrete industry requires the utilization of industrial and agricultural by-products. At present, for a variety of reasons, the concrete construction industry is not sustainable. It consumes huge quantities of virgin materials and the principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. So, finding a solution to substitute for part of the cement seems to be desirable for sustainable development. In the present investigation applications ofAlccofine-1203 as partial replacement of Cement for the Glass fibers reinforced concrete is adopted.

OBJECTIVES

The main objective of the present experimental investigation is to obtain the influence of Alccofine-1203 and Glass fibre on various Mechanical properties of M30 grade concrete.

It consists of following:

- To find out optimum replacement percentage of Alccofine-1203 .
- To determine the mechanical properties such as Compressive Strength, Split Tensile Strength, Flexural Strength and Modulus of elasticity of concrete prepared using alccofine-1203 and Glass fibers and to compare with conventional concrete.

2. MATERIALS

In this experimental investigation the following materials are used

2.1 Cement:

Ordinary Portland Cement (OPC) of 53 grade confirming to IS 12269:2013 was used. The specific gravity is 3.15

2.2 Alccofine-1203:

Alccofine-1203 is a micro fine substance with a much finer particle size than other hydraulic materials developed in India, such as cement and fly ash. Alccofine-1203 is a specifically processed product made from slag with a high glass content and high reactivity achieved through the controlled granulation process. Alccofine-1203 is well-known for its capacity to improve the strength and durability of concrete, as well as minimize permeability and improve the workability of fresh concrete. The chemical properties of Alccofine-1203 as given in Table 1.

Table1:Chemical Properties of Alccofine-1203

Chemical contents	Values
CaO%	>30
SiO_2%	>30
Al_2O_3%	>20

2.3Fine Aggregate:

As per IS: 383, the river sand is conforming to Zone-I and was used as the fine aggregate in the concrete. The physical properties of Fine aggregate as given Table 2.

Table2:Properties of Fine Aggregate

S. No	Property	Value
1	Fineness modulus	2.94
2	Specific Gravity	2.50
3	Zone	I
4	Water Absorption	0.90%

2.4 Coarse aggregate:

Coarse aggregate obtained from local quarry has been used for this study, conforming to IS: 383 is used. Coarse aggregate used is of 12 mm and 20 mm size. The physical properties of Coarse aggregate are shown in Table3.

Table 3: Physical Properties of Coarse Aggregate

S. No.	Property	Value (20 mm)	Value (12 mm)
1	Fineness Modulus	7.12	6.9
2	Specific Gravity	2.65	2.81
3	Water Absorption	0.45%	0.65%

2.5 Chemical Admixture:

Polycarboxylate ether (PCE) based superplasticizers confirming IS 9001-1999(2007) with a specific gravity of 1.06 was used to get the workable concrete.

2.6 Glass Fibre:

Glass fiber is a material consisting of numerous extremely fine fibers of glass. It is formed when thin strands of silica-based or other formulation fibers of smaller diameter. It is widely accepted within the concrete industry that traditional concrete mixes are prone to plastic shrinkage during the setting phase and this can often lead to cracking. The addition of relatively small amounts of these glass fibers as reinforcement can effectively reduce this problem by controlling this early-age plastic shrinkage cracking. The Physical and Chemical properties of Glass fiber are given Table 4 and Table 5 respectively.

Table 4: Physical Properties of Glass Fiber

Properties	Values
Density	910 kg/m^3
Length	12mm
Diameter	20 microns
Aspect ratio	600
Modulus of Elasticity	72GPa
Tensile strength	1000 N/mm^2

Table 5 :Chemical Properties of Glass Fibers

Composition	Values(%)
SiO_2	65
Al_2O_3	25
MgO	10

2.7 Water:

Concrete is typically made with potable water. Water should be free of acids, oils, alkalis, vegetables, and other organic impurities. This experimental project locally available potable water for mixing and curing.

3. CONCRETE MIX DESIGN:

In the present experimental investigation M30 grade of concrete was designed in accordance with the Indian Standard code of practice IS 10262:2019. The concrete mix proportion is 1: 2.15: 3.5. with water-cement ratio as 0.45 and 330 kg of cement per 1m^3. The dosage of super plasticizer is 3.0 lit/m^3.

4. EXPERIMENTAL INVESTIGATION

4.1 Compressive Strength:

To assess the compressive strength of Concrete, test specimens of size 150 mm × 150 mm ×150mm were used. Testing of samples was carried out at 3,7 and 28 days with the help of a compressive testing machine (CTM) of 3000kN capacity as per IS 516:1959 as shown Fig 1a.

4.2Split Tensile Strength:

To assess the split tensile strength of Concrete, test specimens of size 150 mm diameter and 300 mm length were used. Testing of samples was carried out at 28 days with the help of compressive testing machine as per IS 5816:1999 as shown in Fig. 1b.

4.3 Flexural Strength:

To assess the Flexural strength of concrete, beam specimens of size 100 mm x 100 mm x 500 mm were used. Testing of samples at the age of 28 days as per IS 516:1991 as shown in Fig. 1c.

4.4 Modulus of Elasticity:

To find the Modulus of Elasticity of concrete, cylinders of size 150 mm diameter and 300 mm height were cast for each type of mix and tests were conducted on the specimens at the age of 28 days as per IS 516:1991 as shown in Fig. 1d. The load was applied gradually and the deformation was noted at regular intervals of loading. Stress and Strain curve was drawn and then the modulus of elasticity of concrete was determined.



Fig. 1a Compression test, 1b. Split tensile, 1c. Flexure test, 1d. Modulus of Elasticity

5 . RESULTS

5.1 Compressive strength :

Fig.2 shows the variation of compressive strength of different types of concrete mixes at 3, 7, and 28 days of curing. At 28 days of curing, 10%AL+0.2%GF concrete mix exhibits the compressive strength of 47.45 MPa. It can be observed that compressive strength of 10%AL+0.2%GF concrete mix is increased by 20% compared to the control concrete mix.

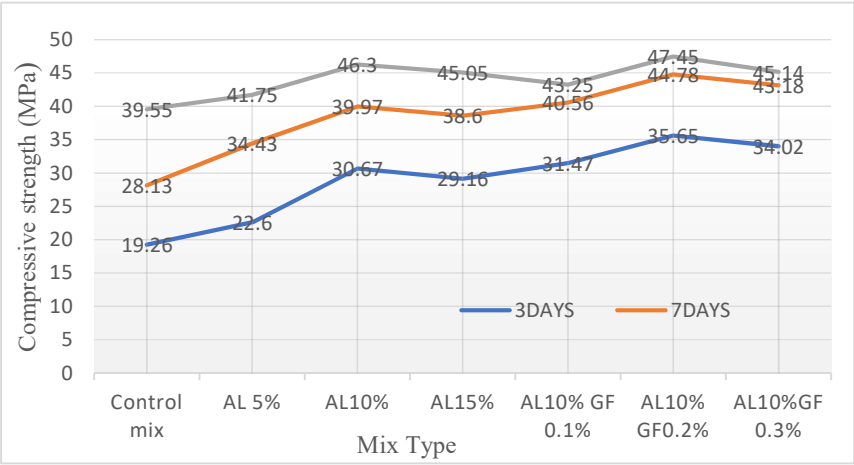


Fig.2:Variation of 3,7 and 28 Days Compressive Strength of Glass fibre Concrete using Alccofine

5.2 Split tensile strength :

Fig.3 shows the variation of split tensile strength of different mix proportions at 28 days of curing. It can be observed that the 10%AL+0.2%GF concrete mix exhibits the split tensile strength of 3.0 MPa. The split tensile strength of AL10%+GF0.2% mix is increased by 22.5% compared to the control concrete mix.

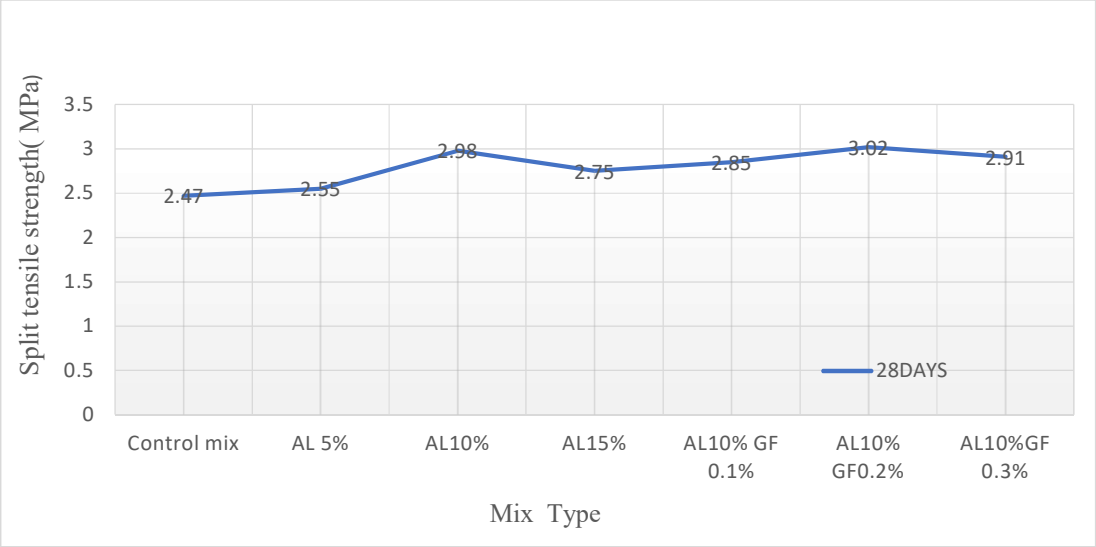


Fig.3:Variation of Split tensile strength of Glass fibre Concrete using Alccofine

5.3 Flexural strength :

Fig.4 shows the variation of flexural strength of different mix proportions at 28 days of curing. At 28 days of curing, 10%AL+0.2%GF concrete mix exhibits the flexural strength of 6.95MPa. It can be observed that Flexural strength of 10%AL+0.2%GF concrete mix is increased by 19.82% compared to the control concrete mix.

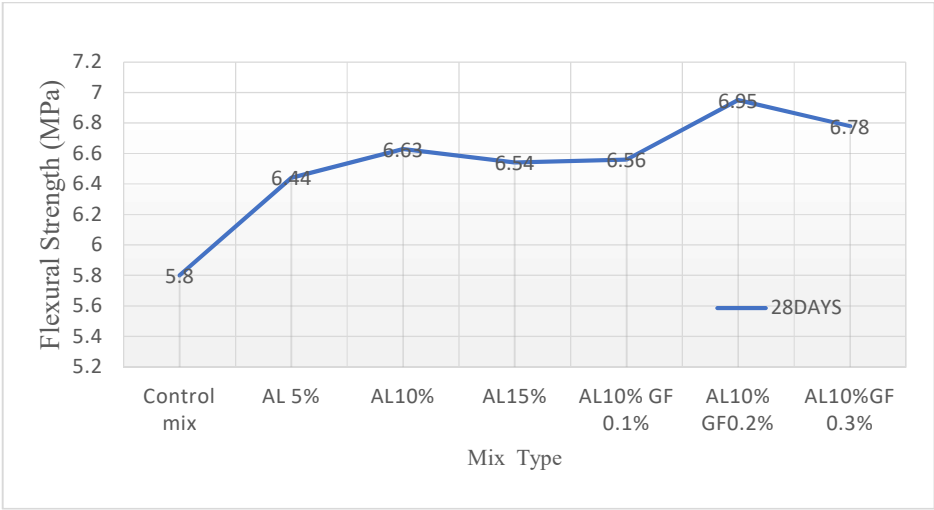


Fig.4:Variation of Flexural Strength of Glass Fibre Concrete using Alccofine

5.4 Modulus of Elasticity:

Fig.5 shows the variation of modulus of elasticity of different mix proportions at 28 days of curing. At 28 days of curing, 10%AL+0.2% GF concrete mix exhibits the modulus of elasticity of 40.34 GPa. It can be observed that Modulus of elasticity of 10%AL+0.2%GF concrete mix is increased by 37.2% compared to the control concrete mix.

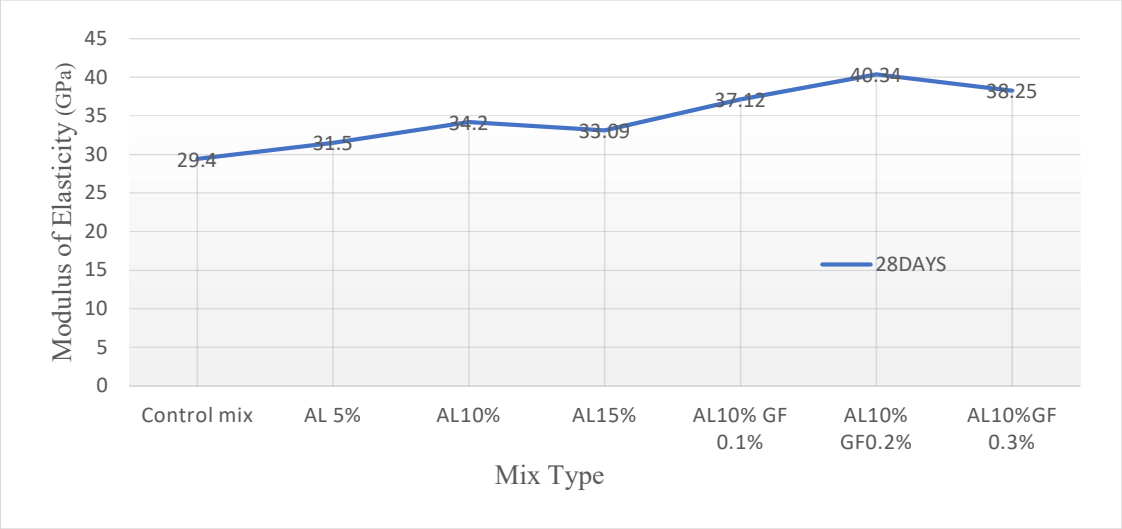


Fig.5: Variation of Modulus of Elasticity of Glass Fibre Concrete using Alccofine

6. CONCLUSIONS

In this experimental investigation, different types of concrete mixes prepared using Alccofine and Glass Fibres were considered and strength characteristics such as compressive strength, flexural strength, split tensile strength and modulus of elasticity were determined. The following are the conclusions based on the test results:

1. The compressive strength of M30 grade 0.2 % Glass Fiber concrete with replacement cement by 10% Alccofine is 47.5 MPa which is 20% more than the control concrete.

2. The Split tensile strength of M30 grade 0.2 % Glass Fiber concrete with replacement cement by 10% Alccofine is 3.0 MPa which is 22.3% more than the control concrete.

3. The flexural strength of M30 grade 0.2 % Glass Fiber concrete with replacement cement by 10% Alccofine is 6.95 MPa which is 20% more than the control concrete.

4. The percentage of increase in modulus of elasticity of M30 grade 0.2 % Glass Fiber concrete with replacement cement by 10% Alccofine is 40.34 MPa which is 37% more than the control concrete.

Based on the results of the experimental investigation, it can be concluded that the improved strength properties of M30 grade concrete is obtained with a combination of 10% replacement of cement with Alccofine and 0.2 % Glass Fibers and can be recommended for structural applications.

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RESEARCH ARTICLE

Parametric studies on the fresh, mechanical and microstructural properties of GGBS blended self compacting geopolymer concrete cured under ambient condition

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Abstract
The primary goal of the present research is to look into the rheological, mechanical as well as microstructural characteristics of flyash based self-compacting geopolymer concrete (SCGPC) comprised of the combination of fly ash and ground-granulated slag from blast furnaces (GGBS), that is cured at room temperature. GGBS is incorporated together with flyash from 0 to 50% with intervals of 10% binder concentration to make GGBS blended SCGPC. The rheological properties of GGBS blended SCGPC mixes which include slump flow, T_{50cm} slump flow, L-Box, and V-funnel are evaluated for various mixes in accordance with the EFNARC guidelines. For various GGBS blended SCGPC mixtures, mechanical characteristics such compressive strength test, split tensile strength test, and flexural strength test are also evaluated. The replacement of GGBS is optimised in accordance with the findings of mechanical and rheological characteristics. In compliance with the EFNARC guidelines, the outcomes revealed that each of the GGBS blended SCGPC mixes satisfied the fresh properties requirements, and that when GGBS was replaced with 40% of the binder, the resulting strength properties was superior to that of other GGBS blended SCGPC mixes. This article also discusses how X-ray diffraction (XRD), scanning electron microscopy (SEM) with EDAX, and Fourier Transform Infrared Spectroscopy (FTIR) techniques were carried out in order to assess the structural, morphological also mechanical characteristics of the SCGPCs. Findings show that replacement of GGBS enabled a greater degree of geopolymerization, which in turn caused the geopolymer matrix to become denser and enhance the attributes of GGBS blended SCGPC when compared to Flyash based control SCGPC.

Keywords Flyash · GGBS · Self Compacting Geopolymer Concrete (SCGPC) · Fresh properties · Mechanical properties · Microstructural properties

1 Introduction

Concrete, which has become essential in the construction sector, is mostly made of cement [1]. Making cement emits greenhouse gases onto the earth's atmosphere [2]. Cement production harms the environment because it is a major source of greenhouse gases entering the atmosphere [3]. The production of one tonne of cement (OPC) results in the release of an equal amount of carbon dioxide into the atmosphere, which accounts for roughly between five and seven percent of the global emissions of carbon dioxide (CO_2) [4]. Because of the alarming situation, There was a critical need for the cement manufacturing industry to decrease emissions of carbon dioxide (CO_2) [5]. To combat global warming, many researchers have concentrated their research to replace cement with cementitious materials. Davidovits created Geopolymers, in which cement was entirely replaced by industrial by-products [6, 7]. Geopolymers are produced by polymerizing an alkaline solution with a silicon- and aluminum-based primary material, which has the same chemical makeup as zeolites but a different kind of internal structure [8]. For the production of alumina and silica-based binders, Green Geopolymers uses binders made from inexpensive ingredients or byproducts of certain industries which include fly ash, GGBS and

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metakaolin [9]. These raw materials react with alkali-activating solvents to form a tri-alumino-silicate chain. Compounds like sodium aluminosilicate and calcium silicate hydrate are also formed during this geopolymerization which enhances mechanical characteristics, while sodium silicate hydrate creates a tetrahedral network with SiO_4 and AlO_4 [10, 11]. A shift from amorphous to semi-crystalline structures occurs as a result of a complicated chemical reaction involving binders and activators [12]. According to reports, the entire process is accelerated by curing at an elevated temperature [13, 14]. Fly ash is a type of industrial waste produced when thermal coal is burned in electricity-generating facilities [15]. Fly ash can lower carbon dioxide emissions in geopolymer concrete by a proportion of 25–45% as a result of the utilization of the combustion of coal waste [16, 17]. The majority of the byproduct material for GGBS comes from iron manufacturing facilities. CaO, MgO, SiO_2, and Al_2O_3 are all present in GGBS, a granular substance. During the activation of GGBS, the main reaction result is gel composed of calcium silicate hydrate (C-S–H gel) [18], This results in the development of adequate strength regardless of ambient curing conditions [19]. GGBS and fly ash have been extensively utilized as SCMs for research purposes due to their benefits to the mechanical characteristics of GPC, the environment, and the economy as a whole [20, 21]. The formwork must be compacted and filled with fresh concrete by trained personnel. To obtain a homogenous mixture without voids (honeycomb), The main goal of this compaction is to release the trapped air in freshly laid concrete. Normally, when being poured and consolidated at the construction location, normal vibrating concrete couldn't be capable demonstrate the appropriate fresh and toughened characteristics. In freshly mixed concrete, proper compaction requires skilled labour. One approach to resolving this problem is to use self-compacting concrete (SCC) [22, 23]. Self-compacted concrete (SCC) is an improved form of concrete owing to its own weight and can be entirely consolidated into frameworks corners. The main objective of SCC development is to achieve the best compaction and to make it easier to place concrete in crowded areas and small apertures [24–26]. The primary features of SCC is its mobility, fill and passage without any indication of separation and bleeding. Flyash based SCGPC is a pioneering concept in the building sector. As can be seen in Fig. 1, it is an upgraded form of concrete which combines all the advantages from both geopolymer concrete as well as SCC [27–29].

For instance, Flyash prolongs the time needed for the mix to set while GGBS slows down FA's development of strength. As a result, an investigation has been carried out on the control samples consisting of 100% flyash and blended mixes with FA replaced with GGBS at various percentages to a maximum of 50%. In this study, FA and GGBS will be combined in different amounts in order to produce GGBS blended SCGPC and analyse the synergistic effects of this combination. Initially, rheological and mechanical properties were assessed. Later, Microstructural experiments involving



Fig. 1 GGBS blended SCGPC production process

Table 1 Chemical and physical characteristics

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	SO_3	L.O. I	K_2O	Na_2O	Specific gravity	Blaine's fineness
Flyash (%)	65.60	20.86	4.98	1.0	0.55	0.5	0.2	0.16	0.82	0.20	2.29	319
GGBS (%)	34.40	16.39	0.69	37.12	8.30	0.74	0.49	1.64	3.63	0.35	2.84	390

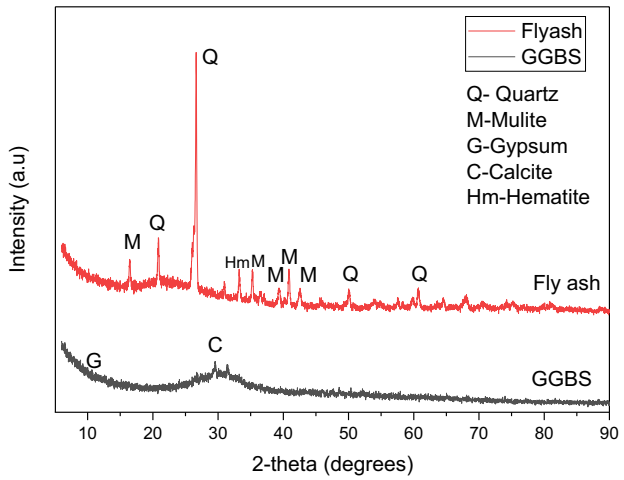


Fig. 2 XRD of flyash and GGBS

XRD, SEM, and FTIR were conducted to investigate the structural and morphologies of the flyash based control SCGPC and GGBS blended SCGPC.

2 Materials

2.1 Flyash

In this study, flyash produced by the Rayalaseema Thermal Power Generating Station (RTTP) in Kadapa, India, and compliant with Indian Standard IS: 3812:2003 [30] was used. Its widespread availability causes disposal issues in many nations, necessitating the utilization of flyash in concrete with the objective to lower the amount of CO_2 in the atmosphere. In the creation of GGBS blended SCGPC, the present study replaces cement with Class F flyash. The physical and chemical attributes of the flyash employed in the current investigation can be found Table 1. The results demonstrate that the fly ash contains silicate glass with a significant silica concentration and considerable levels of the crystalline phases quartz, mullite, and magnetite. It may be used to create SCGPC due to its SiO_2 and Al_2O_3 composition. The XRD analysis was employed to identify the crystalline phase and composition of flyash, as illustrated in Fig. 2. In the Fig. 3a SEM micrograph was used to determine the morphological characteristics of Flyash.

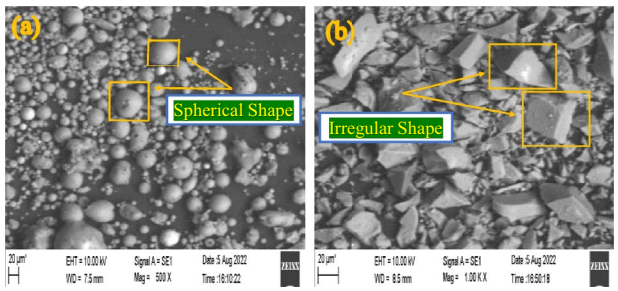


Fig. 3 SEM micrographs of **a** Flyash, **b** GGBS

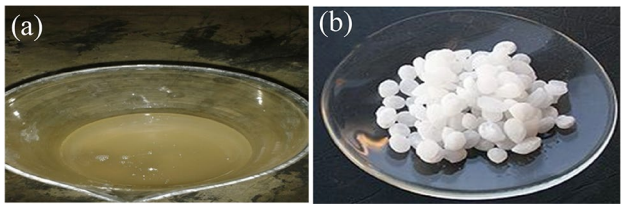


Fig. 4 **a** Sodium silicate, **b** Sodium hydroxide

2.2 GGBS

The by-product of the steel and iron processing sectors is known as GGBS. GGBS would be off-white and have better cementitious properties than other fillers. The supplier of GGBS was JSW Steel Ltd. in Bellary, Karnataka, India. It is referred to as ASTM C 989 and has high silicate and alumina content to improve the material's properties. The physical and chemical characteristics of the GGBFS provided by JSW Steel Ltd. are displayed in Table 1. As seen in Fig. 2 The crystalline structure and phase of the GGBS were determined using the XRD approach. The morphological characteristics of GGBS were determined by capturing micrographs using SEM, as illustrated in Fig. 3b.

2.3 Alkaline activator

In the current experiment, Sodium-based activators were used to produce alkaline activators, including sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) solutions from a dealer of the chemical manufacturer Astrra Chemicals in Chennai as shown in Fig. 4. while maintaining a 2:1 ratio of Na_2SiO_3 to NaOH. To lessen the amount

of heat that is generated throughout the blending process, the prepared alkaline fluid is left for twenty-four hours to settle as well as cool.

2.4 Aggregates

All of these GGBS blended SCGPC mixtures in the present study included a fine aggregate consisting of naturally existing river sand collected from the Tungabhadra Riverbank as well as coarse aggregate with an average size of approximately 12.5 mm as shown in Fig. 5. Using the findings of a sieve examination, it was discovered that the coarse and fine aggregates looked to have specific gravities of 2.64 and 2.60, respectively, and that they complied with IS: 383–1970 [31, 32]. Local suppliers provided the fine and coarse aggregates.

2.5 Super plasticizer

In the current investigation, a superplasticizer from the Master Glenium series was used. It's an admixture made of polycarboxylic ether. This was intended to develop the characteristics of recently laid, extremely efficient concrete. It works effectively with any kind of cement since it doesn't include chlorides or alkalis. A superplasticizer is used to enhance the workability and fluidity of GGBS mixed SCGPC blends without reducing the final product's strength and durability. According to IS 9103:1999 [33], its relative density is roughly 1.09.

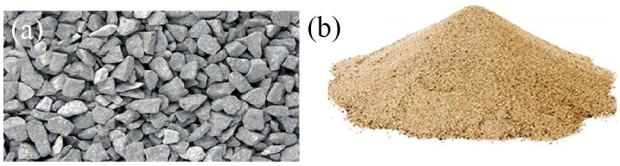


Fig. 5 **a** Coarse aggregate, **b** Fine aggregate

3 Mix proportioning

Six SCGPC blends with GGBS were created by raising the GGBS from 0 to 50%. Liquid to binder ratio was maintained at 0.45, and the total quantity of binder was maintained at 496.55 kg/m^3. In line with the mass of the binder, a superplasticizer (S.P.) with a dosage of 2% and additional water content was used can be seen in Table 2.

3.1 Blending, casting process and curing

Flyash, GGBS and aggregates were all the dry components of the flyash based SCGPC that were mixed together for two to three minutes in a pan mixer. Then, to create alkali activator fluid, the mixture's liquid component, consisting of NaOH and Na_2SiO_3 solution, is combined in a ratio of 1:2 (by weight). In order to complete the perfect blending of GGBS blended SCGPC, Super Plasticizer and Water were provided. For an additional two to three minutes, let these materials mix together. Before being placed onto the moulds, the freshly poured concrete was tested for its rheological characteristics. Before testing, each sample is kept at 27 °C, or room temperature.

3.2 Experimental program

3.2.1 Rheological properties

The rheological characteristics of the GGBS blended SCGPC blends were evaluated utilising slump flow, T_{50cm} slump flow, L-box, and V-funnel experiments. To ascertain the freshly poured concrete's capability for filling, a slump flow experiment was performed. The filling capacity of the mix was determined by timing how long it took the mix to reach a 50 cm diameter employing the T_{50cm} slump flow test. To ascertain if concrete could survive the reinforcing, the L-box test was performed. The vertical section (H_1) and horizontal component's (H_2) leading ends' concrete heights are taken into account for the L-box examination. The V-funnel

Table 2 Mix Proportions of GGBS blended SCGPC

Mix designation	Fly ash (Kg/m^3)	GGBS (Kg/m^3)	C.A (Kg/m^3)	F.A (Kg/m3)	NaOH (Kg/m^3)	Na_2SiO_3 (Kg/m^3)	SP (%)	Extra water added (%)
100FAG0	496.5	0	924	756	74.5	148.9	2	12
90FAG10	446.85	49.65	924	756	74.5	148.9	2	12
80FAG20	397.2	99.3	924	756	74.5	148.9	2	12
70FAG30	347.55	148.95	924	756	74.5	148.9	2	12
60FAG40	297.9	198.6	924	756	74.5	148.9	2	12
50FAG50	248.2	248.2	924	756	74.5	148.9	2	12

experiment was used to gauge the concrete's consistency and filling capacity. Each experiment was conducted in conformity with the guidelines provided by the EFNARC [34].

3.2.2 Mechanical properties

For mechanical characteristics of the GGBS blended SCGPC blends, compressive strength was assessed at 3, 7, and 28 days. Splitting tensile strength and strength in flexural were evaluated after 28 days. Three 150 mm × 150 mm × 150 mm cubes are utilised for the compression strength test in line with IS 516 (1959), and three 500 mm × 150 mm prisms and three 150 mm × 300 mm cylinders were employed for the splitting tensile and flexural strength examinations in compliance with IS 5816 (1999) and IS 516 (1959) standards, respectively [35, 36].

3.2.3 Micro Structural Studies

3.2.3.1 XRD analysis The method that is most frequently employed is X-ray diffraction analysis (XRD), which utilises diffraction patterns to identify the phases and structures of compounds present in a material. By using XRD analysis, the various mineral phases and compounds existing in both the source materials and hardened SCGPC samples were detected. Only the optimal hardened concrete samples (100FAG0and 60FAG40) were pulverised using an agate mortar and sieved using an IS 75-micron sieve prior to examination because the raw materials were already in powder form. Using the fifth-generation Rigaku Miniflex 600 and the programme X'Pert High Score Plus, the test and phase identification were carried out.

3.2.3.2 SEM Analysis For improved visibility and image clarity, several polishing cloths and papers were used to polish the broken GGBS blended SCGPC samples. The samples were then given a final polish with diamond polish before being coated with platinum. For this analysis, an EVO MA18 with Oxford EDS(X-act) was used. This piece of equipment is capable of operating from 100 V and 30 kV especially offers a resolution range of 1–4 nm.

3.2.3.3 FTIR Analysis Employing a Perkin Elmer Spectrometer 2000 in transmission mode having an operating frequency range about 4000 cm-1 to 400 cm-1 and a resolution of 4 cm-1, Fourier infrared spectroscopy analysis (FTIR) was utilised to detect the various functional groups of the developed GGBS blended SCGPC samples. The samples were assessed using pellets of potassium bromide (KBr).

4 Results and Discussion

4.1 Fresh SCGPC properties

Due to qualities including ability to pass, ability to fill, and ability to resist segregation, fresh SCGPC is a very workable concrete. Four tests—Slump flow, T_{50cm} Slump flow, V funnel test, U-box and L-box were performed in order to determine the qualities of fresh SCGPC [34]. Table 3 displays the test outcomes for the newly poured GGBS blended SCGPC characteristics.

4.2 Compressive strength

When evaluating the performance as well as the quality of almost any type of concrete, compressive strength is a key characteristic. Figure 6 illustrates the compressive strengths of the GGBS blended SCGPC samples after 7, 14, and 28 days. In the Fig. 6, The graph illustrates how the compressive strength rises as the percentage of GGBS rises. In comparison to the mixes without GGBS, the GGBS blended SCGPC composites with 10, 20, 30, 40, and 50% GGBS of the total binder, respectively, had compressive strengths that were 21, 33, 53, 65, and 49% higher at 28 days. This increase is in line with the prior research investigation [37]. This rise in strength is attributable to the synthesis of Calcium Alumino Silicate Hydrate gel (C-A-S–H gel) along with Sodium Alumino Silicate Hydrate gel (N-A-S–H gel), that increased the microstructure's compactness [38, 39]. The compressive strength graph demonstrates that mix with 40% GGBS, it increases from 35. 79 MPa at three days and then increases up to52.6 MPa at28 days of curing. This outcome

Table 3 Rheological Properties of GGBS blended SCGPC mixes

S.No	Mix designation	Slump flow (mm)	T_{50cm} slump flow (sec)	V-funnel (sec)	U-box (mm)	L-box (H_2/H_1)
Efnarc guidelines		650–800	2–5	6–12	0–30	0.80–1.0
1	100FAG0	720	3.06	7.9	10	0.89
2	90FAG10	700	3.20	8.1	14	0.91
3	80FAG20	695	3.50	8.4	18	0.93
4	70FAG30	690	3.80	9.4	20	0.94
5	60FAG40	685	3.98	9.8	22	0.95
6	50FAG50	680	4.23	10.3	25	0.97

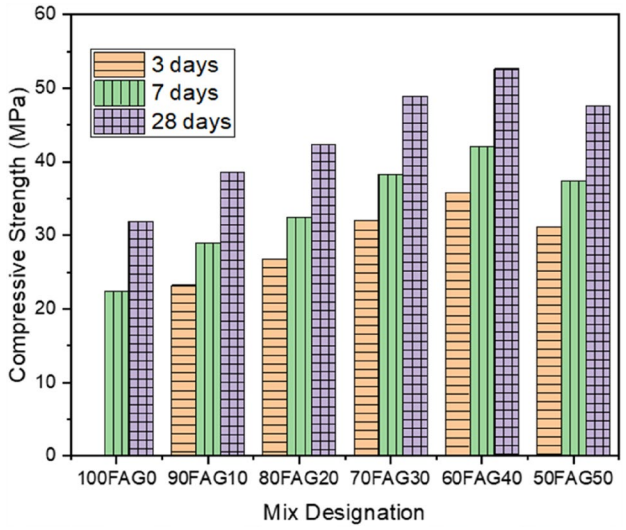


Fig. 6 Compressive strength of SCGPC mixes

is in line with the previous research investigation already in existence [40].

4.3 Split tensile strength

At 28 days, Fig. 7 depicts the outcomes of the splitting tensile strength tests conducted on the GGBS blended SCGPC. The splitting tensile strength of the GGBS blended SCGPC is shown in this graph to be directly proportional to the percentage of GGBS replacement up to 40%. The improvement in splitting tensile strength of GGBS-blend SCGPC mix over flyash-based control SCGPC is roughly 20, 27, 40, 58 and 50% for mixtures of replacement of 10, 20, 30, 40, and 50%, respectively. The outcomes of the splitting tensile assessment support the performance of the compressive strength assessment outcomes.

4.4 Flexure strength test

The outcomes of the flexural strength evaluation for the GGBS blended SCGPC after 28 days after casting are depicted in Fig. 8. The flexural strength of the GGBS blended SCGPC rises as the percentage of GGBS does, as this graph clearly shows. In comparison with the flyash-based control SCGPC mix (100FAG0), the flexural strength of GGBS blended SCGPC mixes of 10, 20, 30, 40, and 50% increased by roughly 16.36, 34.52, 40.47, and 48.21%, respectively. The behaviour of the compressive strength outcomes is enhanced by using the results of the flexural strength evaluation.

4.5 XRD analysis

By using XRD analysis, the mineralogical properties of fly-ash based control SCGPC (100FAG0) and GGBS blended SCGPC incorporated with 40% of GGBS (60FAG40) were inspected after 28 days of healing. Figure 9 displays the XRD pattern. Aluminosilicate substances with an amorphous structure are the primary polymerization products produced in geopolymer (N-A-S–H and C-A-S–H). Thus, a wide amorphous hump of aluminosilicate ($2\Theta = 25°–32°$) and a low crystalline C-S–H gel make up the majority of the 60FAG40 XRD pattern. In fly ash, It is also observed that only the glassy components will react and hence the primary crystalline peak found is quartz (SiO_2) and mullite ($3Al_2O_3$-SiO_2) [41]. Fly ash's reactive glassy fraction and

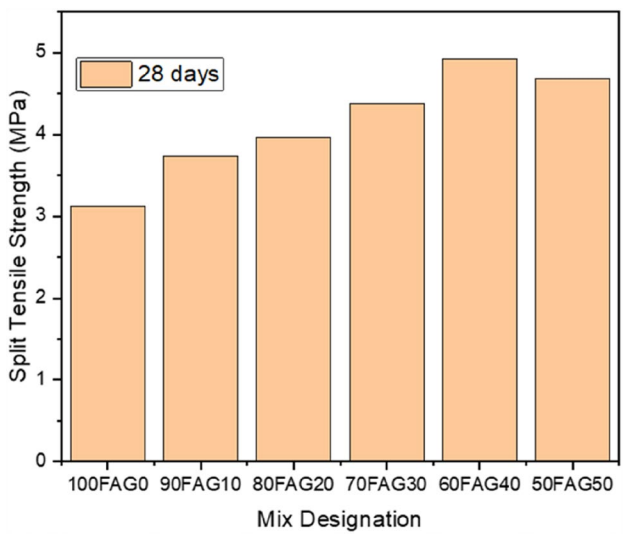


Fig. 7 Splitting tensile strength of SCGPC mixes

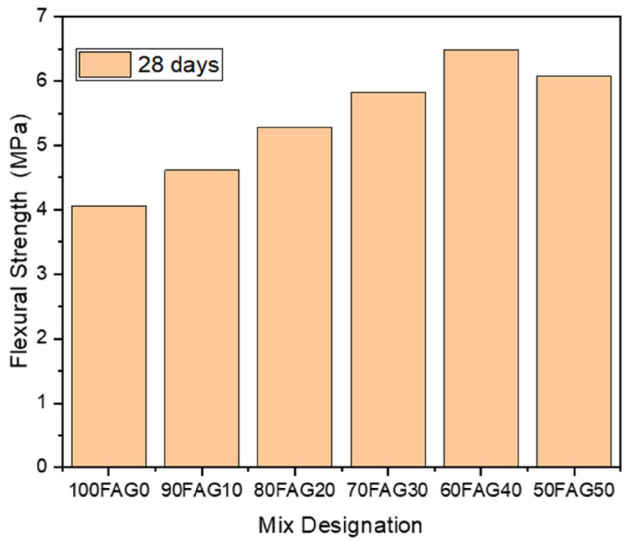


Fig. 8 Flexure strength of SCGPC mixes

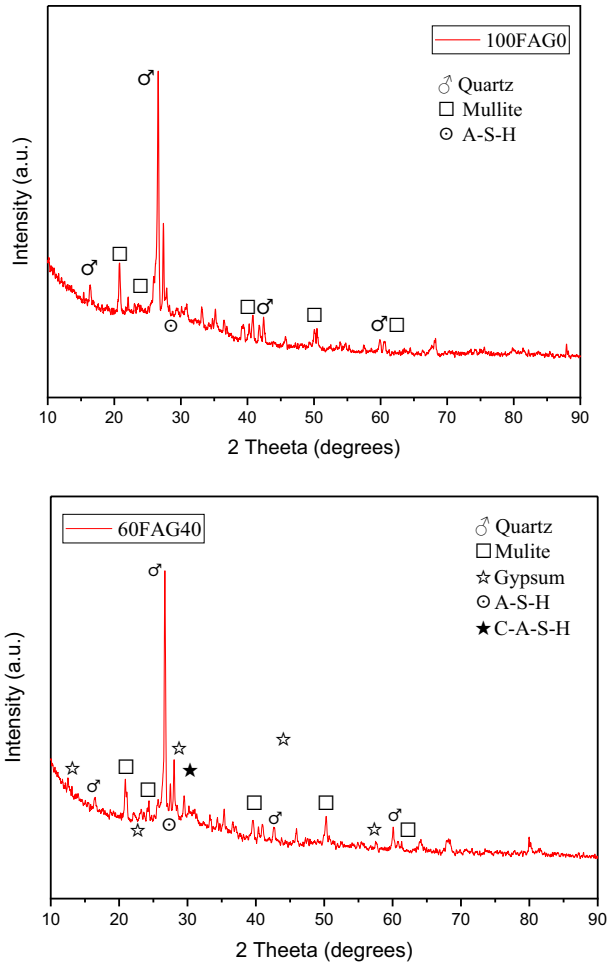


Fig. 9 XRD analysis of SCGPC samples

GGBS reacted to form reaction products that ranged from amorphous to imperfectly crystalline phases. It is crucial to note that only reactive glass participates in geopolymerization, while the fly ash's glass content also includes refractory glass. A wide and dispersed background peak with maximum of around 10° is produced by the hydrotalcite (Mg_6A_{l2}-$CO_3OH_{16}4H_2O$) short-range order which increases C-(N)-A-S–H gel polymerization and a reduction in the available Al element [42, 43].Each sample that included GGBS had detectable peaks at 30° and 50° that belonged to the A-S–H and C-S–H gels. It needs to be noticed that the Peak crystalline phase's intensity reduces as the GGBS increases [44].

4.6 SEM with EDS

Figure 10 displays the SEM images of the control flyash based SCGPC (100FAG0) and the GGBS blended SCGPC with 40% GGBS replacements (60FAG40). The images shown here clearly demonstrate that the mixture of 60% FA and 40% GGBS has a denser microstructure, a matrix that has almost completely reacted, and some cenosphere and plerosphere FA particles that have not yet completely reacted. According to a report, the unreacted particles in the combination did not function as filler but instead gradually increased the matrix's strength alternatively.This is in line with the compression outcomes and the prior literature-reported outcomes [45]. An aluminosilicate gel (N-A-S–H) gets formed when alkali-activation was applied to flyash based control SCGPC (100FAG0). On the other hand, the Calcium ions from GGBS take the place of sodium ions in GGBS mixed SCGPC (60FAG40) with a high pH (> 12), causing C-A-S–H or C-S–H to precipitate till the calcium ions have been used up. Thus, N-A-S–H, C-S–H, and C-A-S–H were identified within the GGBS blended SCGPC (60FAG40) sample [46].The reason why the fly ash particles in Fig. 10 have needle-like shapes is most likely due to the mixture's high activator solution content. This unreacted alkali solution precipitated during the geopolymerization process as minute needle particles in the mixture [47][47].

Based on EDS tests carried out on a selected area in both samples, the primary components of the SCGPC samples, which belong to the N–C-S–H, N-A-S–H, C-S–H, and Mg $(OH)_2$binders type, are Aluminium, silica magnesium, calcium, oxygen, and Sodium. As shoen in Table 5, Higher Si/Al ratios, especially Si/Al > 2.5, are necessary for the creation of 3D networked polysialate- siloxo and polysialatedisiloxo polymers. In addition to calcium and sodium, 3D networks (Ca,K) polysialate-sililoxane also need small quantities of silicon, oxygen, and aluminum. [49].

4.7 FTIR analysis

The FTIR spectra of the 100FAG0 and 60FAG40 mix sample are depicted in Fig. 11. The strong signals seen at 3369and 3432 cm^{-1} in the 100FAG0 and 60FAG40, respectively, are caused by symmetrical bending vibrations of water molecule-associated H–O-H bonds [50]. The C-H groups are responsible for the small bands at 2816 and 2882 cm^{-1} on the spectra of the 100FAG0 and 60FAG40, indicating an existence of organic molecules from super plasticizers [50]. The bands at a distance of 1637–1793 cm^{-1} are also attributable to the stretching and bending vibrations of O–H bonds, which show the water molecules attached to the geopolymer network [51].The efflorescence phenomenon [52], which results from the geopolymerization process between unreacted Na^+ and ambient CO_2, is linked to the splitting of absorption bands in the ranges of 1446–1476 cm^{-1} and 1422–1482 $cm^{-1}$is observed on the 100FAG0 and 60FAG40,respectively. This finding suggests that degenerescency caused by distortion has been eliminated [53]. It is possible that this area may be linked to the silica and

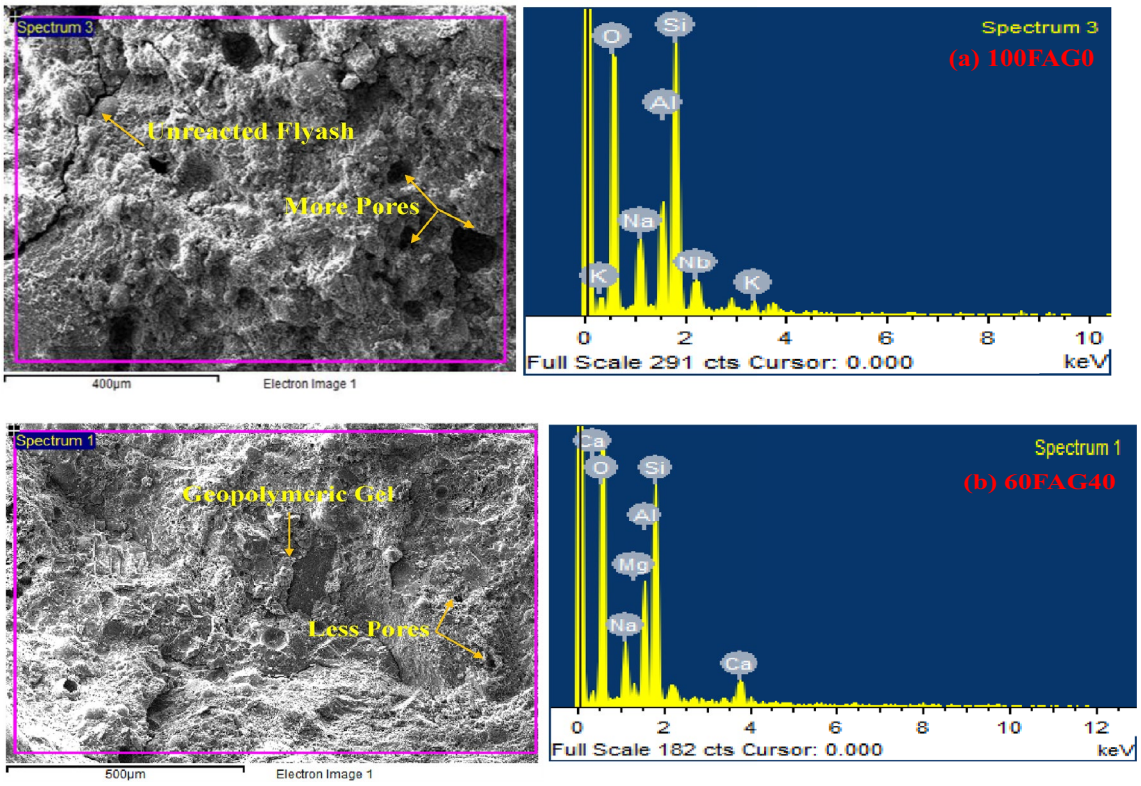


Fig.10 SEM analysis of SCGPC samples

Table 5 Chemical elements (atomic %) and their ratio at 28 days

Mix	O K	Si K	Na K	Ca K	Al K	Si/Al ratio
100FAG0	60.29	24.16	2.09	0.67	7.26	3.32
60FAG40	37.83	33.75	3.09	15.9	8.92	3.78

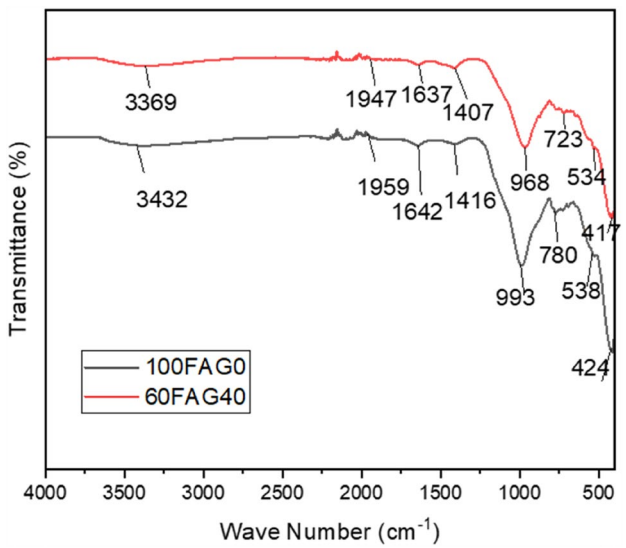


Fig. 11 FTIR analysis of SCGPC samples

alumina connections (C-A-S–H and N-A-S–H) that drive polymerization during the geopolymerization process [54].

5 Conclusions

In this current research, the impact of GGBS on the flyash based SCGPC's performance in both the fresh, hardened phases and Microstructural properties were examined. The following Results were attained;

- The results showed that up to 40% FA was successfully substituted for GGBS as a precursor binder in SCGPC's producing outstanding fresh and mechanical qualities that satisfied the EFNARC standards for SCC.
- With an increase in GGBS quantity in the binder, the workability of the fresh GGBS blended SCGPC's reduced. The reason for this is mainly due to the calcium reacting more

quickly and to the angular shape of the slag in contrast to the spherical shape of the fly ash particles.

- As compared to control SCGPC (100FAG0), the mix with 40% GGBS blended SCGPC (60FAG40) which does not require heat curing, exhibits the highest compressive strength increased by 40.26 and 33.97%after 7 days and 28 days.
- However, when the GGBS grew from 0 to 50%, both the splitting tensile strength and flexural strength of the GGBS blended SCGPC enhanced by about 33.59 and 31.05%, respectively.
- The results of the XRD-based microstructural analysis of SCGPCs revealed a decrease in the number of crystalline phases when the GGBS content was raised as a partial substitute for Flyash. Consequently, the porosity decreased while the density and C, N-(A)-S–H gel were enhanced.
- As shown by SEM and EDAX analysis, the GGBS increased the degree of polymerization and polycondensation, which subsequently improved the densification of the entire system and increased its strength. Cristobalite and stishovite, which are unreacted FA/GGBS, function as fillers by saturating pore spaces, which raises the packing density of the binder phase.
- When the proportion of GGBS is raised, FTIR data revealed shifts in geopolymer process and the development of C-S–H gel, which enhance the strength qualities.

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Author contributions NLNKK: Conceptualization, Data curation, Investigation, Writing-original draft. IVRR: Conceptualization, Supervision, Writing-review & editing.

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Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval Not Applicable.

Consent to participate Not Applicable.

Consent for publication Not Applicable.

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AN EXPERIMENTAL INVESTIGATION ON PROPERTIES OF GEOPOLYMER CONCRETE USING COMPOSITE FIBERS

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ABSTRACT: Geopolymer technology represents a significant advancement in concrete production, especially in mitigating the environmental concerns that arise from the use of conventional cement materials that emit significant amounts of CO_2. By substituting cement with alternative ingredients such as Fly ash and Ground Granulated Blast Furnace slag (GGBFS), a more environmentally friendly approach is possible. Geopolymer concrete, utilizing a synthetic resin binder that reacts with alkaline solutions like sodium hydroxide and sodium silicate, emerges as a viable alternative. This project aims to enhance the properties of fly ash and slag-based Geopolymer concrete by incorporating composite fibers. It seeks to investigate the effects of Crimped steel, Polypropylene, and Glass fibers on the compressive, split tensile, and flexural strength of Geopolymer concrete. By introducing varying proportions of fibers, ranging from 0.5% to 1.5% of the concrete volume, the study intends to determine their impact on the mechanical properties of concrete. These investigative efforts hold significant potential for broadening the application of Geopolymer concrete, providing an efficient alternative to traditional cement concrete for a wide range of construction applications.

***Key words*: Crimped steel fibers, Fly ash, Geopolymer concrete, Ground Granulated Blast Furnace Slag (GGBFS), Glass fibers, Polypropylene fibers, Sodium silicate, Sodium hydroxide.**

I. INTRODUCTION

Concrete, a fundamental material in global construction, relies heavily on cement. However, cement production contributes significantly to greenhouse gas emissions. To address this, researchers have explored alternative binding materials, including non-crystalline alkali-aluminosilicate geopolymers. Geopolymer concrete, made from byproduct waste, reduces direct carbon dioxide emissions during production. Geopolymer concrete is an innovative alternative to traditional cement-based concrete, where pozzolanic materials rich in silica and alumina, such as fly ash or blast furnace slag, are activated by alkaline liquids to act as binders. This substitution reduces the carbon footprint of concrete production. Geopolymerization, the chemical process behind geopolymer concrete, involves exposing alumina-silicate materials to high-alkaline environments, typically sodium or potassium hydroxide solutions. This results in the formation of a strong binder characterized by a Si-O-Al structure. The reaction involves breaking valency bonds between silicon, aluminium, and oxygen atoms, leading to the formation of three-dimensional polymeric chains and ring structures. Alkaline cations like sodium and potassium compensate for charge imbalances caused by aluminium in the gel product. The rate of dissolution and the resulting properties of geopolymers are influenced by factors such as the quantity and content of materials used and the pH of the activating solution. Geopolymer concrete utilizes thermally activated natural resources or industrial by-products as sources of silicon and aluminium. Despite its advantages, geopolymer concrete exhibits brittleness. To overcome this limitation, we turn to fibers. By reinforcing geopolymer concrete with fibers, we aim to enhance its toughness, durability, and applicability across a wide range of construction scenarios. This review sheds light on the promising future of fibre-reinforced geopolymer concrete and emphasizes the need for standardized manufacturing processes.

The objective of this journal paper is to present the results of an experimental investigation on Geopolymer concrete, formulated using fly ash and Ground Granulated Blast Furnace Slag (GGBFS), along with sodium silicate, sodium hydroxide, crimped steel fibers, polypropylene fibers, glass fibers, and a chemical admixture. Specifically, the study utilizes the PCE-based super plasticizer AURAMIX 450 to achieve the desired properties of Geopolymer concrete. The chemical admixture is dosed at 1.4% by weight of binder content based on a trial method, while maintaining a constant water-to-binder ratio of 0.45. The mix design and proportioning of ingredients for the Geopolymer concrete involve maintaining a fixed ratio of 2 for sodium silicate and sodium hydroxide, along with the use of a 12M alkaline solution. The mechanical properties under investigation include compressive strength, split tensile strength, and flexural strength of the concrete specimens. To further enhance the mechanical properties and observe changes, crimped steel fibers, polypropylene fibers, and glass fibers are added in varying percentages (0%, 0.5%, 0.75%, and 1%) collectively. This addition aims to investigate the effects of fiber reinforcement on the Geopolymer concrete's performance. By systematically varying the fiber content and assessing the resulting mechanical properties, the study aims to provide insights into the optimization of Geopolymer concrete formulations for enhanced performance and durability in various engineering applications.

II. OBJECTIVES

The following are the objectives of this experimental investigation:

1. To find the optimum percentage of Steel fibers in developing the strength of the Geopolymer concrete and to mitigate the brittleness of GPC
2. To develop the strength of Geopolymer concrete using Steel fibers and Polypropylene fibers in various percentages from the optimum percentage of Steel fibers and to observe the changes in properties of GPC.
3. To develop the strength of Geopolymer concrete using Steel fibers and Glass fibers in various percentages from the optimum percentage of Steel fibers and to observe the changes in properties of GPC.
4. To determine the mechanical properties of Geopolymer concrete such as compressive strength, split tensile strength and flexural strength by the addition of various percentages of fibers in Geopolymer concrete.
5. To compare the properties of Geopolymer concrete with fibers and without fibers.

III. MATERIALS

In this experimental investigation the following materials are used

3.1 Fly Ash

Fly ash, derived from the combustion of pulverized coal in coal-fired thermal power plants, is a by-product extensively utilized in hydraulic-cement concrete. Class F fly ash, specifically chosen for this experimental investigation, possesses a specific gravity of 2.12.

3.2 Ground Granulated Blast Furnace Slag (GGBFS)

Ground Granulated Blast Furnace Slag (GGBS) is a by-product of the iron-making process in blast furnaces. With a specific gravity ranging between 2.80 and 3.00, slag holds the distinction of having the highest specific gravity among all mineral admixtures. As a processed material, its fineness can be finely adjusted to meet specific requirements. In numerous applications, the fineness of slag closely resembles that of cement. GGBS primarily consists of calcium silicates and alumino-silicates. Its specific gravity is measured at 2.9.

3.3 Fine Aggregate

River sand sourced locally, adhering to the IS: 383-1970 specifications, was utilized as the fine aggregate in the concrete mix. The sand particles pass through a 4.75mm sieve and are retained on a 75µm sieve. Table 3.1 provides details regarding the physical properties of the fine aggregate.

Table 3.1: Physical properties of Fine aggregate

Particulars	Values
Specific gravity	2.58
Fineness modulus	3.15
Grading	Zone II

3.4 Coarse aggregate

For this investigation, well-graded coarse aggregate consistent with the specifications outlined in IS: 383-2016 will be utilized. The coarse aggregate, sourced from local quarry units and conforming to IS: 383-1970 standards, has been selected for this study. The maximum size of the coarse aggregate employed is 12.5mm. The physical properties of the coarse aggregate are detailed in Table 3.2.

Table 3.2: Physical properties of Coarse aggregate

Particulars	Values
Specific gravity	2.60
Fineness modulus	6.30
Water absorption (%)	0.72

3.5 Sodium Hydroxide Flakes

Sodium hydroxide (NaOH) is commonly available in solid forms such as pellets or flakes. Its price varies based on purity. Solutions of NaOH are prepared by dissolving pellets in water to achieve different molarities. It is advised to prepare the NaOH solution at least 24 hours before use and to use it within 36 hours to prevent it from solidifying.

3.6 Sodium Silicate

Sodium metasilicate, also referred to as sodium silicate, is an industrial-grade compound containing 31.12% SiO_2 and 14.2% Na_2O by mass. Manufacturers commonly utilize it as a bonding agent in detergent and textile industries. Sodium silicate is typically found in liquid form.

3.7 Chemical Admixture

Polycarboxylate ether (PCE) based superplasticiser AURAMIX 450 was used.

3.8 Crimped steel fibers

In this study, crimped steel fibers with a length of 35mm and a diameter of 0.5mm are utilized, resulting in an aspect ratio of 70.

3.9 Polypropylene fiber

In this study, FIBERCRETE MF, a synthetic monofilament fiber is used. Polypropylene fibers with a length of 12mm and a diameter of 0.02 mm are utilized, resulting in an aspect ratio of 600.

3.10 Glass fibers

In this study, glass fibers with a length of 12mm and a diameter of 0.014mm are utilized, resulting in an aspect ratio of 857.

IV. EXPERIMENTAL INVESTIGATION

4.1 Mix proportions

In this experimental investigation, the binder content, obtained from a mix design referenced in prior literature, is 496 kg/m^3. This composition consists of 80% fly ash and 20% GGBFS. For the 12M solution, the NaOH content is measured at 74.5 kg/m^3, while the Na_2SiO_3 content is taken as 149 kg/m^3. To achieve the desired fresh properties of Geopolymer concrete, a water-to-binder ratio of 0.45 is selected, alongside a chemical admixture dosage of 1.4% by weight of the binder content, determined through trials. The study assesses the impact of crimped steel fibers on Geopolymer concrete, identifying the optimal percentage, and then explores substitutions with glass and polypropylene fibers at varying proportions of 0.5%, 0.75%, and 1% by weight of the binder content. Table 6 summarizes the concrete mixture proportions for Geopolymer concrete.

Table 6: Mix proportions of Geopolymer concrete addition with percentage of Crimped Steel fibers, Polypropylene fibers &Glass fibers

Materials kg/m^3 / Mix No.	Fly Ash & GGBS	Sodium Hydroxide	Sodium Silicate	Fine Aggregate	Coarse Aggregate	Super plasticizer	Crimped steel fibers (%)	Polypropylene fibers (%)	Glass fibers (%)
M_1	496	74.5	149	756	924	6.9	0	0	0
M_2	496	74.5	149	756	924	6.9	1.5	0	0
M_3	496	74.5	149	756	924	6.9	1	0.5	0
M_4	496	74.5	149	756	924	6.9	0.75	0.75	0
M_5	496	74.5	149	756	924	6.9	0.5	1	0
M_6	496	74.5	149	756	924	6.9	1	0	0.5
M_7	496	74.5	149	756	924	6.9	0.75	0	0.75
M_8	496	74.5	149	756	924	6.9	0.5	0	1
M_9	496	74.5	149	756	924	6.9	0.5	0.5	0.5

4.2 Mix procedure

For the experimental investigation, materials such as fly ash, GGBS, aggregates, sodium silicate, and sodium hydroxide are procured and tested to determine the properties such as specific gravity and water absorption. Mix design for Geopolymer concrete (GPC) is done, considering the desired proportions of the materials. Additionally, different volumes of fibers are incorporated into the mix to assess their impact on the concrete's performance. Following the mix design, concrete samples in the form of cubes, cylinders, and prisms are casted and cured for 24 hours before demolding. Subsequently, the specimens undergo an air-curing process at ambient temperature for durations of 7, 28, and 56 days to facilitate concrete strength development. Mechanical properties including compressive strength, split tensile strength, and flexural strength are then determined at the designated curing ages of 7, 28, and 56 days to analyze the performance of the Geopolymer concrete specimens.

4.3 Test procedure on Hardened concrete

The following tests are conducted to find the mechanical properties on hardened concrete:

Compressive Strength: The compressive strength of Geopolymer concrete is determined by casting the specimens of size 100*100*100mm. These samples undergo testing at ages of 7, 28, and 56 days using a compressive testing machine (CTM) with a capacity of 3000kN, as per IS 516:1959, as shown in Fig 1a.

Split Tensile Strength: The split tensile strength of Geopolymer concrete is determined by casting the cylinders of size 100*200mm. These samples undergo testing at 28 days using a compressive testing machine (CTM) with a capacity of 3000kN, as per IS 516:1959, as shown in Fig 1b.

Flexural Strength: The flexural strength of Geopolymer concrete is determined by casting the beam specimens of size 100*100*500mm. These samples undergo testing at 28 days, as per IS 516:1959, as shown in Fig 1c.



Fig. 1a Compression test



Fig. 1b Split tensile



Fig. 1c Flexure test

V. RESULTS AND DISCUSSION

5.1 Mechanical properties of Geopolymer concrete:

The following are the test results of compressive, split tensile and flexural strength tests to determine the mechanical properties of Geopolymer concrete.

5.1.1 Compressive strength test

Figure 2 illustrates the compressive strength variations of Geopolymer concrete mixes denoted as M1 to M9, each incorporating different types of fibers including crimped steel, polypropylene, and glass fibers. For the control mix (M1), the compressive strength at 7, 28, and 56 days was determined as 34.88, 39.15, and 40.8 N/mm^2, respectively. Upon introducing crimped steel fibers in mix M2, a notable increase in strength was observed compared to the control mix. Of note, mixes M2 and M8 exhibit nearly equal compressive strengths. This suggests that the combination of steel and glass fibers in mix M8 yields a compressive strength similar to that achieved with crimped steel fibers alone.

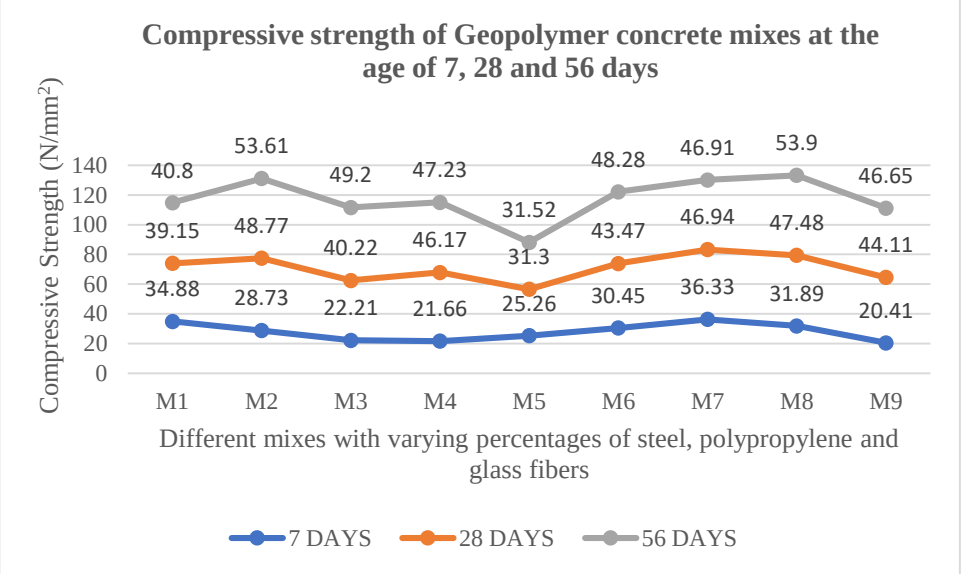


Fig. 2 Variation compressive strength of different mixes

5.1.2 Split tensile strength test

Figure 3 displays the split tensile strength variations of Geopolymer concrete mixes denoted as M1 to M9, incorporating different types of fibers such as crimped steel, polypropylene, and glass fibers. For the control mix, denoted as M1, the 28-day split tensile strength was recorded as 1.705N/mm^2. With the addition of 1.5% crimped steel fibers (the optimum percentage), this strength increased to 4.605 N/mm^2 in mix M2. Remarkably, mix M8 exhibits a split tensile strength similar to that of mix M2. This suggests that the combination of steel and glass fibers in mix M8 yields a split tensile strength comparable to that achieved with crimped steel fibers alone.

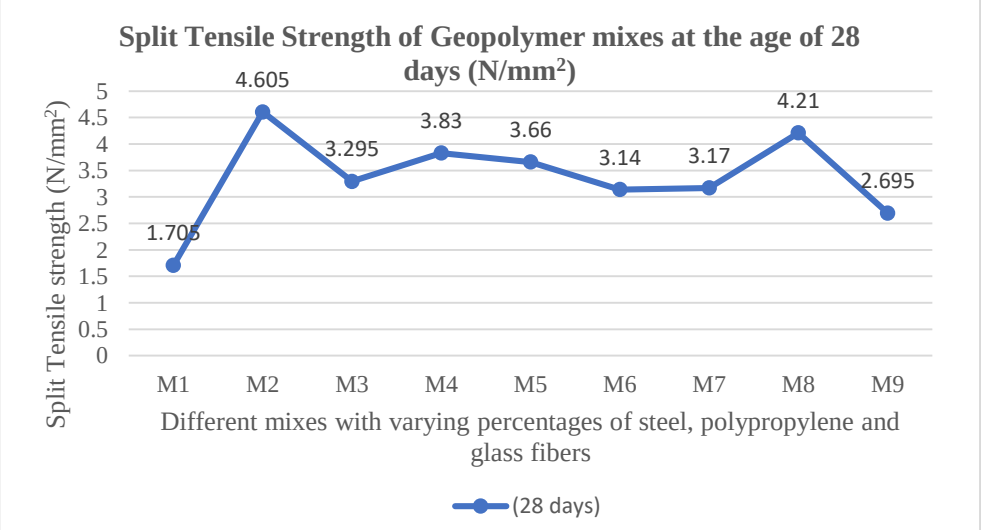


Fig. 3 Variation Split tensile strength of different mixes

5.1.3 Flexural strength test

Figure 4 displays the flexural strength variations of Geopolymer concrete mixes denoted as M1 to M9, incorporating different types of fibers such as crimped steel, polypropylene, and glass fibers. For the control mix, denoted as M1, the 28-day flexural strength was recorded as 4.27 N/mm^2. With the addition of 1.5% crimped steel fibers (the optimum percentage), this strength increased to 6.69 N/mm^2 in mix M2. Remarkably, mix M8 exhibits a flexural strength similar to that of mix M2. This suggests that the combination of steel and glass fibers in mix M8 yields a flexural strength comparable to that achieved with crimped steel fibers alone.

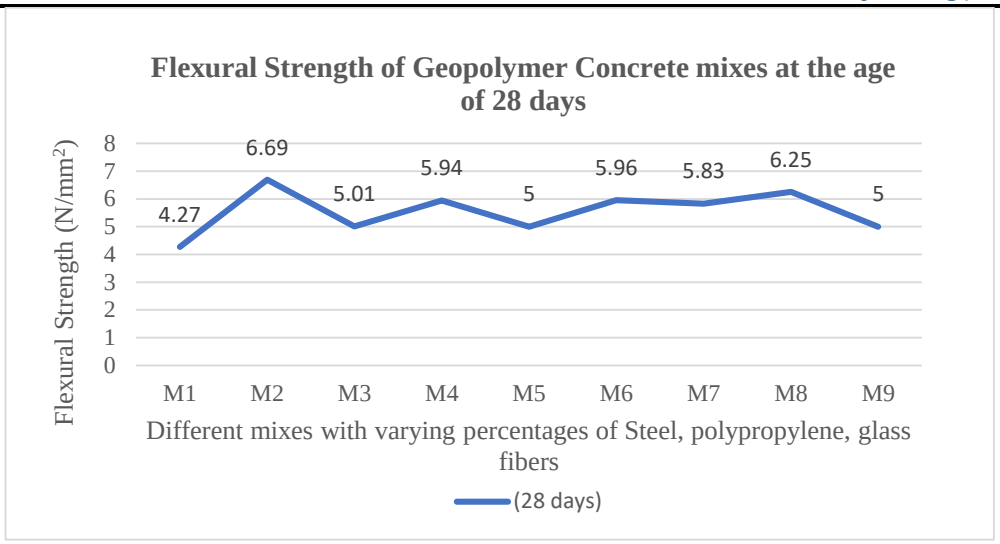


Fig. 4 Variation Flexural strength of different mixes

VI. CONCLUSIONS

In this research work, nine different mixes of Geopolymer concrete were considered to investigate their strength characteristics, including compressive strength, flexural strength, and split tensile strength, with the incorporation of various fiber types such as crimped steel, polypropylene, and glass fibers.

1. The partial replacement of 20% GGBFS in the Geopolymer concrete mixture effectively mitigates setting delays, particularly during air curing at ambient temperatures.
2. Through experimental analysis, a Geopolymer concrete mix design with a liquid binder ratio of 0.45 and an alkaline solution ratio of 2 was identified, exhibiting desirable strength properties and advantageous environmental and economic benefits.
3. Cube compressive strength assessments revealed that mixes M1 and M2, augmented with crimped steel fibers, demonstrated increased strength at 28 and 56 days, with values escalating from 39.15 MPa to 48.77 N/mm^2 and from 40.8 N/mm^2 to 53.69 N/mm^2, respectively. Optimal performance was achieved with a 1.5% addition of crimped steel fibers. Similar strength outcomes were observed in mix M8, which featured a combination of 0.5% crimped steel and 1% glass fibers.
4. Split tensile strength evaluations exhibited a similar trend, with mixes M1 and M2 registering enhancements from 1.705 N/mm^2 to 4.605 N/mm^2 at 28 days upon the incorporation of crimped steel fibers. The optimal mix again featured a 1.5% addition of these fibers, with mix M8 showing comparable results due to the combination of 0.5% crimped steel and 1% glass fibers.
5. Flexural strength assessments followed suit, with mixes M1 and M2 displaying increases from 4.27 N/mm^2 to 6.69 N/mm^2 at 28 days with the inclusion of crimped steel fibers. The optimal mix was identified at a 1.5% addition of crimped steel fibers, mirroring the results of mix M8, which combined 0.5% crimped steel and 1% glass fibers.
6. The overall analysis suggests that Geopolymer concrete incorporating 1.5% crimped steel fibers achieves optimal strength performance. Additionally, composite fiber mixes, particularly those combining steel and glass fibers, exhibit superior performance compared to combinations of steel and polypropylene fibers.
7. Despite the enhanced strength provided by steel fibers, their weight and cost implications prompt consideration of alternatives. Replacement of 1% steel fibers with glass fibers yields lighter, more cost-effective Geopolymer concrete with strength levels approaching those of Geopolymer concrete with optimal steel fiber content.

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RESEARCH

Application and evaluation of ANN and other classification algorithms for identification of clays based on mineralogical composition: a comparative study

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Abstract
Mineralogical identification of clay minerals is essential as clays exhibit different degrees of expansivity based on the minerals present. Montmorillonite clays have high swelling and shrinkage characteristics, followed by Illite and Kaolinite. The presence of such clays affects the stability of the foundation and thus the structure as a whole. Therefore, the geotechnical engineer has to ascertained the presence of expansive clays before design foundation system. XRD and differential thermal analysis are intricate and expensive techniques for identifying clay minerals. Identifying the clay minerals with the help of their index properties is an indirect and inexpensive approach. In machine learning, classification is a predictive modelling problem. The current study examines the suitability of liquid limit and plastic limit/plasticity index as input features for eight classification models viz. Logistic Regression, K Nearest Neighbourhood, Support Vector Machine, Naive Byes, Decision Tree, Random Forest, XG Boost and Artificial Neural Networks. Scikit learning libraries are used for classification models in Python. K-fold cross-validation is used for each classification model to evaluate the training set and accuracy score, and ROC curves evaluate test data performance. The current study found that Montmorillonite clays can be classified with the highest degree of accuracy, followed by Kaolinite and Illite.

Keywords Kaolinite · Illite · Montmorillonite · Classification

Introduction

Majority of clays have Kaolinite, Illite and Montmorillonite as minerals in them. Swelling and shrinkage characteristic of clays are very much dependent on dominant clay minerals present. Expansive soil is typically defined as any soil whose volume variations are moisture sensitive. Due to their adverse effects on the stability of the buildings they support, expansive soils are viewed as problematic (Asuri & Keshavamurthy, 2016). The study of the physico-chemical behaviour of the soils has indicated that clays having Montmorillonite are more expansive followed by Illite and Kaolinite. X-ray diffraction, differential thermal analysis, scanning electron microscopy etc. are promising technics to establish clay minerology. However, for the purpose of soil investigation from geotechnical engineering applications these methods are unfeasible as not many geotechnical labs equipped with these facilities, also such investigations demand skilled workforce.

Many researchers and codes have come up with degree of expansivity of clays by experimental results of index properties such as liquid limit, plastic limit, shrinkage limit, free swelling index and free swelling ratio. Chen and Snethan et al. have suggested liquid limit ranges and the corresponding swelling potential. Holtz and Gibs and Chen have labelled four swelling potentials viz. Low, Medium, High and Very high based on plasticity index. Based on the shrinkage limit, Holtz and Gibbs and Altmeyer have recommended volume changes for expansive soils. Considering percent clay size fraction, Chen and Holtz and Gibbs have proposed four degrees of expansivity for clayey soils. Sridharan and Prakash have suggested clay type, swell potential and dominant clay mineral type based on free swell ratio. Cation exchange capacity, total surface area are also quite instrumental in identifying the clay minerals. Therefore, every clay mineral is a function of Atterberg limits,

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percentage clay fraction, cation exchange capacity and total surface area. Identification of clay minerals can also be carried out with these test results with a reasonably good accuracy rather than more sophisticated tests such as X-Ray diffraction, scanning electron microscope etc. The most challenging part of identifying the clay minerals with the help of index properties is, there is no standard procedure established for this purpose.

Machine learning is a subset of artificial intelligence that focuses on the development of adaptive computing systems that can enhance their performance through the use of experience-based data. (Jasmina Dj et al., 2017). The three types of machine learning algorithms are supervised, unsupervised, and reinforcement learning. The task of developing a capacity from the prepared knowledge is referred to as supervised learning. The preparation information comprises of a lot of perceptions together with its result. Supervised learning can be further separated into classification and regression. Classification methods are utilized to foresee categorical values and Regression methods are utilized to anticipate numerical qualities (Johnson et al., 2019).

Medical research, medication design, astronomy, atmospheric science, agronomy, manufacturing, telecommunications, marketing, business decision making, image processing, traffic design, and road safety are all examples of where classification algorithms are applied.

In the present study, all the eight classification algorithms viz. (1) Logistic Regression (LR), (2) K Nearest Neighbourhood (KNN), (3) Support Vector Machine (SVM), (4) Naive Bayes (NB), (5) Decision Tree (DT), (6) Random Forest (RF), (7) XG Boost (XGB), (8) Artificial Neural Networks (ANN) are applied on the three types of clay sample data collected from various reputed journals viz. Kaolinite, Montmorillonite and Illite with input features liquid limit, plastic limit/plasticity index for the prediction of clay mineral present.

The two main objectives of present work are as follows:

1. To check suitability of liquid limit & plastic limit (also plasticity index) data for classifying clays based on mineralogical composition.
2. To identify appropriate classification model useful in identification clays minerals.

Collection of data

The soil property data of three types of clays considered in the current study viz. Kaolinite, Illite and Montmorillonite is obtained from 152 research articles published in more than 15 reputed journals and a couple of conferences. All the journals have substantiated their claims on mineralogical composition of clays with XRD and other investigation reports.

In the present study the 175 sample data of Kaolinite, 117 sample data of Illite and 192 sample data of Montmorillonite clays accounting to 484 are considered. Liquid limit and plastic limit values for the three types of clays considered are shown in the three independent plasticity charts as shown in the Figs. 1, 2, and 3.

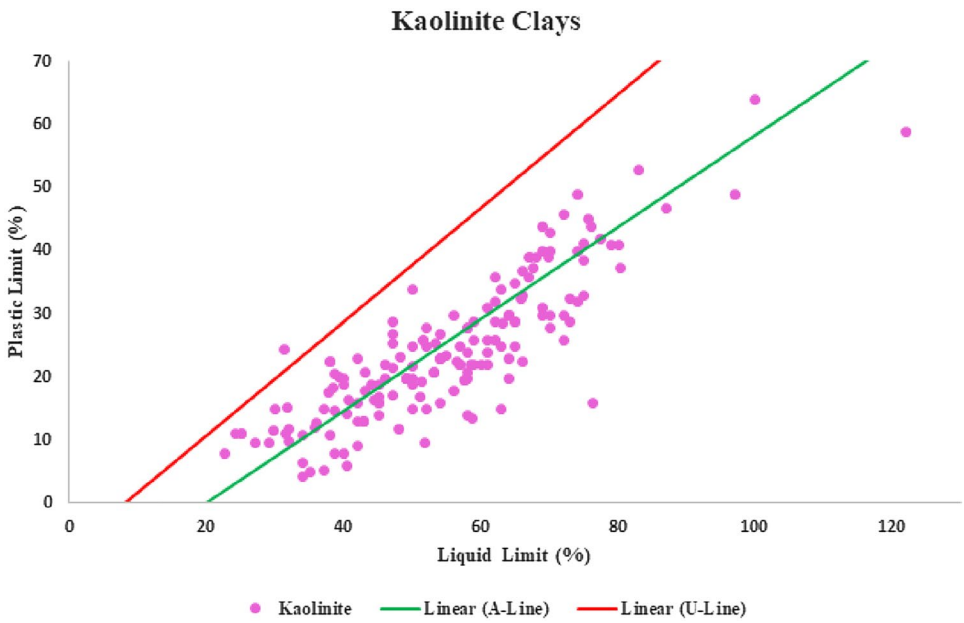


Fig. 1 Kaolinite clay data on plasticity chart

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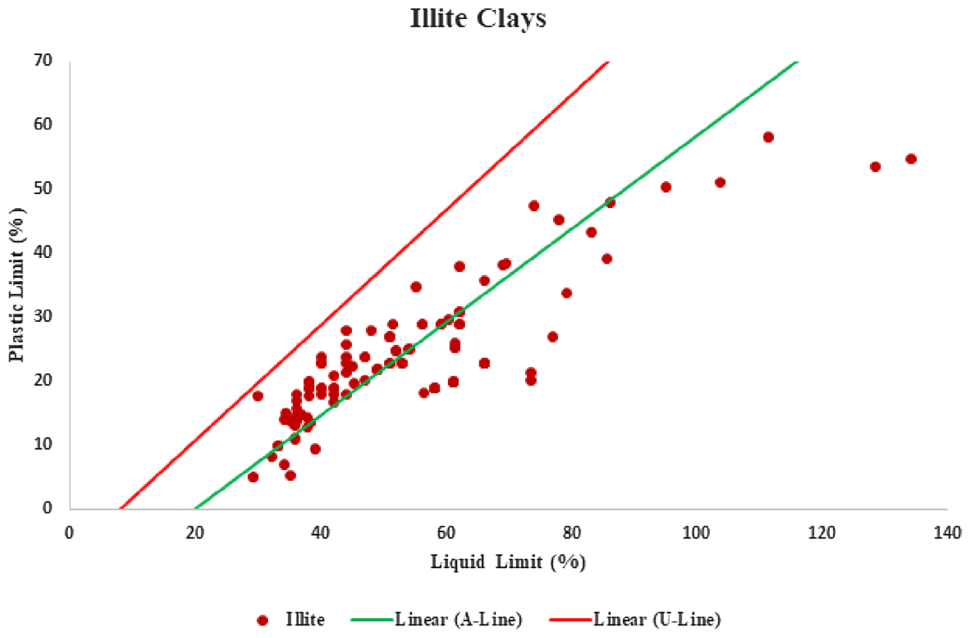


Fig. 2 Illite clay data on plasticity chart

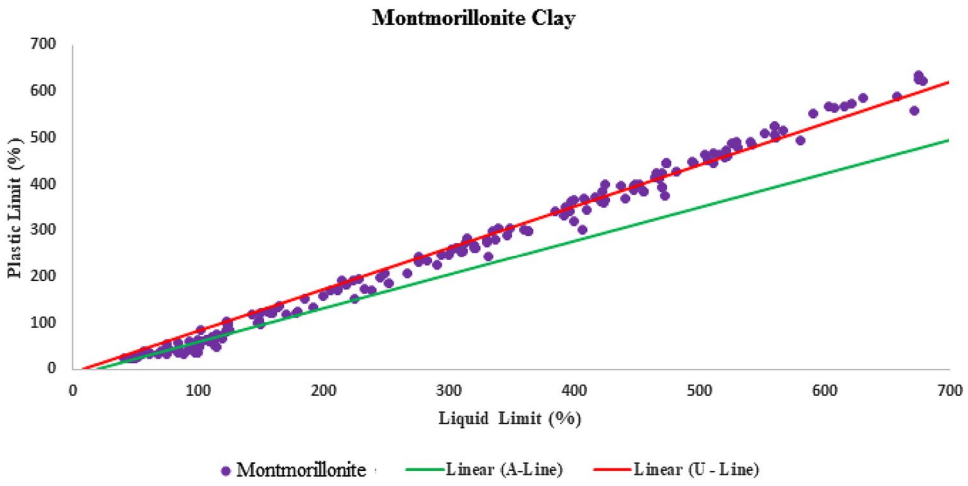


Fig. 3 Montmorillonite clay data on plasticity chart

Methodology

The data is organized into six binary and two multiclass (three class) datasets. Six binary datasets, out of which three have input features as liquid limit and plastic limit, and the remaining three have input features liquid limit and plasticity index. The three having liquid limit and plastic limit as input features are designated as 'A' group, and the remaining three having liquid limit and plasticity index as input features are designated as 'B' group. For '1A' and '1B' datasets, output variables are Kaolinite and Illite. For '2A' and '2B' datasets, the output variables are Illite and Montmorillonite. Similarly, the output variables are Kaolinite and Montmorillonite for '3A' and '3B' datasets. Two multiclass datasets have input features as liquid limit and plastic limit, and the other one has liquid limit and plasticity index and is designed as '4A' and '4B', respectively. For both '4A' and '4B', the output variables are Kaolinite, Illite and Montmorillonite. The details of datasets, input features, output variables and applied classification techniques are shown in Table 1.

In all the eight classification techniques applied on eight datasets, 80% of the data is used to train the model, and 20% is for testing. On each of the datasets, eight classification models are applied viz. (1) Logistic Regression, (2) K Nearest Neighbourhood, (3) Support Vector Machine, (4) Naive Bayes, (5) Decision Tree, (6) Random Forest, (7) XG Boost and (8) Artificial Neural Networks. K-Fold Cross-Validation is used to assess the model performance and is applied to training set data. Each classification model is

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Table 1 Details of dataset for classification model study

Dataset	Input features	Out variables (Class)	Applied classification models
01A	1. Liquid limit 2. Plastic limit	Kaolinite (0) Illite (1)	1. Logistic Regression 2. K Nearest Neighbourhood 3. Support Vector Machine 4. Naive Bayes 5. Decision Tree 6. Random Forest 7. XG Boost 8. Artificial Neural Networks
01B	1. Liquid limit 2. Plasticity index		
02A	1. Liquid limit 2. Plastic limit	Illite (0) Montmorillonite (1)	
02B	1. Liquid limit 2. Plasticity index		
03A	1. Liquid limit 2. Plastic limit	Kaolinite (0) Montmorillonite (1)	
03B	1. Liquid limit 2. Plasticity index		
04A	1. Liquid limit 2. Plastic limit	Kaolinite (0) Illite (1) Montmorillonite (2)	
04B	1. Liquid limit 2. Plasticity index		

evaluated on test data with the help of matrices derived from the confusion matrix and by drawing Receiver Operating Characteristic (ROC) curve to measure the Area Under the Curve (AUC). The better model on each dataset is selected by comprehending K-Fold Cross-Validation, matrices from confusion matrix and AUC of ROC curve.

Implementation and results

Classification models

The eight classification techniques used the present study are briefed below:

Logistic regression

The process of modelling the likelihood of a discrete result given an input variable is called logistic regression. Binary outcomes, such as true/false, yes/no, and other outcomes with only two possible values, are most frequently modelled by logistic regression. Multiple discrete outcomes in a given scenario can be modelled using multinominal logistic regression. (Thomas & David, 2017).

K Nearest Neighbourhood

K Nearest Neighborhood is a classification method that classifies a given example based on the votes of its neighbours. The observation is put in the same category as its nearest K neighbours. The model's input data determines the value of K. In general, the bigger the value of K, the less impact noise or classification errors have. (Johnson et al., 2019).

Support vector machine

The goal of the support vector machine algorithm is to locate an N-dimensional hyperplane (where N is the number of features) that categorizes the data points. Numerous potential hyperplanes might be selected to divide the two classes of data points. The objective of an SVM is to locate a plane with the most significant margin or the most excellent separation between data points from both classes. (Rohith, 2018).

Naive Bayes

A probabilistic classifier called the Naive Bayes classifier, which is based on the Bayes theorem, assumes that each feature contributes equally and independently to the target class. The naive Bayes classifier assumes that each feature is separate from the others and does not interact; therefore, each feature independently and equally influences the likelihood that a sample belongs to a particular class.

For a binary classification problem having two features say, X1 and X2, the probability of a class yi is expressed as (Misra & Li, 2020)

$$P(yi|X1, X2) = \frac{P(X1|yi)P(X2|yi)}{P(X1)P(X2)}$$

Decision tree

A tree-like decision structure with a root node and numerous leaves is produced by the decision tree classifier after processing the training dataset. Internal nodes are all located between the root node and the leaves. Each node is divided into internal nodes and/or leaves so that the dataset becomes purer due to the division; specifically, each split should result in the dataset being divided into groups with samples predominately from one class (Misra & Li, 2020).

Random Forest

An ensemble technique called Random Forest classifier trains several decision trees concurrently with bootstrapping, aggregation, and bagging (Misra & Li, 2020).

XG Boost

XGBoost is a robust machine learning algorithm, specifically where speed and accuracy are concerned.

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XGBoost implements a gradient-based decision tree designed for speed and performance that dominates competitive machine learning.

Artificial neural networks

ANN stands for artificial neural network which is a computing system that works in parallel and is designed to emulate the human brain processes and analyzes the information. By utilizing data from past experiences, it can model, classify, recognize, and predict a wide range of problems (Kaveh & Iranmanesh, 1998). Typically, an ANN is made up of an input layer, one or more hidden layers, and an output layer. There are multiple layers of neurons, each connected to the other via a weighted connection to form a network of processing units (Kaveh et al., 2008). The input neurons receive information from the external environment and transmit it to the hidden neurons, which then process the information and reconstruct the input–output mapping based on the key features they extract (Kaveh & Servati, 2001; Kaveh et al., 2001). Lastly, the neurons of the output layer will provide the network predictions to the outside world (Kaveh et al., 2014).

In Fig. 4, inputs, weights, summation functions, activation functions, and outputs are shown. It is possible for neurons to receive input from external data or to receive output from neurons in previous layers. By calculating the weighted sum of all inputs, adding a bias, and passing this value through a nonlinear activation function, the neuron produces its output. A neuron's output feeds an input for the next neuron of the layer below to it (Nakkeeran & Krishnaraj, 2023).

The mathematical expression is

$$o_j = f\left(\sum_{i=1}^{n} w_{ij}x_i + b\right)$$

where o_j is the output of the jth neuron, w_{ij} the weight, x_i the input, b the bias, and f an activation function. Over-fitting may be avoided by normalizing the variables, which can be done using the equation below (Nakkeeran et al., 2023):

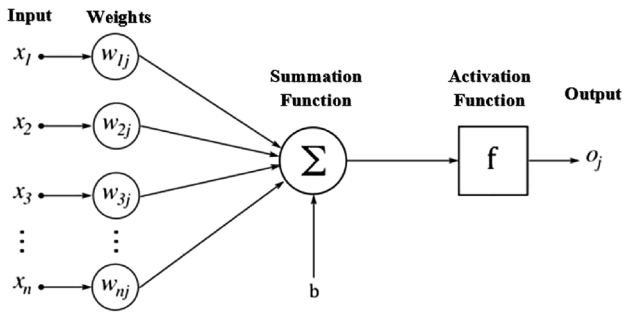


Fig. 4 ANN General Architecture

$$X_{norm} = \frac{(X_{max} - X_{min})(Y_i - Y_{min})}{(Y_{max} - Y_{min})} + Y_{min}$$

X_{norm} is the normalized parameter, X_{max} is the maximum and X_{min} is the minimum value of the scaling range, Y_i is the actual data to be scaled, Y_{max} and Y_{min} are the minimum and maximum values of the actual data, respectively.

Cross-validation

K fold cross-validation is applied to the training set to access the model performance. K fold cross-validation algorithm divides the training set into equal K parts. Out of the K parts, K-1 parts are used to train the model and left out 1 part is used for validating the model in one iteration. Similar iterations are performed by considering another 1 parts of data as test data and the remaining parts as training data. In all iterations, the accuracies are evaluated. The test reports the average of all the accuracies alongside standard deviation. In the current study, the K value is set as 10. The K fold cross-validation data for all the eight datasets are shown in the tables, and the corresponding statistical analysis of the data is shown in the

Table 2 K fold cross-validation data on training set of 01A

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	61.81	0.60
KNN	63.14	7.18
SVM	61.81	0.60
NB	58.34	3.43
DT	69.55	5.12
RF	69.11	7.80
XGB	72.15	6.22
ANN	58.79	4.93

Table 3 K fold cross-validation data on training set of 01B

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	58.36	2.03
KNN	63.08	6.62
SVM	58.37	0.96
NB	56.64	3.33
DT	63.56	8.68
RF	63.14	5.65
XGB	66.57	5.94
ANN	65.23	5.92

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Table 4 K fold cross-validation data on training set of 02A

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	89.46	3.92
KNN	88.65	3.67
SVM	91.10	4.14
NB	89.46	3.92
DT	89.06	4.18
RF	91.10	2.69
XGB	88.66	2.33
ANN	91.10	4.80

Table 5 K fold cross-validation data on training set of 02B

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	88.31	7.21
KNN	89.08	3.00
SVM	88.71	7.24
NB	88.71	7.37
DT	89.90	3.77
RF	87.85	4.23
XGB	88.27	3.79
ANN	89.07	2.71

Table 6 K fold cross-validation data on training set of 03A

Classification Model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	92.16	1.81
KNN	93.18	1.92
SVM	92.84	1.55
NB	93.52	2.18
DT	87.03	3.28
RF	91.80	2.66
XGB	91.45	2.80
ANN	93.86	2.64

Table 7 K fold cross-validation data on training set of 03B

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	91.14	3.24
KNN	93.86	2.34
SVM	92.85	3.85
NB	93.19	3.25
DT	94.54	1.53
RF	92.50	3.03
XGB	94.20	3.21
ANN	94.55	1.91

Table 8 K fold cross-validation data on training set of 04A

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	70.02	1.17
KNN	71.57	5.27
SVM	69.25	0.71
NB	68.21	2.20
DT	71.06	4.86
RF	74.70	4.46
XGB	73.93	5.62
ANN	73.42	4.75

Table 9 K fold cross-validation data on training set of 04B

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	70.03	1.08
KNN	68.47	3.56
SVM	69.51	0.59
NB	68.73	1.15
DT	72.08	3.66
RF	72.61	4.24
XGB	73.90	3.30
ANN	72.08	7.39

form of a box plot. Tables 2, 3, 4, 5, 6, 7, 8 and 9 presents mean accuracy and standard deviation for the classification models on datasets 01A through 04B when K fold cross-validation is applied on their training sets. Figures 5, 6, 7, 8, 9, 10, 11, and 12 are the boxplots drawn for the means obtained on the training sets of datasets 01A through 04B when K fold cross-validation is applied on each classification model.

Evaluating classification models

In order to evaluate the classification model, two approaches are adopted in the current study. The first approach is evaluating the accuracy, precision, recall, and f1 score deduced from the confusion matrix for binary and multiclass classifications. The second approach is to draw the Receiver Operating Characteristic (ROC) curve and measure the Area

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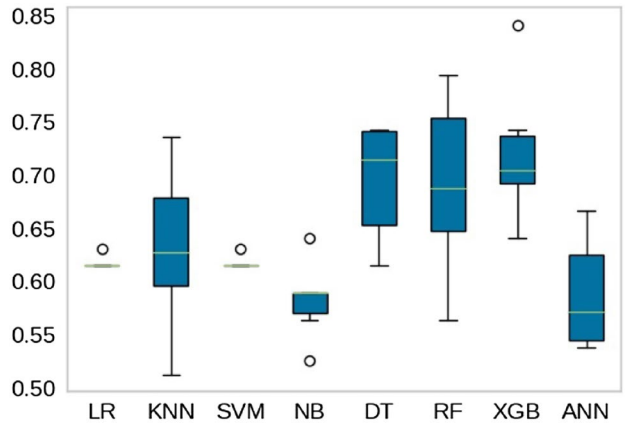


Fig. 5 Boxplot of K fold cross-validation accuracies obtained on training set of 01A

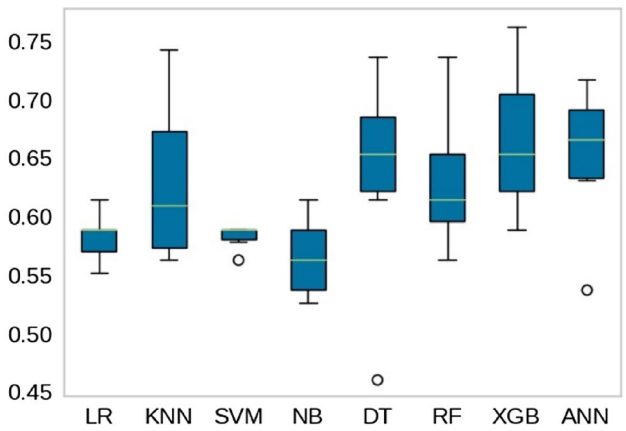


Fig. 6 Boxplot of K fold cross-validation accuracies obtained on training set of 01B

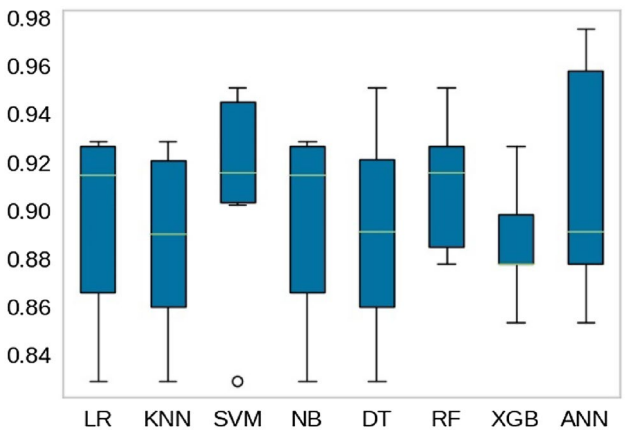


Fig. 7 Boxplot of K fold cross-validation accuracies obtained on training set of 02A

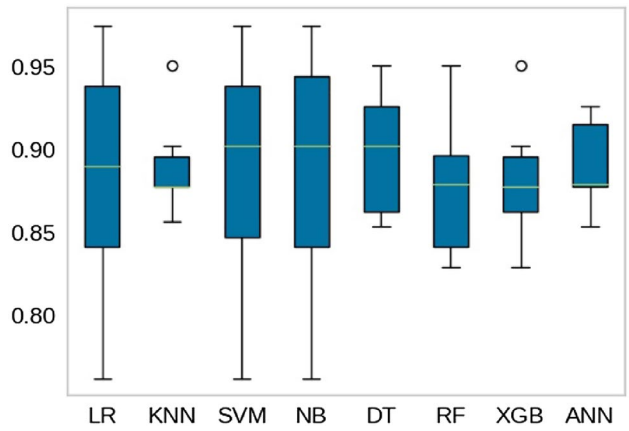


Fig. 8 Boxplot of K fold cross-validation accuracies obtained on training set of 02B

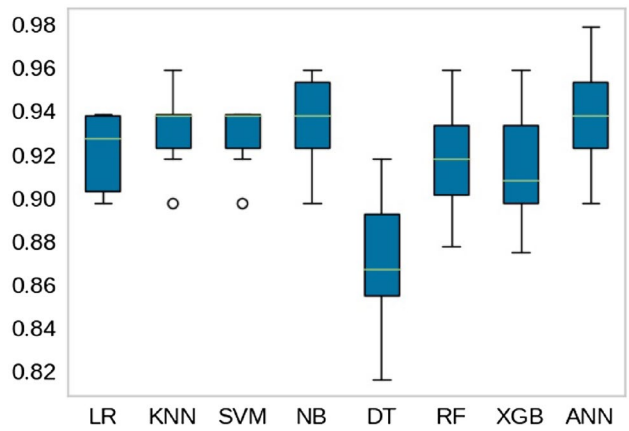


Fig. 9 Boxplot of K fold cross-validation accuracies obtained on training set of 03A

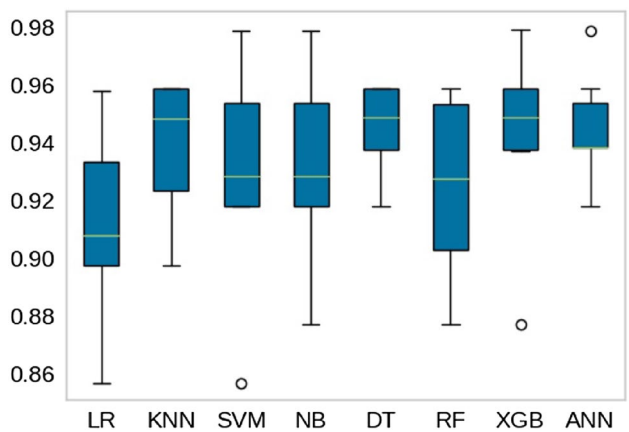


Fig. 10 Boxplot of K fold cross-validation accuracies obtained on training set of 03B

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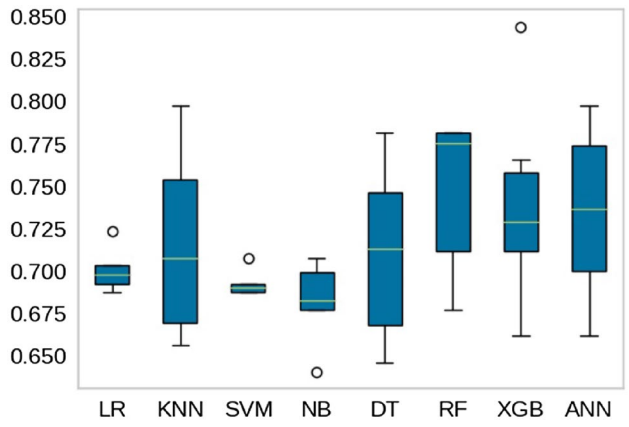


Fig. 11 Boxplot of K fold cross-validation accuracies obtained on training set of 04A

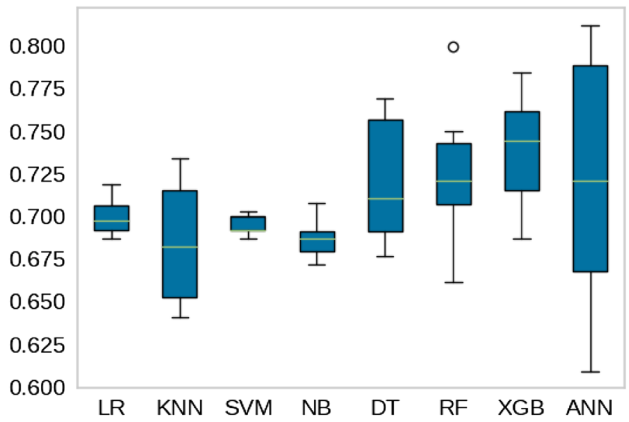


Fig. 12 Boxplot of K fold cross-validation accuracies obtained on training set of 04B

Under the Curve (AUC). Both the approaches and corresponding measured metrics are detailed in the following sections.

Confusion matrix

A confusion matrix is a square matrix formed between predicted values and actual values of the classes of a classification model. The structure and the various metrics calculated from the confusion matrix is explained with the help of a binary classification whose classes are 'Yes' & 'No' as shown in Fig. 13.

Here TP = Count of both predicted and actual positive; FP = Count of actual negative but predicted positive; TN = Count of both predicted and actual negative; FN = Count of actual positive but predicted negative.

The metrices calculated from confusion matrix for a binary classifier are as follows:

		Predicted	
		Yes	No
Actual	Yes	TP	FP
	No	FN	TN

Fig. 13 Confusion matrix for binary classification

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN}$$

$$Precision = \frac{TP}{TP+FP}$$

$$Recall\ or\ True\ Positive\ Rate\ (TPR) = \frac{TP}{TP+FN}$$

$$FalsevPositive\ Rate\ (FPR) = \frac{FP}{TN+FP}$$

$$f1\ Score = \frac{2xRecallxPrecision}{Recall+Precision}$$

Metrices calculated from confusion matrix Precision, Recall, Accuracy and f1 Score are calculated for the six binary datasets and two multiclass datasets on which eight classification algorithms viz (1) Logistic Regression, (2) K Nearest Neighbourhood, (3) Support Vector Machine, (4) Naive Bayes, (5) Decision Tree, (6) Random Forest (7) XG Boost and (8) Artificial Neural Networks is applied. The weighted averages of each metric obtained from the eight classification models are shown in column charts in Figs. 14, 15, 16, 17, 18, 19, 20, and 21 for better visualization.

ROC curve and AUC calculation

Receiver Operating Characteristic curve is a plot drawn between *True Positive Rate* on the vertical axis in function with *False Positive Rate* on the horizontal axis for different cut-off points. Each point on the ROC curve represents FPR, TPR pair corresponding to a particular decision threshold.

The area under the ROC curve is a valuable metric to evaluate the model's performance in the case of a binary classifier. For a truly accurate model, the AUC value is 1. When the AUC value is 0.5, the model cannot distinguish the positive and negative classes. Therefore, the higher the AUC value, the better the ability of the model to distinguish between positive and negative. The Sckit-Learn roc plot can be drawn for the binary classifier alone. With the help of roc_auc_score, AUC values can be calculated for multiclass classifiers. However, the plotting of multiclass ROC curves is not supported by all classification models directly in Sckit-Learn.

Yellowbrick's *ROCAUC* visualizer helps to plot multiclass classification curves containing ROC curves for each class with one-vs-rest (micro score) and one-vs-all (macro score) strategies on the same plot.

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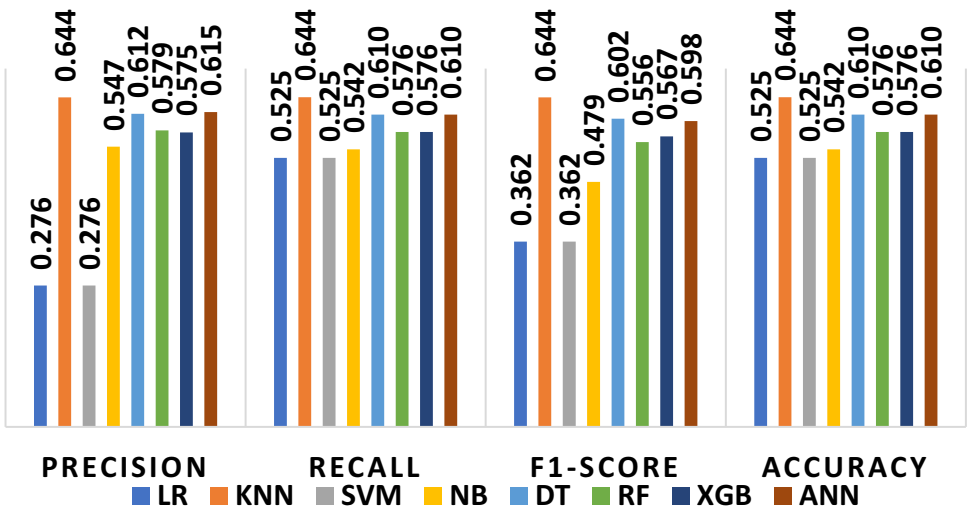


Fig. 14 Weighted average of evaluation metrics of 1A test set

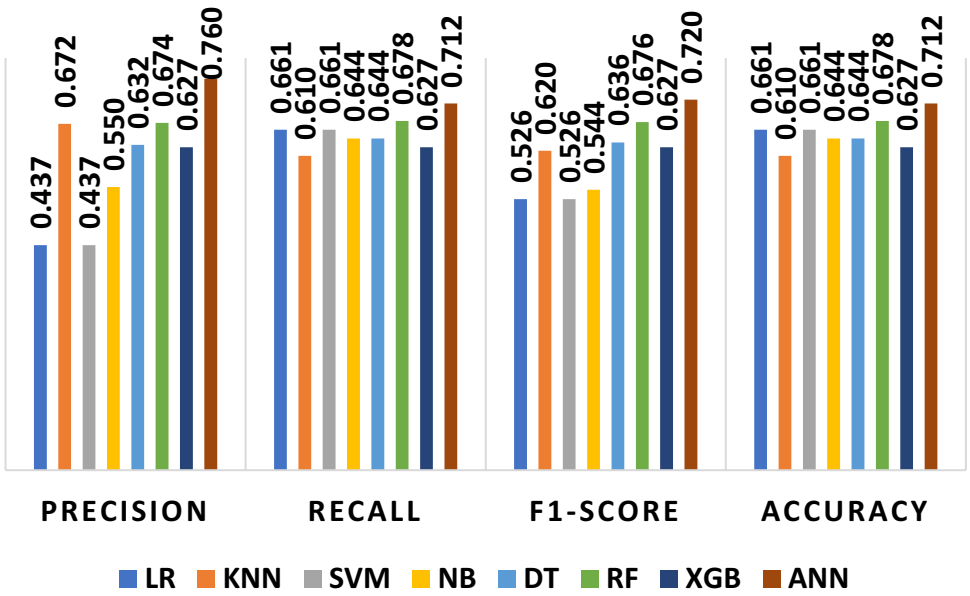


Fig. 15 Weighted average of evaluation metrics of 1B test set

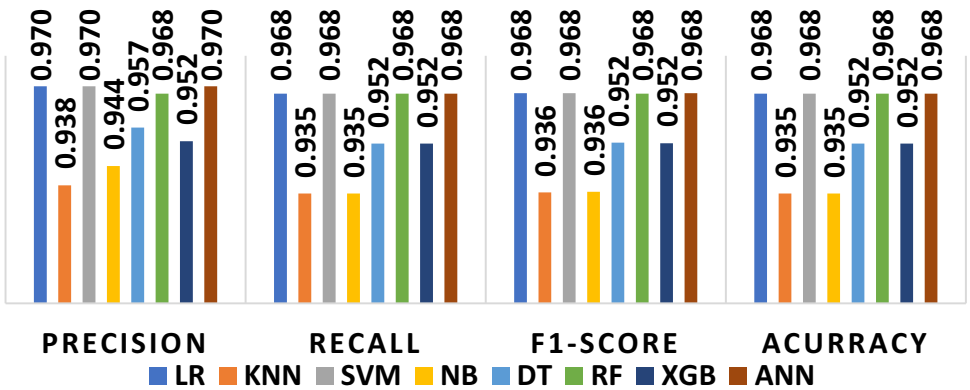


Fig. 16 Weighted average of evaluation metrics of 2A test set

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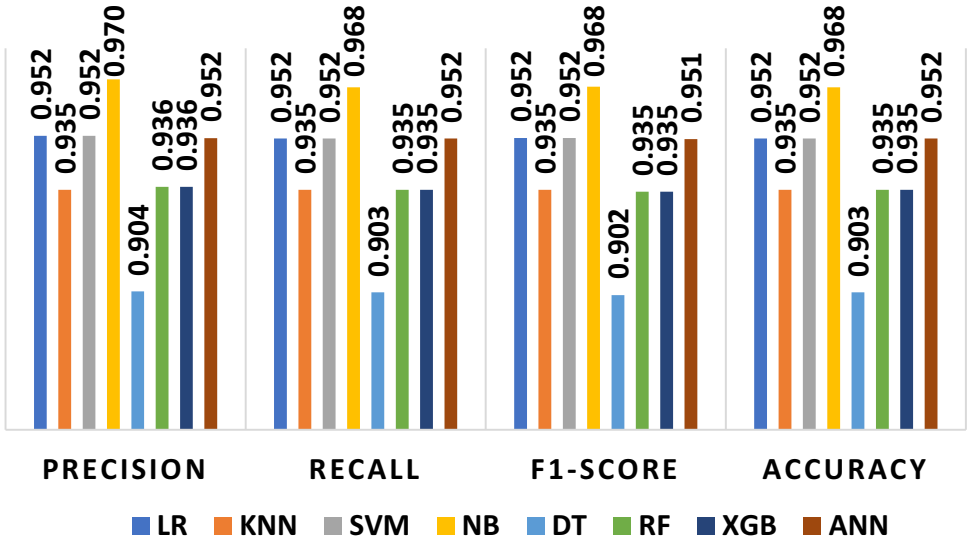


Fig. 17 Weighted average of evaluation metrics of 2B test set

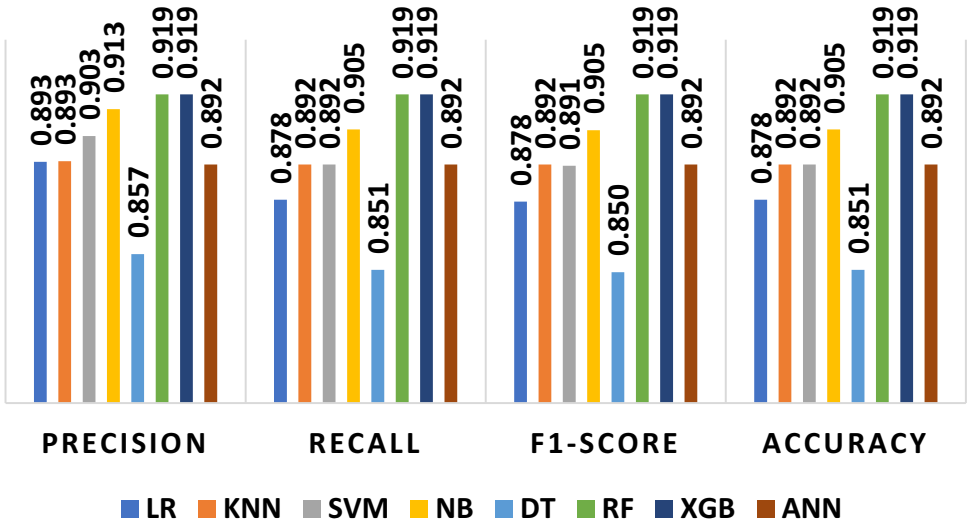


Fig. 18 Weighted average of evaluation metrics of 3A test set

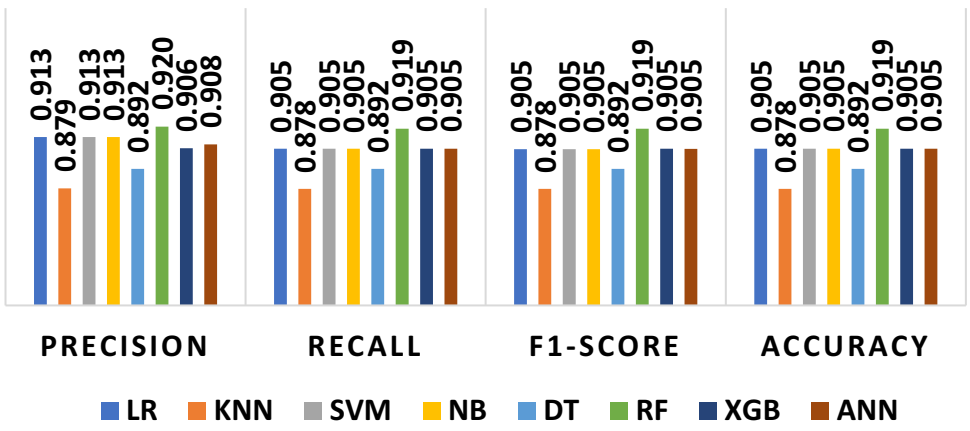


Fig. 19 Weighted average of evaluation metrics of 3B test set

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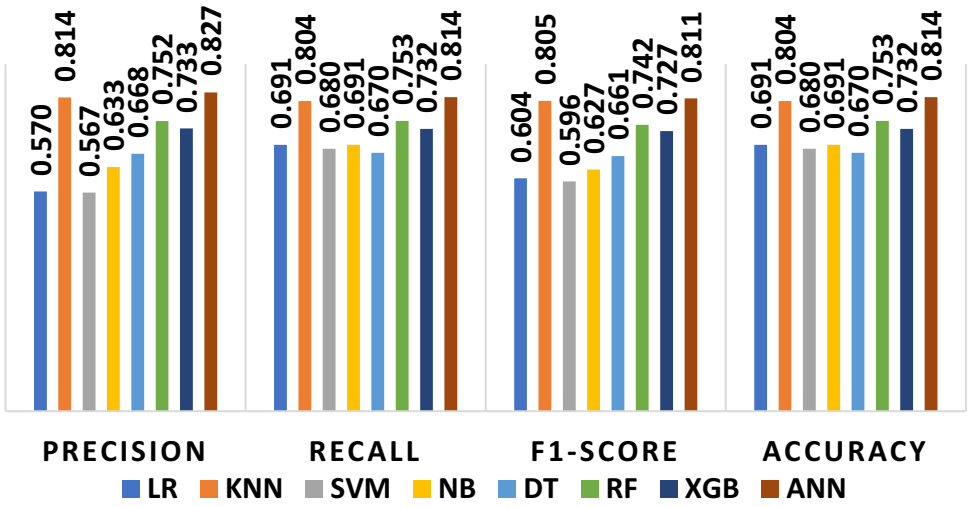


Fig. 20 Weighted average of evaluation metrics of 4A test set

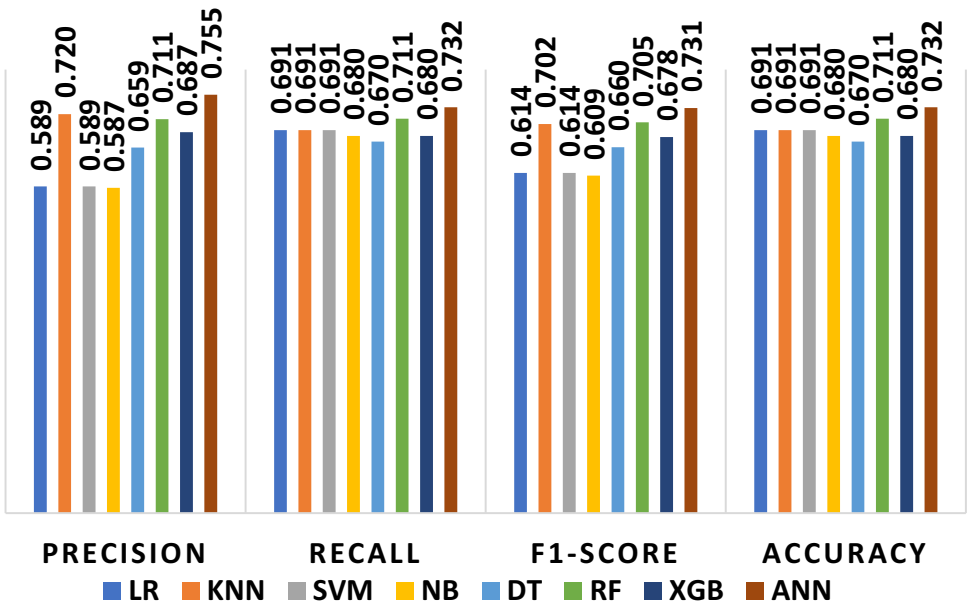


Fig. 21 Weighted average of evaluation metrics of 4B test set

In the current study, Sckit-Learn *RocCurveDisplay* is used to draw ROC curves of different models of a binary classifier on the same plot. For drawing multiclass ROC curves, Yellowbrick's *ROCAUC* visualizer is used.

ROC curves for binary classification datasets On the binary datasets, the eight classification models are applied, and the corresponding ROC curves are plotted on a single graph along with their AUC values for better comparison, as shown in Fig. 22.

ROC curves for multiclass datasets With the help of Yellowbrick's library, ROC curves are drawn for the multiclass datasets. Yellowbrick's ROCAUC visualizer allows drawing ROC curves for one classification model, consisting of ROC curves for each class and their micro-average and macro-average ROC along with their AUC values. Figure 23 shows ROC plots for multiclass datasets namely 04A and 04B for different classification models in the sequence (a) 04A – LR (b) 04A – KNN (c) 04A – SVM (d) 04A – NB (e) 04A – DT (f) 04A – RF (g) 04A – XGB (h) 04B – LR (i) 04B – KNN (j) 04B – SVM (k) 04B – NB (l) 04B – DT (m) 04B – RF (n) 04B – XGB.

Conclusions and future scope

Following conclusions can be drawn from the extensive study on classification models:

- Artificial Neural Networks have better performed and evaluated out of 6 binary classification datasets and two

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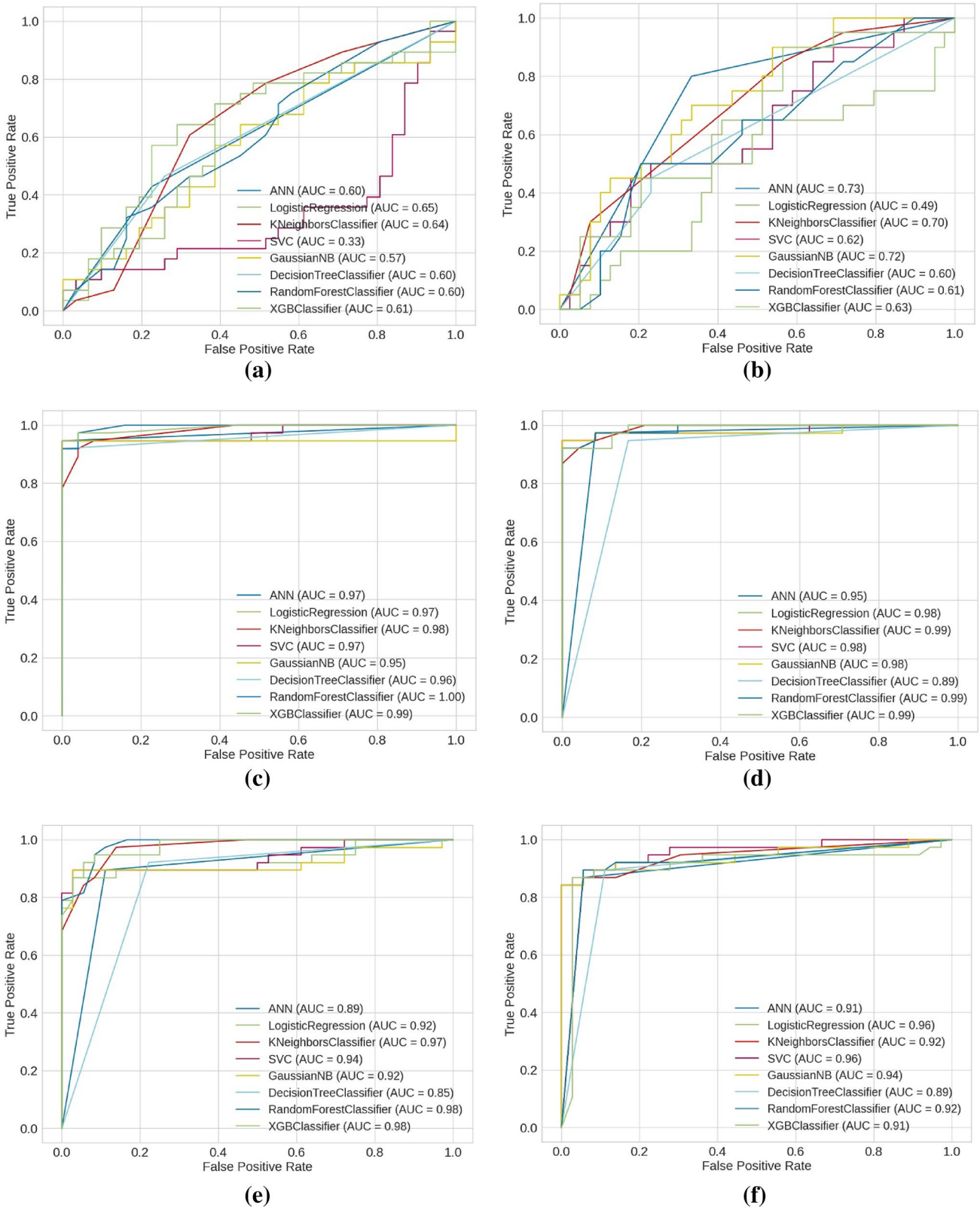


Fig. 22 ROC curves for drawn for classification models on datasets 01A to 03A

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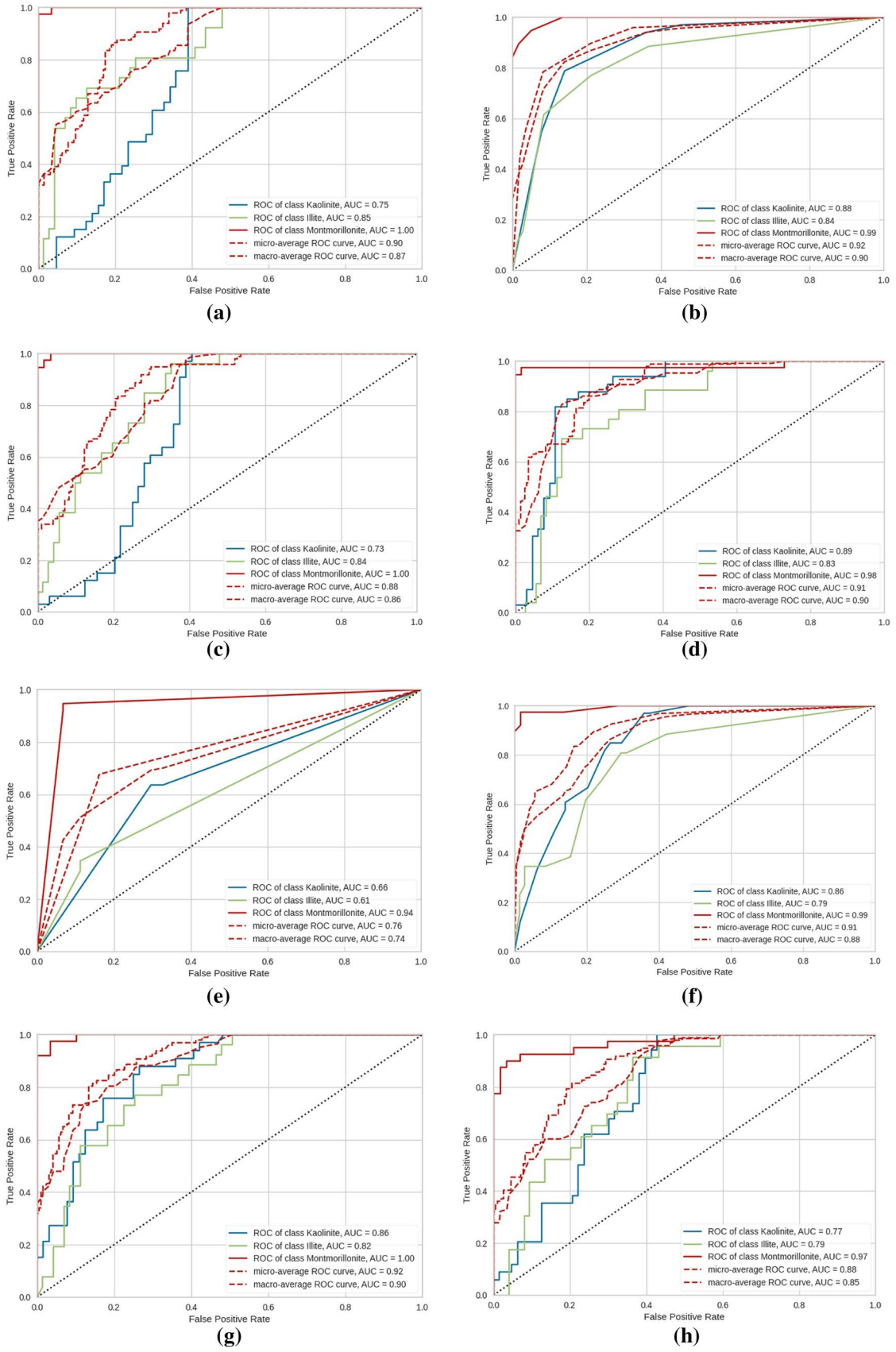


Fig. 23 ROC curves of multiclass datasets for different classification models

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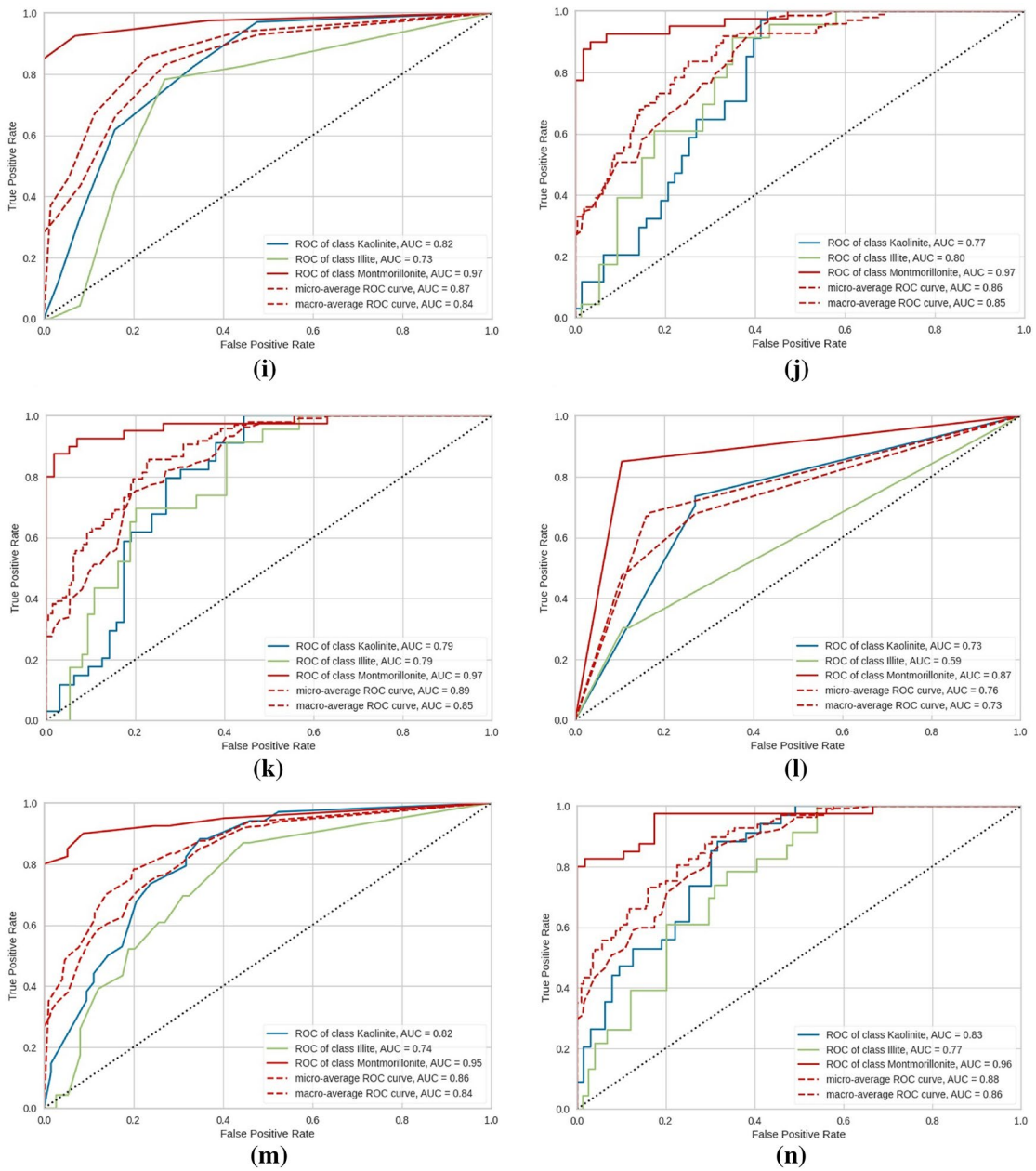


Fig. 23 (continued)

multiclass data sets. ANN proves to be a very effective classification model for multiclass datasets.

- In the 01A binary dataset, both ANN and Decision Tree have better accuracy; however, Decision Tree has consistent accuracy while cross-validating with the least standard deviation.
- For 01B, ANN was proved to be the only model which gave high and consistent accuracies, while K cross-validation was applied with a lower standard deviation.
- For the datasets 03A & 03B, though the Random Forest model gave slightly high accuracy, ANN produced better cross-validation accuracy with significantly less standard deviation proving to be better suitable for these datasets.
- The binary datasets having montmorillonite gave very high accuracy predictions, followed by Kaolinite.
- The plasticity index in place of plastic limit has not significantly contributed to the performance of predictions as an independent variable.

The current study establishes that Atterberg limits, namely liquid limit and plastic limit/plasticity index, are reliable input features for classifying clays based on the mineralogical

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composition. Montmorillonite can be predicted with the highest accuracy with these input features out of the three clay minerals. Next to Montmorillonite, Kaolinite can be predicted with reasonable accuracy; however, classifying Illites is quite challenging with these input features. Other features, namely shrinkage limit, percentage clay fraction, cation exchange capacity, and total surface area, can be examined to improve clays' predictions, especially Illite clays.

Author contributions CSKP: conceptualization, methodology, data curation, original draft Writing.KMR: conceptualization, methodology, data curation, original draft Writing.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

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An Experimental Investigation on Glass Fiber Concrete by Partial Replacement of Cement with Alccofine

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Abstract: Concrete is the most widely used construction material due to its strength, durability, and versatility. However, the production of cement, which is a key component of concrete, is a major contributor to greenhouse gas emission. The use of supplementary Cementitious materials (SCMs) can improve the properties of concrete, reduce use on natural resources and CO_2 emissions. The present study is directed to investigate the effect of Alccofine-1203 (AL) as partial replacement of cement on Glass Fibers (GF) reinforced M30 grade concrete. Different types of concrete mixes were prepared by replacing cement with Alccofine-1203 of 5%, 10% and 15%, respectively, then it is found to be the optimum percentage of replacement of cement with Alccofine-1203 is 10%. Further, the effect of Alccofine and Glass Fiber with different combinations, such as, 10%AL+0.1%GF, 10%AL+0.2%GF, and 10%AL+0.3%GF was also carried out. Based on the test results of Mechanical properties of concrete the optimum dosage is found to be 10% AL and 0.2% GF.

Keywords: Alccofine-1203, Glass fibre, Compressive strength, Split tensile strength, Flexural strength, Modulus of Elasticity .

1. INTRODUCTION

Cement is the most prevalent kind of concrete binder. At present sustainable development of the cement and concrete industry requires the utilization of industrial and agricultural by-products. At present, for a variety of reasons, the concrete construction industry is not sustainable. It consumes huge quantities of virgin materials and the principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. So, finding a solution to substitute for part of the cement seems to be desirable for sustainable development. In the present investigation applications ofAlccofine-1203 as partial replacement of Cement for the Glass fibers reinforced concrete is adopted.

OBJECTIVES

The main objective of the present experimental investigation is to obtain the influence of Alccofine-1203 and Glass fibre on various Mechanical properties of M30 grade concrete.

It consists of following:

- To find out optimum replacement percentage of Alccofine-1203 .
- To determine the mechanical properties such as Compressive Strength, Split Tensile Strength, Flexural Strength and Modulus of elasticity of concrete prepared using alccofine-1203 and Glass fibers and to compare with conventional concrete.

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BUILDING INFORMATION MODELLING OF AN EARTHQUAKE RESISTANT STRUCTURE

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ABSTRACT

Constructing a structure that minimizes earthquake damage can be challenging due to the unpredictable nature of seismic events, making it seem impractical. However, this study focuses on developing earthquake-resistant structure by incorporating Building Information Modelling (BIM) in the design and detailing process. The primary focus is on a G+5 apartment building designed to withstand seismic forces and prioritize occupant safety during earthquakes. BIM technology, using software such as Revit, ETABS, SAFE, SketchUp, AutoCAD, etc., is employed to enhance the structural design. Starting with creating a detailed architectural plan for the G+5 structure and rendered different architectural 3d views by creating models in Blender software. Then the detailed seismic analysis and design is done in ETABS & SAFE as per seismic design code (IS:1893-2016). BIM tools generate a dynamic 3D model, facilitating the visualization and simulation of seismic responses. The project encompasses comprehensive Structural, Architectural, and MEP (Mechanical-Electrical-Plumbing) BIM. The BIM model serves as a central information repository, allowing for precise quantity take-offs and cost assessments. The study's outcomes contribute significantly to the advancement of earthquake-resistant building design, highlighting the efficiency of BIM in optimizing structural performance and cost-effectiveness. These findings hold relevance for professionals in structural engineering, architecture, and construction management, underscoring the pivotal role of integrating BIM in earthquake-resistant designs. Furthermore, the detailed cost estimation for the entire G+5 building is also included.

Keywords: Building Information Modelling (BIM), seismic resilience, G+5 apartment building, earthquake-resistant structure, cost estimation, architectural, MEP BIM.

I. INTRODUCTION

1.1 General

Designing earthquake-resistant structures is crucial in civil engineering, particularly in earthquake-prone areas. Building design must consider hindrances to earthquake forces and ensure adequate support to prevent collapse. In this G+5 project, advanced BIM tools like AutoCAD, ETABS, Revit, and SAFE are employed. These tools help as digital assistants, enhance the design process, provide detailed information, and optimize the building's resilience to both routine and seismic challenges.

In India the earthquake prone area is divided into 4 zones based upon their vulnerability to earthquakes. So, for designing any type of structure in these zones, there are some design codes (see in 1.2). Following these codes will ensure that our constructions are not only safe but also capable of withstanding earthquakes.

Design Guidelines: Structural designers must adhere to key standards for earthquake-resistant design:

- IS 1893: 2016: Criteria for Earthquake Resistant Design.
- IS 13920: 1993: Ductile Detailing of Reinforced Concrete Structures subjected to seismic forces.
- IS: 456-2000: Indian Standard Plain Reinforced Concrete Code of Practice (Fourth Revision).
- IS 875 (Part 1-5): 1987: Code of Practice for Design Loads (excluding earthquake) for Buildings and Structures (Second Revision), encompassing dead loads, live loads, wind loads, snow loads, and special loads.

These streamlined guidelines ensure structures are resilient to seismic challenges in their respective zones, promoting safety and structural integrity.

AN EXPERIMENTAL INVESTIGATION ON POLYPROPYLENE FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH ALCCOFINE

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ABSTRACT: *In this experimental investigation an attempt was made to study the feasibility and effectiveness of integrating Alccofine as a supplementary material in Polypropylene Fiber Reinforced Concrete of grade M25. Various concrete mixes with Alccofine substitution (5%, 10%, and 15%) were examined to determine the optimal percentage. The addition of Polypropylene fibers to concrete at 0.1%, 0.2%, 0.3%, and 0.4% by weight of concrete were prepared to determine the optimum dosage of Polypropylene fibres in concrete which is replaced with optimum Alccofine percentage. These fibers help control cracking from plastic and drying shrinkage, reduce concrete permeability, and enhance impact strength. Addition of Polypropylene fibres transforms the material from brittle to ductile. The study includes determination of compressive strength, split tensile strength, flexural strength and impact characteristics. The findings reveal that a combination of 10% Alccofine substitution along with 0.3% Polypropylene fibers leads to notable enhancement 45.3%, 35.6%, 16.67%, and 191% in compressive, split tensile, flexural, and impact strength, respectively, compared to control concrete. Based on the results it can be concluded that the combination of 10% Alccofine and 0.3% Polypropylene fibers in concrete significantly improves both the strength properties and impact strength of the concrete in comparison to control concrete.*

Keywords: ***Polypropylene Fiber Reinforced concrete, Alccofine, impact characteristics, impact strength***

1. Introduction

The modern construction constantly evolves to meet the demands of sustainable development and enhanced performance. Conventional concrete compositions often rely heavily on Portland cement, a material associated with significant carbon emissions during its production. To address environmental concerns and improve concrete properties, innovative solutions such as Alccofine as partial replacement for cement offers multifaceted benefits. By reducing the cement content, these materials help lower carbon emissions associated with concrete production, aligning with sustainability objectives. Moreover, to enhance the mechanical properties and Impact characteristics of concrete, resulting in structures that exhibit superior performance and longevity. Polypropylene fibers, derived from a thermoplastic polymer, is increasingly recognized for its ability to enhance the impact strength of concrete. When dispersed within the concrete matrix, these fibers act as reinforcement, improving tensile strength, crack resistance, and Impact characteristics. Additionally, Polypropylene fibers mitigate plastic shrinkage cracking and improve Impact strength, making them invaluable in various construction applications. Alccofine, a supplementary cementitious material, offers a sustainable alternative to conventional cement. Produced from finely ground aluminosilicate materials, Alccofine possesses pozzolanic properties that react with calcium hydroxide forming additional calcium silicate hydrate (C-S-H) gel. This reaction not only contributes to the densification of the concrete matrix but also enhances long-term strength of the concrete. Furthermore, Alccofine reduces the heat of hydration and mitigates alkali-silica reaction, thus improving the overall sustainability and performance of concrete structures. In this investigation the effects of incorporating Polypropylene fibers and Alccofine

AN EXPERIMENTAL STUDY ON BULGING BEHAVIOUR OF RAMMED STONECOLUMNS

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Abstract:

Stone columns enhance the functionality of foundations in soft clays by lowering settlements and raising load bearing capacities. After being loaded, the top of a stone column, where the overburden pressures are lowest, bulges outward. The performance of stone column is greatly influenced by partial resistance of surrounding soil to lateral bulging of stone column. There is stiffer and stronger filler material around the column than the original soil. Load transfer due to lateral bulging is reported predominantly than due to end bearing at the column base and skin friction along the column soil interface. The stability of the soil around it plays a major role in determining the extent of bulging. The maximum weight that a stone column can support is directly proportional to its height. Longer stone columns, beyond a length of around 4D to 6D, are not expected to significantly improve capacity. This study aims to learn how the Consistency Index (I_C), length to diameter ratio (L/D) of stone column, soil's liquid limit (LL), and their interaction all affect with load-carrying capacity of a stone column when penetrating soft clays. The capacity for bearing capacity and resulting bulging of stone columns used as footings in soft clay beds. The impact of LL and I_C on column length will also be investigated. Furthermore, it is planned to develop and empirical equations to predict load carrying capacity of stone columns and the extent of bulging, taking into account all of Relative effect of each of three factors, namely LL, I_C, and L/D, and their interaction effects on load carrying capacity, bulging length, and bulging width is quantified using principles of 2^3 factorial experimentation influencing factors, and validating the same with reported results.

Keywords Stone column, Liquid limit (LL), Consistency Index (I_C), length to diameter ratio (L/D), Factorial Experimentation

1.0. INTRODUCTION:

Whenever difficult sub soil conditions are encountered during the construction of a civil engineering structure, and the site cannot be changed, ground improvement becomes necessary. If weak soils are replaced with compacted vertical columns of stones, they may or may not completely penetrate the weak strata, but

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AN EXPERIMENTAL PERFORMANCE OF STONE COLUMNS FILLED WITH REPURPOSING MATERIALS

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ABSTARCT:

Soft soil is a worldwide issue that has caused substantial issues for Geotechnical engineers. Engineers have been endeavoring to improve the engineering characteristics of substandard soils owing to their detrimental effects on project efficacy. The utilization of stone columns for enhancing the bearing capacity and settling characteristics of soft soils has gained significant recognition and popularity due to its demonstrated effectiveness. Utilizing waste materials in civil engineering projects presents a dual advantage of promoting environmental sustainability and yielding economic benefits. Used scrap tyres and crushed bricks are two examples of waste items that have a useful purpose in civil engineering. This study describes the findings of load tests conducted in a laboratory setting on a scaled-down tank model with dimensions of 500 mm in length and 300 mm in diameter. The tank was supported by a stone column with a diameter of 50 mm. Aggregates, tyre chips, and crushed brick obtained from the local vicinity of Tirupati are utilized in our application. The load-bearing ability of the soil was seen to enhance subsequent to the introduction of these fill materials. The load carrying capacity of a clay bed has been enhanced by 40% to 110% through the construction of stone columns using aggregates, tyre chips, and crushed brick, with aspect ratios (L/D) of 5 and 8.

Key words: Stone column, Aggregates, Tyre chips, Crushed brick,

1.0. INTRODUCTION:

The global problem of soil softness has posed considerable challenges for geotechnical engineers. Engineers often encounter a prevalent challenge while constructing structures on or with soils, namely the insufficient strength of the soils to sustain the stresses exerted upon them, both during the construction phase and throughout the operational lifespan of the facility. The soils in the majority of the region exhibit low strength and possess inadequate carrying capacity. Efforts have been undertaken to improve the engineering qualities of these soils in response to their subpar performance in the field of engineering. There exist various ways that can potentially improve the efficiency of low-quality soils. The selection of an appropriate method is influenced by factors such as soil type, soil properties, and the specific objectives and scope of the desired improvement. The adoption of ground improvement techniques has the potential to increase the geotechnical qualities of soil. Numerous techniques are available for enhancing soil quality. The methods employed are contingent upon the properties of the strata and the objectives of the augmentation. Stone columns are a soil reinforcement technique that entails the installation of a network of compacted stone columns. The utilization of this technique was initially observed in France around the 1830s, and its adoption beyond Europe did not gain significant traction until the 1950s. Stone columns, similar to other techniques employed for soil improvement, function to fortify the soil, consequently augmenting its

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Behaviour of stone columns based on 2^4 factorial experiments with uniformly graded materials

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ABSTRACT

The Stone columns are one of the main strategies for enhancing the behavior of engineering properties of soft clays. Stone columns are well known as vertical columns or inclusions of compacted, densely crushed stone piercing delicate clays. On the one hand, it acts as a drainage surface to accelerate consolidation, and on the other, it acts as a reinforcement to improve permissible bearing pressure. In this research two set of stone column capacities were determine by simultaneously varying the Mean particle size (D_{50}), L/D ratio, Density Index (I_D) and Consistency Index (I_c) of the stone columns, laboratory tests. Over a two levels, each one follows a principle of 2^4 factorial experimentation that permits quantifying relative effects of each factor and effects of interaction between four factors. An experimental programming shows that there's a critical L/D ratio beyond which there is no encourage increment in ultimate capacity due to L/D ratio. A regression empirical model was established to predict a capacity of stone columns. It was found to be a function of I_c, I_D, and interaction between I_D and I_c, L/D ratio, D_{50} interaction among the L/D ratio and I_c and interaction between D_{50} and I_c. The validity of all developed models is verified by using data from present study and the results of others from literature that was not utilized in the model development. These predictions are useful not only for design of stone columns but also for a research into reinforced stone columns.
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1. Introduction

The advancement of structures such as buildings, storage tanks, warehouses, earthen dams, etc., built on weak soils is prone to excessive settlement or stability problems. Soil enhancement may solve or mitigate the problems encountered. This technology was first used in France in the 1830s, and since the 1950s, it has become widely popular throughout Europe. Because of their granular nature, stone columns are preferable over sand drains, which provide additional shear strength to the enclosed soils. They stabilize soft soils such as soft clays, silt, and silty sand.

This technique has an advantage in progressing the soil properties underneath a structure (raft and depth) and reducing irregular settlement. Bulging and general shear failures are the two basic types of failure for stone columns under compressive stresses. It has been recorded that many academics have devised hypothetical ways to estimate a bearing capacity and fortified settlement with stone columns. Impact methods, such as falling weight, or Vibro methods, such as Vibro float, can compact the stone. For a stone column installation in cohesive soils, a Vibro-replacement method is broadly utilized [ ]. A comparative method is employed in soft, relatively impenetrable soils, as well borehole steadiness needs to be fixed in locales with high groundwater tables.

Munkfakh et al. studied the influence of Vibro replacement stone columns on the stability of an embankment that simulated the actual design of a wharf structure [ ]. Madhav and Thiruselvam investigated the impact of the installation method on granular pile-reinforced soil behavior [ ]. The influence of moisture content in soft clay and the effect of column slenderness ratio (L/D) on a single column was studied experimentally by Narasimha Rao et al. [ ]. The work was continued (Rao et al., 1997) to study the effects on a group of columns consisting of 2, 3, and 4 columns in soft clay. Wood et al. conducted a model test to understand better the reaction mechanism of stone columns fortified clay beds

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TITLE: HYDROLOGICAL INFERENCE ON THE NANDIVARGAM SUB - WATERSHED FOR WATER RESOURCE ANALYSIS AND MANAGEMENT THROUGH REMOTE SENSING AND GIS TECHNIQUES

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Abstract:
The current study focuses on hydrological analysis for a sub-watershed in Nandivargam, within the Nandyal district, Andhra Pradesh. India. The drainage patterns and acquiring pertinent hydrological inferences related to the sub-watershed using digital elevation model STRM (DEM) imagery. Size, slope, soil type, land use, and vegetation, the drainage area, the length of water courses, hydrological model and morphometric analysis has been successfully accomplished through the integration of remote sensing and geographic information systems (GIS). The watershed's stream order, which travels from first order to fifth order and displays a dendritic type drainage network, it is an indication of the watershed's homogeneous texture. GIS-based watershed model has been developed for this study, Stream network, Stream order, Aspect, land use and land cover, Relief, Contours, Mean and Annual rainfall, the study area, and watershed borders were all generated as GIS layers. The watershed area's drainage density was found to be low to medium, which indicates the area has low relief and highly permeable soils. The bifurcation ratio varies from 1.30 to 2.53 and elongation ratio is 0.83 which reveals that the basin belongs to the oval shaped basin category the mean bifurcation ratio of the basin is 2.15 which indicates that the drainage pattern is not much influenced by geological structures. Mathematical or quantitative measurement helps us in analyzing the landforms accurately for any planning and development purposes. Morphometric Analysis is also very useful as it quantifies the landform features of evolutionary significance.

Key words: Watershed, Nandivargam, Remote sensing, Geographical Information system, Morphometric analysis,

1. Introduction.

The quantitative morphometric analysis of a watershed can yield valuable insights into the hydrological characteristics of the rocks present in the watershed. A drainage map of basin provides a reliable index of permeability of rocks and their relationship between rock type, structures and their hydrological status. Watershed characterization and management requires detail information for topography, drainage network, water divide, channel length, geomorphologic and geological setup of the area for proper watershed management and implementation plan for water conservation measures (Sreedevi et al., 2013). Remote sensing data, along with increased resolution from satellite platforms, makes these technologies appear poised to make a better impact on land resource management initiatives involved in monitoring LULC mapping and change detection at varying spatial ranges in semi-arid regions is undergoing severe stresses due to the combined effects of growing population and climate change. (Singh et al., 2012). Surface hydrological indications are one of the promising scientific tools for assessment and management of water resources. Drainage morphometric analyses are a prerequisite for selection of water recharge site, watershed modelling, runoff modelling, watershed delineation, groundwater prospect mapping and geotechnical investigation. (Magesh et al., 2011; Thomas et al., 2012). The drainage network analysis is generally performed to understand the prevailing geological variation, topographic information and structural set of a basin and their interrelationship. Remote sensing and GIS based drainage basin evaluation has been carried out by number of researchers for different terrains and it is proved to be a very scientific tool for generation of precise and updated information for characterization of drainage

basin parameters (Grohmann, 2004; Korkalainen et al., 2007; Hlaing et al., 2008; Javed et al., 2009; Pankaj and Kumar, 2009). Previously drainage morphometric parameters were extracted from topographical maps or field surveys. Drainage parameter extractions from last two decades are more popular from digital topographical information which is called as digital elevation models (DEM), which is more fast, precise, updated and inexpressive way of watershed analysis (Moore et al., 1991; Maathuis, 2006). One of the most recent near global elevation data sets recorded during the 11 day Shuttle Radar Topographic Mission is based on a C-band interferometric radar configuration. This information, representing the radar reflective surface (which may be vegetation, man-made features or bare earth), was collected in 2000 (Maathuis, 2006). Digital elevation models (DEMs), such as from the Shuttle Radar Topography Mission (SRTM), or the ASTER GDEM product (USGS, Denver, Colorado, USA), have been used to extract different geomorphological parameters of drainage basins, including drainage networks, catchment divides, slope gradient and aspect, and upstream flow contributing areas (e.g. Mark, 1984; Tarboton, 1997). GIS based watershed evaluation using Shuttle Radar Topographic Mission (SRTM) data have given a precise, fast, and an inexpensive way for analyzing hydrological systems (Farr and Kobrick, 2000; Grohmann et al., 2007; Panhalkar, 2014). Recently Bastawesy et al. (2013) utilized remote sensing data and digital elevation models to extract the catchment hydrological parameters to delineate storage areas for the Uganda Equatorial Lakes region. They concluded that digital elevation models (DEMs) are a very accurate tool for morphometrically parameter evaluation and watershed delineation for watershed management. In addition, low-intensity and erratic monsoons create further shortages of surface-water supply. As a result, the demand for groundwater resources has increased tremendously from year to year, causing a drastic decline of groundwater levels. Over-exploitation of groundwater has led to the drying up of the aquifer zones in several parts of the country. It is, therefore, essential to increase the recharge of the basin for the water management program at watershed level (Ellis and Revitt, 2010; subba Rao, 2008); Eyquem, 2007).

The current study focuses on a location where rainfall is the primary source of recharge. An integrated watershed-based morphometric study is essential to get insights into the region's physiographic features. The research analyzes sub-watersheds in Nandivargam, Nandyal, district, Andhra Pradesh, and analyzes their morphology. With the goal of helping in the management of water resources, this research makes use of STRM, satellite imagery, and GIS methods. With the objective to conserve and manage water resources sustainably, the primary objective is to explore and identify multiple drainage factors that might improve knowledge of the watershed's shape. The results of this research can help identify alternate approaches to water harvesting in the study region and can act as a scientific foundation for more in-depth hydrological investigations.

2. Geographical of the Study Area

The study area selected for evaluating morphometrical parameters and conducting watershed delineation for effective watershed management is the Nandivargam sub-watershed, as shown in (Fig-01). This sub-watershed is situated within the Nandyal district, Andhra Pradesh, of India and The watershed is located in between latitudes 15°22'30"N to 15°32'30"N and longitudes 78°7'30"E to 78°25'0"E, covering a total area of 240.80 km^2. The mean elevation of the study area is 425 meters above mean sea level. It experiences a dry climate with an annual average rainfall of 878mm. The mean minimum and maximum temperatures are 21.9 ºC and 38.5 ºC, respectively. Located in the Kundu river basin, also known as Kunderu, Kumurdruthi, it is a tributary of the Penna River in the Rayalaseema region of India. The Kundu valley, known as Renadu, is associated with the term "Renati Pourusham." The Kundu River's flood plains cover an area of around 6,000 acres (24km^2). The study area encompasses the Kunderu river valley, situated between the Erramala and Nallamala hills, forming the western and eastern boundaries, respectively. It includes the entire Koilakuntla and parts of Nandikotkur, Nandyal, Allagadda, and Banaganapalle. The Kunderu River, a tributary of the River Penner, flows southward through the central part of the region. The Madduleru and Jurreru rivers in the west, and the Galeru and Vakkileru Rivers in the east, are the main tributaries of the Kunderu River. The region has an average slope ranging between 200 and 300 meters

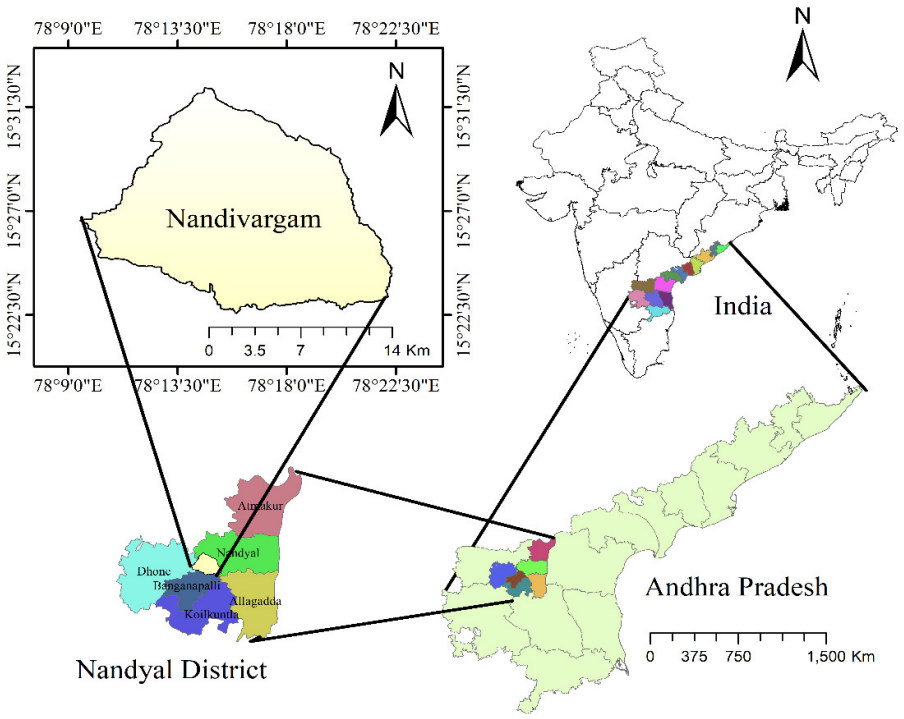


Fig-01: Location map of the study area

2.1 Objective

The primary aim of this study is to explore the morphometric analysis of the watershed in relation to its drainage pattern, utilizing multi-temporal satellite data to examine aspects such as drainage, surface water bodies, and the watershed.

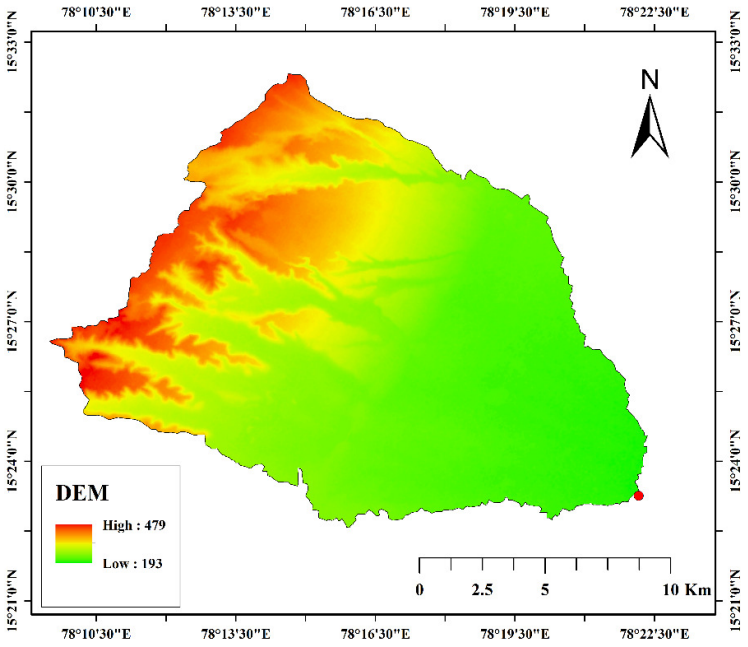


Fig-02: Digital Elevation map of the study area

3.0 Materials & Methodology

3.1 Materials

The source of organisation of data for study area shown in (Table -01) the generation of input parameters for explore the morphometric analysis has been successfully accomplished through the integration of remote sensing and geographic information systems (GIS).

Table -01 Data and resources utilized in the determination of geomorphic in the present area.

S.No.	Source	Map	Description
1	Topo-sheet / Spatial Data	Study area boundary / areas (DEM)	Boundary Topo-sheet was used to demarcate watershed boundary. watershed boundary
2	STRM DEM (USGS website)	Digital elevation model (DEM) and Slope	Digital elevation map (DEM) Contours, a stream network, and stream order watershed borders were all generated as GIS layers
3	Satellite imagery -10m Sentinel – 2 LA2 Thematic	Land use / land cover (LULC)	Land use / land cover (LULC)

3.2 Methods

The present study adopts the following methodology and procedure to achieve its objectives. Collection of satellite data and Topographical maps. Rainfall and other collateral data within the study area. Drainage pattern , stream order, surface water bodies' Contour, Slope, Aspect, and Relief maps based on the Digital Elevation Model (DEM) as shown in (fig-02).Conducting preliminary pre-field interpretation of Hydro geomorphology using Satellite data for delineated sub-watersheds was exported in Arc GIS 10.8 software for used to morphometric analysis. Recommending a land and water resources development plan.

3.2.1 Drainage Morphometric Analysis

In a GIS environment, we conducted an assessment of the basins linear, aerial, and relief characteristics. Subsequently, we generated graphs and performed linear regression analysis to investigate the inter relationships among certain variables. These variables included a range of morphometric parameters of the basin, such as perimeter, stream order, stream length, bifurcation ratio, stream length ratio, basin length, drainage density, texture ratio, stream frequency, form factor, circularity ratio, elongation ratio, and length of overland flow. We thoroughly examined and provided detailed discussions on these parameters. For a comprehensive understanding of the morphometric analysis, refer to the various notations and methodologies outlined in (Table 02)

Table -02 "Methods and sources utilized for the computation of geomorphic parameters."

Ascept	Parameters	Formulae	Values	References
Arial	Area (Km^2)	A	240.80	
Liner	Perimeter (km)	P	*78.96*	
	Length of Basin (km)	L_B	*21.17*	
	Width of Basin (km)	W_B	*15.14*	
	Stream length (L_u)	Length of the stream	*14.67*	Horton (1945)
	Mean stream length (L_{sm})	$L_{sm} = Lu/Nu$	*47.51*	Strahler (1964)
	Stream length ratio (R_L)	$RL = Lu/(Lu-1)$	*1.02*	Horton (1945)
	Bifurcation ration (R_b)	$(Rb) = N_u/N_u+1$	*8.59*	Schumm (1956)
	Mean bifurcation ratio (R_{bm})	R_{bm} = average of bifurcation ratios of all order	*2.15*	Strahler (1957)
Arial	Drainage density (D_d)	$D_d = Lu/A$	*1.82*	Horton (1945)
	Drainage texture (T)	$T = Dd \times Fs$	*5.22*	Smith (1950)
	Stream frequency (F_s)	$F_s = Nu/A$	*2.87*	Horton (1945)
	Elongation ratio (R_e)	$R_e = D/L$	*0.83*	Schumm (1956)
	Circularity ratio (R_c)	$R_c = 4\pi A/P^2$	*0.49*	Strahler (1964)
	Form factor ratio (F_f)	$F_f = A/L^2$	*1.15*	Horton (1945)
Relief	Relief	$R = H - h$	*293*	Hadley and Schumm (1961)
	Relief ratio	$R_r = R/L$	*13.85*	Schumm (1963)
	Basin Relief	Horizontal length (B_h)	*15.14*	
	Ruggdness number	$R_i = (D_d x\ R_r)/100$	*0.25*	

Stream Numbers:

The total number of streams in each order is called as the Stream Number. After Stream Order, the 2nd step in Morphometric analysis is to count the Stream Number. The Stream Number decreases with the increasing order of stream (as shown in Table 02). Stream number is inversely proportional to stream order. Horton has developed 'Law of Stream Number'. According to this Law, when Stream Number (taken in arithmetic scale) is plotted against Stream Order (taken in logarithmic scale), it gives a negative linear pattern. It means number of streams from highest to lowest order in a particular basin tend to give a Geometric Series. In the 5th order river basin shown in (Fig 04), the series is 19, 48, 121, 157, and 352 which is plotted on the logarithmic scale to the Fig-03.

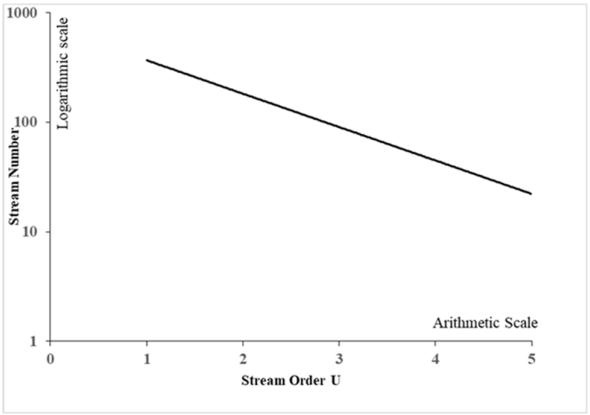


Fig-03: Stream order Vs Stream number (N_u)

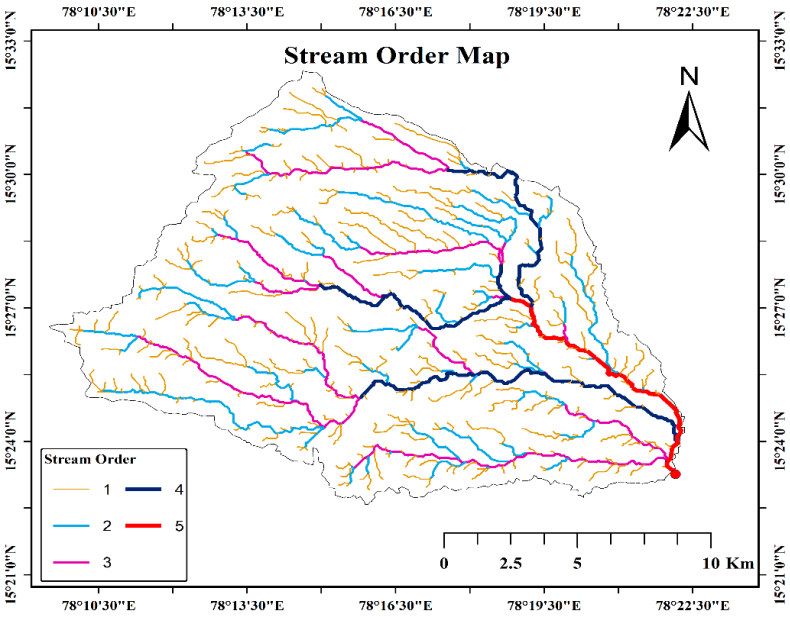


Fig-04: Drainage with stream network and order map of the study area

3.2.2 Stream Order (N_u):

Stream order, also referred to as water body order is a positive whole number utilized in the fields of geomorphology and hydrology to denote the extent of branching within a river system. Various techniques for stream ordering, such as those proposed by (Horton in 1945)[19] and (Strahler in 1952), exist. In this study, Strahler's method, which is a slightly modified version of Horton's approach, was employed to assess stream order. According to this system, the smallest streams, which have no branches, are classified as first order. When two first-order streams converge, they become second order, and two second-order streams joining together become third order, and so on. If streams of different orders merge, they retain the highest order. In the case of the Nandivargam basin, it is classified as a fifth-order stream. In total, 697 streams were identified in the study area, with 352 being first order, 157 second order, 121 third order, 48 fourth order, and 19 fifth order (as shown in Fig-05). The analysis of stream network characteristics is crucial for comprehending the hydrological processes within the basin. Stream magnitude is strongly linked to the portion of the entire basin area that contributes to runoff, making it a reliable indicator of relative stream discharge in smaller river systems. Strahler's stream order classification has been utilized in numerous river systems.

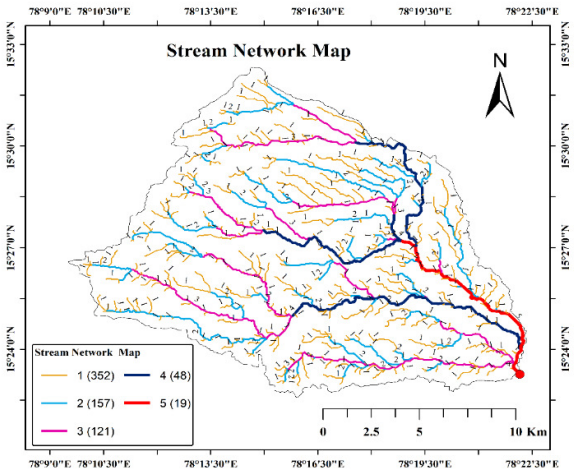


Fig-05: Drainage with stream network and order map of the study area

3.2.3 Stream length (L_u)

The research includes the assessment of the quantity of streams with varying orders inside a sub-watershed, along with the measurement of their lengths from their starting points to the point where they reach the drainage divided. The calculation of stream length (Lu) for 14.67km sub-watersheds has been computed on the proposed by (Horton's 1945) method, as indicated in (Table 2). and according to this law, the cumulative mean length of streams increase in geometrical progression with increase of stream order. If stream order is taken on X- axis on an arithmetic scale and cumulative mean length of stream on Y-axis a logarithmic scale, it gives a positive liner pattern. The relationship Stream length Vs Cumulative stream length which is follows. Stream Order and Total Stream Length exhibit an inverse correlation. Stream Order and Mean Stream Length display a direct correlation. Stream Order and Cumulative Mean Stream Length demonstrate a positive association. Furthermore, (Fig-06) besides, the latter increases geometrically with each successive higher order.

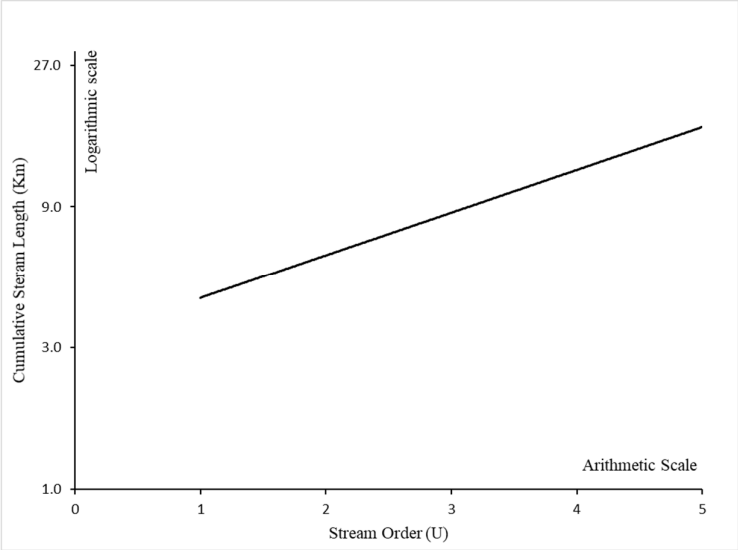


Fig-06: Stream order Vs Cumulative Stream length (L_u)

3.2.4 Mean stream length (L_{sm})

According to Strahler (1964), the mean stream length (Lsm) is an inherent property connected to the drainage network and its associated surfaces. To calculate the mean stream length (Lsm), the total stream length of order 'u' is divided by the number of streams of the same segment or order 'u' (Table 2).

3.2.5 Stream length ratio (RL)

The ratio of the mean length of one stream order to the next lower order of stream segment may be termed as the length ratio (RL). According to Horton's law (1945) of stream length, the mean stream length segments of successive orders in a basin tend to form a direct geometric series, with stream length increasing as the order of streams goes higher. The variation in stream orders within the research area demonstrates sub-basin, likely due to variations in topography, slope. And exhibit an increasing length ratio from lower to higher orders, suggesting a more advanced geomorphic stage. Conversely, the transition from one order to another in the remaining sub watershed indicates a youthful stage (Table-02).

3.2.6 Bifurcation ratio

The term bifurcation ratio (Rb) may be defined as the ratio of the number of the stream segments of given order to the number of segments of the next higher order (Schumn, 1956). Horton (1945) considered the

bifurcation ratio as an index of relief and dissections. Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation for different regions or for different environment except where the powerful geological control dominates.

Table No.03 Liner aspect of the Nandivargam sub-watershed.

Sno.	Stream Order (W)	Number of Stream (Nu)	Bifuration ratio (Rb)	Mean Bifuration Ratio (Rbm)	Total Length of Stream (Km)	Mean length of streams (Km)	Length ratio (R_L)
1	I	352			3.73		
2	II	157	2.24		3.16		
3	III	121	1.30	2.15	3.22	2.93	1.02
4	IV	48	2.52		2.22		
5	V	19	2.53		2.33		
	Total	**697**		**Total**	**14.67**		

Based on the information presented in (Table 3), it can be observed that the bifurcation ratio (R_b) varies between different orders of the drainage system. These variations are influenced by the geological and lithological characteristics of the drainage basin, as explained by (Strahler, 1964). Lower R_b values are indicative of sub-watersheds that have experienced fewer structural disturbances, as noted by (Strahler, 1964) and where the drainage patterns have remained relatively undistorted due to such disturbances, as mentioned by (Nag. 1998). The mean bifurcation ratio (R_{bm}) can be defined as the average of the bifurcation ratios across all orders. In this particular case, R_{bm} ranges from 2.15 in the Nandivargam sub-watershed, classifying it within the normal basin category.

3.2.7 Drainage density

Horton (1932) has introduced drainage density (D_d) into American hydrologic literature as an expression to indicate the closeness of spacing of channels. It is defined as the total length of streams of all orders per drainage area. Langbein (1947) recognized the significance of D_d as a factor determining the time of travel by water and he also suggested a drainage density varying between 0.55 and 2.09 km/km^2 in humid region with an average density of 1.03 km / km^2. Density factor is related to climate, type of rocks, relief, infiltration capacity, vegetation cover, surface roughness and run-off intensity index. Of these only surface roughness has no significant correlation with drainage density. The amount and type of precipitation influences directly the quantity and character of surface run-off. An area with high precipitation such as thundershowers loses greater percentage of rainfall as run-off resulting in more surface drainage lines. Amount of vegetation and rainfall absorption capacity of soils, which influences the rate of surface run-off, affects the drainage texture of an area. The similar condition of lithology and geologic structures, semi-arid regions have finer drainage density texture than humid regions. According to Nag (1998), low drainage density generally results in the areas of highly resistant or permeable subsoil material, dense vegetation and low relief. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture. The average drainage density 1.82km/km^2 indicating low drainage density (Table 2). In the study area, the low drainage density indicates the region has highly permeable subsoil and thick vegetative cover. The drainage density map is shown in (Fig. 07)

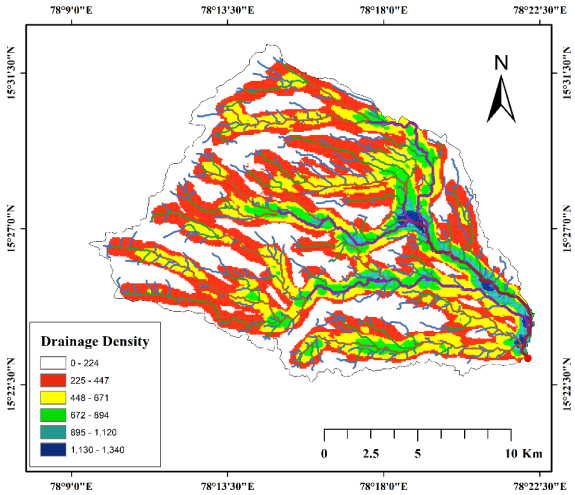


Fig-7: Drainage density map of the Nandivargam sub-watershed

3.2.8 Stream frequency

Horton (1932) introduced stream frequency (F_s) or channel frequency which is the total number of stream segments of all orders per unit area. Stream frequency, also known as channel frequency, refers to the overall count of stream segments of various orders within a given area 2.87(as shown in Table 02). In theory, it is conceivable for two basins with the same drainage density to have different stream frequencies, and conversely, two basins with the same stream frequency may exhibit varying drainage density. Table 2 provides data on stream frequency for the study area. It is noteworthy that there is a positive correlation between stream frequency (F_s) and the drainage density values of these sub-basins, signifying an increase in the number of streams relative to an increase in drainage density.

3.2.9 Drainage texture

Drainage texture (T) is a significant concept within geomorphology that pertains to the relative spacing of drainage lines. It's worth noting that drainage lines tend to be more abundant in impermeable areas compared to permeable ones. According to Horton (1945), "T" is defined as the total number of stream segments of all orders per unit perimeter of a particular area. Horton identified infiltration capacity as the primary factor influencing Rt and considered it as part of drainage texture, which encompasses both drainage density and stream frequency. Smith (1950) further categorized drainage density into five distinct textures. A drainage texture of less than 2 is classified as very coarse, between 2 and 4 as coarse, between 4 and 6 as moderate, between 6 and 8 as fine, and anything greater than 8 is considered very fine drainage texture. In Table 02, it is observed that the drainage texture from 5.22. For instance, sub-watershed exhibits a moderate course.

3.2.10 Form factor

According to Horton (1932), form factor (F_f) defined, as the ratio of basin area to square of the basin length (Table 2). The value of Form factor (F_f) is always less than 0.7854, which is for a perfectly circular basin (Strahler, 1964). The form factor values of the sub watershed in the study area of value 1.15. Basins of low form factor are elongated and have flatter peak flows for longer duration, while the basins with high form factors are circular and have high peak flows for shorter duration.

3.2.11 Circularity ratio

It represents the proportion of the basin's area to that of a circle with an equivalent perimeter as the basin (Miller 1953). Circular ratio (Rc) is affected by various factors such as the length and occurrence of

streams, geological formations, land usage, climate, terrain, and the slope within the basin. In this particular investigation, the Rc value is recorded as 0.49 (as shown in Table 2). The notable Rc value of 0.49 in the Nandivargam sub-watershed indicates that this particular sub-basin possesses a relatively circular shape. Moreover, it features a topography marked by substantial to moderate relief.

3.2.12 Elongation ratio

Elongation ratio (Re) is the ratio defined as the ratio of diameter of the circle of the same area as the drainage basin and the maximum length of the basin (Schumm, 1956). The values of "Re" generally numerical value varies from 0 to 1.0 over a wide variety of climatic and geo- logic conditions. Values close to 1.0 are typical of regions of very low relief, whereas values in the range 0.6–0.8 are usually associated with high relief and steep ground slope (Strahler, 1964). These values can be grouped as a three categories namely (a) Elongated (< 0.7), (b) Oval (0.9 -0.8) (c) Circular (> 0.9). The current research study area computed Re value of Re is 0.83, which is greater than 0.8, this sub watershed has a shape that is almost circular and typically belongs to regions of low relief areas (as shown in Table 2).

3.2.13 Length of overland flow

Surface water movement plays a significant role in triggering the formation of channels. "Overland flow" is the term employed to characterize the movement of water on the basin surface that occurs beyond the boundaries of a defined stream channel. Traditionally, the generation of overland flow is classified into two primary mechanisms: "infiltration excess," by Horton's work (1945). This factor basically relates inversely to the average slope of the channel. The length of overland flow (Lg) approximately equals, to half of the reciprocal of drainage density (Horton 1945). The current research study area calculated Lg value is 0.28.

3.2.14 Relief (R) and Relief Ratio of the Basin.

The term "total relief" refers to the difference in elevation between the highest and lowest points within a basin's valley floor. The "relief ratio," denoted as R_r and introduced by (Schumm 1956), quantifies the minimum relief relative to the horizontal distance along the longest axis of the basin, aligned with the primary drainage channel. This ratio serves as a metric for assessing the overall steepness of a drainage basin and provides insight into the level of erosion occurring on its slopes. the computed R value for the basin is 293, as presented in Table 2. This suggests that a substantial portion of the basin displays a pronounced slope.

3.2.15 Aspect Map

An aspect map typically refers to the orientation of a mountain slope, indicating the direction it faces. This aspect map holds significant importance in understanding the local climate's sensitivity to sunlight within the region. In general, slopes facing west tend to experience the hottest part of the day during the afternoon, and, in most cases, these west-facing slopes are warmer than their sheltered counterparts facing east. The aspect map plays a pivotal role in influencing the types of vegetation found in an area. When derived from SRTM DEM data, the aspect map indicates the compass direction of the slope's orientation, with 0 degrees denoting true north, and a 90-degree aspect pointing to the east (Fig. 8). In the case of the Nandivargam sub-watershed, it predominantly features east-facing slopes. Consequently, these east-facing slopes exhibit higher moisture levels and more abundant vegetation compared to their west-facing counterparts.

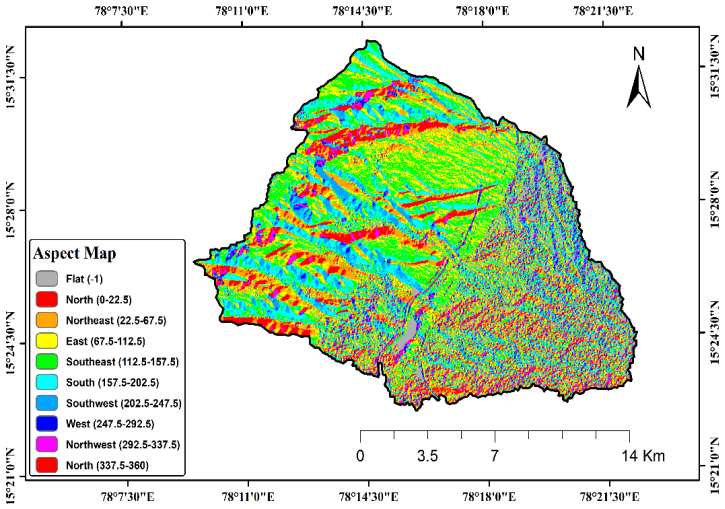


Fig-8: Aspect map of the Nandivargam sub-watershed

3.2.16 Slope Map

Slope is the measure of change in surface value over distance and can be expressed in degrees or as a percentage. In a raster format, the Digital Elevation Model (DEM) is a grid where each cell is a value referenced to a common datum. For extraction of elevation from remote sensing dedicated software packages are required but most GIS packages have routines for point or contour line interpolation. Any two points on the grid will be sufficient to ascertain a slope. Once the slopes have been calculated, then the maximum difference can be found and the gradient can be determined (Burrough and McDonnell, 1998; Maathuis, 2006; Jha et al. 2007). In the present paper topographical elevation map for the study area was developed by Digital Elevation Model (DEM) extracted from the Shuttle Radar Topography Mission (SRTM) data. For this, the DEM was subjected to two directional gradient filters (one in x-direction and another in y-direction).The resultant maps were used to generate a slope map of the study area using ARCGIS Spatial Analyst tools. The highest topographic elevations 395 m and lowest 102m exist in the western and northwestern portions of the area which induces highest runoff and hence less possibility rainfall infiltration. The slope map of the study area has grouped in five classes in degrees viz. 1°–3° (Gentle), 3°–5° (Moderate), 5°–10°(Steep) , 10°–35° (Very Steep) and >35° (Very Very Steep). The current study area observed that the gently slope 0-2.27%, moderate slope 2.28% to 6.28%, Steep 6.29% to12.2%, very steep 12.3% to 18.7%,very very steep 18.8% to34.1%. as shown Fig 09.

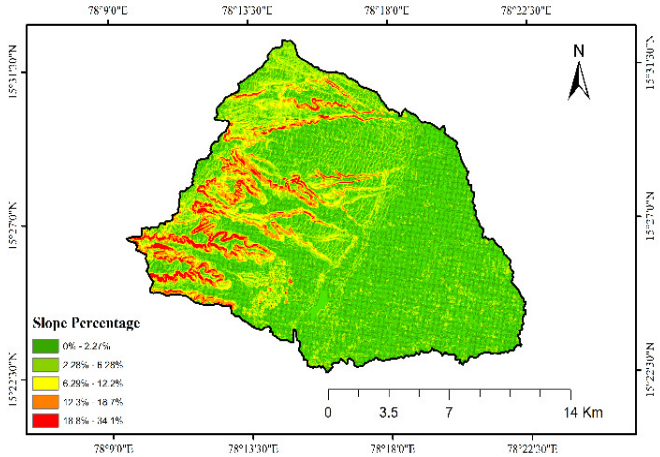


Fig-9: Slop map of the Nandivargam sub-watershed

4.0 Result and discussion

Assessment of watershed using quantitative morphometric analysis can provide information about the hydrological nature of the rocks exposed within the watershed. A drainage map of a basin provides a reliable index of permeability of the rocks and gives an indication of the yield of the basin. The DEM has been obtained with a pixel size of 90 m and furthermore, it has been used to calculate slope and aspect maps of the watershed. The development of drainage networks depends on geology, precipitation apart from exogamic and endogenic forces of the area. Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) data were used for preparing slope, aspect maps and morphometric analysis of the watershed. Linear, areal and relief aspects of the watershed were evaluated in GIS environment using Arc GIS software. Recent development in geospatial technology, the assessment of drainage basin has been more accurate and precise for morphometric parameter evaluation with better accuracy. Satellite data and GIS have been successfully utilized to generate data on the spatial deviations in drainage characteristics thus L providing an insight into hydrologic conditions necessary for developing watershed management strategies (Das and Mukherjee, 2005). Hydrogeological observations, integrated with drainage analysis, provide useful clues regarding broad relationships among the geological framework of the basin. Therefore, the results reveal different levels of agreement using morphometric analysis, which were supposed to be different from one region to another. Factors controlling groundwater storage are different in space and time, and the majority of these factors depend on the following parameters: (1) rainfall availability as the source of water; (2) drainage characteristics have a role in the distribution of runoff and indicate an infiltration scheme and it governs the behaviour of water flow on terrain surface vertically and horizontally; (3) rock type for which the lithologic character governs the flow and storage management; (4) slope is another influencing factor, and it controls water flow energy, which plays a role in facilitating water flow in the basin. The morphometric analysis can be achieved through measurements of linear, areal and relief aspects of basin.

5.0 Conclusion and Recommendation:

The hydrological analysis carried out for the Nandivargam sub- watershed confirms that the watershed is having low relief and circular shape. Drainage network of the basin exhibits as mainly dendritic type which indicates the homogeneity in texture and lack of structural control and helps understand various terrain parameters such as nature of the bedrock, infiltration capacity, runoff, etc. Lower drainage density and stream frequency indicate high permeability rate of the subsurface formation. The observed parameters reveal recharge-related measures and areas where surface-water augmentation measures can be undertaken for water resource management and soil conservation structures. Large scale watershed analysis using GIS, remote sensing data and Digital elevation Model (DEM) has efficient tools for understanding any terrain parameters such as nature of bedrock, infiltration capacity, surface run off etc., which helps in better understanding the status of land form and their processes, drainage management and evolution of groundwater potential for watershed planning and management. This work will be useful for natural resource management at the micro level of any terrain for sustainable development by planners and decision makers for sustainable watershed development programme. The results observed in the present work can be used for site suitability analysis of soil and water conservation structures in the area and subsequently, these parameters were integrated with other hydrological information viz., The study recommended that the watershed needs a hydrogeological and geophysical investigation in future for proper water management and selection

Abbreviations GIS:

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D27 NML Journals

Chemical Engineering & Technology Research Article

Munilakshmi Nijagala[1,*]
Uday Kumar Vallameti[2]

Application of Preformed Floc Adsorbents in the Removal of Acid Dye from an Aqueous Solution

Preformed flocs prepared by using coagulants, i.e. $Fe_2(SO_4)_3$, $MnSO_4.4H_2O$, and $MnCl_2.4H_2O$, were applied as adsorbents for the decolorization of an aqueous C.I. Acid Red 1 dye solution. In order to determine the decolorizing efficiency of different adsorbents, kinetic and equilibrium studies were carried out at the optimum pH. Excellent color removal of 87 % was obtained with $Fe_2(SO_4)_3$ at pH 4, good color removal of 65 % was achieved with manganese sulfate at pH 10, and moderate color removal of 58 % was obtained with manganese chloride at pH 10, at an optimum sorbent dose of 500 mg L^{-1} and an equilibrium contact time of 15 min. The sorption data of the equilibrium studies fitted well to the Langmuir isotherm, stating the occurrence of monolayer formation in the adsorption process of dye color removal. The maximum adsorption capacities of ferric sulfate and manganese sulfate are 47.619 and 23.474 mg g^{-1}, respectively. The data of the kinetic studies fitted well to the pseudo-second-order equation, stating that chemisorption is the rate-limiting step.

Keywords: Adsorption, Flocs, Ferric sulfate, Manganese sulfate, Manganese chloride

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1 Introduction

Dyes are used in many industries, such as in textile, paper pulp, tannery, cosmetics, leather, plastics, printing, rubber, food, and pharmaceuticals production [1–5]. Dyes are aromatic amines with different types of organic functional groups and with heavy metals embodied in the basic structure, like chromium, copper, and cobalt [6]. The presence of such metals retards biological treatment. Their discharge into water bodies causes pollution due to their recalcitrant nature. The toxicity of dyes causes serious problems for the environment, aquatic life, and human and animal health [7].

The presence of coloring matter in significant quantities in receiving water would not only reduce light penetration and photosynthetic activity, but would also render their appearance unaesthetic [8, 9]. Furthermore dyes may impart toxicity to aquatic and plant biota and may be mutagenic and carcinogenic, causing severe damage to human life, such as misfunctioning of the kidneys, brain, liver, reproductive system, and central nervous system [10]. A majority of the used dyes are azo dyes, which are bright in color due to the presence of one or several azo (–N=N–) groups associated with substituted aromatic structures [11–13], and consist of more stable organic compounds that are carcinogenic, also causing allergic responses after exposure to them [7]. Therefore, it becomes mandatory that color should be removed from dye effluents before disposal of the effluent. Treatment processes such as physical, physicochemical, chemical, and biological methods have been investigated and proved to be effective, but to varying degrees of success [14]. Michaels and White [15] observed that treatment through biological methods cannot reduce the chemical oxygen demand (COD) and color, even though it reduces the biochemical oxygen demand (BOD). Chemical coagulation seems to be a very efficient method in the removal of color from dye wastewater [14, 16–19]. Coagulation and flocculation of the inorganic coagulants such as ferric sulfate, manganese sulfate, alum, and iron salts have been used in the decolorization of dye color over many years. But the main disadvantages of coagulation treatment are the process control and the sludge production, for which settling, dewatering, and converting to a cake for land filling is needed [20]. Among different methods, the adsorption process has good potential in removing dyes from effluents, due to its simplicity of design, ease of operation, wide adaptability, high efficiency, and economic viability [21]. The adsorption process produces good-quality effluent and it is

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Ultrasound Assisted Advance Oxidation Process For Removal Of Nickle

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Abstract:
Nickel polluted wastewater is directly or indirectly discharged into the environment increasingly, especially in developing countries. It is difficult to remove nickel from wastewater using conventional methods. Efficient method like advanced oxidation process is an important breakthrough in the removal of nickel. This method is referred to as ultrasound assisted advanced oxidation process in the removal of nickel. This study investigated the use of Hydrogen peroxide, Fenton Reagent, ultrasound homogenously and heterogeneously. The removal efficiency of homogenous process and heterogenous process along with the process parameters like concentration of oxidant, effect of pH, Optimum dosage of Oxidants and time taken were investigated. Results indicated that removal efficiency is strongly dependent on the optimal pH and the dose of the oxidant. All the oxidants can removal nickel effectively from the wastewater but the maximum removal which provides desirable nickel quantity after treatment was obtained by heterogenous processes. At optimal pH:11Fenton reagent and Ultrasound process in combination with Hydrogen peroxide and Fenton reagent has shown 98%, 100% and 100% removal respectively.

Keywords: *Nickel; Advanced Oxidation Process; Hydrogen Peroxide, Fenton, Ultrasound; Optimum dose*

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I. Introduction

Growing industrial development is leading to the production of contaminants that are seriously threatening the ecosystem and the contamination of water resources has been a worldwide environment problem. Heavy metals are the elements having atomic weights between 63.5 and 200.6 and specific gravity greater than 5 which are non bio-degradable. Toxic heavy metals of particular concern in treatment of industrial wastewater include copper, zinc, nickel, mercury, cadmium, lead and chromium. Among these different heavy metals, nickel is extensively utilized in the modern industry.

The tolerance limit of nickel in drinking water is 0.01 mg/L, and for industrial wastewater it is 2.0 mg/L. However, effluents of different industries contain higher concentrations of nickel than its acceptable limit. Nickel is well known heavy metal pollutant, which is present in effluents of electroplating industries to the tune of 20 – 200 ppm (Piyush kant pandey et al., 2007).

The intake of nickel in considerable concentrations may cause formation of free radicals in body tissue which leads to various DNA complications, serious lung and kidney problems, gastrointestinal distress, pulmonary fibrosis, headache, dizziness, dry cough, vomiting, extreme weakness, and direct exposition to nickel cause skin dermatites. So it is very essential to remove Nickel from soil, industrial wastewater and effluents.

Generally, the nickel wastewater is amenable to physical, chemical and biological treatment but is inefficient and involves high cost in removal of nickel. In this sense, procedure known as Advanced Oxidation Process (AOP) are being studied and applied to mineralize non-biodegradable organic compounds or oxidize bio degradable compounds, that converts them completely into CO_2 and H_2O (Hoffman et al., 1995). Advanced Oxidation Process (AOP) is defined as aqueous phase oxidation processes which are based primarily on the intermediacy of the hydroxyl radicals in the mechanism resulting in the destruction of target pollutant (Poulopoulos et al., 2006).

In the present work, synthetic nickel wastewater was prepared by Nickel Ammonium Sulphate for the concentration of 200 mg/L and was treated by Advanced Oxidation Process (AOP). The processes were carried out with Hydrogen Peroxide (H_2O_2), Fenton Reagent, and Ultrasound and with a combination of US + H_2O_2 and US + Fenton Reagent Further removal of nickel has been studied. Various process parameters like concentration of oxidant, effect of pH, Optimum dosage of Oxidants and time taken were investigated.

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An Experimental Investigation on the Properties of Geopolymer Concrete with Partial Replacement of Marble Powder

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ABSTRACT

This research provides a geopolymer concrete investigation in which fly ash is partially replaced with marble powder. Geopolymer concrete uses waste materials such as fly ash (FA) and an alkaline solution (NaOH&Na2SiO3) to form a strong binder, replacing cement and including marble powder as a partial substitute. This experimental study looks at the tensile properties of geopolymer concrete with different quantities of fly ash replaced by marble powder. The major purpose is to use landfilling waste, such as marble powder, as a binding agent in geopolymer concrete at varying percentages (0, 5%, 10%, 15%, 20%, and 25%) instead of fly ash. The geopolymer mix is designed for a 12M, with an alkaline-to-binder ratio of 0.45. By adding fly ashwith marble powder, the concrete achieves 28-day cube strengths ranging from 40 to 60 MPa utilizing air curing procedures. This formulation allows for rapid strength development, making it appropriate for large structural elements (e.g., precast) without the requirement for extended conventional curing times. Superplasticizers, notably PCE (Poly Carboxylate Ether)-based ones, are used to improve workability. Mechanical property tests were performed, including compressive strength for 100*100*100 mm cubes, split tensile strength for 100*200 mm cylinders, and flexural strength for 500*100*100 mm prisms. When compared to conventional geopolymer concrete, which does not contain partial replacement marble powder, the concrete achieves 28-day cube strengths ranging from 40 to 60 MPa using air curing methods. This formulation allows quick strength growth, making it suited for heavy structural parts.

Keywords: Geopolymer concrete, Fly ash, Marble powder, Mechanical properties, Optimum percentage.

INTRODUCTION

Sustainable development is a crucial topic today due to the deterioration of the human environment and natural resources. Cement manufacture is a large contributor to air pollution, accounting for around 7% of global carbon dioxide emissions. Rapid urban development causes building construction and demolition, resulting in large volumes of waste that are frequently dumped in landfills. To address this issue, researchers are investigating the use of industrial waste materials such fly ash, powdered granulated blast furnace slag, and marble powder as alternatives to ordinary cement in construction. Geopolymer, a cement-free binder, is gaining popularity for its ability to include elements such as fly ash and marble powder. In a recent study, marble powder was studied as a partial replacement for fly ash in geopolymer to determine the impact on strength attributes. Various percentages (0%, 5%, 10%, 15%, 20%, and 25%) of marble powder were examined, and mechanical properties of the resulting geopolymer materials were evaluated. The data were compared to traditional concrete mixes to examine the feasibility and effectiveness of employing marble powder in geopolymer concrete manufacture.

This experimental investigation focuses on the strength behavior of geopolymer concrete when Fly Ash is partially replaced with Marble powder. The primary goal of the study is to determine the optimal proportion of Marble powder in enhancing the strength of Fly ash-based Geopolymer Concrete by partially substituting Fly ash with Marble powder at various percentages such as 0%, 5%, 10%, 15%, 20%, and 25%. The geopolymer is designed for 12M and has an alkaline-to-binder ratio of 0.45 and a sodium silicate-to-sodium hydroxide ratio of 2. The mechanical properties of geopolymer materials including fly ash, marble powder, fine aggregate, coarse aggregate, and alkaline solution were tested. For the compression test, 100mm x 100mm x 100mm cubes were constructed.For the purpose of testing split tensile strength, a 200mm diameter by 100mm length cylinder was used, and 500mm x 100mm x 100 mm prisms were constructed. The results of the flexural strength test were compared with the typical control mix, that is, without partial replacement.

Objectives:

- To find the optimum percentage of Marble Powder in developing the strength in Fly ash based Geopolymer concrete mix.
- To determine the mechanical properties of geopolymer concrete such as Compressive strength for cubes(100mm*100mm*100mm), Split tensile strength for cylinders(200mm*100mm), Flexural strength for prisms (500mm*100mm*100mm) at various replacement levels of Marble Powder dust as partial replacement of Fly ash in geopolymer concrete.
- To compare the mechanical properties of Fly ash based Geopolymer Concrete with partial replacement of Fly ash with Marble Powder to those of control concrete mix of Geopolymer Concrete.

MATERIALS USED

Fly ash

Fly ash, a residue derived from the combustion of pulverized coal in coal-fired thermal power plants, serves as a valuable component in hydraulic-cement concrete, significantly enhancing its properties. When mixed with hydraulic cement during hydration, fly ash contributes to the formation of a binding agent. This study employs class-F fly ash as a supplementary cementitious material, aiming to improve both the initial and long-term characteristics of concrete. Typically, fly ash utilized in concrete applications exhibits a color spectrum spanning from dark grey to yellowish tan.

Coarse aggregate

Well graded coarse aggregate conforming to the provision of IS: 383-2016 is going to use throughout the investigation. The aggregate of nominal size 12mm were blended to a desired proportion and mixed intimately to obtain well graded aggregate.

Table-1: Properties of Coarse aggregate

Specific gravity	2.65
Water absorption	0.73%
Fineness modulus	6.31

Fine aggregate

Locally available river sand conforming to is 383:2016 specifications passing through 4.75 mm sieve and retained on 75µm was used as the fine aggregate in the concrete mix. The fineness modulus, specific gravity were determined and sieve analysis of the fine aggregate and the corresponding grading curve is shown.

Table -2: Properties of Fine aggregate

Specific Gravity	2.58
Fineness modulus	3.15
Grading	Zone-II

Marble Powder

Marble powder entering open areas causes environmental, health and economic losses. Waste marble powders can be used in geopolymers to eliminate these disadvantages and provide sustainable environmental and eco-economic benefits. The Marble Powder is a calcium-rich waste material produced from processing plants sawing and polishing of marble blocks.

Table -3: Chemical composition of Marble Powder

Chemical composition	**Percentages**
Silica (SiO_2)	21.12
Iron Oxide (Fe_2O_3)	3.24
Alumina (Al_2O_3)	5.62
Calcium Oxide (Ca O)	62.94
Magnesium Oxide (MgO)	2.73
Potassium Oxide (K_2O)	0.25
Loss on ignition	38.65
Fineness	Completely passing through 90 Micron sieve

Sodium Hydroxide solution
Generally, the sodium hydroxides (NaOH) are available in solid-state in the forms of pellets or flakes. The price of sodium hydroxide varies a lot depending on how pure of product. The solution of NaOH was prepared by dissolving pellets in water for different molarity. It is recommended that NaOH solution should be made 24 hours before casting and should be used within 36 hours of preparing the solution otherwise it will be converted into a semi-solid state.

Sodium Silicate solution
Sodium metasilicate is also known as sodium silicate and is of industrial grade with SiO2 as 29.4% by mass and Na2O as 14.7%. As per the manufacturer, silicate is used as a bonding agent in detergent industries and textiles industries.

Super plasticizer
AURAMIX 450 is utilized as superplasticizer in this project. It is a polycarboxylate ether (PCE) based high performance super plasticizer. It is used for concrete requiring long workability retention. Appearance is light yellow colored and its pH is of minimum 6.

Water
The locally available potable water, which is free from the concentration of acids, organic substances, is used for mixing solution and concrete which promotes chemical reaction and also helps in the strength attaining of concrete. So bad quality of water affects the strength. It is necessary to follow quality analysis and water purity before being used in the project.

MIX DESIGN

Preparation of Alkaline solution
Alkaline solutions are created by mixing sodium hydroxide solution and sodium silicate at room temperature. When these solutions are combined, they initiate a reaction, known as polymerization, releasing a significant amount of heat. It is advisable to let the mixture sit for approximately 24 hours to allow the alkaline liquid to fully form as a binding agent. In this study, geopolymer concrete is prepared using 12 molarities of sodium hydroxide. The molecular weight of sodium hydroxide is 40. To prepare a 12M solution, 480g of sodium hydroxide flakes are measured and dissolved in distilled water to create a 1-liter solution. This process involves slowly adding sodium hydroxide flakes to distilled water in a 1-liter capacity pycnometer until fully dissolved. Water and Super plasticizer are used only for workability purpose. After many trial mixes by changing water and super plasticizer percentages at finally below mentioned percentages got high workability of 110 mm slump.

Table – 4: Ingredients of Geopolymer concrete

Material	Proportions (Kg/m^3)
Coarse aggregate	924
Fine aggregate	756
Binder	496.55
Sodium Hydroxide	74.48
Sodium Silicate	148.96
Super plasticizer	1% of Binder
Water	10% of Binder
Molarity	12M
Na_2SiO_3: NaOH	2

Mix design
In this design, a 12M solution of sodium hydroxide is utilized for alkaline preparation. The ratio between sodium hydroxide and sodium silicate is set at 2. The aggregate volume is determined as 70% of the total volume of the cube. The ratio of alkaline liquid to fly ash is maintained at 0.45. Fly ash is substituted with different percentages ranging from 0% to 25%, including 5%, 10%, 15%, 20%, and 25%.

Table -5: Various mix proportions of Geopolymer concrete

Mixes	Fly ash (%)	Marble Powder (%)
M0	100	0
M5	95	5
M10	90	10
M15	85	15
M20	80	20
M25	75	25

Mix Procedure

In the lab, the dry mixing of fly ash and aggregates took about three minutes in a pan mixer. Aggregates were prepped in a saturated-surface-dry (SSD) condition. Alkaline liquid was combined with superplasticizer and water. This liquid mix was then added to the dry materials, followed by mixing for an additional four minutes. Workability was assessed via the conventional slump test. Air curing is typically advised for low-calcium fly ash-based geopolymer concrete, with curing time and temperature significantly impacting strength. Specimens were cured at room temperature for 24 to 48 hours, with longer durations enhancing polymerization and strength



Figure 1: Casted Specimens



Figure 2: Failure Specimens

RESULTS AND DISCUSSION

Compressive strength Test

The primary test for strength evaluation is compressive strength, commonly conducted on cube specimens measuring 100mm x 100mm x 100mm. Compaction of each layer is achieved using a tamping rod, followed by leveling the top surface of the mould with a trowel. Specimens are tested after 7 days, 28 days, and 56 days to assess compressive strength across varying curing durations.

Table-6: Compressive strength

Mixes	Compressive Strength (MPa)		
	7 days	28 days	56 days
M0(Std mix)	34.88	39.15	40.80
M5	25.52	44.16	45.74
M10	27.67	52.85	54.43
M15	33.43	59.65	60.75
M20	**33.84**	**60.47**	**62.34**
M25	31.87	53.26	54.20

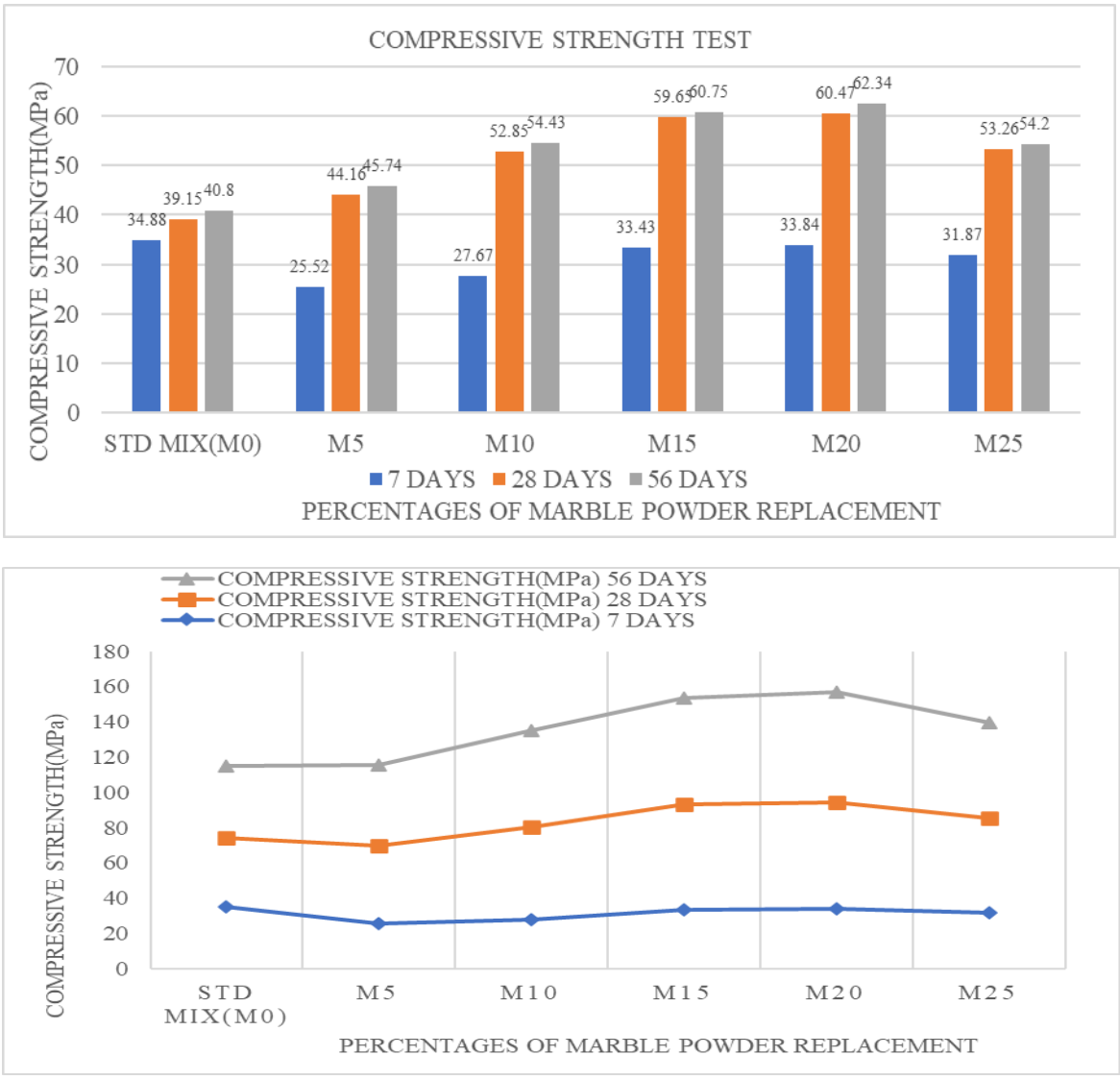


Figure 3: Comparison test of compressive strength on 7, 28 and 56 days with standard mix

Split tensile strength test

This test employs an indirect tension method, involving the placement of a cylindrical specimen horizontally between the compression testing machine's loading surfaces. Load is gradually applied until the cylinder fails along its vertical diameter. Notably, the same compressive testing machine and cylindrical specimen used for compression tests can be utilized. To mitigate high compressive stresses, narrow cracking strips of suitable material are incorporated. The split tensile test is known for its simplicity and ability to produce uniform results.

Table 7: Split Tensile strength

Mixes	Split tensile strength (MPa)
M0(Std mix)	1.71
M5	2.22
M10	2.51
M15	3.05
M20	**3.26**
M25	2.48

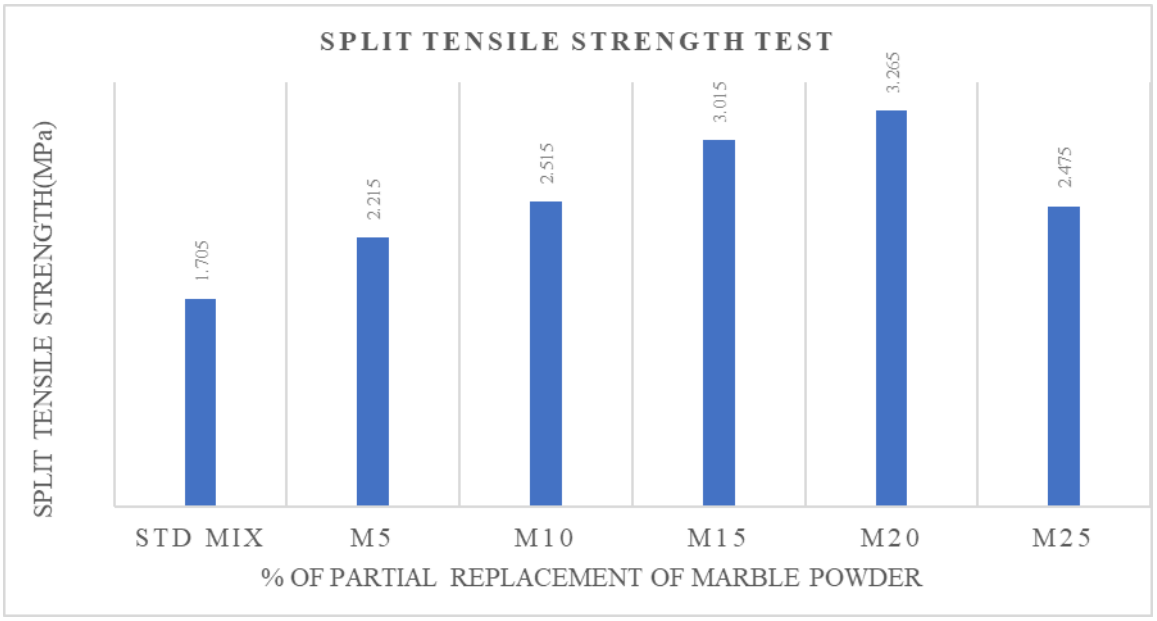


Figure 4: Variation of split tensile strength at 28 days with partial replacement of marble powder

Flexural Strength

The specimen was held on two rollers supports on the testing machine, Until its breakdown, the load was applied hydraulically through two equal rollers placed at the third point of the supporting span. The specimen is of 500 mm length, 100 mm breadth and100 mm height.

Table 8: Flexural strength test

Mixes	Flexural strength (MPa)
M0(Std mix)	4.27
M5	5.46
M10	5.51
M15	5.83
M20	**5.97**
M25	5.94

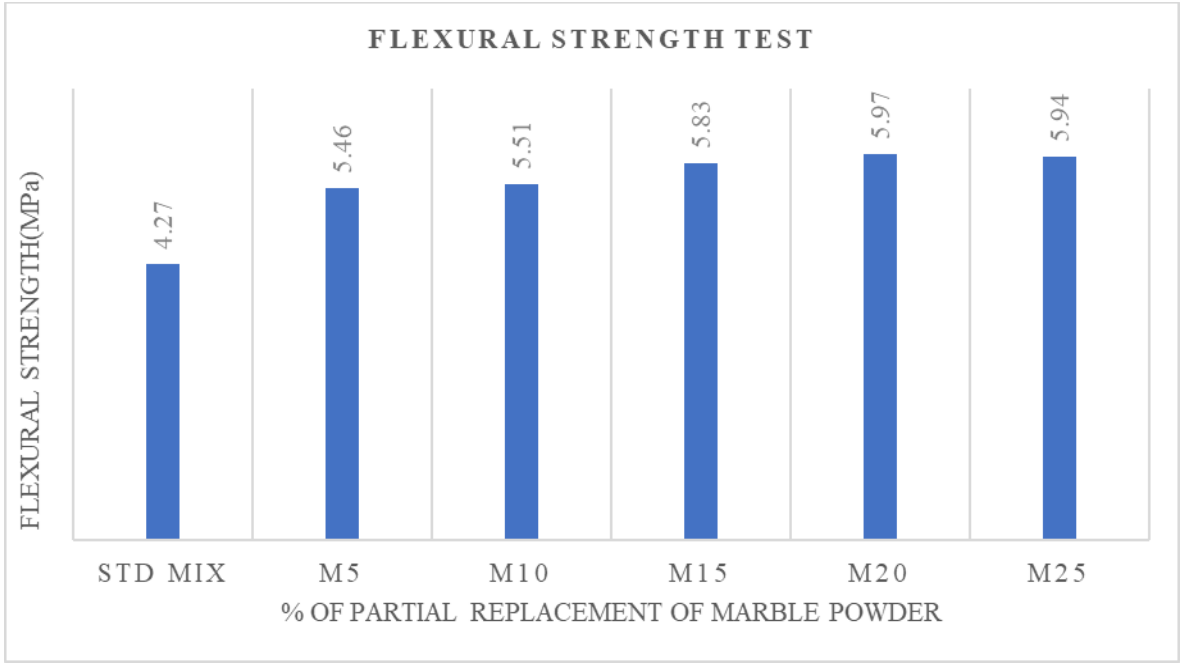


Figure 3: Variation of Flexural strength with partial replacement of Marble powder at 28 days

CONCLUSION

Durable, eco-friendly materials are sought for by the construction sector. GGBS and fly ash provide benefits over regular concrete. Optimizing the use of marble powder is the project's goal. The compressive strength of marble powder substitute peaks at 20% replacement by 28 days, and it is comparable to the regular mix after 7 days. Marble powder can boost the strength of geopolymer concrete by up to 20%. Structure is somewhat impacted by strength when it approaches 20% replacement. Marble powder has a compressive strength of 60.75 MPa at 20% replacement, which is 54% higher than that of normal mix. Marble powder outperforms normal mix, increasing strength by 76% (@M20) at 20% replacement in the split tensile test. At 20% replacement, flexural strength peaks at 5.97 MPa, representing a 40% increase (@M20) above normal mix. Slump value increases with the percentage of marble powder and exceeds that of traditional geopolymer concrete. The ease of geopolymer innovation is especially advantageous for precast applications. Particularly in harsh conditions, geopolymer concrete provides strength and a greater range of applications than regular concrete. Marble powder, an industrial waste that is only used for landfilling, is a very cost-effective addition to geopolymer concrete, and is the primary cause of the compressive strength increase of up to 60 MPa. It also contributes to the geo-polymerization process, which gives strength to the concrete. Instead of using cement, geopolymer concrete employs industrial waste as a binder, which reduces pollution and is also utilized in areas with limited fly ash production. There are therefore numerous benefits to employing these industrial wastes in the geopolymer concrete used for many heavy structural works.

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A Study on the Rheology of Scc with the Addition of Fly Ash in Opc, Ppc and, Psc Cements with Different Mixing Times

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Abstract: In this paper, a study was performed on the rheological properties of self-compacting concrete by the addition of Supplementary Cementitious Material (SCM) as Fly Ash with various percentages of 15%, 20%, 25%, and 30% in the different types of cement OPC, PPC, and PSC. The mix designs of self-compacting concrete were done by two methods of constants: Water-Binder Ratio Constant and Weight and Volume of Aggregates Constant for varying percentages of addition of Fly Ash with a fixed cement content of 380 kg per cubic meter. Flow ability (Flow Table and V Funnel) and Passing Ability (L-Box and U-Box) tests were carried out on fresh concrete in accordance to EFNARC with three different mixing times 5(initial), 30, and 90 minutes were done to find the self-compactibility of designed concrete mixes. Varying dosages of Super Plasticizer (Auromix 450) were added to obtain the required flow ability and passing ability of SCC without bleeding of water and segregation of aggregates. Self-compactibility of the designed SCCs was obtained for 20%, 25%, and 30% addition of SCM in Water-Binder Ratio Constant Method and 15%, 20%, and 30% addition of SCM in Weight and Volume Constant Method.

Keywords: Self-Compacting Concrete, Fresh Properties, Supplementary Cementitious Materials, Fly Ash, Constant methods, Mixing Time.

1. Introduction

With the rapid expansion of numerous structures throughout the world, the demand for self-compacting concrete (SCC) application is growing. Now a day's majority of the construction sites have issues of congestion of reinforcement in the structural members. The considerable seismic danger in the area, the facilities' susceptibility to cyclonic storms, and their massive capacity of expansion, all exacerbate the design flaws. SCC has become the only choice in such difficult site environments. Ideally, the development of concrete mix where placing and compaction have minimal dependence on the Standard of workmanship available on a particular site should improve the true quality of the concrete in the final structure, and hence its durability. This was an important driving force behind the development of self-compacting concrete (SCC). Self-compacting concrete is considered as a breakthrough in concrete technology due to its improved performance and working environment. It has wide application from thin elements to huge structures. SCC can be taken as the greatest technical advancement and most revolutionary development in concrete technology over the years. SCC is the concrete of the future, as it will be replacing normal concrete due to its distinct advantages.

The European Federation for Specialist Construction Chemicals and Concrete Systems (EFNARC) has developed guidelines for SCC, known as the "EFNARC Specification and Guidelines for Self-Compacting Concrete." These guidelines provide recommendations on mix design, fresh and hardened properties, and testing methods for SCC.

SCC can be produced using the same ingredients as that of normal concrete. A closer tolerance is required to ensure strict control of workability characteristics. The proportioning of SCC mix is much more scientific than that of conventional concrete mixes. SCC mix requires high powder content, lesser quantity of coarse aggregate, high range super plasticizer, and VMA (Viscosity Modifying Agent) to give stability and fluidity to the concrete

mix. The workability of SCC is the equilibrium of fluidity, deformability, filling ability, and resistance to segregation. This equilibrium has to be maintained for a sufficient time period to allow for its transportation, placing, and finishing. Combinations of tests are required to characterize the workability properties.

The most commonly used cement in self-compacting concrete (SCC) is Ordinary Portland Cement (OPC). OPC is widely available and has been extensively used in various concrete applications, including SCC. In self-compacting concrete, the cement content is usually adjusted based on the specific requirements of the project and the desired properties of the SCC mix. The selection of cement type may also depend on factors such as the project's location, local availability, and any specific performance requirements. The use of alternative types of cement is becoming more prevalent in the construction industry to address environmental concerns. For example, in some regions, where environmental regulations are stricter, or sustainability is a top priority, blended cements such as Portland Slag Cement (PSC) and Portland Pozzolana cement (PPC), have gained popularity due to their reduced carbon footprint and improved performance characteristics. Blended cements are already a combination of Ordinary Portland Cement (OPC) and supplementary materials, such as fly ash and slag. Adding more SCMs to these blended cements further enhances their properties and performance in SCC mixes such as Improved Workability, Reduced Permeability and Improved Durability, Reduced Heat of Hydration, Sustainable Solution, Setting Time, and Strength Development. The addition of SCMs to blended cements can also bring challenges to the mix design process. The interaction between various materials can affect the rheological behavior, setting time, and strength development of the SCC. Precise mix proportioning and testing are essential to ensure the desired performance of the concrete. The Percentage of dosage of SCMs in blended cements for SCC depends on various factors such as the type of SCM, Cementitious content, water-to-binder ratio, desired strength, and workability. Mix designs should be tested thoroughly to verify the fresh and hardened properties of the SCC to meet project specifications and requirements. In this study, the effect of fresh properties of SCC on addition of SCM to blended cement with different design mix methods was done.

Concrete, in general, loses workability over time because of the evaporation of water, the absorption of water through the aggregates, the hydration of cement, and increased mixing temperature. The properties of SCC deteriorate with prolonged mixing, casting, and finishing time. The effect of mixing time on concrete can be avoided or reduced by adding alternative cement materials or/and by increasing the dosage. Many researchers reported that the addition of high super plasticizer dosage may increase workability and decrease its negative effects that are caused by long mixing time. The increase in super plasticizer dosage may lead to wet surroundings, which increase workability, and the hydration process accelerates as water spreads between the cement granules. Thus, reducing concrete consistency increases bleeding and segregation. The effects of mixing time and suitable super plasticizer dosage still need further investigations to maintain the workability and consistency of concrete for a long time. In this study, workability was measured with 5, 30, and 60 minutes of mixing times with an optimized super plasticizer dosage for each mix.

2. Materials.

2.1. Cement:

In Production of SCC, Ordinary Portland Cement (OPC) - 53 grade, Portland Pozzolona Cement (PPC), and Portland Slag Cement (PSC) were used in this study. Some physical and chemical properties of cements which are collected from the cement manufacturer are shown in Table 1.

Table 1: Physical and Chemical Properties of Cements

Description	OPC		PPC		PSC	
	Tested Value	IS 12269:2013	Tested Value	IS 1489:2015 (Part 1)	Tested Value	IS 455: 2105
Physical Properties						

Fineness	Specific surface (sq m/kg)	308	>225	327	>300	372	>225
	Normal consistency (%)	28.3	-	31	-	-	-
Soundness	Le Chatelier Method (mm)	1.5	<10	1	<10	0.5	<10
	Autoclave (%)	0.05	0.8	0.039	<0.8	0.03	0.8
Setting time	Initial setting time (mins)	210	>30	180	>30	145	>30
	Final setting time (mins)	300	<600	280	<600	195	<600
Specific Gravity		3.15		2.9	-	2.91	-
Chemical Properties							
Lime Saturation Factor		0.93	>0.8 & <1.02	-	-	-	-
Alumina Iron Ratio		1.13	>0.66	-	-	-	-
Insoluble Residue (%)		1.98	<4.0	30.74		1.22	<4.0
Magnesia (%)		1.16	<6.0	0.79	<6.0	4	<10.0
Sulphuric Anhydride (%)		2.4	<3.5	1.82	<3.5	1.97	<3.5
Sulphide Sulphur (%)		-	-	-	-	0.16	<1.5
Loss of Ignition (%)		2.16	<4.0	1.55	<4.0	1.43	<4.0
Alkalies (%)		0.64	-	-	-	-	-
Chlorides (%)		0.02	<0.10	0.001	<0.10	0.006	<0.10
C_3A		5.82	-	-	-	-	-
Fly Ash (%)		-	-	33.5	-	-	-
GGBS (%)		-	-	-	-	45	-

2.2. Fly Ash

For this Study, Class F Fly Ash was used which is procured from Sri Damodaram Sanjeevaiah Thermal Power Station is located in Nelatur Village, near Krishnapatnam, Andhra Pradesh, India. The power plant is one of the coal-based power plants of Andhra Pradesh Power Development Company Limited (APPDCL) and is in compliant with India Standard IS 3812:2003.

Table 2: Physical and Chemical Properties of Fly Ash

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	SO_3	LOI	K_2O	Na_2O	Specific Gravity	Blaines' s Fineness
%	65.80	21.32	4.87	1.00	0.53	0.50	0.20	0.16	0.81	0.21	2.14	321

2.3. Aggregates

2.3.1. Fine Aggregate

Locally available river sand is used as fine aggregate. The sand was dried before use to avoid the problem of bulking. The fine aggregate complies with Zone 2 from the sieve analysis as per Indian Standard IS 383:2016

2.3.2 Coarse Aggregate

Locally available granite with a size ranges from 12.5 mm and down was used as coarse aggregate.

Table 3: Physical Properties of Fine Aggregate

Aggregate	Specific Gravity	Fineness Modulus	Water absorption	Bulk Density	Dry Rodded Unit Weight
Fine Aggregate	2.63	3.65	0.50%	1582.85 kg/m^3	-
Course Aggregate	2.66	6.66	0.10%	1472 kg/m^3	1495 kg/m^3

2.5 Super Plasticizer

For this study, the super plasticizer used in Auramix 450 manufactured by FOSROC Chemicals which complies with Indian Standards IS 9103: 1999. Properties of Auramix 450 which are collected from the manufacturer are shown in Table 7.

Table 4: Properties of Super Plasticizer

Specific Gravity	pH	Chloride Content	Appearance
1.07	6.1	Nil	Light yellow colour liquid

2.6 Water

Potable water is used in this study.

3. Mix Design of Self Compacted Concrete

Mix design procedure of self-compacting concrete is adopted by taking guidelines from the reference of works by Dr. Okamura and Dr. Ouchi, Japanese researchers who first developed Self Compacting concrete and the norms given in EFNARC. These guidelines are not intended to provide specific advice on mix design but give an indication of the typical range of constituents in SCC by weight and by volume. These proportions are in not restrictive and SCC mixes may fall outside this range for one or more constituents.

3.1. Self Compacting Concrete Proportions

Generally, most of the researches are conducted by simple replacement method. Replacement of cement is done in different percentages of Supplementary Cementitious Material (SCM) either by volume or Weight (Mass). In this method the quantity of Binder Material (BM) is fixed and when replacement of SCM is done in different percentages of quantities, there will be change in the cement quantity and SCM quantity. The replacement method is represented in the form of equations as

C_0 + 0% SCM = BM i.e. C_0 = BM

C_1 + 5%SCM = BM

C_2 + 10%SCM = BM

C_3 + 15%SCM = BM etc

C_0, C_1, C_2, C_3 etc of quantities of Cement and %SCM is of BM

However, in this work, the addition method is adopted which involves the direct addition of SCM without changing the quantity of cement which is fixed and SCM is added with an increase of percentages of 15%, 20%, 25%, and 30% for binder material in SCC. The percentage of SCM is of the quantity of Binder Material.

$C + 15\%SCM = BM_1$

$C + 20\%SCM = BM_2$

$C + 25\%SCM = BM_3$

$C + 30\%SCM = BM_4$

C = Cement is taken as 380kg in this work. The experiments are conducted taking OPC, PPC, and PSC Cements, and SCMs are Fly Ash (F) and GGBS (G) added separately to each individual kind of cement in percentages given above

Further, the design of concrete in this work is done by addition method by taking two methods of constants.

1. Water Binder Ratio Constant Method
2. Aggregate Weight and Volume Constant Method

3.1.1. Water Binder Ratio Constant Method.

In this method as mentioned above the binder material is varied in all the types of cement (OPC, PPC, and PSC) by adding SCM percentages. The design is done by keeping the water-binder ratio constant for all quantities of binder material. The quantities of aggregates are adjusted accordingly for the volume of 1 cum of SCC satisfying the EFNARC norms and the dosage of super plasticizer is adjusted for getting the required fresh properties of SCC.

The equation of design will be as following in this method.

$SCC_1 = BM_1 + CA_1 + FA_1 + W\% + SP$

$SCC_2 = BM_2 + CA_2 + FA_2 + W\% + SP$

$SCC_3 = BM_3 + CA_3 + FA_3 + W\% + SP$

$SCC_4 = BM_4 + CA_4 + FA_4 + W\% + SP$

$W\% = 0.4\ BM_{1\ to\ 4}$

After few trails the suitable water binder ratio for this work was fixed at 0.4

3.1.2. Aggregate Weight and Volume Constant Method

In this method similar to the earlier method the binder material is varied in all the types of cement (OPC, PPC, and PSC) by adding SCM percentages. The design is done by keeping the quantities of aggregates constant. The weight and volume of aggregates are kept constant for all mixes and the water binder ratio is changed accordingly for 1 cum of SCC satisfying the EFNARC norms and the dosage of super plasticizer is adjusted for getting the required fresh properties of SCC.

The equation of design will be as following in this method.

$SCC_5 = BM_1 + CA + FA + W_1\% + SP$

$SCC_6 = BM_2 + CA + FA + W_2\% + SP$

$SCC_7 = BM_3 + CA + FA + W_3\% + SP$

$SCC_8 = BM_4 + CA + FA + W_4\% + SP$

CA = Coarse Aggregate is constantly taken as 50% weight of Dry Rodded Unit Weight, and

FA = Fine Aggregate is constantly taken as 55% of the total aggregate weight.

These values of aggregate quantities are also constant in terms of the volume of aggregates satisfying the EFNARC norms.

SP, the super plasticizer dosage was fixed on trial and error basis with number of trials to achieve at he mix with satisfactory fresh properties in both methods.

Table 5. Mix Proportions with Water Binder Ratio Constant method

MIX	Cement	Fly Ash	Fine Aggregate	Course Aggregate	Water	Super Plasticizer		Unit Weight
	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	%	kg/m^3
OPC - SCC_1	380.00	70.00	953.00	790.00	180.00	8.10	1.80	2381.10
OPC - SCC_2	380.00	95.00	920.00	770.00	190.00	6.65	1.40	2361.65
OPC - SCC_3	380.00	126.67	877.00	747.50	202.67	3.55	0.70	2337.39
OPC - SCC_4	380.00	162.86	796.00	747.50	217.14	2.71	0.50	2306.21
PPC - SCC_1	380.00	70.00	940.00	775.00	180.00	8.10	1.80	2353.10
PPC - SCC_2	380.00	95.00	900.00	768.00	190.00	4.28	0.90	2337.28
PPC - SCC_3	380.00	126.67	877.00	747.50	202.67	3.55	0.70	2337.39
PPC - SCC_4	380.00	162.86	796.00	747.50	217.20	2.71	0.50	2306.27
PSC - SCC_1	380.00	70.00	953.00	790.00	180.00	8.10	1.80	2381.10
PSC - SCC_2	380.00	95.00	910.00	785.00	190.00	4.75	1.00	2364.75
PSC - SCC_3	380.00	126.67	878.00	747.50	202.67	3.55	0.70	2338.39
PSC - SCC_4	380.00	162.86	796.00	747.50	217.20	2.71	0.50	2306.27

Table 6. Mix Proportion with Aggregate Weight and Volume Constant Method

MIX	Cement	Fly Ash	Fine Aggregate	Course Aggregate	Water	Super Plasticizer		Unit Weight
	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	%	kg/m^3
OPC - SCC_5	380.00	70.00	913.50	747.50	214.94	3.60	0.80	2329.54
OPC - SCC_6	380.00	95.00	913.50	747.50	202.62	4.28	0.90	2342.90
OPC - SCC_7	380.00	126.67	913.50	747.50	186.14	6.08	1.20	2359.89
OPC - SCC_8	380.00	162.86	913.50	747.50	167.30	8.14	1.50	2379.30
PPC - SCC_5	380.00	70.00	913.50	747.50	214.94	3.60	0.80	2329.54
PPC - SCC_6	380.00	95.00	913.50	747.50	202.62	4.28	0.90	2342.90
PPC - SCC_7	380.00	126.67	913.50	747.50	186.14	6.08	1.20	2359.89

PPC - SCC_8	380.00	162.86	913.50	747.50	167.30	8.14	1.50	2379.30
PSC - SCC_5	380.00	70.00	913.50	747.50	212.41	6.30	1.40	2329.71
PSC - SCC_6	380.00	95.00	913.50	747.50	199.52	7.60	1.60	2343.12
PSC - SCC_7	380.00	126.67	913.50	747.50	182.35	10.13	2.00	2360.15
PSC - SCC_8	380.00	162.86	913.50	747.50	161.21	14.66	2.70	2379.73

4. Results

4.1. Fresh Properties of Self Compacted Concrete

The fresh properties of Self Compacting Concrete designed and mixed with different cements and addition SCMs as per the tables given above are tested for Flow Ability and Passing Ability. The flow ability is tested by Slum Flow, T_{500} Slump Flow and V Funnel methods and passing ability is tested by L-Box and U-Box methods.

4.1.1. Slump Flow

The slump flow of fresh Self Compacting Concrete is measured on flow table using Abraham Cone. Unit of measurement of slump flow is millimeters. The acceptance levels as per EFNARC are 650 mm to 800 mm. In this work the acceptance levels of slump flow are taken from 600 mm and above.

Table 7. Slump Flow (mm)
(Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	600	580	550
OPC - SCC_2	600	610	630
OPC - SCC_3	660	670	680
OPC - SCC_4	650	680	640
PPC - SCC_1	600	560	540
PPC - SCC_2	600	660	650
PPC - SCC_3	650	680	660
PPC - SCC_4	700	680	640
PSC - SCC_1	590	610	580
PSC - SCC_2	630	660	620
PSC - SCC_3	650	680	640
PSC - SCC_4	660	680	640

Table 8. Slump Flow (mm)
(Aggregate Weight and Volume Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	630	630	610
OPC - SCC_6	610	660	670
OPC - SCC_7	600	650	690
OPC - SCC_8	570	600	590
PPC - SCC_5	570	630	630
PPC - SCC_6	600	660	650
PPC - SCC_7	660	640	640
PPC - SCC_8	600	580	580
PSC - SCC_5	640	620	600
PSC - SCC_6	660	600	580
PSC - SCC_7	650	610	590
PSC - SCC_8	630	590	570

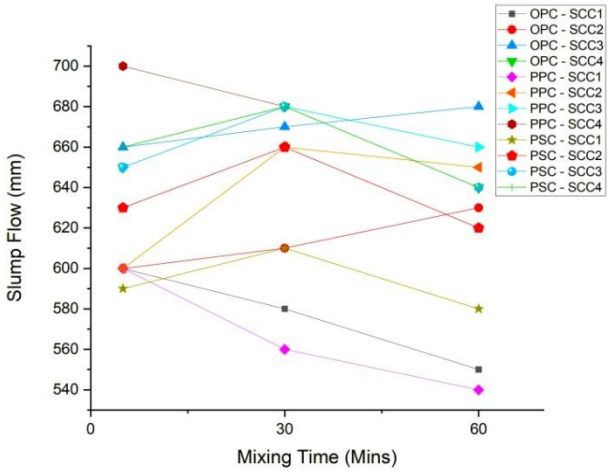


Fig. 1. Slump Flow (Water Binder Constant)

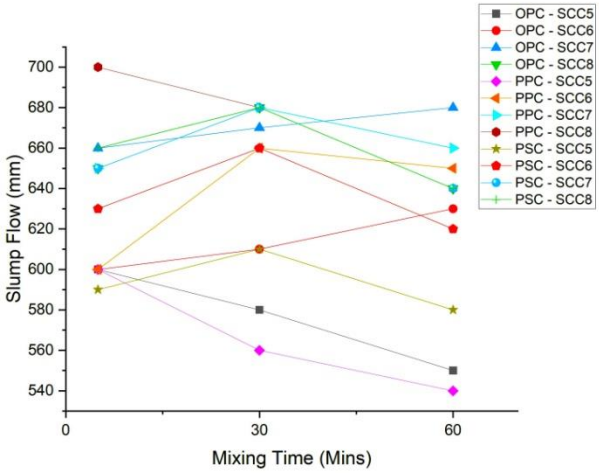


Fig.2. Slump Flow (Aggregate Weight and Volume Constant)

4.1.2. Slump Flow – T_{500}

Viscosity of the Self Compacting Concrete can be assessed by T_{500} time during slump flow test. The time value obtained does not measure the viscosity of SCC but is related to it by describing the rate of flow. Concrete with a low viscosity will have a very quick initial flow and the stop. Concrete with high viscosity may continue to creep forward over an extended time. The acceptance levels as per EFNARC are 2 sec to 5 sec. In this work the acceptance levels of slump flow are taken from 2 sec and 7 sec.

Table 9. Slump Flow – T500 (sec) (Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	7.8	7.9	8
OPC - SCC_2	5.0	4.5	2.3
OPC - SCC_3	3.2	2.8	2.8
OPC - SCC_4	3.0	2.0	0.4
PPC - SCC_1	4.0	7.2	7.6
PPC - SCC_2	4.0	2.8	3.0
PPC - SCC_3	2.4	2.2	2.1
PPC - SCC_4	2.0	2.0	3.2
PSC - SCC_1	4.0	3.5	4.3
PSC - SCC_2	3.0	2.0	3.6
PSC - SCC_3	2.0	2.0	3.0
PSC - SCC_4	2.0	2.0	3.2

Table 10. Slump Flow – T500 (Sec) (Aggregate Weight and Volume Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	2.5	2.5	2.6
OPC - SCC_6	2.7	2.0	2.0
OPC - SCC_7	5.0	4.0	2.0
OPC - SCC_8	6.2	5.8	6.1
PPC - SCC_5	3.5	2.4	2.7
PPC - SCC_6	4.0	2.8	3.0
PPC - SCC_7	4.2	4.9	2.9
PPC - SCC_8	4.0	5.0	5.3
PSC - SCC_5	3.1	3.4	4.1
PSC - SCC_6	2.0	3.6	4.4
PSC - SCC_7	2.0	3.2	4.0
PSC - SCC_8	4.0	6.0	-

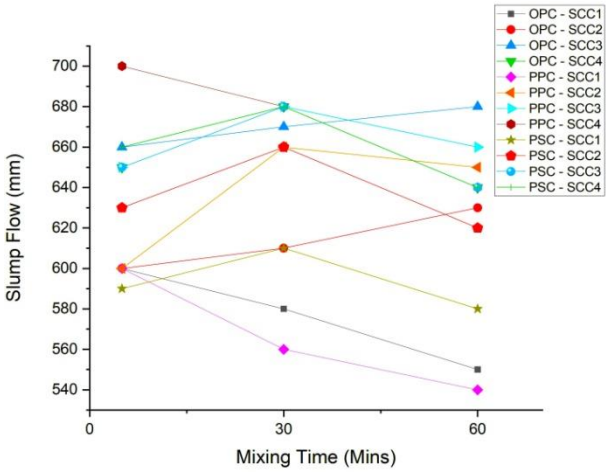


Fig. 3. Slump Flow – T500 (Water Binder Constant)

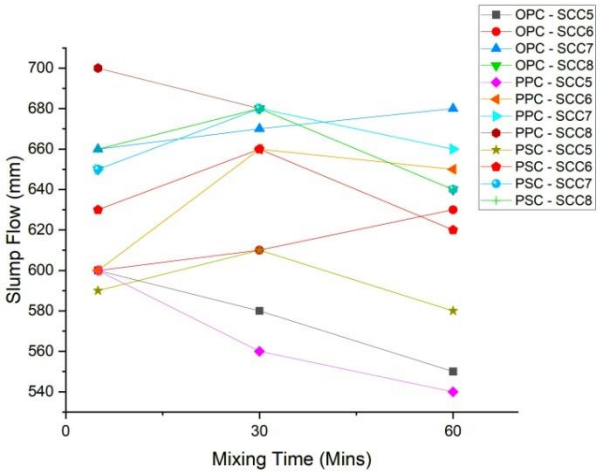


Fig.4. Slump Flow-T_{500} (Aggregate Weight and Volume Constant)

4.1.3. V-Funnel Test

Flowing ability and viscosity of the Self Compacting Concrete can be assessed by V-Funnel flowing time. The acceptance levels as per EFNARC are 6 sec to 12 sec.

Table 11. V Funnel Flow (Sec) (Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	6.4	6	6.3
OPC - SCC_2	5.2	5.4	5.7
OPC - SCC_3	5	5.2	5.1
OPC - SCC_4	5.4	5	5
PPC - SCC_1	7.3	9.4	14.7
PPC - SCC_2	7	4.1	4.4
PPC - SCC_3	6.5	4.3	4.7
PPC - SCC_4	4	4.1	5.3
PSC - SCC_1	11	9.3	14
PSC - SCC_2	7.1	5.2	6.9
PSC - SCC_3	5.3	5	5.6
PSC - SCC_4	6	4.8	5

Table 12. V Funnel Flow (Sec) (Aggregate Weight and Volume Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	4.7	6	6.4
OPC - SCC_6	5.3	4.9	5.2
OPC - SCC_7	8	6	5.6
OPC - SCC_8	11.3	9	11.1
PPC - SCC_5	11	5.7	6.2
PPC - SCC_6	7	4.1	4.4
PPC - SCC_7	5.2	6.1	7.3
PPC - SCC_8	7.2	6.7	7.2
PSC - SCC_5	6.1	9	13
PSC - SCC_6	6.1	13	16
PSC - SCC_7	6.2	12	14
PSC - SCC_8	7.4	14	18

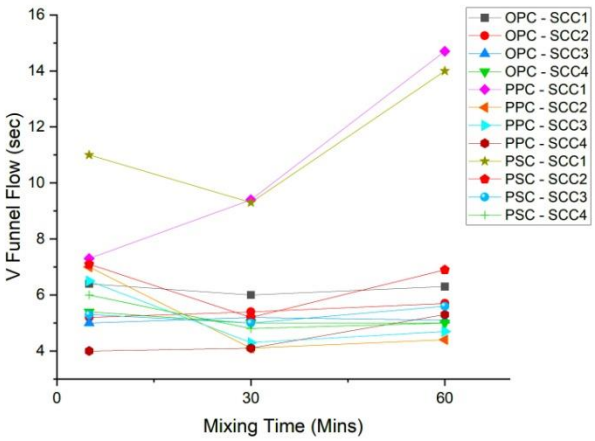


Fig.5. V Funnel Flow (Water Binder Constant)

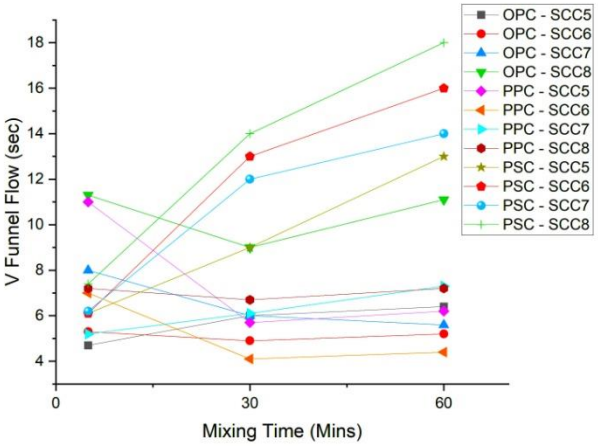


Fig.6. V Funnel Flow (Aggregate Weight and Volume Constant)

4.1.4. L-Box Test

Aggregate blocking must be avoided as Self Compacting Concrete flows through the reinforcement and the L-Box Test is indicative for passing ability of Self Compacting Concrete mix. The acceptance levels as per EFNARC are 0.8 to 1.0 (Ratio of h_2/h_1, h_1 is interior height and h_2 exterior height in L-Box base line after concrete stops flowing).

Table 13. L-Box (Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	0.75	0.79	0.80
OPC - SCC_2	0.78	0.79	0.83
OPC - SCC_3	0.84	0.89	0.93
OPC - SCC_4	0.88	0.94	1.00
PPC - SCC_1	0.83	0.84	0.77
PPC - SCC_2	0.72	0.97	0.96
PPC - SCC_3	0.89	0.93	0.98
PPC - SCC_4	1.00	1.00	1.00
PSC - SCC_1	-	0.68	-
PSC - SCC_2	0.74	0.88	0.82
PSC - SCC_3	0.89	1.00	0.95
PSC - SCC_4	1.00	1.00	1.00

Table 14. L-Box (Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	0.82	0.83	0.83
OPC - SCC_6	0.79	0.87	0.90
OPC - SCC_7	0.77	0.89	0.96
OPC - SCC_8	0.68	0.71	0.70
PPC - SCC_5	0.72	0.79	0.91
PPC - SCC_6	0.72	0.97	0.96
PPC - SCC_7	0.86	0.82	0.84
PPC - SCC_8	0.76	0.72	0.73
PSC - SCC_5	0.76	0.72	-
PSC - SCC_6	0.85	0.79	-
PSC - SCC_7	0.84	0.77	-
PSC - SCC_8	-	-	-

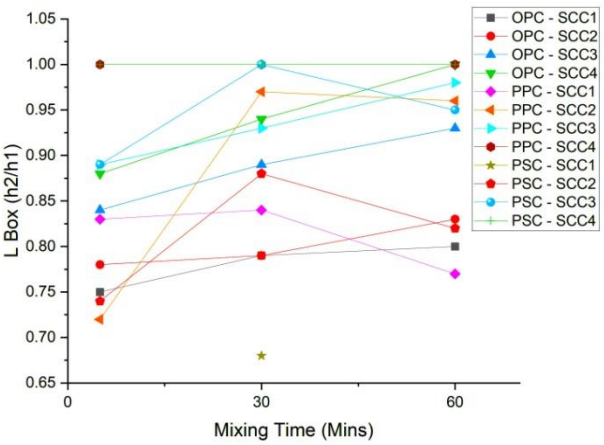


Fig.7. L-Box (Water Binder Constant)

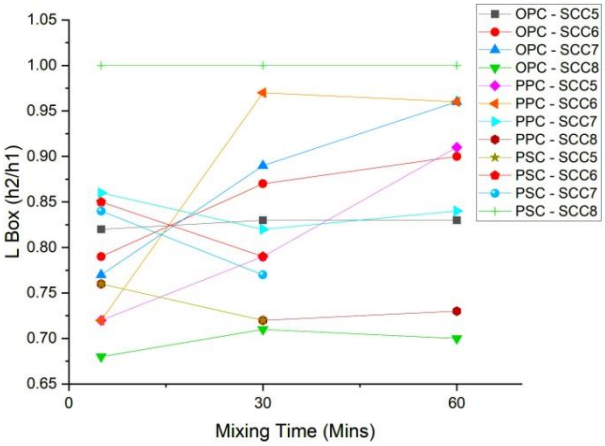


Fig.8. L-Box (Aggregate Weight and Volume Constant)

4.1.5. U-Box Test

U-Box test is also an indicative for passing ability of Self Compacting Concrete to avoid aggregate blocking during the flow. The acceptance levels as per EFNARC are 0 to 30 mm (h2-h1, the level difference of concrete in the two legs of U-box after stop of flow)

Table 16. U-Box (mm)
(Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	45	34	39
OPC - SCC_2	32	15	0
OPC - SCC_3	22	0	0
OPC - SCC_4	18	0	7
PPC - SCC_1	40	25	15
PPC - SCC_2	35	0	0
PPC - SCC_3	25	0	0
PPC - SCC_4	0	0	12
PSC - SCC_1	-	-	-
PSC - SCC_2	35	10	15
PSC - SCC_3	0	0	10
PSC - SCC_4	0	0	10

Table 16. U-Box (mm)
(Aggregate Weight and Volume Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	35	29	21
OPC - SCC_6	29	0	0
OPC - SCC_7	25	0	0
OPC - SCC_8	-	-	-
PPC - SCC_5	35	0	0
PPC - SCC_6	35	0	0
PPC - SCC_7	0	15	20
PPC - SCC_8	45	55	60
PSC - SCC_5	40	-	-
PSC - SCC_6	25	40	-
PSC - SCC_7	25	40	-
PSC - SCC_8	-	-	-

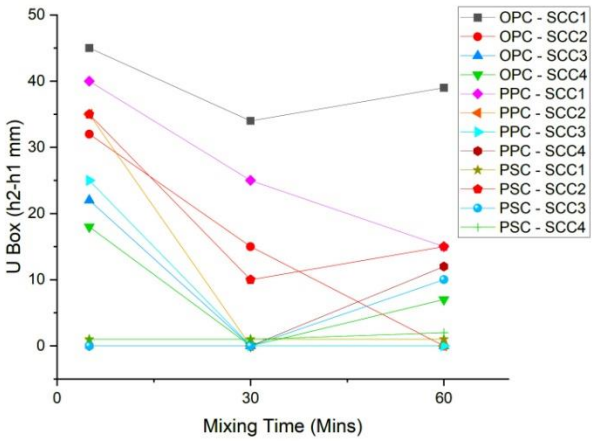


Fig.7. U-Box (Water Binder Constant)

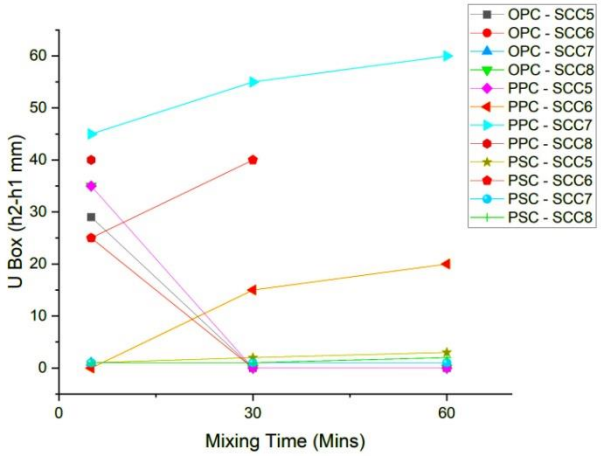


Fig.8. U-Box (Aggregate Weight and Volume Constant)

4.2. Discussion

The fresh properties of the mixes were mostly within the acceptance levels for the 20%, 25% and 30% addition with Water Binder Ratio constant method and 15%, 20% and 25% addition with Aggregate Weight and Volume Constant Method.

The slump flow in almost all mixes was observed with slight bleeding after resting of flow with initial mixing of 5 minutes. On Continuous mixing for 30 minutes the flow was good and no bleeding was observed in any of the mixes. After 60 minutes of continuous mixing the flow reduced when compared to 30 minutes with no bleeding.

The values of Slump flow $-T_{500}$ for almost all the mixes were was within the range of acceptance levels.

The V Funnel flow was good for all the mixes which had satisfactory slump flow. No blockage was found at the bottom of funnel for any of the mixes during the flow. The $T_{5Minutes}$ flow in V Funnel were also within the range of acceptance levels for all the mixes.

The values of L Box flow and U-Box Flow were observed to be good with addition of fly ash in OPC and PPC. Addition in PSC was observed with blockage and bleeding of water.

5. Conclusions

From the results and observations in this study the following conclusions may be made:

1. In Water Binder Ratio Method for 15% addition of fly ash in all types cements the quantity of aggregates was at higher side and the water was not sufficient for the binder material for getting the sufficient viscosity to get the required flow. If the super plasticizer was added more to get the flow, bleeding was observed with very low values of flow. The similar kind of observation was found in Aggregate Weight and Volume Method with addition of 30% of fly ash in all types of cements. The water content was not sufficient for the powder to get the viscosity and there were mixes with no flow. All other percentages of addition of fly ash in both the methods of mix design the results were all within the range of acceptance levels.
2. The mixing time in this study was one of the major factors. The initial mix for 5 minutes of continuous mixing in the pan mixer for all the mixes are within the acceptances levels but observed with some bleeding after the flow rested. After 30 minutes of continuous mixing almost all the mixes showed very good results with all the values within the acceptance levels. After the 60 minutes of continuous mixing almost all the flows slowed down when compared to the values 30 minutes of mixing but within the acceptance levels.
3. The mixes SCC2, SCC3, SCC4, SCC5, SCC6 and SCC7 were found to be self compactable almost satisfying the acceptance levels. All these mixes are found to be highly good with 30 minutes of continuous mixing.
4. The mixes which satisfied self compactibility can be further tested for strength properties

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شعبۂ عربی، فارسی واردو، جامعہ سری وینکٹیشورا، تروپتی، آندھراپردیش۔انڈیا

دہلی کے بلّی ماراں محلّہ سے مرزا اسداللہ خاں غالبؔ کی شہرت کا سلسلہ شروع ہوتا ہے۔ جورفتہ رفتہ ہندو پاک اورایران کی سرحدوں کو پار کرتے ہوئے دنیائے ادب پر چھا گیا ہے۔ غالبؔ ایک آفاقی شاعر ہیں۔ان کی شاعرانہ عظمت کے چرچے صرف اردو اور فارسی تک محدود نہیں ہیں۔ بلکہ دنیا کی دیگر زبانوں کے ادیبوں اور شاعروں نے بھی غالبؔ کو بڑا شاعر تسلیم کیا ہے۔مختلف زبانوں میں غالبؔ کی شاعری کے ترجمے ہورہے ہیں۔اور روز بہ روز غالبؔ کے شیدائیوں اور پرستاروں میں اضافہ ہورہا ہے۔اُنہیں پرستاروں میں ایک نام امیر علی خاں یسیرؔ کرنولی کا ہے جو غالبؔ دکن کے لقب سے مشہور ومعروف ہیں۔

یسیرؔ کرنولی کی ولادت، غالبؔ کی ولادت کے سو سال بعد ۱۹۰۶ء میں جنوبی ہند کی ریاست آندھراپردیش کے شہر کرنول میں ہوئی۔ پٹھان گھرانے میں پیدا ہوئے۔ابا واجداد جاگیردار تھے۔یسیرؔ نے بی۔اے۔اور ایم۔اے۔کی تعلیم حاصل کی۔ بعد میں بی۔ایل۔بھی پاس کیا۔سرکاری ملازم ہوئے۔ ملازمت کو اپنی طبیعت سے ناموافق پاکر استعفی دے دیا۔وکالت کی۔یہاں بھی دل نہ لگا۔پیشۂ وکالت کو بھی خیرباد کہکر گھر پر رہنے لگے۔پھر کسی پیشہ یا ملازمت سے وابستہ نہ ہوئے۔اور شادی بھی نہیں کی۔وراثت میں جاگیر ملی تھی۔گزر بسر کے لیے یہی کافی تھی۔شعر کہنے میں اور شاگردوں کی اصلاح میں مصروف رہے۔ ۱۹۸۸ء میں وفات پائی۔

یسیرؔ کرنولی نے اپنا دیوان ''نفیر شوق'' بطور یادگار چھوڑا ہے۔ جو ۱۹۸۰ء میں کرنول سے شائع ہوکر منظر عام پر آیا۔اس دیوان کے مطالعہ سے بخوبی واضح ہوتا ہے کہ یہ غالبؔ کی پیروی میں لکھا گیا ہے۔اس دیوان کی بیشتر غزلوں کی زمینیں، ردیف وقافیے، موضوعات، زبان، انداز بیان دیوان غالبؔ سے مماثلت رکھتی ہیں۔اور یہ سچ بھی ہے۔اس کا اندازہ ہمیں اس بات سے بھی ہوتا ہے کہ انہوں نے اپنا دیوان ''نفیر شوق'' غالبؔ کے پرستاروں کے نام معنون کیا ہے۔ انتساب میں لکھتے ہیں:

''نجم الدولہ دبیر الملک نواب مرزا اسداللہ خاں غالبؔ کے پرستاروں کے نام۔'' (نفیر شوق، ص:۳)

یسیرؔ کرنولی نے شاعری کی ابتداء تحصیل علم کے زمانے میں ہی کی تھی۔ غالبؔ کی طرح یسیرؔ کے خاندان میں بھی کوئی شاعر گزرا ہے اور نہ ہی ان دونوں نے شاعری میں کسی کی شاگردی اختیار کی ہے۔بغیر کسی استاد کے عروض کی کتابیں پڑھیں۔استاذی شعراء میرؔ، غالبؔ، مومنؔ، ذوقؔ، نصیرؔ اور ناسخؔ کا مطالعہ کیا۔مزاج شاعرانہ تھا اور طبعیت میں روانی تھی۔ بہت جلد فن شعر پر دسترس حاصل کرلی اور شعر کہنے لگے۔ چوں کہ وہ غالبؔ سے بے حد متاثر تھے، لہذا غالبؔ ہی کے رنگ میں شعر کہنا اپنا شیوہ بنالیا۔ڈاکٹر یعقوب شریف لکھتے ہیں:

''یسیرؔ، غالبؔ سے بہت متاثر رہے ہیں۔انہوں نے نہ صرف غالبؔ کے طرزِ ادا اور اسلوب کی پیروی کی ہے بلکہ غالبؔ کی غزلوں کی بحریں، زمینیں، ردیف وقافیے بھی من وعن اپنا لیے ہیں۔'' (غالب دکن۔یسیر کرنولی، ص:۱۶۴)

یہی وجہ تھی کہ یسیرؔ کو ''غالبؔ دکن'' کہا جانے لگا۔غالبؔ دکن کے لقب سے متعلق ملک الشعراء اوج یعقوبی یورقم طراز ہیں:

''جب اُس مشاعرہ میں غالبؔ کی ایک سنگلاخ زمین میں یسیرؔ صاحب نے غزل سنائی تو خود میری ہمہ گوئی اور ہمہ دانی کا احساس متزلزل رہ گیا۔ میں سوچ بھی نہیں سکتا تھا کہ کرنول جیسے دور افتادہ مقام میں ایسا شاعر بھی ہوگا۔ میں اگر زیادہ صاف گوئی سے کام لوں تو بلا جھجک یہ کہہ سکتا ہوں کہ رفع شک کے طور پر میں نے ان سے کچھ سنانے کی خواہش کی۔ چنانچہ یسیرؔ صاحب نے غالبؔ ہی کی زمینوں میں مزید دو غزلیں سنائیں۔ نتیجہ کے طور پر مجھے کہنا پڑا کہ علامہ یسیرؔ کو غالبؔ دکن کا خطاب دینا چاہیئے۔ غالباً یہ بات میرے دل کی گہرائیوں سے نکلی تھی جس میں بھرپور خلوص تھا کہ آج سارا آندھرا پردیش آپ کو غالبؔ دکن ہی کے نام سے جانتا ہے۔'' (نفیر شوق' ص:۴ اور ۵)

اوج یعقوبی نے سنگلاخ زمینوں کے استعمال پر یسیرؔ کو غالبؔ دکن کہا تو مولوی سید افتخار احمد نے فکری اعتبار سے یسیرؔ کو غالبؔ دکن سے یاد کیا ہے۔ خود یسیرؔ کرنولی ''نفیر شوق'' میں لکھتے ہیں:

''میرے مکرم دوست مولوی سید محمد افتخار احمد صاحب بشرؔ نے پہلی بار مجھے غالبؔ دکن کے نام سے یاد کیا' اس بنا پر کہ میرے شعر غالبؔ کے اشعار کی طرح دعوتِ فکر دیتے ہیں۔'' (نفیر شوق' ص:۳۵)

اس میں کوئی شک نہیں کہ یسیرؔ کرنولی نے غالبؔ کی پیروی کی ہے۔ غالبؔ اور یسیر کے درمیان ایک صدی کا فاصلہ ہے۔ یسیرؔ کے زمانے میں اردو کی شعری روایات کافی بدل چکے تھے۔ تاہم یسیرؔ نے اپنی شاعری میں کلاسیکی روایات کی پاس داری کی ہے۔ عشقیہ واردات کی ترجمانی' فارسی تراکیب کا استعمال 'غزل کی لفظیات اور طرز بیان ان سب سے یسیرؔ کی غزل مزین ہے۔ کلاسیکی روایات کا لحاظ کرتے ہوئے غالبؔ کی سنگلاخ زمینوں میں غزل کہنا یسیرؔ کرنولی کا وصف خاص رہا ہے۔ غالبؔ پسندی کا ذکر کرتے ہوئے ڈاکٹر ابوالفضل سید محمود قادری لکھتے ہیں:

''غالبؔ اور یسیرؔ کے درمیان ایک صدی سے زیادہ عرصہ کا فصل موجود ہے۔ اس طویل عرصے میں ادبی اقدار نے طرح طرح کی کروٹیں بدلیں' لیکن یسیرؔ کے ذہن و شعور پر غالبؔ ہی غالب رہے۔ یہاں تک کہ ترتیبِ دیوان کے مرحلے پر بھی 'نقش فریادی ہے کس کی شوخیٔ تحریر کا' کی زمیں میں یسیرؔ نے بھی نفیرِ شوق کو کاغذی پیرہن میں پیکرِ تصور بنایا۔'' (نفیر شوق ایک جائزہ' ص:۷ اور ۸)

''نفیر شوق'' کی پہلی غزل ہی اس بات کی غماز ہے۔ جس میں دیوان غالبؔ کی پہلی غزل کی زمین' ردیف و قافیہ کی پیروی کرتے ہوئے نہایت خوب صورت شعر کہے ہیں۔ دیوان غالبؔ کے پہلے دو شعر ملاحظہ ہوں:

نقش فریادی ہے کس کی شوخیٔ تحریر کا — کاغذی ہے پیرہن ہر پیکر تصوری کا
کاو کاوِ سخت جانی ہائے تنہائی نہ پوچھ — صبح کرنا شام کا لانا ہے جوئے شیر کا

اسی طرز پر لکھے یسیرؔ کرنولی کے شعر ملاحظہ ہوں:

ہے یہ عالم اضطرابِ شوق کی توقیر کا — ضبط بھی صیدِ زبوں فتراکِ دار و گیر کا
اشکِ خوں میں بہہ گیا دل عاشقِ دلگیر کا — تشنہ لب رہ جائے گا پیکاں کسی کے تیر کا
جذبۂ ایثار کی گرمی کا عالم دیکھنا — دیر تک فتراک سے ٹپکا لہو نخچیر کا
یوں بھی غالبؔ کی زمینوں میں غزل لکھنا یسیرؔ — فکر کے کہسار سے لانا ہے جوئے شیر کا

غالبؔ اور یسیرؔ کی غزلوں کا تقابلی مطالعہ کیا جائے تو ان دونوں کے اشعار میں بحر' ردیف اور قافیہ کے علاوہ فکر اور احساس میں بھی مماثلت اور یکسانیت کو دیکھا جا سکتا ہے۔ چند شعر ملاحظہ ہوں:

غالبؔ: بازیچۂ اطفال ہے دنیا میرے آگے ہوتا ہے شب و روز تماشا مرے آگے
یسیرؔ : ایک وہم ہے رنگینیٔ دنیا مرے آگے یہ محو تماشا ہے ' تماشا مرے آگے

غالبؔ: ابن مریم ہوا کرے کوئی میرے دکھ کی دوا کرے کوئی
یسیرؔ : اک زحمتِ نظر تو گوارا کرے کوئی میرے غمِ دوراں کا مداوا کر ے کوئی

غالبؔ: کیا کیا خضر نے سکندر سے اب کسے رہنما کرے کوئی
یسیرؔ : جنابِ خضر کو بھی ہمسفر میں کر نہیں سکتا ابھی جو فرق کر نا ہے مجھے رہبر و رہزن میں

غالبؔ: کیوں جل گیا نہ تابِ رخِ یار دیکھ کر جلتا ہوں اپنی طاقتِ دیدار دیکھ کر
یسیرؔ : یوں کھو گئے جمالِ رخِ یار دیکھ کر ہم دیکھتے رہے انہیں سو بار دیکھ کر
غالبؔ: میں نے مجنوں پہ لڑکپن میں اسدؔ سنگ اُٹھایا تھا کہ سر یاد آیا
یسیرؔ : حالِ مجنوں پہ اڑے ہوش یسیرؔ سنگ یاد آیا نہ سر یاد آیا

غالبؔ کی طرح یسیرؔ نے بھی فارسی تراکیب کا بخوبی استعمال کیا ہے۔یسیرؔ' دکن کے شاعر ہیں۔تاہم انہوں نے اشعار میں فارسی تراکیب کو اس خوبصورتی سے برتا ہے کہ ایسا لگتا ہے کہ یسیرؔ شمالی ہند کے کلاسیکی شاعر ہیں۔جیسے :صیدِ زبوں' انیسِ شام' پروانۂ شتاب' چرخ نیلی فام' چراغِ سرِ مدفن' لباس حریر ضبط وغیرہ۔

مثال کے طور پر دو شعر ملاحظہ ہوں:

خیالِ یار کو میں نے انیس شام کیا طلوعِ صبح، تمنا کا اہتمام کیا
زندگی کانپتے گزری ہے شبِ فرقت میں ایک افسردہ چراغِ سرِ مدفن

مذکورہ بالا اشعار میں یسیرؔ کرنولی نے انوکھی اور دلاویز تشبیات سے شعروں میں معنوی دینا آباد کردی ہے جو کلام غالبؔ کی بھی ایک نمایاں خصوصیت ہے۔جیسے خیال یار کو انیس شام اور مشکل بھری زندگی کو چراغِ سرِ مدفن۔

غالبؔ اور یسیرؔ کے کلام میں دقیقہ رسی اور مشکل پسندی کے ساتھ ساتھ سہل الممتنع کی کیفیت بھی پائی جاتی ہے۔نفیر شوق کے مطالعہ سے ایسا محسوس ہوتا ہے کہ یسیرؔ نے بعض مقامات پر کلام غالبؔ کی تقلید و تتبع کرنے کی کوشش کی ہے۔ذیل میں یسیرؔ کے چند مطلعے ملاحظہ ہوں:

ان کا انداز نظر یاد آیا ساتھ ہی زخمِ جگر یاد آیا
یوں کھوگئے جمالِ رخِ یار دیکھ کر ہم دیکھتے رہے انہیں سو بار دیکھ کر
ایک وہم ہے رنگینیٔ دنیا میرے آگے ہر محو تماشا ہے تماشا مرے آگے
ملا ہے درد' حیاتِ رواں دواں کے لیے نفیر شوق ضروری تھی کارواں کے لیے

غرض یسیرؔ کرنولی کا شمار غالبؔ کے معنوی شاگردوں میں ہوتا ہے۔ انہوں نے من وعن غالبؔ کی پیروی کرنے کی کوشش کی ہے۔ غالبؔ کی طرح سنگلاخ زمینوں میں غزلیں کہی ہیں۔ بحر، ردیف اور قافیہ کا اہتمام کیا ہے۔ کلاسیکی روش کو اختیار کرتے ہوئے بہترین شعر کہے ہیں۔ اس میں شک نہیں کہ یسیرؔ کرنولی نے ''نفیرِ شوق'' کی شکل میں غالبؔ شناسی کا مبیّن ثبوت دیا ہے۔

حواشی:

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☆☆☆

شہہ میریہ خانوادہ کے چند شعرا کا دکنی کلام

پروفیسر محمد نثار احمد
صدر شعبۂ اردو، سری وینکٹیشورا یونی ورسٹی، تروپتی، آندھرا پردیش۔انڈیا

ریاست آندھرا پردیش کے علاقۂ رائل سیما کے معروف صوفی خانوادۂ شہہ میریہ کو یہ امتیاز حاصل ہے کہ یہ ایک علمی وادبی خانوادہ ہے۔اس سلسلہ کے کئی شعرا کا کلام محفوظ ہے۔اس خانوادے کے شعرا نے دکنی میں کئی تصانیف یادگار چھوڑی ہیں۔اس خانوادے کا ادبی سرمایہ شاعری اور نثر دونوں میں موجود ہے۔

ہندوستان کے دیگر صوبوں کی طرح آندھرا پردیش میں بھی صوفیاء کرام کی آمد ہوئی اور یہاں کے مختلف خطوں میں انھوں نے اسلام کی تبلیغ واشاعت اور تلقین کا فریضہ انجام دیا۔رائل سیما صوبۂ آندھرا پردیش کا ایک اہم خطہ ہے اور یہ چار اضلاع پر مشتمل ہے، کرنول، کڑپہ، انت پور اور چتّور۔رائل سیما میں صوفیانہ شعروادب کی روایت حضرت خواجہ بندہ نواز گیسودرازؒ سے وابستہ ہے۔

خانوادۂ شہ میریہ کے بعض قلمی تصانیف سے بھی پتہ چلتا ہے کہ رائل سیما میں صوفیانہ شعروادب کی روایت حضرت خواجہ بندہ نواز گیسودرازؒ ہی سے وابستہ ہے۔حضرت جلال الدین اکمل فرزندِ حضرت شاہ کمال ثانی جامیٔ دکن کی تصنیف ''مقصود السالکین'' کے اس اقتباس سے بھی واضح ہوجاتا ہے کہ رائل سیما کے صوفیاء نے جب تصنیف وتالیف کا آغاز کیا تھا تو ان کے سامنے حضرت میراں جی شمس العشاق، حضرت برہان الدین جانم اور حضرت امین الدین اعلیٰ کی ادبی روایتیں موجود تھیں۔مقصود السالکین کا یہ اقتباس ملاظہ ہوں:

''حضرت شاہ برہان الدین جانم بیجاپوری والدِ ماجد حضرت امین الدین اعلیٰ قدس سرہٗ جو ہمارے پیروں کے پیر اور حضرت خواجہ سید محمد حسینی گیسودراز بندہ نوازؒ قدس سرہٗ کے سلسلہ اور خلفاء میں ہیں۔'' (مقصود السالکین۔ص۲۳)

رائل سیما میں شہ میریہ خانوادہ میں کئی علماء، شاعر، ادیب، صاحبِ تصنیف بزرگ گذرے ہیں۔شہ میریہ خانوادہ بخارا سے نکل کر شمالی ہند، گلبرگہ، بیجاپور ہوتے ہوئے حیدرآباد، کرنول، کڑپہ، گرم کنڈہ پہنچا۔رائل سیما میں یہ خانوادہ تقریباً چار سو سال کی تاریخ رکھتا ہے۔اس خانوادہ میں جو صاحبِ تصانیف بزرگ گذرے ہیں وہ یہ ہیں: حضرت شاہ میرؔ، حضرت شاہ نورؔ، حضرت شاہ کمالؔ، حضرت بیرنگؔ، حضرت سالکؔ، حضرت مقبلؔ، حضرت لامعؔ اور حضرت اکملؔ وغیرہ۔ان بزرگوں نے حقائق ومعارف کے ذریعہ تبلیغِ اسلام واحسان کی اہم خدمات انجام دیں۔

حضرت شاہ میرؔ:

حضرت شاہ میرؔ حضرت سید شاہ جمال الدین کے لڑکے اور حضرت سید شاہ کمال اول کے پوتے تھے۔آپ کا اسمِ گرامی سید محمد حسینی اور لقب شاہ میر تھا۔آپ حضرت مخدوم جہانیانِ جہاں گشتؒ کی اولاد میں سے تھے۔شاہ میر کے بھائی شاہ نوراللہ بخاری اپنی تصنیف 'تجلیٔ انوار' میں لکھتے ہیں ؎

حضرت سید محمد مرشد روشن ضمیر تاجِ سر سلطان کا' اور قطبِ حق دوران کا

ڈاکٹر رفیعہ سلطانہ لکھتی ہیں:

''ان کا نام سید محمد حسینی اور لقب شاہ میر تھا۔ والد کا نام سید شاہ جمال الدین تھا جو حضرت مخدوم جہانیان جہاں گشتؒ کی اولاد سے تھے۔'' (اردو نثر کا آغاز وارتقاء۔ص ۲۳۷)

نصیرالدین ہاشمی کے الفاظ ملاحظہ ہوں:

''شاہ میر دکن کے ایک صوفی بزرگ گذرے ہیں جو قادریہ اور حسینی طریقہ کی بیعت لیا کرتے تھے۔.....شاہ میر شاہ میاں کے لقب سے بھی موسوم تھے۔''

مندرجہ بالا تمام بیانات سے یہ بات واضح ہوجاتی ہے کہ بام سید محمد حسینی تھا۔ لیکن آپ نے اپنے تخلص شاہ میرؔ کے نام سے شہرت پائی۔ آج بھی دنیائے ادب اور خانقاہوں میں آپ شاہ میرؔ ہی کے نام سے جانے اور پہچانے جاتے ہیں۔

حضرت سید محمد حسینی میرؔ تخلص کیا کرتے تھے۔ کہیں کہیں شاہ میرؔ یا شہ میرؔ بھی تخلص کے طور پر باندھا ہے۔ ذیل کے اس شعر میں تخلص میر استعمال کیا ہے ؎

کر تلاوت رات دن اپنا وجود باتدبر میرؔ در ہر فصل و باب (شاہ کمال۔ کلماتِ کمالیہ۔ص۔۲۰۸)

حضرت شاہ میر نے اپنی رباعی میں اپنے مشہور نام کو بطور تخلص استعمال کیا ہے۔

شہ میر نہ کر فکر تو کچھ قوت کی واللہ
رازق تیرا قادر و قیوم ہے اللہ
چیرا ہے جنے منہ کو تیرے ولے رزق نہ دے وے
لاحول ولاقوۃ الا باللہ!!

حضرت شاہ میر کا نمونۂ کلام:

ذات کو ہر شئے کے نیں ہے انقلاب اور صفت کو انفکاک و انسلاب
جو کہ آب آتش نہ ہوئے عکس نیر سلب نہ ہوئے عرق آتش غرق آب
نا ہوےء صرفِ عدم محض وجود حال بیداری نہ ہوئے حال ِخواب
نا مبدل ذات نا متغیر صفات یہ عقائد سنت و راہِ صواب
ذات کو ہر دم تلبس ہے و لیک صورت ہر وصف سے اے کامیاب
اور صفت کو صورت افعال سے ہے تلبس ہر زماں بے ارتیاب
فعل کو آثار کے صورت سے ہے ہم تجلی ہم تلبس ارتکاب
ذات کو ہر شئے کے یوں ہے خلع بس اس کو کہتے ہیں تجدد ذولباب
گر نہ یوں ہو ذات کیونکر ہو بدیع بے بدیعیت کا یہ سارا حساب
خلع کو کہتے عدم در اصطلاح بس کو بولیں وہ وجود اے بہرہ یاب
مصطلح اہلِ حقایق کا سخن نیں لغت سے کام ان کو اے صحاب
کیا فنا اور کیا موت وحیات یا دو غفلت انکشاف و احتجاب
عینیت اور غیریت وصل و فراق ذوق و جدان و یقیں ریب ونقاب
کفر و ایمان راہِ منزل اور مقام سیر وطیر و جذب وسعی واکتساب

نفی و اثبات اورقرب و حضور بیخودی و باخودی کشف و حجاب
یہ مسائل اصطلاحی ہیں سمجھ یک بہ یک واللہ اعلم بالصواب
کر تلاوت رات دن اپنا وجود باتدبر میؔر در ہر فصل وباب
(کلماتِ کمالیہ۔ص۲۰۸)

حضرت شاہ نوؔر:

نام سید نوراللہ حسینی الملقب بہ سید شاہ نوراللہ بادشاہ بخاریؒ۔آپ کا نام خود آپ کی تصانیف میں اس طرح لکھا ہوا ہے۔حضرت شاہ نوؔر رسالۂ ارشادِ نوریہ میں اس طرح لکھتے ہیں:''ہندی زباں سوں سید نوراللہ بن جمال الدین آسان کرکر حضرت سید محمد حسینی شاہمیر صاحب قدس سرہٗ کی فیض ہورارشادِنوریہ کی برکت سوں ہورحق تعالیٰ کی عنایت ہور ہدایت کی اعانت سوں لکھتا ہے۔''(ارشادِنوریہ۔ص۷۶)

آپ نوؔر تخلص کیا کرتے تھے۔آپ اپنے فارسی واردو کلام کے کئی بیتوں میں تخلص نوؔر استعمال کیا ہے۔اس کی چندایک مثالیں ملاحظہ ہو:

محبوب ندا کند کہ اے نوؔر آنجا کہ توئی منم ہمیشہ (تجلیِ انوار۔ص۱)
بندی نورکونورایمان دے تیرادیدجنت منی دان دے (عقائدِنوریہ۔ص۵)

حضرت شاہ نوراللہ بخاری کے ہمعصروں میں کئی صوفیاء کرام اورعلماء وشعراء ہیں۔جن میں حضرت شہ میر اول،مولانا باقر آگاہ ویلوری،شاہ فی الحال کرنولی،وجدی کرنولی،سراج اورنگ آبادی کے علاوہ آپ کے بھائی حضرت سید شاہ کمال مصنف''مخزن العرفان''وغیرہ تھے۔

شاہ نوؔر کثیرالتصانیف بزرگ ہیں۔آپ کو عربی،فارسی اوراردو زبانوں پرعبور حاصل تھا۔شاہ نوؔر فارسی اوراردو میں کئی تصانیف اپنی یادگار چھوڑی ہیں۔جن میں عقائدِ نوریہ،تجلیاتِ نورانی اورمجموعہ التکسیر ہیں۔یہ تمام کتابیں قلمی ہیں اورکتب خانۂ کمالیہ،گرمکنڈہ،ضلع چتّور میں موجود ہیں۔

نمونۂ کلام:

ذاتِ رب کی جسم و جسمانی نہیں نفس بی نیں اور نفسانی نہیں
قلب و قلبی بھی نہ پہچانے اوسے بلکہ نیں ہی روح وروحانی نہیں
ذات وذاتی ذات اوراسکے صفات یوں جو نا سمجھے سو عرفانی نہیں
معرفت رب کی،ہر اک پرفرض ہے ہور عبادت انکی جس ثانی نہیں
ذاتِ مطلق ہے ہمہ باطن ہے لیک باہمہ ظاہر ہے پنہانی نہیں
منشائ ہر دوھے وحدت جمع توں او حقیقت احمدی فانی نہیں
بعد اس کے ہے الٰہیت سو کیا غیر نفس الامر انسانی نہیں
بعدہٗ ہے جان ارواح ومثال جاں اگن پانی پوں پانی نہیں
(تجلیِ انوار،ص۔۲۶)

حضرت شاہ کمالؔ:

حضرت شاہ کمالؒ(دوّم)۔حضرت سید شاہ کمال الدین بخاری رحمۃ اللہ علیہ اپنے وقت کے بلندمرتبت ولی کامل گزرے ہیں۔علم وعرفان کی دنیا میں آپ کی ذات قطعاًمحتاج تعارف نہیں۔درس وتدریس،تالیف وتصنیف،پندونصائح اورمجاہدہ وریاضت ایسے جملہ امور میں اپنی نظیر آپ تھے۔حضرت شاہ کمال اپنے عہد کے ایک قادرالکلام اور باکمال اور پرگو شاعرومصنف ہیں۔آپ ایک فطری اوروہبی شاعر تھے،بلا مبالغہ ہزاروں اشعار آپ کے نوکِ قلم سے تخلیق

پائے ہیں۔آپ کے اشعار کا موضوع تصوف واحسان ہونے کے باوجود آپ نے اس پامال مضمون کو اپنے قلمِ معجز رقم سے زندۂ جاوید بنادیا،اس کی نظیر اس دور کے دیگر شعرا میں ملنا بہت مشکل ہے۔آپ کو عربی، فارسی اور دکنی اردو تینوں زبانوں پر عبور حاصل تھا۔آپ نے عربی، فارسی اور دکنی اردو زبانوں میں تصانیف چھوڑی ہیں۔حضرت سلطان ٹیپو شہیدؒ نے آپ کو بجا طور پر ''جامیٔ دکن'' کے خطاب سے سرفراز فرمایا تھا۔بقول محمد سخاوت مرزا آپ کو اپنے تمام ہم عصروں میں اپنے طرز و رنگ کے لحاظ سے فوقیت حاصل ہے۔حضرت شاہ کمالؒ (دوم) کے علم وفضل وتقویٰ و بزرگی کا عالم یہ تھا کہ عوام تو عوام خواص الخاص بھی آپ کے عقیدت مندوں کی قطار میں نظر آتے تھے،جن میں جلیل القدر سلطان ٹیپو شہیدؒ کا بھی نام شامل ہے۔

آپ کا نام سید شاہ کمال الدین تھا۔آپ سید شاہ جمال الدین بخاریؒ کے تیسرے فرزند تھے۔شاہ کمال نے اپنے دیوان ''مخزن العرفان'' میں اپنا نام اس طرح لکھا ہے ؎

دیکھ اس کے حال پر اپنی نوازش کی نظر جم جم کمال الدین تیرا بندہ ہے کمتر یا جمال الدین

(دیوانِ مخزن العرفان۔ص۱۸۶)

رسالۂ اردو میں سخاوت مرزا نے بھی حضرت شاہ کمال کا نام کمال الدین ہی لکھا ہے۔سخاوت مرزا لکھتے ہیں:

''اسمِ گرامی کمال الدین سادات الحسینی الحسنی ابن سید جمال الدین۔۔۔۔۔'' (رسالۂ اردو۔بابت ماہ اپریل،۱۹۳۹ء ص۔۲۶۳)

ڈاکٹر زور نے بھی کتب خانہ اداریۂ ادبیات اردو،حیدرآباد کی وضاحتی فہرست جلد سوم میں حضرت شاہ کمال کا ذکر یوں کیا ہے:''سید شاہ کمال الدین ولد سید شاہ جمال الدین شاہنور (بیجاپور) کے رہنے والے تھے۔بعد کو کڑپہ اور کرنول میں مقیم ہوئے۔'' (وضاحتی فہرست جلد سوم۔کتب خانہ اداریہ ادبیات اردو ،ص۲۰۷)

نصیر الدین ہاشمی نے بھی حضرت شاہ کمال کے بارے میں اپنے خیالات کا اظہار کیا ہے۔وہ لکھتے ہیں:''شاہ کمال المتخلص بہ کمال کڑپہ آپ کا مولد تھا۔صاحبِ باطن بزرگ تھے۔'' (وضاحتی فہرست کتب خانۂ سالار جنگ میوزیم،ص۔۷۶۸)

حکیم محمود بخاری لکھتے ہیں:''اسمِ گرامی کمال الدین جامیٔ دکن لقب کمال تخلص فرماتے تھے۔آپ سید جمال الدین بادشاہ بخاری اول کے تیسرے فرزند اور سید محمد حسینی شاہ میر اول کے چھوٹے بھائی ہیں۔'' (شہ میری اولیاء،ص۔۱۱۳)

شاہ کمال الدین کمالؔ تخلص کیا کرتے تھے۔دکن کے پہلے صاحبِ دیوان شاعر محمد قلی قطب شاہ کی طرح آپ نے بھی کئی تخلص اپنائے۔شاہ کمال اپنے کلام میں کمالی،کمالا،کمال اللہ اور کمالیا کو تخلص کے طور پر استعمال کیا ہے۔کہیں کہیں پورا نام کمال الدین بھی تخلص کے طور پر باندھا ہے۔اس طرح انھوں نے اپنے نام اور تخلص کو کلام میں مختلف طرح سے لکھا ہے۔

دیوانِ مخزن العرفان (منظوم دکنی اردو)،معراج نامہ (منظوم دکنی اردو)،ضیافت نامہ (منظوم دکنی اردو)،حسن السوال وحسن الجواب (منظوم دکنی اردو)۔فارسی زبان میں بھی شاہ کمال نے کئی تصانیف قلم بند کی ہیں۔جن میں نصاب،کمال المعرفت،کلماتِ کمالیہ،معدنِ محاسن،رحیما اور دیوانِ کمال بہت مشہور ہیں۔

اول الذّکر تصنیف حضرت شاہ کمالؔ کا منظوم دکنی اردو دیوان ہے۔جس میں انھوں نے اپنے سارے تجربوں،مشاہدوں اور فنی وادبی صلاحیتوں کو اس دیوان کے ذریعہ اجاگر کیا ہے۔شاہ کمالؔ نے اپنے صوفیانہ نظریات کو بڑی حکمت و آسانی کے ساتھ سمجھایا ہے۔اس دیوان کے دو حصّے ہیں جس میں کئی غزلیات،رباعیات،مثنویات کے علاوہ منقبتی کلام بھی موجود ہے۔دیوان میں نعتیہ کلام سے زیادہ تصوف کے مسائل بیان کئے گئے ہیں۔اس کے علاوہ مختلف بزرگانِ دین کی مدح میں بھی کئی نظمیں لکھی گئی ہیں۔ساتھ ہی شاہ کمالؔ نے ریختی صنف پر بھی طبع آزمائی فرمائی اور انھوں نے اپنی ریختیوں کے ذریعہ صوفیانہ نکات کو واضح کیا ہے۔اس کے علاوہ شاہ کمالؔ نے ایک چکّی نامہ بھی اپنی یادگار چھوڑا ہے۔اس چکّی نامہ کو شاہ کمالؔ نے تمثیلی انداز میں پیش کیا ہے جو معرفت کے خزانے

سے مزین ہے۔حضرت شاہ کمالؔ نے اپنی صوفیانہ شاعری کے ذریعہ فصاحت و بلاغت کے دریا بہائے ہیں۔آپ کی شاعری میں آمد ہی آمد نظر آتا ہے۔شاہ کمالؔ کوالہامی شاعر کہا جائے تو بے جانہ ہوگا۔ذیل میں آپ کے کلام سے چند ایک نمونے ملاحظہ فرمائیں۔

جیئو مین پیئو عیان تھا مجھے معلوم نہ تھا آشکارا ہو نہاں تھا مجھے معلوم نہ تھا
میں سمجھتا تھا مرا پیئو ہے مرے سے جدا سربسر وہم وگماں تھا مجھے معلوم نہ تھا
پیئو کے ہی ذات وصفت باطن وظاہر ہے مرا میں تو نامی بہ میاں تھا مجھے معلوم نہ تھا
متلبس ہو وہ یک پیئو سدا جلوہ نما درلباسِ دوجہاں تھا مجھے معلوم نہ تھا
پیئو ہے ہست بجز نیست نہیں پیئو کا غیر عینِ ایمان یہ بیاں تھا مجھے معلوم نہ تھا
پیئو زمین پیئو زمان پیئو مکین پیئو مکان پیئو تن پیئو ہی جاں تھا مجھے معلوم نہ تھا
پیئو کو پیر سے پانا ہے وگر نئیں تو محال پیر یوں فیض رساں تھا مجھے معلوم نہ تھا
پیئو نے پیر کے گھنگٹ میں دکھایا ہے جمال یہ عجب رازِ نہاں تھا مجھے معلوم نہ تھا
پیئو نے پیر نما آپ ہوا ہے ورنہ پیئو بے نام ونشاں تھا مجھے معلوم نہ تھا
پیر نے پیئو کو ہر شئی میں بتایا ہے مجھے نئیں تو وہ پیئو کہاں تھا مجھے معلوم نہ تھا
پیئو کو پیئو سے دکھلانے مرے تئیں یہ کمالؔ پیر شہمیر ضماں تھا مجھے معلوم نہ تھا

(مخزن العرفان،ص۱۰۵)

حضرت شاہ کمال کی ایک ریختی کے چند شعر:

تجھ حُب کا جب سے لذت پائی ہوں اے دھنی میں
تب سے بندھی ہوں اپنی راحت سے دشمنی میں
قُمری نمن لگا کر سب تن کو راکھا اپنے
تجھ سرو قد کے کارن بن گئی ہوں جوگنی میں
چولے پہ تجھ برہ کے سینہ کے رکھ توے کو
دل اور جگر اُپس کا دھنیان نمن بھنی میں

حضرت شاہ کمال کے کلام میں صنائع اور بدائع کے مطالعہ سے پتہ چلتا ہے کہ آپ جملہ محاسنِ سخن کے رمز شناس تھے۔آپ نے اپنے کلام میں اسرارِ معرفت کے بیان اور اپنی غزلوں میں جہاں علوم ومعارف کے اسرار ورموز بیان کئے ہیں، وہیں آپ نے ظاہری محاسن اور جملہ کلام کے خصائصِ لفظی ومعنوی کا بھی بطورِ خاص لحاظ رکھا ہے۔

حضرت شاہ کمال کے کلام میں غزل،حمد ونعت اور مناجات کے علاوہ دیگر اصناف جیسے قصیدہ،منقبت،مرثیہ اور مثنوی کے ساتھ ساتھ مخمس،ترجیع بند، رباعی،سی حرفی اور ریختی پر بھی طبع آزمائی ملتی ہے۔

مخزن العرفان کی زبان اردو کی قدیم دکنی زبان ہے۔لیکن یہ دکنی زبان نہایت قدیم اور مشہور دکنی تصانیف کی طرح غریب لفظیات کی حامل نہیں ہے ،جیسا کہ قلیؔ،وجہیؔ،غواصیؔ،ابن نشاطی وغیرہ کے ہاں قدیم دکنی الفاظ ہی ملتے ہیں۔حضرت شاہ کمال کا زمانہ اس کے کافی بعد کا زمانہ ہے،جس کی وجہ سے زبان میں کافی اصلاحات ہوچکی تھیں اور زبان میں معیاری الفاظ کے استعمال کا رواج عام ہو چکا تھا۔یہی وجہ ہے کہ مخزن العرفان میں شامل کلام میں معرب اور مفرس

الفاظ کے ساتھ ساتھ معیاری زبان کے الفاظ بھی ملتے ہیں۔ یہ کہا جا سکتا ہے کہ اس عہد تک دکنی زبان نے کافی ترقی کر لی تھی۔ بھاشا کے الفاظ اور جنوبی ہند کے علاقائی زبانوں کے الفاظ بھی ملتے ہیں، بلکہ اگر یہ کہا جائے تو بیجا نہ ہوگا کہ حضرت شاہ کمال کے کلام میں مستعمل اردو زبان کافی معیاری اور معتبر لسانی ساخت کے ساتھ فصاحت و بلاغت کے تمام محاسن سے لبریز ہے۔

حضرت عبدالحق شاہ میرؔ:

سید عبدالحق نام عرف شاہ میر بادشاہ اور تخلص شاہ میرؔ تھا۔ آپ کی پیدائش ۱۲۸۷ھ میں محلّہ نبی کوٹ کڑپہ میں ہوئی۔ حکیم محمود بخاری نے شہ میری اولیاء میں لکھتے ہیں: ''اسمِ گرامی عبدالحق عرف شاہ میر بادشاہ، شاہ میرؔ تخلص فرماتے تھے۔ سن بارہ سو ستیاسی ہجری (۱۲۸۷ھ) مطابق اٹھارہ سو ایکہتر عیسوی میں بہ مقام کڑپہ (محلّہ نبی کوٹ) اپنے قدیم آبائی گھر میں پیدا ہوئے۔'' (شہ میری اولیاء، ص۔۱۷)

حضرت شاہ میر سن ۱۲۸۷ھ مطابق اٹھارہ سو ایکہتر عیسوی میں بہ مقام کڑپہ (محلّہ نبی کوٹ) اپنے قدیم آبائی گھر میں پیدا ہوئے۔

حضرت شاہ میر کے اکیسویں دادا حضرت سید جلال الدین حسین جلال اعظم سرخ بخاریؒ سلطان شہاب الدین غوری کے زمانہ میں ملتان تشریف لائے اور نویں دادا حضرت سید جمال الدین بخاریؒ نے ملتان سے گلبرگہ آکر حضرت سید محمد حسینی بندہ نواز گیسو درازؒ کی پڑپوتی سے شادی کی۔ سید جمال الدین بخاری کے پوتے حضرت سید کمال الدین بخاری نے گلبرگہ سے بیجاپور آکر چندے قیام فرمایا۔ پھر شاہ نور اور کرنول ہوتے ہوئے کڑپہ پہنچے اور گرمکنڈہ جا کر انتقال فرمایا۔ اس طرح یہ خاندان تقریباً تین سو سال سے علاقۂ رائل سیما میں آباد ہے۔

آپ کی تصانیف میں دیوانِ شاہ میر، حقیقتِ محمدیہ، گلدستہ اشرف العالمین، فضائلِ توبہ، منازل المصحف، نصابِ نصیحت قابلِ ذکر ہیں۔ آپ کا دیوان، دیوانِ شاہ میر کے نام سے طبع ہو چکا ہے۔

نمونۂ کلام کے طور پر حضرت شاہ میر کی ایک نعت پیش ہے:

آتش ہجر پیمبر میں ہوں جلتا جاتا — ہے دھواں آہ کا سینے سے نکلتا جاتا
دن قریب آئے ہیں طیبہ سے جدا ہونے کے — چشمۂ غم مرے دل سے ہے ابلتا جاتا
ذکرِ رخصت جو کیا کرتے ہیں زائر باہم — غمِ فرقت سے مرا دم ہے نکلتا جاتا
مجھ سے کیوں کہتا ہے زائر کہ چلو طیبہ سے — دل مرا ایسی ہی باتوں سے ہے جلتا جاتا
ہند کے رہنے سے حیراں و پریشاں تھا میں — اب مدینے میں جو ہوں دل ہے بہلتا جاتا
دل کو دیتی جو کبھی طاقتِ رفتار جواب — سر کے بل راہِ مدینے میں میں چلتا جاتا
دشتِ طیبہ کو جو جاتا ہوں تو ہر پتھر سے — مثلِ فرہاد سر اپنا ہوں کچلتا جاتا
خوابِ غفلت میں عبث عمر کی شب کٹتی ہے — شمع کی طرح ہوں اس غم میں پگھلتا جاتا
آرہا ہے مرے لب پر جو محمد کا نام — دل ِ بیتاب ہے سینے میں اچھلتا جاتا
غیرتِ گوہر ِ نایاب ہے وہ اے شہ میرؔ — سخن نعت جو منھ سے ہے نکلتا جاتا

حضرت سید جلال الدین اکملؔ:

حضرت سید جلال الدین نام اور اکملؔ تخلص ہے۔ آپ حضرت شاہ کمال الدین بخاری کے فرزند اور خلیفہ تھے۔ آپ نے درس نظامیہ کی تکمیل مدراس میں فرمائی۔ تحصیل علم ظاہری کے بعد آپ نے خرقۂ خلافت اور فیض باطنی والد ماجد سے حاصل فرمایا۔ آپ کے دو صاحبزادے تھے۔ سید مراد علی عرف علی مراد شاہ

افضلؔ اور سید فقیر محی الدین متقبلؔ۔ آپ کی وفات ۱۲۷۷ھ میں ہوئی۔ مزارِ اقدس محل، ضلع چتّور میں واقع ہے۔

اکملؔ کو نثر اور نظم دونوں پر قدرت حاصل تھی۔ آپ کی تصانیف میں مقصود السالکین اور چہل حدیث قابلِ ذکر ہیں۔ چہل حدیث اکملؔ کی منظوم تصنیف ہے جو آپ کے والد ماجد کی فارسی نظم چہل حدیث کا منظوم ترجمہ ہے۔ اس کے علاوہ آپ نے چند ایک حمد و نعت بھی کہے ہیں۔ نمونہ کلام ملاحظہ ہوں: ؎

کروں حمدِ خدا یہ دم ہے کہاں — یہ لب و لہجہ اور فہم ہے کہاں
کس طرح یہ رقم ہونا — دست و لوح اور قلم ہونا
ایسا دست اور دوات و خامہ کہاں — وہ سکت یہ سیاہ نامہ کہاں
ہے زبس یہ ثنا کا بام بلند — کیوں وہاں پہنچے فکر کا یہ کمند

حضرت جلال الدین اکملؔ کے چیدہ کلام سے دو غزلیں اور ایک رباعی بطورِ نمونہ پیش ہیں۔

رات دن پیچ و تاب ہے ہم کو — طلب آفتاب ہے ہم کو
اپنے چہرے سے تو اٹھایا نقاب — نے حجابی حجاب ہے ہم کو
حسنِ خلق اے فرشتہ خو تیرا — گلِ باغ گلاب ہے ہم کو
معنیٔ وجہ حق سمجھنے کو — تیری صورت کتاب ہے ہم کو
رات دن یاد بن نہ گزرے تری — اپنے دم کا حساب ہے ہم کو
ہم تو ہیں خاکسار اے اکملؔ — جد علیؓ بو تراب ہے ہم کو

حضرت اکملؔ نے مناجاتِ بجناب سرورِ کائنات علیہ التحیہ والتسلیمات کے عنوان سے ایک مناجات بھی لکھے ہیں۔ اسکے چند ابیات یہ ہیں ؎

عرض ہے یہ حضورِ انور سے — تیری درگاہِ پاک و برتر سے
شاق ہے مجھ پہ ہجرِ دلبر کا — چمنِ نازک کے صنوبر کا
سرور گلزار جس کی قامت ہے — جس سے اس دل پہ اک قیامت ہے
جب سے اس دل کو اس نے چھین لیا — دل لیا اور میرا دین لیا
آہ وزاری ہے بے قراری ہے — یا نبی وقت انتظاری ہے
یہ زمانہ تو ہے عجب الٹا — جس کو دیکھو تو ہے کہ ڈھب الٹا
ایسا کچھ کرئے یا رسولِ کریم — کہ ملے مجھ سے میرا یار قدیم
جس نے مجھ کو کیا فریفتہ ہو — یاد سے اس نے ہمارا شیفتہ ہو
آہنِ دل کو اس کے گرم کرو — موم کی طرح نرم نرم کرو
ماہِ رخ مہربان ہو جائے — ملتفت جانِ جان ہو جائے
یا محمد تم اس ستم سے چھڑاؤ — اپنے یوسف کو بند غم سے چھڑاؤ
میرے دلبر سے مجھ کو جلد ملاؤ — یا نبی میری التجا بر لاؤ

حضرت سید علی مراد شاہ افضلؔ:

آپ کا اسم مبارک مراد علی عرف مراد شاہ اور افضلؔ تخلص کیا کرتے تھے۔ آپ حضرت سید جلال الدین اکملؔ کے بڑے صاحبزادے اور شاہ کمال جامیؒ

دکن کے پوتے ہیں۔۱۲۴۹ھ میں آپ کی ولادت ہوئی۔ابتدائی تعلیم والد صاحب سے حاصل کی۔علومِ ظاہری کے بعد نعمتِ باطنی اور خلافت اپنے والدِ ماجد حضرت اکمل سے پائی۔

نمونۂ کلام:

نہ ورد میں ہے نہ لالہ میں نہ سمن میں ہے — بہار جو ترے رخسار کے چمن میں ہے
نہ زعفراں میں نہ ہے مشک میں نہ عنبر میں — جو نکہت اس شہ کونین کے بدن میں ہے
ہو کس طرح نہ دل ہر کدام کا پروانہ — کہ شمع نور کی تیرے ہر انجمن میں ہے
ہے نور صدید ِبیضا کا ہر کف پا میں — اثر ہزار مسیحا کا ہر سخن میں ہے
فقط نہ روئے زمیں پر ہے تذکرہ تیرا — وظیفہ چرخ پہ شام وسحر عدن میں ہے
ہے ہم سے ذکرِ الٰہی میں دو جہاں مشہور — ترا ہی نام ِمقدس ہر اک دہن میں ہے
صفات وذات میں تیرا عدیل اورمانند — نہ کوئی قدرت خلاق ذوالمنن میں ہے
نصیب کیجئے شاہا سفر مدینے کا — مزہ وہ رنج کا کب راحتِ وطن میں ہے
کبھی نہ بھول وظیفہ درود کا افضلؔ — کہ لفظ ِصلّ ِعلیٰ کاہراک دہن میں ہے

بہ اعتبارِ مجموعی کہا جاسکتا ہے کہ حضرات شہہ میری اولیاء نے علاقۂ رائل سیما اور آندھرا پردیش کے علاقوں کو اپنی صوفیانہ تعلیمات سے متاثر کیا۔اس عہد کی مقبول عام دکنی زبان کو اظہارِ خیال کا وسیلہ بنایا۔دکنی میں شہہ میری خانوادے کے شعرا کا کلام اہمیت کا حامل ہے۔آج بھی عوام وخواص اس سلسلہ سے جڑے ہوئے ہیں اوران صوفیائے کرام کی تعلیمات سے فیض حاصل کررہے ہیں۔شہہ میری سلسلہ کے دکنی رسائل اور کتابوں پر تحقیق کا سلسلہ بھی جاری ہے۔

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MARKETING STRATEGIES TO OVERCOME THE CHALLENGES FACING THE PHARMACEUTICAL COMPANIES IN INDIA

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Abstract:

This paper analyses and examines the current situation, recent developments, issues and challenges for Pharmaceutical companies in India from the perspective of marketing management. This paper highlights the current position of pharmaceutical companies in the Global pharma markets in order to understand its implications for current market challenges faced by the pharma industry. The challenges faced by pharmaceutical companies in the Indian market with reference to the Marketing function have been examined in this article. The discussion is focused on the marketing mix for pharmaceutical companies comprising the 4Ps, namely, Product, Price, Place and Promotion. This paper suggests a few effective strategies to overcome the challenges faced by the pharmaceutical industry.

Key terms: Product, challenges, marketing, Price, Place and Promotion.

Introduction:

Indian pharmaceutical industry is the 3rd largest in the world by volume and is USD 40 billion in terms of value. India contributes around 3.5% of total drugs and medicines exported globally. India exports pharmaceuticals to more than 200 countries and territories including highly regulated markets such as the USA, The UK, European Union, Canada etc. The Indian Pharma sector has complete ecosystem for development and manufacture of pharmaceuticals. Its Pharma companies possesses the state of the art facilities including highly skilled/technical manpower. Our

countries also has a large number of renowned pharmaceutical educational and research institutes as well as a robust ecosystem of allied industries.

India is the largest provider of generic drugs globally. Access to affordable HIV treatment from India is one of the greatest success stories in medicine. India is one of the biggest suppliers of low-cost vaccines in the world. Because of low price and high quality, Indian medicines are preferred worldwide, thereby rightly naming the country "the pharmacy of the world". The Pharmaceutical sector currently contributes around 1.72% to the country's GDP.

At present a major constituent of Indian exports are low value generic drugs while a large proportion of the demand for patented drugs is met through imports. This is because the Indian Pharmaceutical sector lacks in high value production along with world class pharma R&D. In order to encourage the global and domestic players to enhance their investment and production in these product categories, a well-designed and suitably targeted intervention is required. This would promote the manufacture of specific high value goods such as biopharmaceuticals, complex generic drugs, patented drugs or drugs nearing patent expiry, cell based or gene therapy drugs.

Further, in order to ensure drug security by, unbridled support to the domestic production capability in APIs/KSMs is needed. This would enhance the resilience of the Indian pharmaceutical industry to external shocks. These initiatives improve our ability to achieve the ultimate to objective of affordable healthcare in the country and the target of Health for all by 2030.

History of Pharmaceutical companies in India

Bengal Chemicals and Pharmaceutical Works is the first pharmaceutical company in India. Today, it is one of the five government-owned drug manufacturers that was incorporated on 12th April, 1901. For the next 60 years, most of the drugs in India were imported by multinationals either in fully-formulated or bulk-drug form. The government has actively encouraged the growth of drug manufacturing by Indian companies in the early 1960s, and with the Patents Act in 1970, the Indian an pharma industry emerged stronger. The patent act 1970 deleted the from food and drugs. However, retained the process patents, whose duration was shortened to a period of five to seven years. The absence of patent protection made the Indian market unattractive to the

multinational companies who had dominated the Indian market. As a result, the Indian companies gradually replaced the MNCs. The Indian companies carved a niche in both the Indian and world markets with their expertise in reverse-engineering, in innovative process design for manufacturing drugs at low costs. Although some of the larger companies have taken baby steps towards drug innovation, the industry as a whole has been following this business model until the present.

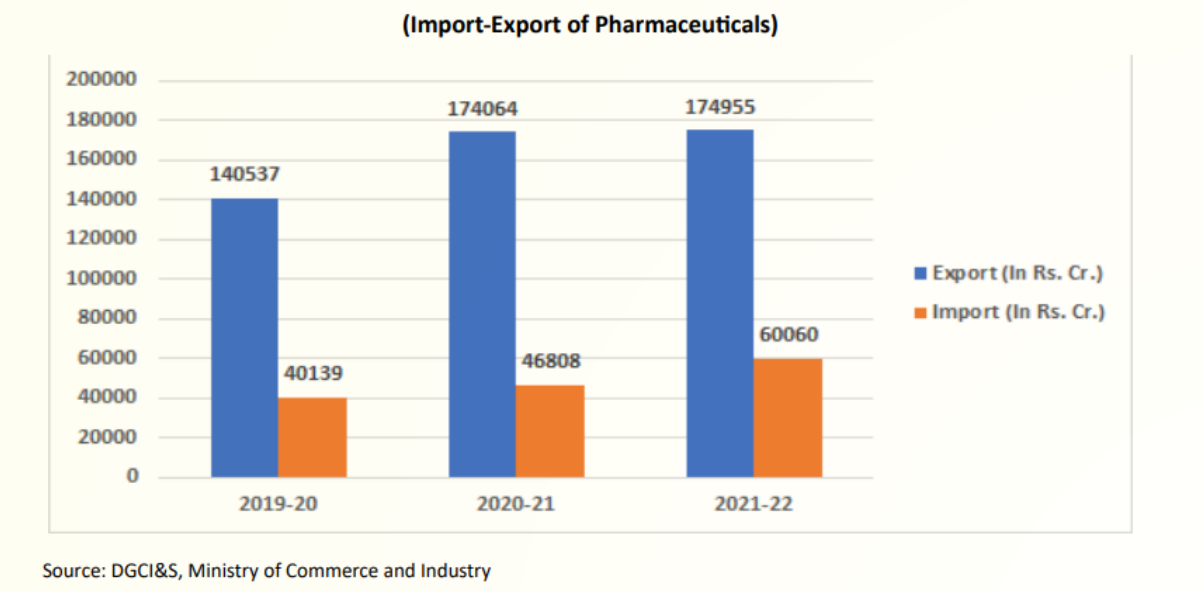
India's pharmaceutical sector is well-known for producing affordable vaccines and generic medications at a third-place global volume in pharmaceutical manufacture. In 2020–21, the industry made up around 1.32% of the Indian economy's gross value added (calculated using constant prices from 2011–2012). For the fiscal year 2021–2022, Pharmaceuticals had a total yearly sale of Rs. 3,44,125 crore (USD 42.34 billion). Generic medications, over-the-counter medications, bulk medications, vaccines, contract research and production, biosimilars, and biologics are some of the main sectors of the Indian pharmaceutical industry. When it comes to the provision of DPT, BCG, and measles vaccinations, India leads the world. About 8% of the worldwide API industry is contributed by 500 API firms. The main source of generic medications is India. It produces over 60,000 distinct generic brands in 60 therapeutic areas, making approximately 20% of the world's generic drug supply. One of the biggest medical achievements is the availability of reasonably priced HIV therapy from India. Indian pharmaceuticals are favored globally due to their affordable prices and superior quality, earning them the title of "pharmacy of the world." The industry has been expanding at a robust pace.

Table shows the sector's yearly turnover trend over the last five years.

Financial Year	Turnover (Rs. in Crore)	Growth Rate
2017-2018	2,26,423	3.03
2018-2019	2,58,534	14.18
2019-2020	2,89,998	12.17
2020-2021	3,28,054	13.12
2021-2022	3,44,125	4.89

Source: Pharmatrac/NPPA/DGCIS, Kolkata

The Indian pharmaceutical business is a major worldwide player, providing millions of people with low-cost, accessible generic medications. The industry provides lower costs without sacrificing quality, as evidenced by the fact that India is home to the greatest number of pharmaceutical facilities outside of the United States that have received approval from the US Food and Drug Administration (USFDA). Additionally, a sizable number of these facilities comply with Good Manufacturing Practices (GMP) regulations set forth by the World Health Organization (WHO) and have also received approval from foreign regulatory bodies. As can be observed from Graph 1A, India's pharmaceutical industry contributes significantly to the nation's international trade and has been steadily producing trade surplus. Pharmaceutical exports totalled Rs. 1,74,955 crore (USD 23.5 billion) in 2021–22, while pharmaceutical imports totalled Rs. 60,060 crore (USD 8.06 billion). As a consequence, there was a trade surplus of Rs. 1,14,895 crore (USD 15.44 billion).



Source: DGCI&S, Ministry of Commerce and Industry

Future growth prospects of Indian Pharmaceuticals:

The pharmaceutical sector has seen significant changes in recent years, putting new demands on payers, providers, and manufacturers. Customers today expect the same variety and convenience from the pharmaceutical sector as they do from other industries. Pharmaceutical marketing aids in raising knowledge of treatments for chronic diseases, which are the major cause

of health-care costs. India is also anticipated to become a pharmaceutical R&D hub in the coming decade, with the Department of Pharmaceuticals preparing a road map for India to become a worldwide player in the industry by 2030.

The Indian Pharmaceutical industry is predictable to grow up to USD 130 billion in value by the end of 20301. In FY22 India had exported pharmaceutical products worth USD 24.62 billion and it has been expected that Indian pharmaceutical exports will reach USD 27 billion in FY 2023. India also has the largest number of manufacturing sites approved by the United States Food and Drug Administration (US FDA) outside of the United States.

Some of the recent developments/investments in the Indian pharmaceutical sector are as follows:

1. In December 2020, Piramal Pharma Solutions announced plans to invest Rs. 235 crore (US$ 32 million) to expand its facility in Michigan, US, with additional capacity and new capabilities for development and manufacturing of active pharmaceutical ingredients (APIs).
2. In November 2020, Indian Immunologicals (IIL) commenced work on Rs. 75 crore (US$ 10.17 million) viral antigen manufacturing facility in Genome Valley, Telangana, that will enhance its vaccine production capacity by 35% by October 2021.
3. In November 2020, the Indian Institute of Technology (IIT) Bombay has stepped up research and development (R&D) amid COVID-19 and researchers are developing products such as a portable sterilization device and germicidal cabinet; wheeled sterilization unit, especially for hospitals; portable and rechargeable car sanitizer; eco-friendly sprays, and alcohol-free and bleach-free sanitizers.
4. In October 2020, six generic drug makers--Dr. Reddy's Laboratories, Zydus Cadila, Glen mark Pharmaceuticals, Torrent Pharmaceuticals, Hetero Drugs and Ackerman Pharma signed a deal with Hidalgo ,a state in Mexico, to establish a large pharmaceutical cluster for production and logistics in Mexico.
5. In October 2020, Aurobindo Pharma acquired MViyeS Pharma Ventures for Rs. 274.22 crore (US$ 37.30 million).

6. In May 2020, Jubilant Generics Ltd entered into a non-exclusive licencing agreement with US-based Gilead Sciences Inc to manufacture and sell the potential COVID-19 drug Remdesivir in 127 countries, including India.
7. Affordable medicines under Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP) achieved record sales turnover of Rs 52 crore (US$ 7.38 million) in the month of April 2020.
8. During December 2019, on moving annual total (MAT) basis, industry growth was at 9.8%, with price growth at 5.3%, new product growth at 2.7%, while volume growth at 2% y-o-y.
9. In October 2019, Telangana Government proposed Hyderabad Pharma City with financial assistance from the Central government of Rs 3,418 crore (US$ 489 million).

Review of Literature:

Saurabh Kumar Saxena[9], (2008), came out with a paper titled as "A Review Of Marketing Strategies Work By Different Pharmaceutical Companies" Provides valuable insights into the supply chain processes and end customer perceptions that determine the formulation of marketing strategies.

Eric Langer, Abhijeet Kelkar (2008), in their paper entitled "Pharmaceutical Distribution in India. Biopharma International", insights the challenges faced by Indian Pharm companies in ensuring the delivery of uncompromised quality in the multilayered distributed system.

P.Parveen, P.Usha, V.Vasu naik, Rajesh Akki (2013), in their paper entitled "Pharmaceutical Distribution in India" this presents the marketing strategies of a pharma company that shifts from Acute-base to chronic therapy base. This study focus on the processes and outcomes of globally distributed pharma companies as well as the drug pricing control order. The DPCO has been a mill stone around the neck of the Indian industry as its severely restricted pharmaceutical companies.

Dr. Pramod Kumar, Dr. Pramod Kumar (2013)," Marketing Mix of Pharmaceutical Industry in India: An Exploration", this paper explores the marketing mix of pharmaceutical

industry in India**.** It provides a crical evaluation of policies and strategies of the pharma companies in the light of the complex interplay of the 4Ps or marketing mix of the pharma companies.

Anil Kalotra (2014), in the paper entitled "Marketing Strategies Of Different Pharmaceutical Companies", has focused on the three stakeholders in the pharma sector that are fundamental to the success of the marketing strategies. The success the marketing strategies in the competitive context is derived from either a cost advantage or a value advantage or ideally from a combination of both. That flows from a synergistic balance amongst the three stakeholders (the firm, its competitors and its customers)

Manvi Aayush Sood (2019), in their paper entitled "Evolution of Indian Pharmaceutical Industry-Overview" The Indian Pharmaceutical Industry has witnessed several fluctuations in its fortunes over the last three to four decades. It is one of the most efficient industry in India it provides employment and health care to the nation. This paper mainly concentrates on the evolution of the industry, its growth and recent trends.

Issues and Challenges faced pharmaceutical companies in India

Several Indian pharmaceutical companies have successfully deployed many standard strategies with a view to target the various customer types. However, the emerging business and customer trends throw up many challenges and opportunities that may improve the profitability. In the pharmaceutical and healthcare industries, a complex web of decision-makers determines the nature of the transaction (prescription) for which direct customer (doctor) of pharmaceutical industry is responsible. However, as the end-user (patient) consumes the product, he/she pays the cost. The appointment of medical representatives for marketing the products to physicians and to convenience the others in the hierarchy of decision makers has been a time-tested tradition.

The industry is still faced with some very serious strategic and operational level issues:

1. Real-time good manufacturing practices and research components are severely lacking in the Indian pharmaceutical business. This has consistently been the main challenge facing the Indian pharmaceutical business. The Pharma businesses should ideally be set up so that they have superior operational capabilities and infrastructure.

2. Indian pharmaceutical businesses are not making enough money since their revenues are essentially much lower than those of their competitors in other nations, like the US. The Indian pharmaceutical sector is thus unable to support its research initiatives.
3. The pharma industry is dependent on China for the supply of raw material for generic medicines production of Active Pharmaceutical Ingredients (API).
4. India needs user friendly government policy for the common man to establish small scale, raw material manufacturing units/ incubators in all states of the country to improve availability of raw materials to manufacture generic drugs at affordable rates.
5. The government and industry should facilitate the pharmacist community to become entrepreneurs and promote incubators' establishment.
6. Raw material produced from small scale units should be properly validated in the testing laboratory of the state to ascertain their quality specifications.
7. There is a need for a functional testing laboratory in every state to hasten the work of raw materials specification.
8. Small scale produces may be re-processed in another industry or via a chain of industry for quality products that can be used for parenteral/tailor-made formulations.
9. Skilled manpower from academic institutions can be achieved through continuing education programmes.

Marketing Mix Strategy for pharmaceutical companies in India

The classical marketing mix consists of four different Ps; product, price, place and promotion (McCarthy 1960). Conceptually, this mix may be adapted and relevant to a most product segments. However, experts are skeptical about its utility and relevance in the case of for marketing of services. Some experts also argue that marketing approach in such cases should not be imitated from Kotlerian Marketing.

In order to outline efficient marketing of services the 7Ps approach were introduced - adding people, physical evidence and process to the traditional mix.

Marketing is an essential function in any business upon which the survival of the business entity is dependent. "There can be no effective corporate strategy that is not marketing oriented, that does not in the end follow this unyielding prescription: The purpose of business is to create

and keep customer" (Theodore Levitt 1960). However, Levitt should also add that businesses must also develop products and services that customers want and at prices they are willing to pay. Marketing may be broadly conceived as the process of making decisions about what products or services to put on the market, who are the potential customers for these goods, how to reach the target markets and induce them to buy; how to price the product or service optionally so as to be make is attractive to the customers; and finally how to provide the goods physically to the ultimate customers. These matters are often expressed as the four Ps of marketing: Product, Price, Promotion and Place.

The four Ps of Pharmaceutical marketing are discussed below.

Product:

Product is an item that is created in an organization to fulfill the demand of the consumers. It can be intangible or tangible – i.e. service or goods.

The Product related decisions encompass the following aspects such as Brand name, Functionality, Product styling, Quality, Safety, Packaging and After-sales service.

The Product related decision fringes on what your customer wants from you. The Product parameters many changes according to its phase of the Product Life Cycle. For instance, during the introduction phase, the company may launch limited versions of the product just to explore adaptability to the customer needs. Similarly, the number of service centers for after-sales service as well as their location may be determined by the geographical spread of its customers**.**

The following are some of the challenges faced by the Pharma sector with respect to 'Product':

The recent COVID-19 Pandemic has highlighted the short comings of the pharma sector in providing the necessary quantities of drugs and other protective items including sanitizers to meet the unexpected surge in the international demand for drugs and accessories to tackle the Pandemic.

1. Demand forecasting and Market Potential
2. Risk management
3. Social Challenges
4. Legal and Regulatory Challenges
5. Distribution Challenges
6. Identifying Customer Pain Points

Price:

Price of the product is the amount that the customer is willing to pay for it. The 'Price' element of the marketing mix is vital for ensuring the economic viability of the Product.

The Major decision elements of 'Price' are pricing strategy (model), retail price, wholesale price, discounts offered, seasonal pricing, bundling pricing, price flexibility and price discrimination.

The decision of price depends on Product Life Cycle. A product during its journey from the Introduction stage to the Decline stage has to modify its Pricing strategies according to the changing market situation.

It gives an advantage to the company as the early adopters buy the product at the very initial stage even at a higher price.

India is recognized lowest priced drug manufacturer and marketer of pharmaceuticals products domestically and internationally. One reason for lower value share is the lower cost of drugs in India ranging from 5% to 50% less as compared to most other countries.

The Pricing Policies of the Indian Pharma sector have to overcome the following challenges. They are:

1. High 'Out of Pocket (OoP) expenditure
2. Pricing of patented drugs
3. Non-Standard drugs

4. Public and government pressure to make drug prices more affordable
5. Inadequate health insurance schemes is an impediment to high-priced drugs.
6. Higher healthcare cost forces the Pharma sector to focus on cost minimization.
7. Unknown value of revenue from each retailer in the territory.

Place:

This P is all about placement and distribution of the product in the market. The place also suggests the Point of Sale of the product. A business has to make sure that the availability of the product should be easy for the customers.

The 'Place' factor comprises of several decision elements such as (i) Distribution channels, (ii) Market coverage, (iii) Inventory, (iv) Warehousing, (v) Order processing and (vi) Transportation.

Market coverage can be intensive, selective or exclusive. For example cigarettes have intensive coverage, while Smartphones selling involves selective coverage in a city. In contrast, luxury products like Mercedes Benz have exclusive coverage.

The decision concerning the 'Place' is determined by the stage in the PLC (Product Life Cycle).

The following are some of the challenges faced by the Pharma sector with respect to 'Place':

1. Storage and Transportation of Temperature sensitive drugs.
2. The availability of adequate transportation facilities could pose a challenge in the delivery of drugs to remotely located destinations.
3. As the decision of the customer (the Patient) to use a particular drug is dependent on the Prescription of the Doctor. Hence, the success of the Distribution channel is dependent on the ability of the Drug manufacture to convince the professional Doctor who is mainly responsible for prescribing the drug. As a result, the Pharma sector faces a stiff competition with respect to cringing the Doctors recommendation for the drug.

4. Absence of transportation on the amount of time invested on profitable and not-so profitable customers and lack of time-share planning towards developing customer base for future and un-tapped markets.
5. Unavailability of go down on storage of cold medicines.

Promotion:

Promotion is comprised of elements like advertising, sales promotion, personal selling, public relation, publicity, etc.

The various phases of PLC give the different meaning of promotion. The advertising activity is extensive at the introduction stage and comes to selective channels in the maturity stage.

Sales promotion also varies at different stages. The budget of the overall advertising also gets affected. At the decline stage, a business dedicates almost nil budget for advertising. It becomes very crucial to work with the advertising or marketing agency that understands the connection of stages of PLC and Promotion.

The following are some of the major challenges faced by the Pharm sector vis-à-vis 'Promotion':

1. Increased competition and unethical practices adopted by some of the propaganda base companies.
2. Low level of customer knowledge (Doctors, Retailers, Wholesalers).
3. Poor customer (both external & internal) acquisition, development and retention strategies.
4. Varying customer perception.
5. The number and the quality of medical representatives
6. High training and re-training costs of sales personnel.
7. Busy doctors giving less time for sales calls.
8. Poor territory knowledge in terms of business value at medical representative level.
9. Unclear value of prescription from each doctor in the list of each sales person.

10. Absence of ideal mechanism of sales forecasting from field sales level, leading to huge deviations

Conclusion:

The Indian pharmaceutical industry has recognized a strong presence in the international generics market by distributing high-quality drugs at measure. The industry has made innovations in processes and formulations and developed itself as are liable, high quality and cost-effective global drug supplier. Currently the industry is worth over USD 38 billion and can hope to grow to USD 120 to 130 billion by 2030 by exploiting on the wonderful opportunities that lie ahead. However the Indian pharma companies can achieve the aspiration of eleven to twelve percent CAGR.

Marketing may be broadly conceived as the process of making decisions about what products or services to put on the market, who are the potential customers for these goods, how to reach the target markets and induce them to buy; how to price the product or service optionally so as to be make is attractive to the customers; and finally how to deliver the goods physically to the ultimate customers. The Indian pharmaceutical companies facing challenges related to the four Ps of marketing: Product, Price, Promotion and Place.

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Research Article

Marketing Challenges And Organizational Performance: An Empirical Investigation With Special To Pharmaceutical Organizations In India

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ABSTRACT

Marketing challenges is a crucial strategic driver for increasing operational performance and maximizing the achievement of organizational objectives, such as improved productivity, improved customer service and enhanced profitability. The age of both market globalization and outsourcing has started, and many companies tend to manage their marketing challenges activities. Most of these organizations understand that marketing challenges needs to be tested for its performance in order to create an effective and efficient marketing. The marketing challenges is the most critical element for companies to boom in pharmaceutical, which needs to be quick, uninterrupted and safe. The competition is fierce because not one or two, but hundreds of pharmaceutical companies are competing for market share, each finding and creating specific strategies for sale and distribution. The present study is an attempt to examine various marketing challenges in the pharmaceutical context. Although there is a lack of literature in this context, the current study critically reviewed the current literature and built a questionnaire with the inputs from leading pharm marketing representatives by identifying the main marketing challenges such as product, price, place, promotion and trying to find the effect of these variables on organizational efficiency. A sample size of 100 employees employed in pharmaceutical departments at different levels of ten leading pharmaceutical organizations in India was taken for a questionnaire survey as a sampling unit. The study found fascinating insights of marketing challenges in pharma, which eventually benefit the marketers to design more effective marketing challenges. Further, the study is confined to Ten Pharma organisations in India which becomes a limitation in generalizing the findings.

Key Words: Marketing Challenges, Operational Performance, Pharmaceutical Organizations

I. INTRODUCTION:

The pharmaceutical sector generates around 2.8 trillion dollars in revenue globally, making it the largest industry in the world. Recent years have witnessed significant changes in the pharmacy sector, putting new demands on payers, providers, and manufacturers. Consumers now expect the pharmaceutical business to provide them with the same options and conveniences as other market segments. The Indian pharmaceutical sector is expected to grow rapidly and steadily over the coming years due to a variety of factors.

The pharmaceutical industry in India stands at the crossroads of opportunity and challenge. With a robust domestic market fueled by a burgeoning population and increasing healthcare awareness, coupled with a strong presence in the global pharmaceutical arena, Indian pharmaceutical companies have made significant strides. However, amidst these achievements lie formidable marketing challenges that require meticulous navigation and strategic acumen to surmount.

At the heart of these challenges lies the regulatory landscape. India's pharmaceutical sector is subject to rigorous regulatory oversight, spanning drug approvals, pricing regulations, and stringent advertising

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guidelines. Navigating this intricate web of regulations demands not only compliance but also agility to adapt to evolving regulatory frameworks. Moreover, with recent regulatory reforms aimed at enhancing drug safety and efficacy, pharmaceutical companies face heightened scrutiny, necessitating robust compliance mechanisms and risk mitigation strategies.

Beyond regulatory hurdles, understanding the dynamics of consumer behavior and healthcare preferences is imperative. India's healthcare landscape is undergoing a paradigm shift, driven by factors such as increasing urbanization, rising disposable incomes, and a growing emphasis on preventive healthcare. Consequently, consumers are becoming more discerning, seeking value-driven healthcare solutions and placing greater emphasis on factors such as brand reputation, efficacy, and affordability. Pharmaceutical marketers must therefore unravel the complexities of consumer behavior, leveraging insights to tailor marketing strategies that resonate with target audiences and drive brand loyalty.

Amidst these shifts, competitive pressures further compound the challenges faced by pharmaceutical companies. The Indian pharmaceutical market is fiercely competitive, characterized by a myriad of domestic players vying for market share alongside multinational giants. Price competitiveness, product differentiation, and market segmentation emerge as pivotal battlegrounds, necessitating continuous innovation and strategic positioning to stay ahead of rivals. Moreover, with the emergence of disruptive technologies and digital platforms, the landscape of competition is evolving rapidly, requiring pharmaceutical marketers to embrace digital transformation and harness data-driven insights to gain a competitive edge.

II. LITERATURE REVIEW:

Giuseppe Festa, Ashutosh Kolte, Maria Rosaria Carli, Matteo Rossi (2022), in their study focussed on annual growth in pharmaceutical, medicinal chemical, and botanical production for healthcare purposes. The country sells generic medications on a big scale, having significant impact in American and European markets. Although the industry's infrastructure and R&D skills have grown, difficulties such as pricing regulation, sector fragmentation, and intellectual property continue to exist. Patents are a major topic of contention in the national industry. Despite India's large population and low per capita income, stronger patent regulations may result in reduced access to medicine for a considerable portion of the population. Affordability of drugs poses a serious challenge in India and South Asia, potentially affecting life and death. The study found a strong economic, business, and commercial outlook for the Indian pharmaceutical industry, notwithstanding certain worries. The sector's main problem is to strike a balance between commercial aspirations for innovative growth and social needs for affordable healthcare.

Abinav Sharma (2020) made an attempt, to study the creation, communication, and provision of value to the target market by healthcare professionals is greatly aided by healthcare marketing. Rather than starting with goods or services, modern marketers start with the customer. Establishing a long-lasting connection holds greater significance than completing a single transaction. Creating a high degree of customer satisfaction should be the goal of a healthcare service provider in order to encourage repeat business from satisfied clients. According to the report, hospitals face a number of difficulties when trying to sell their services, but there are also opportunities in the market that healthcare organizations can take advantage of. With a carefully thought-out marketing strategy, hospitals can maintain their competitive edge and build a long-lasting relationship with patients by providing top-notch care and building a solid reputation.

Priyanka Singh (2013) examined a particular facet of rural marketing that these markets have not been utilized in any way. Its sole objective is to draw attention to the rural markets' increasing significance in the rapidly shifting economic landscape. Due to the wide range of courses that must be taken in rural marketing, particular consideration must be given to the product, its quality, packaging, brand, price, advertisement, personal selling, and distribution channel. The rural marketing strategy must be suitable, fully understanding the dispersed nature of rural consumers and the requirement for a distinct communication mix due to the lower educational attainment and environmental variations. All of this necessitates coordinated and coordinated action from the sector and the government. Even while producers may experience early losses due to high promotion and distribution costs, they shouldn't let this stop them from entering the market because the potential in the rural area is enormous. The country's shifting economic landscape combined with the rural population's increased purchasing power means that the recently established rural markets will undoubtedly pay off handsomely.
Luv Saini and P.K. Agarwal (2023) in their study highlighted a pharmaceutical business would be a smart decision because the industry is growing and has a bright future. The process involves several steps, which present the entrepreneur with a variety of challenges. Materials and information must come from trustworthy and credible sources. This study focuses on the various challenges that come with starting a pharmaceutical business in India. The study is qualitatively descriptive and makes use of secondary data. The results show that registration and licensing, resource requirements, financial concerns, business plan formation, raw material availability, skilled labor, and workforce optimization are the primary barriers to starting a pharmaceutical company in India.

Kalyani Rajput and Dr. Rajesh Kumar Pandey (2022) examined product marketing is a standard practice recognized by the worldwide business community as being essential to organizations seeking to achieve their targeted outcomes. The pharmaceutical industry is one of the most important and widespread industries. Its scope is broad, encompassing anything from over-the-counter (OTC) goods to life-saving medications to medical equipment. So much so that pharmaceutical education is given its own area in medical education as a whole, and the foundation for the production of pharmaceutical products is laid by these excellent educational opportunities. It takes a certain set of abilities to get these medications on the market, which is why pharmaceutical marketing is involved. Pharma marketing is more essential than general product marketing because it falls into the category of necessities and useful goods rather than desired goods, as most people don't plan to purchase medications or medical equipment unless they are prescribed or advised by a healthcare professional. This element presents a significant obstacle for the pharmaceutical marketing industry.

III. METHODOLOGY:

This research study aims to assess the association among important marketing challenges components empirically, namely Product challenges, Price challenges, Place challenges, Promotion challenges and how these critical components influence effective performance, which impacts the organizational performance. The present study framed the following objective of the study to enhance the limited literature available on Marketing challenges in the Pharma context: To study the relationship between marketing effectiveness and organizational Performance in Pharmaceutical organizations in India.

The following Hypotheses were framed for the present study
Ha01: There is a significant relationship between Marketing (4P's) challenges and Organizational Performance.
Ha02: There is a significant relationship between Marketing Effectiveness and Organizational Performance.
Data was collected from both Primary and secondary sources. The primary data was collected by administering a structured questionnaire from the employees working in the selected Pharmaceutical organizational in marketing domain. The secondary data was collected from research articles, journals, company records, and manuals. Measures for the research constructs used in the present study were developed by seeking the help from real time professionals who are working in the Pharma organizations with a framework borrowed and adapted by compiling various standard studies from prior literature. Most of the items were measured using a 5-point Likert scale ranging from "very poor" to "excellent". The antecedents in our research model comprise four constructs. "Product Performance of Marketing challenges" was assessed using six items; "Price Performance of Marketing challenges" was assessed using Five items. Nine items used to capture "Place Performance". "Promotion Performance" was assessed using eight items. Finally, "Marketing Effectiveness Performance" and "Organizational Performance" were assessed by using twelve and eight items respectively. A pilot study with a sample size of 50 responses was conducted before arriving at the final questionnaire. Reliability analysis ***(Cronbach's alpha)*** was applied to check the reliability of items used in initial questionnaire which showed that *Cronbach Alpha ranges from 0.7 to 0.9*(which is quite reliable). Based on reliability analysis and feedback from the Marketing representatives working in Pharma organizations, the final questionnaire was prepared.
The population universe consists of the employees working in India's marketing management wing of the pharmaceutical organization. The present study has limited the scope by restricting the universe as a pharmaceutical organization that only deals with marketing mix challenges. A total of 100 questionnaires were distributed and collected from the employees working in marketing management in pharmaceutical organizations in India.

IV. ANALYSIS

The profile of the respondents includes age, gender, designation, and work experience. The distribution of respondents based on their characteristics is shown in table 1. Analytical aspects of these characteristics are worth noting.

Tabel: 1 Profile of the Respondents

Variables	Categories	Frequency	Per cent
Age of the Respondent	Less than 25 years	24	24.0
	25 – 35 years	56	56.0
	Above 35 years	20	20.0
	Total	100	100.0
Education	Certificate Level	23	23.0
	Diploma Level	7	4.0
	Degree	28	28.0
	Masters	42	42.0
	Total	100	100.0
Qualification	Related to Job	58	58.0

	Unrelated to Job	42	42.0
	Total	100	100.0
Place of Work	City	28	28.0
	Town	38	38.0
	Both	34	34.0
	Total	100	100.0
Experience as Medical Representative	0 – 2 years	25	25.0
	2 – 5 years	44	44.0
	> 5 years	31	31.0
	Total	100	100.0

The final sample (N=100) was respondents are in the age group less than 25 is 24(24%), age group of '25 – 35 years is 56 (56%), 20 respondents are in the age group of 'above 20 years' (20%), Designation wise, the majority of the respondents are at 'Team lead level' (N=56). Twenty respondents are at 'Executive level', and 24 respondents are managers. Similarly, majority of the respondents have experienced are 2-5 five years. 25 respondents have experienced '0-2 years', 31 respondents have experience of 'above 5 years' in the marketing department. As the present study is based on the employees' perception towards marketing challenges practices, having more respondents from team lead level and good experience in marketing departments will make the data collected more authenticate in this survey. Table 2 is designed to exhibit the mean distribution of marketing effectiveness and marketing variables along with organizational performance scale. From the table, it can be noted that the highest mean was observed to the scale 'Product challenges' (M=3.68) and 'Organizational Performance' (M=3.65), whereas low mean was observed to the scales 'Pricing Challenges' (M=3.61) and 'Marketing effectiveness'(M=3.63).

Table:2 MARKETING CHALLENGES AND ORGANIZATIONAL PERFORMANCE

S. No	**Variable**	**Mean**	**S.D.**
1	Product Challenges	3.68	0.676
2	Pricing Challenges	3.61	0.564
3	Place Challenges	3.64	0.689
4	Promotion Challenges	3.67	0.560
5	Marketing Effectiveness	3.63	0.647
6	Organizational Performance	3.65	0.624

The present paper attempts to examine the relationship between marketing effectiveness and organizational performance with two hypotheses. The following deals with hypotheses testing by applying suitable statistical tools. Ha1: There is no significant relationship between selected variables on marketing challenges and Organizational Performance H01: There is a significant relationship between selected variables on marketing challenges and Organizational Performance. The hypothesis is framed to test the statistically significant relationship between marketing effectiveness and organizational performance. To test this hypothesis, linear regression is employed by considering organizational performance as dependent variables and variable of the marketing challenges such as Product challenges, Price challenges, Place (Distribution) challenges, and Plance challenges as independent variables. Table 3a portrays the regression test results, giving that marketing effectiveness variables can explain 71.1% of organizational performance.

Ha01: There is a significant relationship between Marketing (4P's) challenges and Organizational Performance.

Table: 3a **Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.843[a]	**.711**	.699	.35513

Table: 3b **ANOVA[a]**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	29.455	4	7.364	58.387	**0.000[b]**
	Residual	11.981	95	0.126		
	Total	41.436	99			

Table: 3c **Coefficients[a]**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.196	0.266		0-.738	.463
	Product Challenges	0.406	0.079	0.424	5.170	**0.000**
	Pricing Challenges	0.520	0.078	0.453	6.705	**0.000**
	Distribution Challenges	0.095	0.079	0.101	1.202	0.232
	Promotion Challenges	0.030	0.119	0.026	0.248	0.804

From table 3b, it can be inferred from the ANOVA test result that the overall model is significant. Table 3c shows that all the marketing challenges variables significantly influence organizational performance except two variables: product challenges and price challenges. Thus, the null hypothesis (H01) is rejected from the regression analysis test results, and the alternate hypothesis (Ha1) is accepted. H02: There is no significant relationship between marketing effectiveness and Organizational Performance Ha1: There is a significant relationship between Marketing Effectiveness and Organizational Performance. This hypothesis is framed to examine the relationship between marketing challenges and organizational performance. The earlier hypothesis has considered the variables of marketing challenges as independent variables. In this hypothesis, the marketing challenges is regarded as an independent variable and organizational performance as a dependent variable. Linear regression is applied to examine the relationship between the two selected variables. Table 4a shows that 64.1% of organizational performance can be explained by Marketing Effectiveness, which found to be consistent with the previous finding of the present study.

Ha02: There is a significant relationship between Marketing Effectiveness and Organizational Performance.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.783[a]	**0.614**	0.610	.38980

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.637	1	23.637	155.564	**0.000[b]**
	Residual	14.890	98	0.152		
	Total	38.527	99			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.913	0.223		4.089	**0.000**
	MARKETING EFFECTIVENESS	0.755	0.061	0.783	12.473	**0.000**

Table 4b and 4c have given a p-value less than 0.05, which means that there is a statistically significant relationship between marketing effectiveness and organizational performance. Hence, the null hypothesis (H02) is rejected, and an alternative hypothesis (Ha2) is accepted

V. LIMITATIONS

- Any study based on a survey through a predesigned questionnaire suffers from the basic limitation.
- The study is confined to Ten Pharma organisations in India which becomes a limitation in generalizing the facts.
- Non-Probabilistic Sample used in for the survey stands as another limitation of the present study.

VI. CONCLUSION

The study found that organizational performance can be attained by effective marketing management. Marketing challenges can be effective only if designed to meet the various product, price, place and promotion. The study found that product and price are the key issues that significantly impact organizational purpose. The researcher found that the place and promotion are the key issues to address while studying marketing challenges, especially in the pharmaceutical market.

As the study selected marketing segment, product and stock-out situations are unavoidable. But still, efforts should be made to reduce the occurrence of these situations in the future. There are many issues to focus on detail like the product design, accessibility, return policy etc. Hence, further study is recommended to the researchers who shown interest in marketing management.

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IMPACT OF EMPLOYEE RETENTION STRATEGIES ON JOB SATISFACTION OF IT PROFESSIONALS

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ABSTRACT

In the contemporary and dynamic landscape of business, the retention of skilled and experienced software professionals is a critical challenge faced by organizations. High turnover within the software industry not only results in substantial costs but also leads to a loss of productivity and knowledge. To address this challenge, organizations must adopt effective strategies to attract and retain talented software professionals. This research study aims to assess the various employee retention strategies implemented by organizations within the software industry. The study will delve into factors influencing employee retention and evaluate the effectiveness of diverse strategies employed to retain software professionals. Specifically, the research will investigate the impact of organizational culture, work-life balance initiatives, career development opportunities, compensation packages, and employee engagement practices on employee retention. Through a comprehensive analysis, the study seeks to contribute valuable insights that can inform organizations in developing and enhancing their strategies to retain skilled software professionals in the competitive business environment.

Keywords: Employee retention, Productivity, Organizational strategies, Compensation packages, Employee engagement, Human resources.

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1. INTRODUCTION

In the contemporary global business arena, the retention of top-tier talent has emerged as a critical concern for organizations, particularly within the fiercely competitive software industry. With India solidifying its position as a major hub for software development and technology services, companies in this sector face unique challenges in retaining skilled professionals amidst high demand and intense competition [1]. Effective employee retention is pivotal for organizational success, contributing to stability, enhanced productivity, and reduced recruitment and training costs. This study seeks to explore the diverse strategies employed by software companies in India to retain their professionals and evaluate the effectiveness of these strategies in fostering long-term commitment. Given the high demand and competition for skilled professionals in the software industry, organizations deploy a variety of retention strategies to maintain a stable workforce, minimize turnover costs, and cultivate a positive work environment conducive to employee satisfaction and loyalty [2][3]. This paper examines several commonly implemented employee retention strategies in the Indian software industry. It includes many factors such as Competitive Compensation Packages, Career Development Opportunities, Work-Life Balance Initiatives, Recognition and Rewards, Employee Engagement Programs, Transparent Communication, Employee Well-being Initiatives and Strong Leadership and Management [4]. Generally, to attract and retain top talent, companies strive to offer competitive salaries and benefits that align with industry standards, reflecting the value of employees' skills and expertise. Recognizing the motivation driven by growth, organizations invest in employee development, providing clear career paths through training programs, mentorship initiatives, and challenging project opportunities. Acknowledging the importance of balancing work and personal life, software companies often implement flexible schedules, remote work options, and paid time off policies to support work-life integration, reducing burnout and increasing employee loyalty. Fostering a positive work culture involves acknowledging and appreciating contributions through rewards, bonuses, and public appreciation programs, boosting morale and creating a sense of loyalty among employees. Recognizing the link between engagement and retention, software firms implement team-building activities, social events, and employee resource groups to create a supportive work environment that fosters a sense of belonging and camaraderie [5][6]. Open and transparent communication channels build trust and loyalty. Ensuring access to organizational information, regular feedback sessions, and performance reviews provide opportunities for employees to voice concerns and receive constructive feedback. Prioritizing employee well-being involves offering wellness programs, mental health support, and access to fitness facilities, demonstrating a genuine concern for employees' health and building trust and loyalty. Effective leadership and management practices significantly influence retention. Investments in training managers to be supportive, empathetic, and skilled in employee development foster positive relationships, reducing turnover [7]. By examining these strategies, this research paper aims to contribute valuable insights for organizations seeking to enhance their employee retention approaches in the dynamic and competitive landscape of the Indian software industry. The key factors that helps to assess the strategies implemented by Indian software industries for investigating the employee retention strategies in the Indian software industry and the benefits of the employee retention is shown in the following fig.1.



Fig 1: Employee retention in IT industry

II. LITERATURE REVIEW

Employee retention strategies play a crucial role in the contemporary business landscape, particularly within the Information Technology (IT) sector, where attracting and retaining skilled professionals is paramount. This literature review seeks to explore and synthesize existing research on the impact of employee retention strategies on the job satisfaction of IT professionals. Understanding the intricate relationship between retention strategies and job satisfaction is essential for organizations striving to create a positive work environment and retain their valuable IT workforce. Through investigation on the research papers available in the literature reveals the following observations and conclusions.

Rahman, M., Islam, M. A. presented a paper on "Effective Strategies for Employee Retention in the IT Industry"[8]. The presented research work explores, in the ever-evolving landscape of the Information Technology (IT) industry, the retention of skilled professionals stands as a critical imperative for organizational success. This literature review examines several key studies that delve into effective strategies for employee retention within the IT sector. The insights provided by these studies contribute to a comprehensive understanding of the multifaceted approaches organizations employ to reduce turnover, enhance employee satisfaction, and elevate overall organizational performance

Madhavan, A., & Mahadevan, N, presented a paper on “The Impact of Compensation and Benefits on Employee Retention in the IT Sector"[9]. Their research scrutinizes the intricate relationship between compensation and benefits and employee retention within the IT sector. The study underscores the pivotal role of competitive salaries, incentives, and comprehensive benefits packages in attracting and retaining IT professionals. Additionally, it explores the significance of non-monetary rewards, such as flexible work arrangements and career growth opportunities, in bolstering employee retention.

Mehta, P presented a paper on "Employee Retention Strategies and Organizational Performance: A Comprehensive Review with Special Reference to IT Industry"[10]. Mehta's comprehensive review delves into the nexus between employee retention strategies and organizational performance, with a specific focus on the IT industry. The study explores strategies encompassing career development, work-life balance, employee recognition, and leadership development. It provides valuable insights into the positive impact of these strategies on employee commitment, satisfaction, and overall organizational success.

Jain, A., & Kaur, P submitted study on "A Study of Employee Retention Practices and its Effectiveness in IT Sector"[11]. Jain and Kaur's study systematically explores employee retention practices within the IT sector, evaluating their effectiveness. The research meticulously examines factors such as compensation, career growth opportunities, work environment, and employee engagement. It identifies the pivotal role of a positive work culture, supportive leadership, and effective communication in retaining IT professionals.

Singh, A., & Verma, N. presented a paper on “Impact of Work-Life Balance on Employee Retention: A Study in Indian IT Industry"[12]. Singh and Verma's research focuses on the critical impact of work-life balance initiatives on employee retention within the Indian IT industry. The study accentuates the role of flexible work arrangements, family-friendly policies, and employee well-being programs in not only reducing turnover but also enhancing job satisfaction.

Altogether, these studies provide comprehensive understanding of the diverse strategies and practices employed within the IT industry to retain skilled professionals. The insights gathered from these works offer a valuable resource for organizations seeking to refine and implement effective employee retention strategies, thereby fostering a resilient and satisfied IT workforce.

III. RESEARCH METHODOLOGY

To assess the employee retention strategies of software professionals in India, a mixed-methods research approach will be employed. The study will commence with a comprehensive literature review to establish a theoretical foundation and identify existing frameworks and models relevant to employee retention in the software industry. Subsequently, qualitative data will be gathered through semi-structured interviews with HR professionals and software experts to gain insights into the industry's specific context and nuances. The interview data will be thematically analyzed to identify recurring patterns and themes related to effective retention strategies. Additionally, a quantitative survey will be administered to a representative sample of software professionals across different organizations in India. The survey will encompass standardized measures of job satisfaction, perceptions of organizational culture, and the perceived effectiveness of various retention strategies. Statistical analyses, including regression analysis and correlation assessments, will be conducted to determine the relationship between retention strategies and job satisfaction. The combined findings from qualitative and quantitative data will contribute to a holistic understanding of the efficacy of employee retention strategies in the Indian software industry [13] [14] [15].

The survey comprises two sections: The initial part delves into respondents' demographic details, while the subsequent section focuses on gathering insights into their perspectives on the correlation between strategic impact elements and customer perceptions and purchasing behaviors. Using a Likert scale ranging from 1 (strong agreement) to 5 (strong disagreement), respondents rated the claims. Disagreement is denoted by scores of 4 or 5 [16] [17]. Regarding the sample design, a convenience sample was employed, distributing a total of 300 questionnaires, with 240 being fully completed. Upon thorough examination, an impressive 80 percent response rate was achieved. Descriptive statistics indicated a final sample size of 241, comprising both males and females.

IV. CONCEPTUAL FRAMEWORK

The conceptual framework for assessing employee retention strategies among software professionals in India is structured around key dimensions: organizational context, individual factors, and retention strategy effectiveness. The organizational context involves analyzing industry dynamics, examining organizational culture, and evaluating leadership effectiveness. Individual factors encompass demographic variables, job satisfaction, and professional

development needs [18]. The retention strategy effectiveness dimension involves assessing the impact of compensation, career development programs, work-life balance initiatives, and recognition programs on employee retention. The interactions between these dimensions will be explored through qualitative interviews and quantitative surveys.

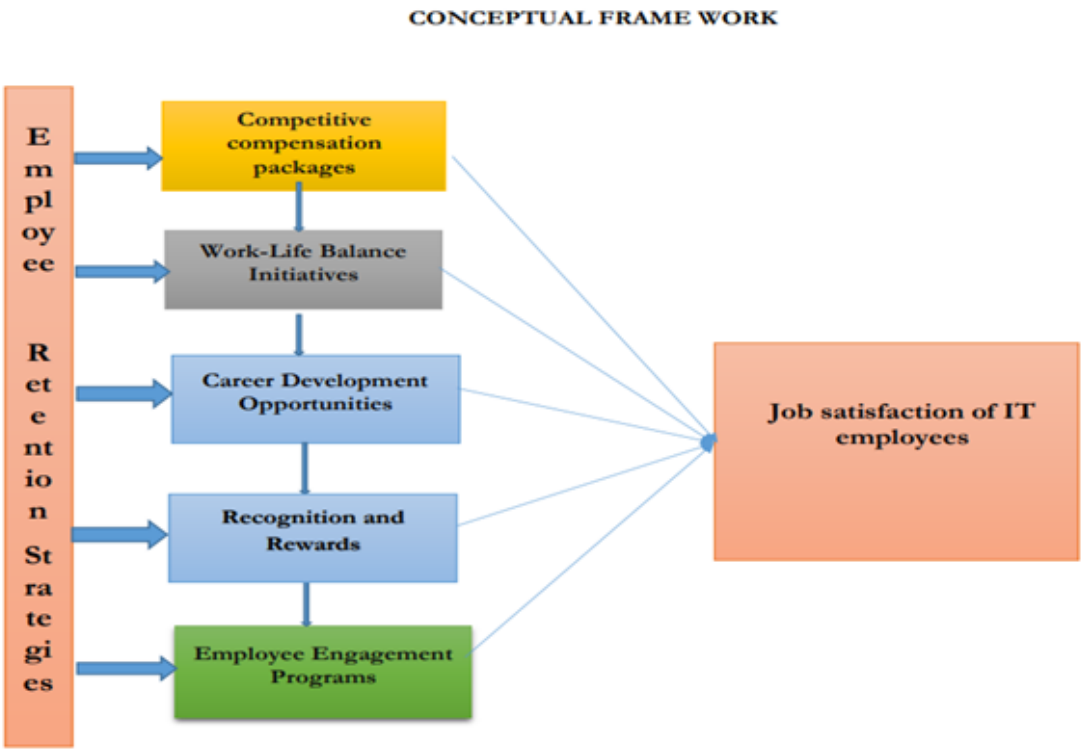


Fig 2: Conceptual frame work

The study aims to delineate the interplay of these factors in the Indian software industry, providing a nuanced understanding of effective retention strategies and their alignment with the unique needs and expectations of software professionals in this dynamic context [19]. The figure 2 revels the concept of the conceptual frame work.

V. OBJECTIVES

The main objective of this paper is to understand the influence of strategies on the job satisfaction of IT employees. The specific objectives of this research study are outlined as follows:

- Evaluate the impact of competitive compensation packages on the job satisfaction of IT employees.
- Analyze the influence of work-life balance initiatives on the job satisfaction of IT employees.
- Assess the impact of career development opportunities on the job satisfaction of IT employees.
- Examine the influence of recognition and rewards on the job satisfaction of IT employees.
- Evaluate the impact of employee engagement programs on the job satisfaction of IT employees.

VI. HYPOTHESIS

Competitive Compensation Packages:

- H0: The impact of Competitive Compensation Packages on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Competitive Compensation Packages on Job satisfaction of IT employees.
- Work-Life Balance Initiatives:
- H0: The impact of Work-Life Balance Initiatives on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Work-Life Balance Initiatives on Job satisfaction of IT employees.
- Career Development Opportunities:
- H0: The impact of Career Development Opportunities on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Career Development Opportunities on Job satisfaction of IT employees.
- Recognition and Rewards:
- H0: The impact of Recognition and Rewards on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Recognition and Rewards on Job satisfaction of IT employees.
- Employee Engagement Programs:
- H0: The impact of Employee Engagement Programs on Job satisfaction of IT employees is statistically significant.
- H1: There is no statistically significant impact of Employee Engagement Programs on Job satisfaction of IT employees.

VII. RESULTS & DISCUSSION

To attain the desired outcome of this research work, a systematic research methodology is implemented and the respective outputs were described in this section to conclude the impact of employee retention strategies on job satisfaction of it professionals. In this proposed work, Statistical Package for the Social Sciences SPSS is a software package widely used for statistical analysis in various fields, including management and social sciences. In management, SPSS is often used for tasks such as data analysis, statistical modelling, and reporting. SPSS 22 is a statistical software tool that can be utilized in management for analysing and interpreting data, making informed decisions, and gaining insights into various aspects of organizational processes and behaviour. In this research work SPSS 22 is used to analyse the data. The study under consideration employs exploratory factor analysis to illustrate concept validity and assesses internal consistency using Cronbach's alpha. To identify potential relationships between variables, the study utilizes the regression method. Principal Component Analysis (PCA) is employed in the Exploratory Factor Analysis (EFA) to validate constructs. Referring to Hair et al.'s research in 1998, a factor loading equal to or greater than 0.30 is considered to meet the minimum criterion, followed by factor loadings of 0.40 and 0.50, which are deemed progressively more crucial. This study establishes a termination point at a factor loading of 0.50. The outcomes of the factor analysis are presented in the accompanying table. KMO is a statistic used in management research, particularly in the context of factor analysis, to assess

the adequacy of the data for identifying underlying factors or constructs. The value of KMO, when it is between 0.5 and 1.0, a component analysis is advantageous for the data.

The extent of interdependence among variables is assessed through Bartlett's sphericity test, with researchers measuring the outcome by computing the test's significance level. If the resulting values are significantly small, typically below 0.05, it indicates substantial correlations between the variables. Conversely, a p-value exceeding 0.10 suggests that the data may not be well-suited for factor analysis. The findings affirm the appropriateness of employing factor analysis for the given dataset, as all twenty-one items were validated for the final analysis, with none exhibiting a loading value below 0.5.

Table 1: Results of Exploratory Factor Analysis

Table 1: Results of Exploratory Factor Analysis								
Macro Variable	**Micro Variable**	**Factor loadings**	**KMO Measureof Sample Adequacy (>0.5)**	**Bartlett's Test of Sphericity**		**Items confirmed**	**Items dropped**	**Cum % of loading**
				Chi Square	**Sig. (<.10)**			
Impact of strategies	Competitive compensation packages -1	.907	.574	211.429	.000	3	0	65.843
	Competitive compensation packages - 2	.843						
	Competitive compensation packages -3	.665						
	Work-Life Balance Initiatives-1	.878	.705	355.625	.000	3	0	78.536
	Work-Life Balance Initiatives-2	.857						
	Work-Life Balance Initiatives-3	.922						
	Career Development Opportunities: - 1	.737	.642	309.165	.000	3	0	72.860
	Career Development Opportunities: -2	.901						

Reliability Assessment:

The researchers utilized Cronbach's Alpha calculation to assess the internal consistency and reliability of the questionnaire. Nunally and Bernstein (1994) recommend an alpha value as low as 0.60 for new scales, with acceptability extending to lower values. However, common practice often dictates a requirement for an internally consistent established scale with an alpha value of 0.70 or higher. In this study, the predefined threshold for Cronbach's alpha is established at 0.7.

Table 2: Results of the Reliability Examination

	Independent Variable	Cronbach Alpha
1	Competitive compensation packages	.722
2	Building trust and credibility	.861
3	Career Development Opportunities:	.808
4	Recognition and Rewards	.669
5	Employee Engagement Programs	.946
Over all Reliability of the Questionnaire		.801

Table 2 reveals, the presents Cronbach's alpha values for various independent variables, indicating their internal consistency or reliability within a questionnaire.

1. **Independent Variable:** This column lists the different factors or constructs that were assessed in the questionnaire.
2. **Cronbach Alpha**: Cronbach's alpha is a measure of internal consistency, which assesses how closely related a set of items are as a group. It ranges from 0 to 1, where higher values indicate greater reliability. Competitive compensation packages have a Cronbach alpha of 0.722, suggesting moderate internal consistency. Building trust and credibility has a Cronbach alpha of 0.861, indicating high internal consistency. Career Development Opportunities have a Cronbach alpha of 0.808, indicating a high level of internal consistency. Recognition and Rewards have a Cronbach alpha of 0.669, suggesting moderate internal consistency. Employee Engagement Programs have a Cronbach alpha of 0.946, indicating high internal consistency. The overall reliability of the questionnaire, including all items, has a Cronbach alpha of 0.801, suggesting a good level of internal consistency.

These values provide insights into the reliability of the questionnaire items related to each independent variable, with higher Cronbach alpha values indicating greater reliability.

Table 3: Correlations

	CCP	CDO	R&R	EEP	WLB
Competitive compensation packages(CCP)	1				
Career Development Opportunities: (CDO)	.806**	1			
Recognition and Rewards(R&R))	.755**	.798**	1		
Employee Engagement Programs(EEP)	.757**	.768**	.723**	1	
Work-Life Balance Initiatives(WLB)	.308**	.348**	.343**	.367**	1

Table 3 reveals that the Cronbach's alpha values surpass the acceptable cutoff of 0.7, indicating satisfactory reliability. Specifically, the questionnaire exhibits an overall reliability demonstrated by a Cronbach's alpha value of 0.801.

Moving on to the correlation analysis, the study on independent variables indicates a robust connection among all of them. Each variable demonstrates a significant correlation with the five variables under examination in the "impact of strategies" framework. Notably, all five independent variables within the "impact of strategies" framework exhibit substantial associations with one another (refer to Table 4). The correlation between "Career Development Opportunities" and "Competitive Compensation Packages" is the highest at 0.806, while the least significant relationships are observed between "Building Trust and Credibility" and "Competitive Compensation Packages" at 0.308.

Regression Analysis:

The study utilizes stepwise regression analysis to discern the predictor-criterion relationship between dependent and independent variables. Specifically, the correlation between the impact of retention strategies on job satisfaction was explored.

Results of Hypotheses Testing for Job Satisfaction of IT Employees as Dependent Variable:

Multiple regression models were developed and tested to assess the job satisfaction of IT employees as the dependent variable. The study considered five factors related to the impact of strategies—Competitive Compensation Packages (CCP), Career Development Opportunities (CDO), Recognition and Rewards (R&R), Employee Engagement Programs (EEP), and Work-Life Balance Initiatives (WLB)—as independent variables in the regression models.

Table (4a): Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.863[a]	.744	.743	.355
2	.911[b]	.830	.829	.290
3	.936[c]	.876	.874	.248
4	.955[d]	.912	.910	.210
5	.962[e]	.926	.925	.192

The results of the stepwise regression analysis indicate that, according to Table 4(a), five factors (Competitive Compensation Packages, Career Development Opportunities, Recognition and Rewards, Building Trust and Credibility, Employee Engagement Programs) emerged as significant predictors of "Job satisfaction of IT employees." With an R-square value of 0.934, these five variables collectively explain job satisfaction to the extent of 93.4 percent in the dataset.

a. Dependent Variable: Job satisfaction of IT employees
b. Predictors: (Constant), Career Development Opportunities:
c. Predictors: (Constant), Career Development Opportunities: Employee Engagement Programs
d. Predictors: (Constant), Career Development Opportunities: Employee Engagement Programs,
e. Predictors: (Constant), Career Development Opportunities: Employee Engagement Programs, Recognition and Rewards

Table (4b). ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	87.776	1	87.776	696.150	.000[b]
	Residual	30.135	239	.126		
	Total	117.911	240			
2	Regression	97.885	2	48.943	581.674	.000[c]
	Residual	20.026	238	.084		
	Total	117.911	240			
3	Regression	103.276	3	34.425	557.490	.000[d]
	Residual	14.635	237	.062		
	Total	117.911	240			
4	Regression	107.488	4	26.872	608.429	.000[e]
	Residual	10.423	236	.044		
	Total	117.911	240			
5	Regression	109.232	5	21.846	591.557	.000[f]
	Residual	8.679	235	.037		
	Total	117.911	240			

Moreover, Table 4(b) showcases the ANOVA outcomes for the regression model, affirming validity with a 95 percent confidence level.

Table (4c): Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	.498	.087		5.752	.000
1	Career Development Opportunities:	.800	.030	.863	26.385	.000
2	(Constant)	.517	.071		7.310	.000
	Career Development Opportunities:	.475	.039	.512	12.280	.000
	Employee Engagement Programs	.325	.030	.457	10.961	.000
3	(Constant)	.215	.069		3.124	.002
	Career Development Opportunities:	.440	.033	.475	13.217	.000
	Employee Engagement Programs	.284	.026	.400	11.055	.000
	Building trust and credibility	.183	.020	.231	9.343	.000
4	(Constant)	.156	.058		2.663	.008
	Career Development Opportunities:	.262	.034	.283	7.811	.000
	Employee Engagement Programs	.224	.023	.316	9.928	.000
	Building trust and credibility	.171	.017	.216	10.310	.000
	Recognition and Rewards	.271	.028	.328	9.765	.000
5	(Constant)	.074	.055		1.358	.176
	Career Development Opportunities:	.185	.033	.199	5.655	.000
	Employee Engagement Programs	.191	.021	.268	8.965	.000
	Building trust and credibility	.168	.015	.212	11.045	.000
	Recognition and Rewards	.250	.026	.302	9.758	.000
	Competitive compensation packages	.173	.025	.191	6.873	.000

a. Dependent Variable: Job satisfaction of IT employees

A brief scrutiny of the corresponding coefficients in Table 4(c) discloses beta values for the factors— "Competitive Compensation Packages (CCP), Career Development Opportunities (CDO), Recognition and Rewards (R&R), Employee Engagement Programs (EEP), Work-Life Balance Initiatives (WLB)"—as 0.129, 0.221, 0.215, 0.265, and 0.195, respectively. These findings strongly underscore the significance of these factors in influencing job satisfaction among employees.

Table 5: Test Results for Hypotheses

Hypothesis	Independent Variables	Dependent Variables	R-Square	Beta Coefficient	t-value	Sig Value
H1	Competitive compensation packages (CCP)	Job satisfaction of IT employees	0.129	3.593	0.076	Accepted
H2	Career Development Opportunities (CDO)	Job satisfaction of IT employees	0.221	7.437	0.000	Accepted
H3	Recognition and Rewards (R&R)	Job satisfaction of IT employees	0.215	11.793	0.003	Accepted
H4	Employee Engagement Programs (EEP)	Job satisfaction of IT employees	0.265	8.771	0.012	Accepted
H5	Work-Life Balance Initiatives (WLB)	Job satisfaction of IT employees	0.195	7.379	0.017	Accepted

The table 5 presents the findings of a research study examining the relationship between various factors and the job satisfaction of IT employees. The study hypothesized that factors such as competitive compensation packages, career development opportunities, recognition and rewards, employee engagement programs, and work-life balance initiatives influence job satisfaction in the IT sector. The results indicate that all hypotheses were supported, as evidenced by the statistically significant relationships between the independent variables and job satisfaction. Specifically, career development opportunities, recognition and rewards, employee engagement programs, and work-life balance initiatives showed particularly strong associations with job satisfaction, as indicated by their higher beta coefficients, t-values, and lower significance values. These findings suggest that organizations seeking to enhance job satisfaction among IT employees should prioritize initiatives related to career development, recognition, engagement, and work-life balance. Overall, the study highlights the importance of considering various organizational factors in understanding and promoting job satisfaction within the IT industry. The research findings support the hypotheses with numerical evidence and are summarized as follows. Competitive compensation packages (CCP): The relationship with job satisfaction has a beta coefficient of 0.129, a t-value of 3.593, and a significance value of 0.076.Career Development Opportunities (CDO): The association with job satisfaction is stronger with a beta coefficient of 0.221, a t-value of 7.437, and a significance value of 0.000.Recognition and Rewards (R&R): This factor has a beta coefficient of 0.215, a t-value of

11.793, and a significance value of 0.003, indicating a significant impact on job satisfaction. Employee Engagement Programs (EEP): The relationship with job satisfaction is notable, with a beta coefficient of 0.265, a t-value of 8.771, and a significance value of 0. 012.Work-Life Balance Initiatives (WLB): This factor shows a beta coefficient of 0.195, a t-value of 7.379, and a significance value of 0.017, indicating a statistically significant relationship with job satisfaction.

These numerical values provide quantitative evidence supporting the conclusion that career development opportunities, recognition and rewards, employee engagement programs, and work-life balance initiatives have significant associations with job satisfaction among IT employees.

VIII. RECOMMENDATIONS & SUGGESTIONS

Based on the extensive research conducted on employee retention strategies and their impact on job satisfaction of IT professionals, the primary recommendations and suggestions are listed below.

1. **Tailor Compensation Packages**: Customize compensation packages to align with industry standards and the unique skills and expertise of IT professionals.
2. **Invest in Career Development**: Prioritize investments in training programs, mentorship initiatives, and challenging project opportunities to support career growth and advancement.
3. **Promote Work-Life Balance**: Implement flexible work arrangements, remote work options, and paid time off policies to support work-life integration and reduce burnout.
4. **Enhance Recognition and Rewards**: Recognize and reward outstanding performance through bonuses, incentives, and public appreciation programs to boost morale and loyalty.
5. **Strengthen Employee Engagement**: Foster a supportive work environment through team-building activities, social events, and employee resource groups to promote engagement and camaraderie.
6. **Facilitate Transparent Communication**: Establish open channels of communication between management and employees to address concerns and provide feedback effectively.
7. **Prioritize Employee Well-being**: Offer wellness programs, mental health support, and access to fitness facilities to demonstrate genuine concern for employee health and well-being.
8. **Develop Leadership Skills**: Invest in training managers to be supportive, empathetic, and skilled in employee development to foster positive relationships and reduce turnover.
9. **Promote Diversity and Inclusion**: Create a diverse and inclusive workplace culture where all employees feel valued and respected.
10. **Regularly Review HR Policies**: Continuously review and update HR policies to ensure they meet the evolving needs and expectations of IT professionals and the organization.
11. **Encourage Cross-Functional Collaboration**: Facilitate collaboration between IT teams and other departments to promote innovation and problem-solving.
12. **Implement Mentorship Programs**: Pair junior IT professionals with experienced mentors to facilitate knowledge transfer and career development.
13. **Offer Performance-Based Incentives**: Tie rewards and incentives directly to individual and team performance to motivate IT professionals and drive results.

14. **Provide Leadership Opportunities**: Identify and groom future leaders within the IT department by offering leadership training and opportunities for advancement.
15. **Support Continuous Learning**: Encourage IT professionals to attend workshops, conferences, and training programs to stay updated with the latest technologies and trends.
16. **Create a Positive Work Culture**: Foster a culture of trust, collaboration, and appreciation to enhance job satisfaction and employee retention.
17. **Promote Flexibility**: Allow IT professionals to have autonomy over their work schedules and environments to accommodate personal preferences and obligations.
18. **Encourage Innovation:** Create avenues for IT professionals to contribute ideas and solutions to drive innovation within the organization.
19. **Provide Clear Expectations**: Communicate clear goals, expectations, and performance metrics to ensure alignment and accountability.
20. **Seek Feedback and Iterate**: Regularly solicit feedback from IT professionals and adapt retention strategies based on their input and changing needs.

These recommendations aim to help organizations in the IT industry develop and enhance their employee retention strategies to foster job satisfaction and create a conducive work environment for their valuable IT workforce.

Altogether, the recommendations and suggestions outlined provide a comprehensive framework for organizations within the IT industry to enhance their employee retention strategies and promote job satisfaction among their workforce. By implementing tailored compensation packages, investing in career development, promoting work-life balance, and fostering a supportive work culture, organizations can create an environment where IT professionals feel valued, motivated, and engaged. Additionally, prioritizing transparent communication, recognizing and rewarding performance, and supporting employee well-being are essential components of effective retention strategies. By continuously reviewing and updating HR policies, promoting diversity and inclusion, and encouraging innovation, organizations can adapt to the evolving needs and expectations of their workforce while staying competitive in the dynamic IT landscape.

Ultimately, by incorporating these recommendations into their retention strategies, organizations can cultivate a dedicated and loyal IT workforce, driving organizational success, growth, and innovation. As the IT industry continues to evolve, organizations must prioritize employee satisfaction and retention to remain competitive and thrive in the ever-changing market.

IX. CONCLUSION

Research on employee retention strategies within the software industry consistently emphasizes the robust correlation between these strategies and job satisfaction. The software industry, renowned for its competitiveness and high demand for skilled professionals, grapples with substantial challenges in retaining its workforce. Nevertheless, organizations can overcome these challenges by deploying effective retention strategies, thereby establishing a positive work environment conducive to job satisfaction, heightened employee commitment, and increased loyalty. Numerous studies have pinpointed key employee retention strategies integral to fostering job satisfaction in the software industry. These encompass competitive compensation packages, career development opportunities, work-life balance initiatives, recognition and rewards, employee engagement programs, transparent communication, employee well-being initiatives, and robust leadership and management practices. Research findings underscore the critical importance of offering competitive salaries and benefits in

attracting and retaining software professionals. Furthermore, providing avenues for career development, such as training programs and clear career paths, proves instrumental in promoting job satisfaction by enabling skill enhancement and career progression within the organization. In the demanding landscape of the software industry, work-life balance initiatives, including flexible work schedules and remote work options, emerge as pivotal contributors to job satisfaction, facilitating a healthy integration of work and personal life. Recognition and rewards programs significantly contribute to job satisfaction by acknowledging employee contributions and nurturing a positive work culture. Engagement programs, transparent communication channels, and employee well-being initiatives collectively play a substantial role in cultivating a supportive and fulfilling work environment, thereby enhancing job satisfaction. Finally, strong leadership and management practices that prioritize employee development and support further contribute to job satisfaction and employee retention. In summation, the literature review unequivocally supports the conclusion that the implementation of effective employee retention strategies in the software industry leads to heightened job satisfaction among software professionals. By addressing key influencers of job satisfaction, organizations can cultivate a dedicated and loyal workforce, ultimately bolstering the company's success and growth.

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COMPREHENSIVE EVALUATION OF THE DIGITAL INDIA PROGRAMME TO ADDRESS PAIN POINTS IN INDIA'S DIGITAL TRANSFORMATION

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ABSTRACT

The Digital India Programme represents a transformative vision aimed at reshaping India's digital landscape to promote widespread digital inclusion and socio-economic development. Despite significant advancements in digital banking, e-governance, and rural development, the programme faces numerous challenges, especially in rural areas. These challenges include inadequate digital literacy, poor infrastructure, socio-economic disparities, and cybersecurity threats, which hinder the effective adoption of digital financial services. Studies highlight these impediments and underscore the need for interventions to ensure equitable distribution of digital benefits. This comprehensive evaluation identifies pain points associated with the programme's implementation and suggests measures to enhance its efficacy. This study discusses key issues such as network and infrastructure limitations, digital literacy gaps, socio-cultural resistance, economic barriers, insufficient customer support, and slow regulatory responses. The findings emphasize the importance of strategic investments, regulatory support, and community engagement to overcome these challenges and achieve the programme's full potential.

Keywords: Digital India, digital literacy, rural development, e-governance, cybersecurity.

1. INTRODUCTION

The Digital India Programme represents a transformative vision to fundamentally reshape India's digital landscape, promoting widespread digital inclusion and enhancing socio-economic development. However, the programme's implementation has encountered significant challenges, especially in rural areas where barriers such as inadequate digital literacy, poor infrastructure, and socio-economic disparities persist. Literature reviews, including studies from the Thane District, reveal that these challenges hinder the effective adoption of digital financial services, underscoring the need for interventions to ensure equitable distribution of digitalization benefits. Despite notable advancements in digital banking and e-governance, cybersecurity threats and the need for regulatory frameworks remain pressing issues. The programme's impact on rural development is evident through improved access to information, education, healthcare, and government schemes, yet

obstacles like unreliable internet connectivity and resistance to change within governmental bodies persist. Furthermore, digital initiatives in education and healthcare, such as telemedicine and mobile health applications, highlight both the potential and the hurdles of digital transformation, with infrastructural deficiencies and digital illiteracy posing significant barriers. The role of the Digital India Programme in fostering entrepreneurship and growth in MSMEs is also notable, though limited digital skills, access to finance, and infrastructural constraints need to be addressed through supportive policies and capacity-building initiatives. This comprehensive evaluation aims to identify the pain points associated with the Digital India Programme's implementation and suggests measures to enhance its efficacy. The study employs a descriptive research design, drawing on secondary data from journal articles, books, and electronic sources. Key issues discussed include network and infrastructure limitations, digital literacy gaps, socio-cultural resistance, economic barriers, insufficient customer support, and slow regulatory responses.

2. LITERATURE REVIEW:

The Digital India Programme has made significant strides in fostering digital inclusion and enhancing financial literacy among marginalized communities, yet it faces considerable challenges, particularly in rural areas. Studies, such as the one conducted in Thane District, highlight several barriers to the effective adoption of digital financial services, including a lack of digital literacy, inadequate infrastructure, and socio-economic challenges. These impediments hinder the programme's goal of creating a digitally empowered society. While the initiative has made headway in promoting digital inclusion, there is a clear need for interventions to address these challenges and ensure the equitable distribution of digitalization benefits. Furthermore, the transformative impact on the Indian banking sector through the Digital India Programme has been profound, with digital banking services like mobile and internet banking reshaping traditional models. This transformation has enhanced efficiency, customer experience, and broadened financial inclusion, especially in rural areas, though cybersecurity threats and the need for regulatory frameworks remain pertinent challenges.

The role of the Digital India Programme in enhancing e-governance and its socio-economic impact on rural communities underscores its broad influence across various sectors. The integration of digital technologies into government-led operations has improved transparency, efficiency, and citizen engagement, as evidenced by successful initiatives like the Digital Locker system and online grievance redressal mechanisms. However, persistent hurdles such as the digital divide and resistance to change within governmental bodies need addressing. In rural India, digital initiatives have facilitated access to information, education, healthcare, and government schemes, contributing significantly to rural development. Despite these positive outcomes, challenges such as inadequate internet connectivity and lack of awareness about digital services continue to pose obstacles. Sustained efforts are required to bridge these gaps and ensure inclusive digital growth, highlighting the importance of strategic investments in infrastructure and comprehensive digital literacy campaigns.

The Digital India Programme's impact on education, healthcare, and entrepreneurship further illustrates its transformative potential and the accompanying challenges. Digital education initiatives hold promise for transforming education by making learning more accessible and interactive, though infrastructural deficiencies

and digital illiteracy among students and teachers pose significant barriers. Similarly, digital health initiatives like telemedicine and mobile health applications have improved healthcare access, particularly in underserved areas, but issues related to data privacy and the digital divide persist. The programme has also spurred entrepreneurship and growth in MSMEs by creating new business opportunities and expanding market access. However, limited digital skills, access to finance, and infrastructural constraints remain challenges that need to be addressed through supportive policies and capacity-building initiatives. Overall, the Digital India Programme has made commendable progress, but achieving its full potential requires addressing these challenges through strategic investments, regulatory support, and community engagement.

3. OBJECTIVES AND RESEARCH METHODOLOGY:

Objectives:

1. To study the pain points associated with the implementation of Digital India Programme.
2. To suggest, based on the findings, various measures to the Government of India to advance the Digital India Programme.

Research Design: Used a descriptive research design.

Data Sources:

The researcher collected secondary data from journal articles, write-ups from books and electronic sources.

Discussion:

Network and infrastructure issues result in fewer digital payments, as unreliable connectivity disrupts transactions and undermines trust in digital financial systems. The limited digital infrastructure in these regions exacerbates the problem, with many rural areas lacking essential facilities like reliable internet and digital devices, thus hindering access to digital services. Poor internet connectivity further restricts the use of online platforms for education, healthcare, and government services, isolating rural populations from digital advancements. Additionally, the dependence on an unreliable power supply for digital devices poses a major challenge. Frequent power outages and unstable electricity supply disrupt the functioning of digital services, making it difficult for rural communities to maintain consistent digital connectivity.

Many rural individuals lack the basic skills to navigate and utilize digital platforms, which limits their ability to benefit from digital initiatives. The limited outreach of digital literacy campaigns exacerbates this issue, as many such efforts fail to reach remote and underserved communities, leaving a substantial portion of the rural population without essential digital knowledge. Furthermore, a lack of awareness about digital financial services leads to underutilization of digital payment systems, online banking, and other financial technologies that could enhance economic efficiency and inclusivity. Additionally, insufficient training and capacity-building programs for rural users mean that even those who have access to digital technologies struggle to keep pace with rapidly evolving digital environments.

Resistance to adopting new digital technologies in rural areas where traditional methods are preferred. This reluctance is compounded by a lack of trust in digital financial transactions, with fears of security breaches and

digital fraud discouraging engagement with online financial services. Cybersecurity concerns and the fear of fraud further deter users, as potential risks associated with cyber threats and scams create apprehension about the safety of digital transactions. Socio-cultural barriers also play a crucial role, as deeply entrenched norms and practices in rural communities foster suspicion and skepticism towards digital adoption. These socio-cultural attitudes, along with a lack of digital literacy, reinforce distrust and resistance.

High costs of digital devices and internet access create significant barriers for rural and economically disadvantaged populations, preventing them from fully participating in the digital economy. Many individuals and families in these areas cannot afford the initial investment in smartphones, computers, or consistent internet connectivity, which are essential for accessing digital services. Furthermore, limited access to financial resources for digital investments exacerbates this problem. Without sufficient financial support or affordable financing options, rural users are unable to invest in the necessary infrastructure to benefit from digital advancements.

Insufficient customer support for digital services significantly in rural and remote areas where users often require assistance to navigate new technologies. The limited availability of localized digital content and services further exacerbates this issue, as many digital platforms fail to cater to the specific needs and preferences of diverse regional populations. This gap in service availability prevents users from fully benefiting from digital initiatives designed to improve their daily lives. Additionally, the lack of multilingual support on digital platforms creates a barrier for non-English speaking users, making it difficult for them to access and utilize digital services effectively. This language barrier particularly affects rural users, who may be more comfortable with regional languages.

Many rural populations remain excluded from formal financial systems. This exclusion is exacerbated by ineffective digital payment systems in rural areas, where poor connectivity and inadequate infrastructure hinder seamless transactions. Consequently, the slow adoption of digital payment systems by small businesses further restricts the economic benefits of digitalization, as these enterprises struggle to transition from cash-based operations to digital platforms. Moreover, there is a dependency on intermediaries for digital transactions, which increases costs and reduces trust among users. These intermediaries often charge fees for facilitating transactions, making digital payments less attractive for both consumers and small businesses.

Slow regulatory responses to emerging digital challenges hinder the program's ability to adapt and evolve in a rapidly changing technological landscape, leaving gaps in legal and operational frameworks necessary for effective digital governance. Limited collaboration between the private and public sectors further exacerbates these issues, as the lack of coordinated efforts and shared goals between these entities stifles innovation and the effective implementation of digital initiatives. Additionally, limited financial incentives for digital adoption discourage businesses and individuals from transitioning to digital platforms, slowing the overall progress of the programme.

Verification challenges often stem from inconsistencies and inaccuracies in digital identity databases, leading to difficulties in authenticating users and accessing services. This undermines trust in digital systems and discourages their use. Additionally, the lack of seamless integration between digital services and existing government schemes hampers the efficiency and effectiveness of digital initiatives. Without cohesive integration, beneficiaries face obstacles in leveraging digital platforms to access various welfare and support programs.

The Digital India Programme faces significant challenges in achieving its goals due to the digital exclusion of elderly and less-educated populations. These groups often lack the necessary digital skills and familiarity with technology, which prevents them from fully participating in and benefiting from digital initiatives. The elderly, in particular, may find it difficult to adapt to new digital tools and platforms, leading to their marginalization in an increasingly digital society. Individuals with lower levels of education may struggle to understand and use digital services, further exacerbating the digital divide.

To address the challenges faced by the Digital India Programme, the Indian government needs to implement a comprehensive and integrated approach that leverages existing capacities while fostering innovation and collaboration. Enhancing network and infrastructure is paramount; thus, investments in expanding reliable internet connectivity and robust digital infrastructure, particularly in rural areas, must be prioritized. This could include initiatives such as deploying satellite internet services and strengthening the power supply to ensure consistent digital connectivity. Simultaneously, expanding digital literacy campaigns is essential to equip rural populations with the skills needed to navigate digital platforms. Tailored training programs, supported by localized and multilingual content, can bridge the knowledge gap and foster greater digital inclusion. To build trust and overcome resistance to digital adoption, the government should enhance cybersecurity measures, provide extensive awareness campaigns about the safety and benefits of digital transactions, and establish customer support networks. Encouragingly, subsidies and financial incentives for purchasing digital devices and internet access can alleviate economic barriers, enabling wider participation in the digital economy. Additionally, fostering public-private partnerships can drive innovation and resource-sharing, expediting the development and deployment of digital solutions tailored to diverse regional needs. Improving the regulatory framework to adapt swiftly to emerging digital challenges will ensure legal and operational coherence, enhancing the program's effectiveness. Furthermore, streamlining digital identity verification processes and integrating digital services with existing government schemes can bolster trust and efficiency in accessing welfare programs. To specifically address the needs of elderly and less-educated populations, targeted outreach and simplified digital interfaces can make digital services more accessible and user-friendly.

4. CONCLUSION

The Digital India Programme faces significant challenges that hinder its effectiveness, particularly in rural areas where network and infrastructure issues disrupt digital payments, education, healthcare, and government services. Limited digital literacy, resistance to adopting new technologies, and cybersecurity concerns further exacerbate these issues, creating a significant digital divide. High costs of digital devices and internet access, insufficient customer support, and verification challenges add to the complexity, preventing

many from fully benefiting from digital initiatives. To address these challenges, a comprehensive and integrated approach is essential. Prioritizing investments in reliable internet connectivity, expanding digital literacy campaigns, enhancing cybersecurity measures, and providing financial incentives can foster greater digital inclusion. Public-private partnerships and improved regulatory frameworks can drive innovation and adaptability, while tailored outreach programs can make digital services more accessible to elderly and less-educated populations. By adopting this holistic strategy, the Indian government can advance the Digital India Programme, ensuring inclusive participation in the digital revolution.

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Legal Rights of Girl Child: Indian scenario

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Abstract

International Day of the Girl Child increases awareness of issues faced by girls around the world. International Day of the Girl Child is an international observance day declared by the United Nations; it is also called the Day of Girls and the International Day of the Girl. October 11, 2012, was the first Day of the Girl Child. In 2022, we commemorate the 10th anniversary of the International Day of the Girl (IDG). In these last 10 years, there has been increased attention on issues that matter to girls amongst governments, policymakers and the general public, and more opportunities for girls to have their voices heard on the global stage. Yet, girls' rights remain limited and girls around the world continue to face unprecedented challenges to their education, their physical and mental wellness, and the protections needed for a life without violence. The paper aims at discussing Legal Rights of Girl Child and their situation in Indian scenario based on secondary data.

Keywords

Female Foeticide, Education, Safe environment, Abusive, Stridhan, Child marriage, Sexual harassment and Work place

Introduction

India's population of the girl child and adolescents is 253 million as per UNICEF report and the sex ratio at birth is 929 per 1000 male children as per NFHS-5. Girl is considered of no value in her parental home. Out of 12.5 million children married in India, 8.9 million are girls as per UNICEF report. India is the only large country in the world where more baby girls die than baby boys. The gender differential in child survival is currently 11 per cent, states UNICEF. A woman gives birth to a daughter the new mother risks being shamed and abused by her own family. A daughter may be considered a financial burden and likely not be able to support her and her husband in their older age. A strong preference for sons is a consequence of patriarchal and 'patrilineal' societies that favour men in both power and status. It can be most pronounced in highly agricultural and subsistence societies. These systems value sons over daughters because family assets are passed through male family members (patrilineal), and the greater earning potential of men in patriarchal societies leads

households to rely on boys as future supports as parents age. Though there are many laws in favour girl children in India, practices, such as, female foeticide, female infanticide, child marriage, malnutrition, exploitation, child trafficking, neglect and discrimination, child mortality and child abuse. In addition, opportunities need to be promoted to facilitate education and employment opportunities among them.

Objective and method

The main purpose of this research paper is to acquire an understanding of status of girl child in India. The paper aims at discussing the legal rights of girl children and examines the prevailing situation in India based on secondary data collected through various sources. It will helpful to create awareness on the legal rights of girl children and their situation in India.

Discussion

The legal rights of girl children in India and their prevailing situation briefly discussed hereunder.

Right against female Foeticide

Female foeticide refers to a practice which removes the female foetus after 18 weeks of growth in the uterus. It has been still practicing at high rate all over India though the government of India banned pre-natal sex determination under the PC-PNDT Act 1994. It was enacted on 20 September 1994, amended and effectively implemented in 2003 and strictly amended in 2011with the intent to prohibit prenatal diagnostic techniques for determination of the sex of the foetus leading to female feticide. Therefore, one cannot find out the sex of their unborn child till birth. Though it has been illegal in India since 1996, at least 9.0 million (0.9 crore) female births went “missing” between 2000 and 2019 because of female-selective abortions, as per Pew Research Centre. However, the average annual number of baby girls “missing” in India fell from about 480,000 (4.8 lakh) in 2010 to 410,000 (4.1 lakh) in 2019, the Center’s analysis finds (Yunping Tong, 2022). According to Amartya Sen (1990) around 37 million females missing from the Indian population, caused by a deepening crisis of gender inequality that had led to the widespread practice of sex selective abortions, female infanticide and neglect of girl-children. Gender-biased sex selection is a profound form of discrimination that results from the combination of three factors: strong preferences for sons within a society, the rising use of modern technologies, and generally declining fertility rates.

Right to Education

The Right to Education Act, 2009, provides all children between the ages of 6 and 14 years the right to free and compulsory elementary education. Although this law is gender-

neutral, it gives a push to the education of girl children, by giving them enhanced access to schooling. Further, the recent National Education Policy (NEP) 2020 envisages equitable and inclusive education for all, with special focus on children and youth, especially girls, from socially and economically disadvantaged groups. The policy's focus is important because despite effort to educate women, the dropout rate for girls is still high after secondary education. The enrolment ratio too dips at the secondary and higher secondary levels. Among many reasons, the onset of menstruation and the lack of availability of hygienic toilets are responsible for girls leaving school without completing education. The National Family Health Survey-5 (2019-21) indicates that over 21,800 girls who had dropped out of school before the 2019-20 school year, just over 13% girls did so as they were required for house work and almost 7% did so as they were married off even though child marriage is illegal. UNICEF's U-Report poll (2022) reveals that 38% of respondents knew at least one female student to have dropped out of school.

Right to be raised in a safe environment

All children, including female children, have the right to be brought up in a safe and protected environment. The Juvenile Justice Act, 2015 makes it illegal for parents and guardians of children to abuse, assault, neglect, or abandon a child. Study on Child Abuse: India (2007), out of the total working children, 23.2% was child domestic workers. Among these 81.16% were girls. Out of all child domestic workers, 44.19% were in the age group of 5-12 years followed by 33.27% in the age group of 15-18 years and 22.54% in the age group of 13-14 years. Further, the study reveals that majority of the girl child respondents (70.57%) reported neglect of one form or the other by family members. 48.4% of the girls reported having gone through such feelings as less attention, less food, less time for recreation, more household work, etc. an overwhelming majority 68.99% reported physical abuse, out of which most of the respondents (54.68%) were boys. UN Women supported survey, 2013 in Delhi shows 95 per cent of women and girls feel unsafe in public spaces.

Right against abusive family members

The Domestic Violence Act, 2005 protects all females from any kind of physical, emotional, sexual, or financial abuse by family members. The protection extends to all family members with whom the female shares a house-including her own family members like parents, siblings, uncles, aunts, etc. Therefore, this law protects female children from being abused at home. But, the Ministry of Women and Child Development (MWCD, 2007) released a study report on child abuse. Of the young adults (ages 18-24)

interviewed, almost half of them reported having been physically or sexually abused as children.

Right to stridhan

'Stridhan' is the property of a female, both movable and immovable, which is her own. It can be a gift, inheritance, maintenance, or even her own earnings. Only she has rights over her 'stridhan' and she can exclusively decide what she wants to do with it. This law applies only to Hindus. Since 2005, Hindu women have equal rights as men to inherit property. Therefore, a girl can inherit the same amount of property as her brother. Inheritance can be through a Will or through succession (if the deceased person does not leave a Will, the property will pass on to legal heirs according to the law). Supreme Court of India passed a landmark judgement declaring that all gifts made over to a woman at the time of her marriage remained her absolute private property till the end; and that her husband, or any other, had no right to them without her sanction.

Right against child marriage

The minimum age of marriage for girls is 18 years (and for boys, it's 21 years). Any adult responsible for marrying a female child under the age of 18 can be punished by law. Interestingly, the Parliament is now looking to increase the marriageable age for girls to 21 years now (on par with boys). In spite of the Prohibition of Child Marriage Act (2006), the practice of child marriage remains pervasive due to factors spread across the socio-ecological spectrum, including structural inequalities and regressive social norms in India. Girls with either no or below primary level education have experienced higher levels of child marriage. As per theNFHS-5, 23.3% women got married before attaining the legal age of 18 years from 26.8% reported in NFHS-4 and 48% of girls with no education were married below 18 years of age as compared to only 4% among those who attained higher education

Right against sexual harassment

Sexual harassment broadly means any kind of unwelcome physical contact, sexual gestures, comments, sexual advances, requests for sexual favours, etc. by a man to a woman. Indian law protects all women from sexual harassment by men. By virtue of this law, every girl child in India is protected against sexual harassment. Sexual violence is a major problem faced by women and girls in India. It is already a challenge for survivors to obtain justice in the Indian legal system, and those from the country's marginalized communities face even more major barriers. According to official crime data, there were 3,486 reported cases of rape against Dalit (Scheduled Caste) women and girls in 2019, and 1,110 reported rape cases against Adivasi women and girls (Scheduled Tribes). According to the latest National Family

Health Survey (NFHS-5), nearly 1 in 3 Indian women age 18-49 have suffered some form of spousal abuse; and around 6% have suffered sexual violence. Study on Child Abuse: INDIA 2007 reveals that among respondents, 48% of boys and 39% of the girls faced sexual abuse. The prevalence of sexual abuse in upper and middle class was found to be proportionately higher than in lower or in lower middle class. Sexual abuse was found to be prevalent in both joint and nuclear families.

Right against sexual harassment at work place

It is common for young girls these days to intern or work in offices, while they are still studying. The Prevention of Sexual Harassment at Workplace Act 2013 protects all female workers, whether they are full-time, part-time, consultants, or even interns, against any kind of sexual harassment at work. It defined sexual harassment; lay down the procedures for a complaint and inquiry, and the action to be taken. It broadened the Vishaka guidelines, which were already in place. As per NCRB Report 2020, total cases of sexual harassment reported stood at 17,003 in 2020, down by 1,331 cases from 2019's 18,334. With most people working from home in the last year, only 485 incidents of workplace sexual harassment were reported, down marginally from 2019's 505 cases.

Right to abortion

Abortion was legalized in the country in 1971. A female child has the right to abortion to terminate an unwanted pregnancy. The Medical Termination of Pregnancy Act, 1971 permits a minor girl to have an abortion, with the written consent of her guardian. However, abortion is only permitted under special conditions like if the pregnancy is 'likely to cause injury to the physical or mental health of the pregnant women'. At least 7% of all women aged 15-19 years began child-bearing in 2019-21, as per National Family Health Survey-5. Teenage pregnancies are higher in rural India (8%) than urban (4%). UNFPA's State of the World Population in 2008 suggested that teen pregnancy in India is high with 62 pregnant teens out of every 1,000 women. In 2015, abortions among teenage girls had seen an alarming rise at 67 per cent. Abortion among girls under the age of 15 in Mumbai has risen by 144 per cent over the last three years as per BMC (The Times of India, 2015).

Conclusion

India is home to 20 per cent child population of the world. Here, nearly 100 million children fall in the poorest wealth quintile. Though the girl children has legal rights, they facing many problems such as Female infanticide and Foeticide, Early Marriage, better education, health, Neglect and Discrimination, Trafficking, Abuse , exploitation and Violence etc. However, The opportunity to be born, opportunity to grow in a safe and secure

environment, opportunity to develop ones' full potential are some of the major issues concerning the girl children in India must be taken into account for giving girl children their due position in India.

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Women's Empowerment in India:A critical analysis based on NFHS-5

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"You can tell the condition of a nation by looking at the status of its women."

- Jawaharlal Nehru

Abstract

Women's empowerment refers to the process of enabling women to have greater control over their lives and to be able to make their own decisions. This can include empowering women to participate fully in the economy and in the political process, as well as empowering them to make decisions about their own health and well-being. It is the key to improving their participation in decision-making, which is the most crucial factor in socio-economic and cultural development. India is a developing country, has a very poor economic status of females due to its male-dominated nature. Women constitute roughly 50 per cent of the country's population, and most of them are still economically dependent, unemployed, and in many ways inferior to men. However, women's empowerment is very necessary to create a bright future for the family, society and country. Empowering women would mean encouraging women to self-sufficiency, financial independence, positive self-esteem, creating confidence in difficult situations and active participation in various socio-political development endeavours. The paper aims at examine the six key indicators on women empowerment, based secondary data collected from NFHS-5 by taking descriptive research design and suggestions are made to empower women in India.

Key words

Women Empowerment, Household Decisions, Work Participation, Own of Property, Access to Bank & Mobile Phone, and Health withHygienic

Introduction

Women's empowerment can be defined to promoting women's sense of self-worth, their ability to determine their own choices, and their right to influence social change for themselves and others. It means increasing and improving the social, economic, political and legal power of women, ensuring equal rights and sufficient self-confidence for women to claim their rights and develop independently. Women's empowerment equips and allows women to make life-determining decisions through the different societal problems.The empowerment of women is a key aspect in achieving gender equality, where men and women

have equal power and opportunities for education, health, economic participation and personal development. The empowerment of women is essential for the health and social development of families, communities and countries. Panda (2017) opined that the empowerment of women is not a necessary fact for our country, but it is necessary for the sustainable development of the nation. When women live safe, satisfied and productive lives, they can reach their full potential. In addition, they contribute their skills to the workforce and can raise happier and healthier children. Women are key factors in the economy and play an important role in the workforce and contribute to the growth and development of the family, society and nation. India's journey towards women empowerment has its ups and downs.

Seema Singh and Antra Singh (2020) concluded that while thinking about improving educational attainment and political participation, the downward trend in economic participation and opportunity and health and survival segment has been quite significant.Women empowerment refers to women's ability to make strategic life choices that were previously denied themAs India progresses economically, the country is encouraged to pay more attention to social and human development, including women's empowerment. The equal rights of men and women are enshrined in Articles 14 to 16 of the Constitution of India, which came into force on 26 January 1950 (Constitution of India, 2020). Empowerment refers to a situation where the powerless gain greater control over resources and ideologies. It is associated with concepts such as autonomy, power, status and agency. The empowerment of women in India is highly dependent on several variables which include geographical location (urban/rural), social status (caste and class), educational status, marital status, religion and age. As a traditional patriarchal society, women have been given a secondary status, which is reflected economically, socially and politically. However, women's equality and empowerment has always been a priority and taken very seriously by stakeholders (Seema Singh and Antra Singh, 2020).

Review of Literature

Shettar (2015) concludes that access to education; employment and changes in the social structure are only factors contributing to the empowerment of women. Khatri (2016) focuses on the impact of literacy and education on the empowerment of women and a proposal to improve the changes considered for the empowerment and economic development of women. Suresh and Sivakumar (2017) found that the empowerment of women is essentially a process that raises the economic, social and political status of

traditionally disadvantaged women in society. It is a process to protect them from any kind of violence. A study by Banashri Mandal (2018) shows that women empowerment means increasing and improving the social, economic, political and legal power of women to ensure equal rights for women and make them confident enough to demand their rights.SangeethaMenon et al (2020) examined at indicators of women's empowerment such as women's decision-making power in domestic affairs, economic autonomy, also freedom of movement and access to education. Sobha Rani (2023) states that the empowerment of women would mean giving women financial independence, self-confidence and positive evaluation so that they can face difficult situations and participates in development activities.

Objective

1. The paper examines the six key indicators of women empowerment in India and
2. Suggest measures to improve women status in India.

Methodology

The paper is descriptive in nature also based on secondary data collected from NFHS-5 (National Family Health Survey-2019-21) for India and 14 States /UTs included in two Phases of the Survey and gathered information from 6,36,699 households covering 7,24,115 women of aged 15-49 years. The six key indicators of women empowerment considered in paper are:1. Currently married women who usually participate in three household decisions (Decisions about health care for herself, making major household purchases, and visits to her family or relatives), 2. Women who worked in the last 12 months and were paid in cash 3. Women owning a house and/or land (alone or jointly with others) 4. Women having a bank or savings account that they themselves use, 5. Women having a mobile phone that they themselves use and 6. Women age 15-24 years who use hygienic methods of protection during their menstrual period (Locally prepared napkins, sanitary napkins, tampons, and menstrual cups are considered to be hygienic methods of protection.)

Results and Discussion

The women empowerment aspects such as participation of women in household decision, paid work, Ownership of house/land, Access to mobile phone and bank and Practice of Menstrual Hygiene are briefly discussed hereunder.

Women in Household decision

One of the characteristics of women's empowerment is decision-making. The participation of women in household decision-making can reduce the perceived gender inequality. Nowadays, married women reveal their position in the family, usually involved in making three household decisions (e.g. self-care, important household purchases, and

visitingfamily or relatives).Acharya,et al. (2010) found that almost half (47.1%) of ever-married women made their health care decisions alone or with their spouse. This proportion is 52.8% for large household purchases, 57.6% for everyday household purchases and 56.6% for family/friends.

Table-1: Currently married women who usually participate in three household decisions

S. No	India/ State/ Union Territory	NFHS-5 (2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	91.0	87.7	88.7	84.0
2.	Arunachal Pradesh	89.2	86.6	87.0	89.1
3.	Chhattisgarh	96.5	91.6	95.7	90.5
4.	Haryana	90.7	86.2	87.5	76.5
5.	Jharkhand	94.6	89.8	91.0	86.6
6.	Madhya Pradesh	91.7	84.1	86.0	82.8
7.	Odisha	89.9	90.3	90.2	81.8
8.	Punjab	93.3	90.3	91.4	90.2
9.	Rajasthan	90.6	86.8	87.7	81.7
10.	Tamil Nadu	91.8	93.7	92.8	84.0
11.	Uttar Pradesh	90.1	86.8	87.6	81.7
12.	Uttarakhand	91.8	90.6	91.0	89.8
13.	Chandigarh	94.6	-	94.6	96.6
14.	NCT Delhi	92.0	94.3	92.0	73.8
15.	Puducherry	98.4	96.6	97.9	85.1

Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)

Table-1 depicts that currently married woman (aged 15-49) who usually participate in three household decisions like health care for herself, making major household purchases, and visits to her family or relatives has been slightly increased from NFHS-4 to NFHS-5. Further, women who reside in urban areas have more involved in household decisions than their rural counterparts. Women who participated in household decisions were differing by states and union territories.

Participation in paid works

Paid work is still the privilege of few women around the world, although it can be said that all women work. One of the main factors preventing women from controlling household decisions is the value of the work they do. There is substantial evidence that women in India have limited opportunities to participate in paid work outside the home (Mehrotra et al., 2016).

Table-2: Per cent of women who worked in the last 12 months and were paid in cash

S. No	India/ State/ Union Territory	NFHS-5 (2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	25.0	25.6	25.4	24.6
2.	Arunachal Pradesh	23.0	23.6	23.5	17.2
3.	Chhattisgarh	28.4	42.6	31.1	36.8
4.	Haryana	22.6	17.0	18.8	17.6
5.	Jharkhand	18.8	17.7	18.0	24.8
6.	Madhya Pradesh	23.2	28.0	26.8	29.9
7.	Odisha	26.3	25.6	25.7	22.5
8.	Punjab	25.6	20.2	22.3	18.5
9.	Rajasthan	17.0	17.5	17.4	18.6
10.	Tamil Nadu	35.4	45.5	40.8	30.5
11.	Uttar Pradesh	17.7	14.8	15.5	16.6
12.	Uttarakhand	20.2	22.2	21.6	15.5
13.	Chandigarh	22.0	-	22.0	32.6
14.	NCT Delhi	25.0	17.2	24.9	21.1
15.	Puducherry	35.4	44.8	38.2	21.2

Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)

Table-2 portrays that currently married woman (aged 15-49) who worked in the last 12 months and were paid in cash has been meagrely increased from NFHS-4 to NFHS-5. Further, women who reside in urban areas have worked in the last 12 months and were paid in cash than their rural counterparts. Women who worked in the last 12 months and were paid in cash were more or less similar in many states and but differ in union territories.

Ownership of house/land

Women's access to and control over productive resources, especially ownership of agricultural land, is key to their economic empowerment, social status, physical security, and their own and their families' overall well-being. It also analyses intra-gender gaps, and identifies the factors–individual, household and regional–affecting a woman's likelihood of owning land. Despite significant advancement towards equality in inheritance laws, women are found to constitute barely 14% of landowners owning 11% of agricultural land in rural landowning households, averaged across states. (Agarwal, B., et al, 2020).

Table-3: Percent of women owning a house and/or land (alone or jointly with others)

S.No	India/ State/ Union Territory	NFHS-5(2019-21)			NFHS-4 (215-16)
		NFHS-5(2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	38.3	45.7	43.3	38.4
2.	Arunachal Pradesh	69.8	70.3	70.2	59.7
3.	Chhattisgarh	46.1	45.5	45.6	26.4
4.	Haryana	35.7	41.0	39.3	35.8
5.	Jharkhand	57.4	66.5	64.2	49.7
6.	Madhya Pradesh	35.8	41.3	39.9	43.5
7.	Odisha	35.4	45.5	43.5	63.5
8.	Punjab	58.0	67.1	63.5	32.1
9.	Rajasthan	26.5	26.6	26.6	24.1
10.	Tamil Nadu	43.2	52.0	47.9	36.2
11.	Uttar Pradesh	46.8	53.5	51.9	34.2
12.	Uttarakhand	23.3	25.1	24.6	29.2
13.	Chandigarh	30.4	-	30.4	21.6
14.	NCT Delhi	22.6	27.4	22.7	34.9
15.	Puducherry	36.8	38.3	37.2	40.3
Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)					

Table-3 reveals that women owning a house and/or land (alone or jointly with others)have been significantly increased from NFHS-4 to NFHS-5. Further, significantly higher per cent of rural women owned a house and/or land (alone or jointly with others) than women reside in urban areas. Women who owning a house and/or land (alone or jointly with others)were significantly varied in many states and but differ in union territories.

Access to Bank

Financial inclusion is essential for economic growth and sustainable development; for women, it is a pathway to economic and social empowerment. Expanding financial access for women is proven to have a positive impact not only on the women themselves but, consequently, on household incomes. Banks as part of their programs facilitate women by providing personalised banking services which are designed specially according to their needs and preferences. Jan DhanYojana is an initiative towards financial inclusion which also paves way for women financial empowerment. ShrutiJha (2019) stated that various initiatives are being implemented and more to roll out, Indian women is on the way of empowerment, socially and financially, to reach towards the goals of gender equality and empowerment.

Table-4: Per cent of women having a bank or savings account that they themselves use

		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	80.9	77.4	78.6	53.0
2.	Arunachal Pradesh	86.0	76.7	78.2	56.6
3.	Chhattisgarh	77.9	81.1	80.3	51.3
4.	Haryana	76.3	72.4	73.6	45.6
5.	Jharkhand	79.2	79.8	79.6	45.1
6.	Madhya Pradesh	78.5	73.3	74.7	37.3
7.	Odisha	82.8	87.4	86.5	56.2
8.	Punjab	86.9	82.1	81.6	58.8
9.	Rajasthan	81.7	79.0	89.6	58.2
10.	Tamil Nadu	92.7	91.7	92.2	77.0
11.	Uttar Pradesh	79.8	78.1	75.4	54.6
12.	Uttarakhand	81.3	79.8	80.2	58.5
13.	Chandigarh	87.1	-	89.1	79.6
14.	NCT Delhi	72.3	84.8	72.5	64.5
15.	Puducherry	90.9	96.6	97.9	85.0

Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)

Table-4 shows that women having a bank or savings account that they themselves use have been significantly increased from NFHS-4 to NFHS-5. Further, significantly higher per cent of urban women having a bank or savings account that they themselves use than women reside in rural areas. Women who women having a bank or savings account that they themselves use were significantly varied in many states and but differ in union territories.

Access to mobile phone

Many have heralded mobile phones as promising new tools for women's empowerment in the Global South. The mobile phone revealed the opportunities and freedom of women to make their own choices, improve their social network, change attitudes and change their lives. The mobile phone is changing the general socio-economic, political and psychological life of women. Only 28% of all 612 million women own mobile phones, compared to 43% of men. The gender gap in mobile phone ownership is as high as 114 million. "Gender inequality is relatively large and widespread in India, affecting women's access to and use of mobile phones.Ashim Nandi (2021) found that mobile phone use generally facilitates women's empowerment, but mobile phone use does not support women's empowerment in a male-dominated economy.

Table-5: Per cent of women having a mobile phone that they themselves use

S.No	India/ State/ Union Territory	NFHS-5(2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	69.4	46.6	54.0	45.9
2.	Arunachal Pradesh	81.9	75.3	76.4	59.8
3.	Chhattisgarh	61.2	34.0	40.7	31.0
4.	Haryana	65.1	43.4	50.4	50.5
5.	Jharkhand	65.2	43.7	49.0	35.2
6.	Madhya Pradesh	58.8	31.4	38.5	28.7
7.	Odisha	58.8	48.0	50.1	39.2
8.	Punjab	71.0	54.9	61.2	57.2
9.	Rajasthan	65.5	45.3	50.2	41.4
10.	Tamil Nadu	81.2	68.9	74.6	62.0
11.	Uttar Pradesh	59.9	52.4	46.5	37.1
12.	Uttarakhand	73.1	55.7	60.9	55.4
13.	Chandigarh	70.0	-	70.0	74.2
14.	NCT Delhi	73.7	81.0	73.8	66.6
15.	Puducherry	85.5	86.6	82.9	67.3
Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)					

Table-5 illustrations that women were having a mobile phone that they themselves use have been significantly increased from NFHS-4 to NFHS-5. Further, significantly higher per cent of urban women having a bank or savings account that they themselves use than women reside in rural areas. Women who women having a mobile phone that they themselves usewere significantly varied in many states and but differ in union territories.

Practice of Menstrual Hygiene

Poor menstrual hygiene,however, can lead to serious health risks, such as reproductive and urinary infections, which in the future can lead to infertility and birth complications. Not washing your hands after changing menstrual products can spread infections such as hepatitis B and thrush. Dasgupta and Sarkar(2008) found that 78 (48.75%) girls knew how to use sanitary napkins during menstruation. Of the practices, only 18 (11.25%) girls used sanitary napkins during menstruation. When cleaning, 156 (97.5%) girls used both soap and water. Singh, A., Chakrabarty, M., Singh, S. jt 2022)

Table-6: Per cent of women age 15-24 years who use hygienic methods of protection during their menstrual period

S.No	India/ State/ Union Territory	NFHS-5 (2019-21)			NFHS-4 (215-16)
		Urban (%)	Rural (%)	Total (%)	Total (%)
1.	India	89.4	72.3	77.3	57.6
2.	Arunachal Pradesh	93.5	91.4	91.8	73.4
3.	Chhattisgarh	83.2	64.8	68.8	47.1
4.	Haryana	96.7	91.6	92.2	78.3
5.	Jharkhand	88.2	70.8	74.9	49.6
6.	Madhya Pradesh	81.9	53.4	60.5	37.6
7.	Odisha	91.7	79.5	81.5	47.4
8.	Punjab	95.4	91.1	93.2	84.4
9.	Rajasthan	92.2	81.9	84.1	55.2
10.	Tamil Nadu	98.6	98.0	98.3	91.4
11.	Uttar Pradesh	86.7	68.4	72.6	419.1
12.	Uttarakhand	94.5	89.7	91.2	69.9
13.	Chandigarh	93.3	-	93.0	92.1
14.	NCT Delhi	96.9	98.4	96.9	90.0
15.	Puducherry	99.1	99.1	99.1	96.5

Source: Government of India; 2019-21: Ministry of Health And Family Welfare, Compendium of Fact Sheets, India and 14 States/UTs (Phase-11), National Family Health Survey (NFHS-5)

Table-6 depicts that women age 15-24 years who use hygienic methods of protection during their menstrual period (Locally prepared napkins, sanitary napkins, tampons, and menstrual cups are considered to be hygienic methods of protection) have been significantly increased from NFHS-4 to NFHS-5. Further, significantly higher per cent of urban women having a bank or savings account that they themselves use than women reside in rural areas. Women who women having a mobile phone that they themselves use were significantly varied in many states and but differ in union territories.

Conclusion

Most of the currently married women (aged 15-49 years) have usually participated in three household decisions. But, only about one-fourth of currently married woman (aged 15-49) had worked in the last 12 months and was paid in cash. On an average, less than half of women were owned a house and/or land (alone or jointly with other). Nearly four-fifths of women had a bank or savings account that they themselves used. Nearly half of the were having a mobile phone that they themselves used and nearly four-fifths of women aged 15-24 years had used hygienic methods of protection during their menstrual period by way of locally prepared napkins, sanitary napkins, tampons, and menstrual cup. However, the six

empowerment aspects examined have been increased from NFHS-4 to NFHS-6 period, but rural-urban differentials were observed. Based on the findings, it is suggested that gender discrimination can be reduced by creating awareness on need of women empowerment and their benefits. Further, apart from new programmes, existing women empowerment policies should strengthen in rural areas, where in more women are residing. Women empowerment helpsthe women to handle their issues in better.It can direct them towards progress and development by channelizing their energies and efforts into productive purposes, thus creating gender equality and accelerating the speed of development of the Indian economy.

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Determinants of the performance achieved by the Auxiliary Nurse Midwifes under MCH Services in National Rural Health Mission - A study

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Abstract

India's Primary Health Care and the Family Planning Programs have come a long way after the independence in improving health indicators in general, yet it has high 'maternal' and 'under five' mortality rates. However, a lot of ground still needs to be covered to complete the demographic and epidemiological transition and improve Maternal and Child Health Indicators in a country which is as big as a continent. It is important to understand why the role of Auxiliary Nurse Midwifes (ANMs) changed from primarily a Midwife in 60s to a Preventive Health Worker with focus on Family Planning and Immunization. Changes in Program Priorities - emphasis on Preventive Services, lack of focus on Curative/Midwifery Services, changes in monitoring mechanism, lack of supervision/training, weak management, neglect by International Agencies and NGOs are major factors associated with this change. The present study aims at examines the Determinants of the performance achieved by the Auxiliary Nurse Midwifes under MCH Services in National Rural Health Mission. It is based on primary date by covering the sample size of 175 Auxiliary Nurse Midwifes with simple random sampling technic and suggestions are made for policy implications

Keywords

Auxiliary Nurse Midwifes The National Rural Health Mission, Maternal and Child Health, Health Care System, Performance and Rural Areas.

Introduction

The National Rural Health Mission (NRHM) launched by the Hon'ble Prime Minister on 12th April 2005 throughout the country with special focus on 18 states, including eight Empowered Action Group (EAG) states, the North-Eastern states, Jammu & Kashmir and Himachal Pradesh seeks to provide Accessible, Affordable and Quality Health Care Services to Rural Population, especially the Vulnerable Sections. The NRHM operates as an omnibus broadband programme by integrating all Vertical Health Programmes of the Departments of Health and Family Welfare including Reproductive & Child Health Programme and various Diseases Control Programmes. The NRHM has emerged as a Major Financing and Health Sector Reform Strategy to strengthen States Health Systems. The National Rural Health

Mission (NRHM) has been launched with a view to bringing about dramatic improvement in the Health System and the health status of the people, especially those who live in the Rural Areas of the Country. The Mission seeks to provide Universal Access to Equitable, Affordable and Quality Health Care which is accountable at the same time responsive to the needs of the people, reduction of Child and Maternal Deaths as well as Population Stabilization, Gender and Demographic Balance. In this process, the Mission would help achieve goals set under the National Health Policy and the Millennium Development Goals during the Mission Period i.e., 2005-2012. Later, the Mission Period has been extended up to 2017. To achieve these goals NRHM will:

- ✓ Facilitate increased Access and Utilization of Quality Health Services by all.
- ✓ Forge a partnership between the Central, State and the Local Governments.
- ✓ Set up a platform for involving the Panchayat Raj Institutions and Community in the management of Primary Health Programmes and Infrastructure.
- ✓ Provide an opportunity for promoting Equity and Social Justice.
- ✓ Establish a mechanism to provide flexibility to the States and the community to promote Local Initiatives.
- ✓ Develop a framework for promoting inter-spectral convergence for Promotive and Preventive Health Care.

The Objectives of the NRHM Mission

The influences of major determinants like a) Socio-Demographic Characteristics viz., Age, Marital Status, Religion, Caste, Education, Income b) Awareness on NRHM Goals and c) Professional Factors like Experience and Transfers on the performance rendered under MCH Services by the ANMs were presented. MCH Services viz., 1). ANC Registration, 2). IFA Tablet Distribution, 3). TT(PW), 4). Total Deliveries, 5). Institutional Deliveries, 6). BCG, 7). OPV, 8). Hepatitis-B, 9) Fully Immunized and 10). Family Planning Cases of the ANMs for the last two years have been taken as the dependent variable, and the influence of different factors like Socio-economic, demographic, knowledge and professional factors on it have been analysed.

Review of Literature

A study on Factors governing the performance of Auxiliary Nurse Midwives in Pune district, India by Pyone T et al concluded that focusing on the tasks of ANMs with technical inputs alone is insufficient to achieve the full potential of ANMs in a changing context. Systematic efforts tackling factors governing ANMs in their workplaces can produce a useful cadre that can play an important role in achieving universal health coverage in India. Razee

.H et al (2012) focussed on 'Listening to the rural health workers in Papua New Guinea-the social factors that influence their motivation to work'. Sunder Gujral (1991) studied the determinants of community health workers' performance in India. Bhombe, Ishwari et al (2019) studied the workload and work pattern of ANMs and identify the causes for improving work efficiency of ANMs and conclude that clarity about job responsibilities of ANMs is lacking and available working time is not effectively utilized. Time spent on supporting tasks such as travel and waiting is maximum and training to manage time for priority tasks and to improve skills is required. Factors influencing ANMs in their practices, scope of work and the mechanisms that influence ANMs' performances remain understudied. According to Zahra Hadizadesh Talasaz, Shahla Nourani Saadoldin et al, Mashhad, Iran, (2014), the mean age of the participants was 39.63±6.92 years. Spearman Correlation Test showed a direct correlation between Job Satisfaction and the Total Score of Job Performance ($P<0.001$, $r=0.490$). A direct relationship was also found between Job Satisfaction and the quality of Educational Performance ($P<0.001$, $r=0.415$), Care Performance ($P<0.001$, $r=0.335$), and Communicative Performance ($P<0.001$, $r=0.510$). There was a positive correlation between Job Satisfaction and Job Performance of Midwives. Ch. Platis, P. Reklitis, S. Zimeras et al, (2014**):** Relation between Job Satisfaction and Job performance in Healthcare Services

Objective

The paper aimed to study Determinants of the performance achieved by the Auxiliary Nurse Midwifes under MCH Services in National Rural Health Mission in Krishna District, Andhra Pradesh, India.

Methodology

The study is based on primary data consisting of 170 Auxiliary Nurse Midwives working in 18 PHCs covering a total of all the 109 Sub-Centres were interviewed with a semi structured questionnaire. There are ten MCH services of the ANMs during 2014-15 & 2015-16, weightages have been to MCH services rendered by ANMs. Basing on the performance under MCH services of the ANMs, the average performance of the each ANM per year was calculated and all the ANMs under study have been categorized into three groups based on the individual achievements under each service' are categorized in three as "high performance, average performance and poor performance".

Results and Discussion

These changes will require sustained and careful planning and resource allocation. Increasing resources along with systemic reforms will improve health status of the women

and children who are the focus of Reproductive Child Health programs. Nurses' Job Satisfaction is an important indicator of Nurses' Job intent to stay, provide quality of Nursing Care and Professional Performance, which therefore needs a greater focus of Administrators or Managers. The determinants such as Job-satisfaction, Attitude and Awareness about the programme those are likely to influence the performance of the Auxiliary Nurse Midwives (ANMs).

Table-1: Association between the Type of appointment of ANMs and their performance under MCH Services

Type of Appointment	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
2nd ANM	20	21.74%	42	45.65%	30	32.61%	92	100.00%
Regular ANM	18	23.08%	44	56.41%	16	20.51%	78	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
3.28	2		> 0.05				Not Significant	

From Table-1, slightly more proportion of Regular ANMs (23.08%) recorded 'High Performance' as against (21.74%) among 2nd ANMs. (56.41%) of Regular ANMs manifested as 'Average Performance' as against (45.65%) among 2nd ANMs. (32.61%) of 2nd ANMs recorded under 'Poor Performance' as against (20.51%) among Regular ANMs. The difference observed is statistically not significant at $P > 0.05$.

Table-2: Association between the Religion of the ANMs and their performance under MCH Services

Religion	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Hindus	34	21.25%	82	51.25%	44	27.50%	160	100.00%
Christians	4	40.00%	4	40.00%	2	20.00%	10	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
1.91	2		> 0.05				Not Significant	

From the table-2, out of total 170 ANMs (both Regular and 2nd ANMs), only meagre number i.e., only 10 ANMs are recorded under 'Christians'. However, slightly more proportion of 'Christians' category ANMs recorded 'High Performance' as against 21.25% of 'Hindu' category ANMs. 51.25% of 'Hindu' ANMs recorded 'Average Performance' as against 40.00% of 'Christian' ANMs. 27.5% of 'Hindu' ANMs recorded 'Poor Performance' as against 20.0% of 'Christian' ANMs.

Table-3: Association between the Income of the ANMs and their performance under MCH Services

Income (per month)	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
< Rs. 15,000/-	20	21.74%	42	45.65%	30	32.61%	92	100.00%
Rs. 15001/- to Rs. 30,000/-	0	0.00%	4	100.00%	0	0.00%	4	100.00%
> Rs. 30,001/-	18	24.32%	40	54.05%	16	21.62%	74	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%

From the table-3, It is evident that slightly more proportion (24.32%) of ANMs whose income is more than Rs: 30,001/- recorded 'High Performance' as against (21.74%) among ANMs whose Income is less than Rs: 15,000/-. No one is recorded 'High Performance' among ANMs whose Income is in between Rs: 15,001/- & Rs: 30,000/-. Though, meagre number 100 % (4) ANMs whose Income is in between Rs: 15,001/- & Rs: 30,000/- recorded 'Average Performance as against 54.05% among ANMs whose Income is more than Rs. 30,001/- and 45.65% among ANMs whose Income is less than Rs. 15,000/-. More proportion (32.61%) of ANMs whose Income is less than Rs: 15,000/- recorded 'Poor Performance' as against (21.62%) among ANMs whose Income is more than Rs: 30,001/-. No one is recorded 'Poor Performance' among the ANMs whose Income is in between Rs: 15,001/- & Rs: 30,000/-.

Table-4: Association between the Education of the ANMs and their performance under MCH Services:

Education	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Up to 10th Class	22	19.64%	48	42.86%	42	37.50%	112	100.00%
Inter/PUC	14	29.17%	30	62.50%	4	8.33%	48	100.00%
Degree & above	2	20.00%	8	80.00%	0	0.00%	10	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%

Education is an important influencing factor in rendering better services in any sector. From the table-4, also it is quite evident that better the education higher the performance. 'High Performance' is recorded in high proportion i.e., 29.17% of ANMs who studied 'Inter/PUC' as against 20% among ANMs studied 'Degree & above' and 19.64% among ANMs studied 'Up to 10th Class'. However, out of total 172 ANMs, only 10 ANMs studied 'Degree & above'. 'Average Performance' is recorded in high proportion i.e., 80% of ANMs who studied 'Degree & above' as against 62.5% among ANMs studied 'Inter/PUC' and

42.86% among ANMs studied 'up to 10th Class'. High proportion (37.5%) of ANMs studied 'up to 10th Class' recorded 'Poor Performance' as against 8.33% of ANMs studied 'Inter/PUC'. No one from ANMs studied 'Degree & above' recorded 'Poor Performance'.

Table-5: Association between Total Length of Service of ANMs and their performance under MCH Services

Length of the Service of the ANMs (Yrs)	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Up to 10 Yrs	26	23.21%	56	50.00%	30	26.79%	112	100.00%
> 10 to < 20 Yrs	8	30.77%	12	46.15%	6	23.08%	26	100.00%
> 20 Yrs	4	12.50%	18	56.25%	10	31.25%	32	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
2.93	4		> 0.05				Not Significant	

From the table-5, slightly more proportion (30.77%) of ANMs whose service is in between '10 Years & 20 Years' recorded 'High Performance' as against (23.21%) of ANMs whose service is 'Up to 10 Years' and (12.5%) of ANMs whose service is '> 20 Years'. High proportion (56.25%) of ANMs with '> 20 Years' of service recorded 'Average Performance' as against (46.15%) of ANMs with service 'between 10 & 20 Years' and (50%) of ANMs with service 'Up to 10 Years'. (31.25%) of ANMs with '> 20 Years' of service recorded 'Poor Performance' as against (23.08%) of ANMs with service between 'between 10 & 20 Years' and (26.79%) of ANMs whose service is 'Up to 10 Years'. The said difference is statistically not significant at P > 0.05.

Table-6: Association between Preferences of ANMs to join in the present post and their performance under MCH Services:

Preference to join in the present post	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Interest and desire to serve the people	36	25.00%	66	45.83%	42	29.17%	144	100.00%
Economic Necessity/ Shifted from the other department	2	7.69%	20	76.92%	4	15.38%	26	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
8.71	2		< 0.01				Highly Significant	

From the table-6, it is evident that the ANMs who joined in the present post with 'Interest and desire to serve the people' have performed better MCH Services. 25% of ANMs who joined with 'Interest and desire' recorded 'High Performance' as against only 7.69% of ANMs who joined with 'Economic necessity'. 76.92% of ANMs joined with 'Economic Necessity' recorded 'Average Performance' as against 45.83% of ANMs joined with 'Interest and Desire'. 15.38% of ANMs joined with 'Economic Necessity' recorded 'Poor Performance' as against 29.17% of ANMs joined with 'Interest and Desire'. The said difference is statistically highly significant at $P < 0.05$.

Table-7: Association between ANM's present Sub-Centre happens to be her native place and their MCH Services:

Present Sub Centre whether native place or not of the ANM	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
Yes	8	12.90%	32	51.61%	22	35.48%	62	100.00%
No	30	27.78%	54	50.00%	24	22.22%	108	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
6.48	2		< 0.05				Significant	

From the table-7, it is evident that the performance of ANMs who's present Sub-Centre is not her Native Place recorded 'high' when compared with the performance of ANMs who's present Sub-Centre happens to be her Native Place. Slightly more proportion (27.78%) of ANMs who's present Sub-Centre is not her native place recorded 'High Performance' as against (12.9%) of ANMs whose present Sub-Centre happens to be her native place. The difference observed is statistically significant at $P < 0.05$.

Table-8: Association between the Transfers of the ANMs and their performance under MCH Services:

No., of Transfers in the service	Performance under MCH Services						Total	
	High		Average		Poor			
	No.	%	No.	%	No.	%	No.	%
No Transfers	28	25.93%	50	46.30%	30	27.78%	108	100.00%
One Transfer	2	9.09%	16	72.73%	4	18.18%	22	100.00%
Two & more Transfers	8	20.00%	20	50.00%	12	30.00%	40	100.00%
Total	38	22.35%	86	50.59%	46	27.06%	170	100.00%
Chi-Square Value	Degree of freedom		P - Value				Inference	
5.76	4		> 0.05				Not Significant	

From the table-8, slightly more proportion (25.93%) of ANMs who have not been transferred in their service recorded 'High Performance' as against (20%) of ANMs who

have 'Two & more transfers' and (9.09%) of ANMs who have 'No Transfer'. 46.3% of ANMs with 'No Transfer', 72.73% of ANMs with 'One Transfer' and 50% of ANMs with 'Two & more Transfers' recorded 'Average Performance' where as 27.78% of ANMs with 'No Transfer', 18.18% of ANMs with 'One Transfer' and 30% of ANMs with 'Two & More Transfers' recorded 'Poor Performance'. The difference is statistically not significant at P > 0.05.

Conclusion

The findings of all these major aspects related Determinants of the performance achieved by the Auxiliary Nurse Midwifes under MCH Services to may be very useful for the administrators and decision makers of health sector in identifying the shortfalls in National Health Mission and to change its administrative policies accordingly, to get good results in terms of principles of Primary Health Care namely Equitable Distribution, Community Participation, Intersect oral Co-ordination and Appropriate Technology. Therefore, it is recommended that Health Care Administrators provide organizational supports for Midwives to improve their Professional Performance.

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GEOGRAPHICAL ANALYSIS

RESEARCH ARTICLE

A Perspective on Ecological View and Ecodevelopment Approach for Land Use Planning in The Drought Prone Areas: A Case Study of United Anantapur District, Andhra Pradesh

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Abstract

Land is a basic natural resource. It forms the basis for all the biological, human and economic activities. In the developing countries like India, where agriculture is the main source of economy and livelihood for more than two-thirds of the working population, proper utilisation of land resource is vital.

Introduction

In recent years, serious concern has been shown on ecological management and optimum utilization of land resources for the benefit of mankind. Hence the use of land resource is "central to all discussions of land problems and policies [(1)] . Land use at any region is a complex, diversified and dynamic concept. It is due to the operation of whole range of environmental factors but modified by socio-economic and historical elements. In dry areas, the use of land resources is virtually associated with climatic and edaphic conditions, besides the socio-economic needs of the mankind. Undoubtedly, the erratic behaviour of the monsoon, frequent occurrences of drought and prolonged dry spells have had a devastating and debilitating effect on land use pattern and as a result, the landscapes in dry areas gets continuously varied and modified. Since land itself is one of the important components of the ecosystems, a critical study on landscape ecology and its planning calls for greater attention to be paid to the drought prone areas to keep the ecological balance between the environment and the socio-economic needs of the region.

Ecological View of Landscape

In the sense of ecology, land carries ecosystems, but is itself also a part of these ecosystems. Although the use of land resource may be considered from abroad view of human welfare, its use is always a process of modifications of ecosystem. The idea that land use is a process of modification of ecosystem was well explored by Simmons [(2)] .

He suggested that land use ecology might form a central theme in biogeography. It is also mentioned that the ecosystem concept provides the necessary modern scientific framework to the study of land use. The form and function of land use is a human enterprise, while the development of landscape is the continuous efforts of man for his needs and sustenance under every possible combinations of terrain, climatic, edaphic and vegetative conditions. By all means, it suggested that any scientific and rational land use planning should see that the ecological balance was not disturbed and that proper equilibrium between the environment and the socio-economic needs of the area be maintained.

Ecological Problems of Land Use

In the process of land use management and optimisation, ecological problems are becoming a most serious concern. The ever increasing pressure of population and decreasing man-land ratio are posing challenging problems to the land-use planners. Structurally, a land-use system consists of three interacting spheres namely, ecological (environmental), economic and social. Each sphere has its own unique set of human-ascribed goals. Ecological problems are those, which appear in connection with human socio-economic needs, change the quality of the physical environment and indiscriminate use of natural resource base. Ecological problems appear in different types of physical environment and various socio-economic, technological and political conditions.

The negative ecological effects like degree of decertification, land degradation, soil erosion, soil salinisation, chemical contamination and water pollution are frequent in the dry areas but taking place in different intensities and degree of criticality. The other problems related to land use are under-utilisation, over-utilisation and mis- utilisation of land resources. So the question is what are the reasons for the appearance of negative ecological effects in different environmental and socio- economic conditions. Off all, undoubtedly, man's indiscriminate use of land resources has resulted in the creation of negative ecological effects. His failure to recognise the long term implications of deforestation, faculty methods of cultivation, overgrazing, massive application of fertilisers and pesticides, practice of single crop monocultures, imbalances in the input and output factors and large scale exploitation of land and soil resources throughout an entire ecosystem. Results in widespread degradation.

The practice of monoculture was accompanied subsequently by great losses of genetic varieties in the fields, involving high risks of large hectarages being destroyed by single drought or pest. To cultivation of the same crop continuously and their synthetic fertilisation year after year has resulted in the disruption of the soil balance. With diminishing organic matter in the soil, its ability to retain moisture is also reduced and as a consequence, the soil becomes sterile and dry. To circumvent some of these problems a critical examination of landscape ecology is essential for a more rational approach to land use planning and conservation of resources.

Eco-development and Ecological Planning of Land Use

Generally speaking, ecological planning is a fundamental tool for landscape and regional planning, such that many landscape ecological studies are now done as integral parts of landscape and regional planning projects[3] . It offers an effective means of helping mankind to adapt to the dynamic changing environment of which he is but one integral part. Mc Harg[4] has defined ecological planning as "an instrument for revealing regions as interacting and dynamic natural systems having intrinsic opportunities and constraints for all human uses.

The goals of such planning are derived from the region and its people as proffered by locations where all or most advantageous (safe, healthy and beautiful) factors exist with none or few detrimental factors for any and all anticipated future uses. What constitutes 'detrimental' or 'advantageous' is derived from the use itself and the value system of the initiating person or group. The concept of eco-development forms the main strategy of 'Habitat Ecology'. It helps in explaining the form of planned growth which is concerned with the development of local available land resources within the constraints of local environment with a view to optimise the local capacities of the biosphere to support the welfare of life. The eco-development approach is very close to ecological and environmental planning to balance and harmonise the various enterprises of land use which man for his own benefit has superimposed on physical environment.

The eco-development approach related to land use rests on (i) rational utilisation, (ii) development of mankind pertaining to their well-being rather than in economic sense, and (iii) advancing a true symbiosis between man and environment. To activate and regulate the harmony between landuse development and environment both the demand and supply side of the equation must be acted upon. In the eco-development and ecological planning sense, any land use planning should not be considered merely from the agricultural point of view and bringing more land under the plough making it viable for cultivation, but should include rational utilisation of land resource, conservation of land from erosion, development of nutrients and soil cover through multiple vegetative systems, improving the potential capacity of land, application of modern scientific technology and lastly the preclusion of over exploitation of land.

Study Region

Anantapur district is one of the chronically drought-prone areas in the country. It is located in the rain-shadow region of

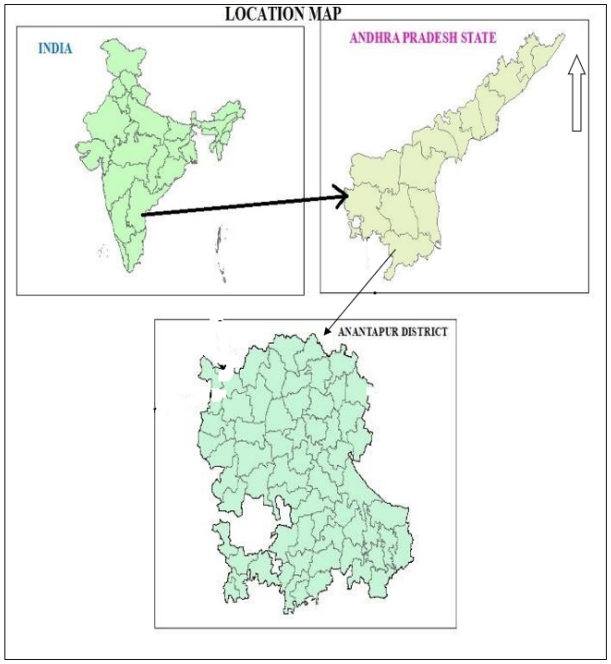


Fig. 1. Location map

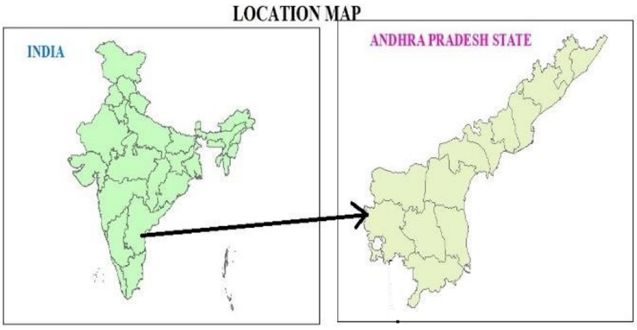


Fig. 2. Location map

the Western Ghats in Andhra Pradesh. It is the largest district in terms of area in the State. The population spread is very sparse with a density of population of 166 persons per Sq.Km. Agriculture is the predominant occupation of the people. The average annual rainfall of the district is 544 mm. with the lowest number of rainy days of 35 in the State. The district has been experiencing a drought once in every two years which is really serious and detrimental to stable agriculture.

Methodology

The spatial distributional pattern and changes in important land use types namely, forest land, fallow land and crop-land are examined and delineated with the help of both quantitative and cartographic techniques. The quantum of change is determined through percentages, regression trend and growth rates The impact of rainfall on land use types is measured with correlation testing.

Forest Land Use

Forests form distinct ecosystems. In fact, Anantapur district is very poor in forest cover with only 10.3% of the total geographical area of the district. The nature and character of forests in the district does not indicate any dense growth of tree population with different variety of plants. The forests of the district may be described as dry mixed deciduous and thorny open scrub types.

The distribution of forest-cover in the district is not only very low in proportion but also most uneven. Relatively, higher concentrations (15.1-20% and >20%) of forest-cover are found in southern, south-eastern and north-eastern parts of the district. In these areas, the amount of rainfall is comparatively higher than the other parts of the district. The western part of the district is found with very thin forest cover with discontinuous thorny thickets and scrub woodlands whose vegetative growth is stunted due to poor edaphic and very low isohyetal conditions.

During the three decades under consideration (1960-90) total area under forest has not shown any substantial change but showed a small increase of 0.1 per cent or 2000 hectares. The regression analysis has also revealed that the trend of forest land is marginally positive with 2 per cent of the goodness of fit. The annual compound growth rate has also shown a negligible rate of increase of 0.003 per cent.

Planning for the Development of Forest Land

In drought-prone areas, maintenance of ecological balance is one of the most important considerations to build-up the humus contents in the soil, avert soil erosion, increase the moisture in the atmosphere, raise the ground water level and heap in ground water recharge and storage besides other economic purposes. However, the poor quantity of forest cover in the district is too short to fulfil the requirement of ecological balance and is seriously jeopardizing the ecosystem of the region it is necessary to take up massive efforts on war-footing to develop forest-cover in the district

The development of forest-cover in the district heavily depends upon the (i) plantation of drought resistant species in large parts of the reserve forest areas, which are devoid of any vegetative cover, (ii) there are number of tanks in the district which are silted and do not fill up with meagre rainfall The foreshore of these tanks can be planted with eucalyptus and subabul plantations., (ii) depending upon the suitability of site and topography, particularly in the slopy agricultural lands and cultivable wastelands and all along the road sides the species like tamarind, neem, gulmohar, eucalyptus, fruit and flowering plants can be planted extensively. Agave species

can be planted in 'estate concept' mainly to yield raw material for fibre extraction and to put otherwise unproductive areas to productive use and (iv) pasture development can be taken up on the barren hills, slopy soils, community lands and village poramboke lands. Having all the afforestation schemes, it is utmost necessary to convert this dry belt gradually into a green belt for balancing the ecosystem.

Fallow Land Use

Land under fallows accounted for 17 per cent of the geographical area of the district. which is indeed a high proportion. More than one fifth of the geographical area under fallows is found in 17 mandals mostly located in western and north-eastern parts of the district.

During thirty years period, the proportion of fallow land has increased by 5.6 per cent amounting to about 106 thousand hectares. The increase is found in many parts of the district. The regression analysis has also confirmed this trend of increase of fallow land but is accounted by 22 per cent of co-efficient of determination. It indicates that the increase in the area under fallows is not perpetual from year to year but highly fluctuating. The annual average rate of increase is 0.6 per cent.

It is suggested that an increasing trend of fallow land should be controlled and utilised at optimum level through scientific land use management systems. If possible all the fallow lands should be brought under dry farming cultivation with suitable drought resistant rain-fed crops like millets, pulses, fodder crops and agro-forestry A considerable change in the outlook of farmers is to be brought out from traditional practices to new methods of dry farming for optimum use of fallow lands with multi-tier vegetations in different ecological systems and the sound management of Sylvi-Agri-Pastoral Systems.

Agricultural Land Use

The district has vast agricultural land resource base but suffers from instability due to vagaries of monsoon. The net area sown in the district accounted for 49.9 per cent of the total geographical area which is significantly. Higher than the average proportion of net sown area in Andhra Pradesh State (41.3 per cent)

The quantum of change in the proportion of net area sown during 1960- 1990 showed a significant decline of 5.5 per cent amounting to 105 thousand hectares. The trend of net area sown in the district has been negative. The goodness of fit of the regression trend states that the present negative trend is to the tune of 11 per cent only. It means that the negative trend of the net area sown is not exactly perfect but it is highly fluctuating from year to year depending on the variation of rainfall On an average, the annual compound growth rate declined at 0.03 per cent.

Impact of Rainfall on Arable Land

In the drought-prone region, where rain-fed farming is predominant and irrigation development is very low, it is a common assumption that the increase or decrease in either cropped area or fallow land will be in close association with the success or failure of monsoons. In the present study, the correlation analysis has revealed that there has been a positive correlation between rainfall and net area sown in the district to the tune of 0.55 Co-efficient value and negative correlation between rainfall and fallow land to the tune of 0.62 co-efficient value. A high negative correlation of 0.85 is found between net area sown and fallow land. It shows that if there is an increase in rainfall, the land under cropping may increase or if there is decrease in rainfall, the land under fallows may increase. It indicates that these two land use types are inversely correlated and functionally related with each other.

Strategy for the Development of Suitable Cropping Pattern

The present cropping pattern dominated by groundnut, cannot be treated as inappropriate and it appears to be a more or less natural consequence of the poor natural resource endowments of the district. Now that it required all the more is the optimisation and strengthening of present cropping pattern without further spatial extension of mon-crop groundnut. In view of varying drought conditions and agricultural drought which differs from one crop to another crop in an area, an extending monoculture groundnut farming to wider area may not be advisable, as a wide-spread drought may adversely affect the agricultural economy of the district. In such circumstances, all rainfed crops which are of high value and low water consuming must be preferred. The risks from droughts could be reduced by popularising suitable inter-cropping methods. If there is failure of rain, at least one of the component crops will yield something and thereby minimise the risk of total loss. The non-traditional crops like sunflower, safflower and castor etc. should also be grown in the suitable soil and moisture conditions.

Soil Characteristics and Problems

The soil is a dynamic layer which immediately reacts to the pattern of its use or changes in the soil forming environment. The district has 82 per cent of red soils and 18 per cent of black soils. The phosphorus and organic matter 3 content is poor in 82 to 90 per cent of the soils. But more than 90 per cent of the soils are moderately rich in potash more than 95 per cent of the soils are neutral or weakly alkaline. Less than 5 per cent of the soils are having severe saline and or alkaline problems.

The results of studies made by different organisations reveal that the soil characteristics are being changed in a short span of time by such activities of man like (i) removal of vegetation cover, (ii) application of heavy irrigation, (iii)

change of cropping pattern and (iv) change of morphology. The conclusions are that (1) in the undulating piedment regions where dry farming is practiced there is an increase of rill and gully erosion, (2) there is steady increase in the salinity and alkalinity problems in the canal irrigated mandals like Rayadurg, Gooty. Tadipatri and Anantapur, (3) there is a decreasing tendency in the potassium content of the soils particularly in the paddy cultivated areas and (4) with the shift from millet oriented to groundnut oriented cropping pattern, the soils have shown sulphur and zinc deficiency. Iron deficiency is also predicted in the near future.

Soil Management

The soil management programme in a semi-arid region like Anantapur district should be comprehensive and integrated one. First and foremost adequate importance should be given to the extension programmes to create the awareness in the farming community about the dangers of the mismanagement of the soil ecosystem and to motivate them to follow proper soil management 2 guidelines. The soil forming environment could be improved by managing catchments at t micro-level Construction of check dams and watersheds on small catchments serves as a multi-purpose schemes in this direction Both agronomic and engineering measures of soil conservation should be implemented in a complementary manner to achieve better results. The alkalinity and salinity problems of the soils have to be solved with suitable measures like zypsum application and leaching of excessive salts with suitable dosage of irrigation respectively Proper care should also be taken to minimise water sepage from the irrigation canals which will lead to the problems of salinity and alkalinity.

Conclusion

It has been observed that man, rather than the nature is bringing considerable change in the quality of land in a short span of time. The short- sighted and unplanned commercial and subsistence gathering of resources from the nature's bounty have caused considerable damage to the land system Many of his activities though fetching short-term gains, are causing long-term and sometimes irreversible damages to the quality of landscape system in this dry region. In view of very low proportion of forest cover, high proportion of fallow land, instability in agriculture land followed by mono-cultures and poor nature of soil cover, the landscape ecosystem of this region is delicate and is being easily disturbed.) The maintenance of ecological balance is one of the most important 4 considerations and is to be looked into it very seriously. To achieve the required goals, "Sustainable Land Use Development" is the way of environmental feature. Jacobs [5] has referred to sustainable development as "the offspring of ecological planning". To understand both and carry them out, environmental education is essential at all levels and in all sectors of the population.

It is also often emphasised that the transformation of rural habitat is the fundamental lead for the eco-development of the region the integrated Rural Development (IRD) is to be concerned with ecological and environmental issues in addition to the integration of sectors and policies in space-time dimensions. The IRD concept is also to be conceived as strategic design of problem solving planning process for the effective involvement of local human and physical resources to improve the socio-economic and ecological situation of the rural habitat.

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INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

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AN ANALYTICAL STUDY ON IMPACT OF SAVITRIBAI PHULES SOCIAL REFORMS ON WOMENS DEVELOPMENT IN INDIAN SOCIETY

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Abstract: This paper explores the profound social reforms and contributions of Savitribai Phule to the advancement of women in Indian society. Born on January 3rd, 1831, in Naigaon village, Maharashtra, Savitribai Phule, along with her husband Jyoti Rao Phule, dedicated themselves to empowering women, particularly those from marginalized communities. She staunchly advocated for women's education, viewing it as a powerful tool to combat social discrimination. Through her pioneering efforts, she laid the foundation for significant societal change. She started teaching girls in Pune and fought off those who opposed girl education at that time.

Key words: Savitribai Phule, Social Reforms, Women Education Development, Indian Society.

Introduction

Savitribai Phule, born on January 3rd, 1831, in Naigaon village, Maharashtra, emerged as a pivotal figure in India's social reform movements of the 19th century. Despite facing numerous challenges and societal opposition, Savitribai, alongside her husband Jyoti Rao Phule, embarked on a mission to uplift women and marginalized communities through education and social reform. This paper delves into Savitribai Phule's remarkable contributions to women's development in Indian society.

Early Life and Education: Savitribai Phule was born to Lakshmi Bai and Khandoji Nevse Patil in Naigaon village, Maharashtra. At the tender age of nine, she was married to Jyoti Rao Phule, a visionary social reformer. Despite her early marriage, Savitribai's thirst for knowledge remained unquenched. Encouraged by her husband, she pursued education and training, eventually becoming India's first female teacher. Her journey into education marked the beginning of her lifelong dedication to empowering women through knowledge.

Establishment of Schools: In 1848, Savitribai and Jyoti Rao Phule established the first indigenous school for girls in Pune, Maharashtra. Despite facing ostracism from both family and society, the couple remained undeterred in their mission. They provided education to girls from all castes, including those considered untouchable. Their efforts expanded with the establishment of multiple schools, aimed at breaking the chains of illiteracy and social oppression.

Advocacy for Women's Rights: Savitribai Phule was a vocal advocate for women's rights in a patriarchal society plagued by oppressive customs and traditions. She actively campaigned against practices such as child marriage, sati, and the mistreatment of widows. Savitribai's unwavering commitment to social justice extended to promoting widow remarriage and providing support to marginalized women. Her advocacy laid the groundwork for gender equality and women's empowerment in India.

Legacy and Recognition: Savitribai Phule's tireless efforts and unwavering dedication to social reform earned her widespread recognition and accolades. In 1852, the British government honored the Phule family for their contributions to education, with Savitribai being acclaimed as the best teacher. Posthumously, her legacy continued to inspire generations, leading to the renaming of the University of Pune as Savitribai Phule Pune University. Her remarkable life and achievements continue to be commemorated through various tributes and memorials across India.

Review of Literature

Sourav and Subir (2021) discussed in this study on "Savitribai Phule the first lady teacher and social reformer in nineteenth century of India". Savitribai Phule was an important social reformer and leading character of the then Maharashtra. She was the first lady teacher of first girl's school in India. Not only a teacher she was a great social reformer. In nineteenth century, she was a power source of woman education and woman empowerment. She was also a founder of modern Marathi poetry. At this crisis time she and Jyoti Rao Phule established a girl's school with nine students in 1848 at Pune in Bhide Wada and she also taught in this school. She did not stop there, she raised her voice against the practice of child marriage, sati paratha and child widows for the betterment of humans and society. At the same time, she promoted a positive attitude towards widow remarriage. She was an idol of Dalit and Mang community like Bhimrao Ramji Ambedkar. She also moved against untouchability and rule out the discrimination grounded on caste and gender.

Rita (2021) describes in his study on "Savitribai Phule: A Great Social Reformer". Savitribai Phule whose mission in life was to support the downtrodden women. She is an inspiration for all women undergoing suffering in various fields in society. To alleviate the position of women, women should get educated. Education was the prerogative of the elite caste, and to initiate the process of the transformation of society, both men and women should be educated. The life of Savitribai Phule is an inspiration for the student and the teacher, the parent, and the community at large. With the dynamic backing of her liberal minded husband, Mr. Jyoti Rao Phule, she embarked on a mission to cleanse society of the age-old superstitious evils, which debarred the welfare of the lower caste people. Savitribai encountered various challenges from the elite class, which she faced with a steadfast determination, and paved the path for the education of women in India.

Katke (2019) Conducted a study entitled "Savitribai Phule Contribution towards Indian Social Elements – A Study". In this study it was mentioned that Savitribai Jyoti Rao Phule was a famous Indian social reformer, educator, and poet who played an active role in the education and empowerment of women in the 19th century. Savitribai is one of the few educated women of this time and is responsible for having founded the first girls' school in Pune, Bhide Wada, with her husband Jyotirao Phule. She went to great lengths to raise and emancipate child widows, opposed child marriage and Sati Pratha, and advocated the remarriage of widows. As a major protagonist of Maharashtra's social reform movement, she is considered an icon of the Dalit Mang caste along with B. R. Ambedkar and Annabhau Sathe. She campaigned against untouchability and actively campaigned for the abolition of caste and gender discrimination.

Santoshkumar (2019) describe in his study on "Savitribai Phule Contribution towards Indian Social Elements – A Study". Savitribai Jyoti Rao Phule was a prominent Indian social reformer, educationist and poet who played an instrumental role in women education and empowerment during the nineteenth century. Counted among few literate women of those times, Savitribai is credited for founding the first girl's school in Pune in Bhide Wada with her husband Jyoti Rao Phule. She took great effort towards educating and emancipating child widows, campaigned against child marriage and sati pratha, and advocated for widow remarriage. A leading figure of Maharashtra's social reform movement, she is considered an icon of Dalit Mang caste along with likes of B. R. Ambedkar and Annabhau Sathe. She campaigned against untouchability and worked actively in abolishing caste and gender-based discrimination.

Pandey (2019) Conducted a study entitled "Locating Savitribai Phule's Feminism in the Trajectory of Global Feminist Thought". Feminism shows shades of the first wave of feminism when she talked about the ability to reason, self-reliance, and public schools. Her feminism showed traces of the second wave of feminism as she raised her voice over shelters and marriages between castes. Her feminism also showed some valuable characteristics of third wave feminism when she talked about raising women with different identities and bringing Stree Shudra Atishudra together. Savitribai was also the first woman to put her husband's stake in the whole history of India. Her decision to light her husband's pyre must have shocked the most radical feminists all the time.

Mangala (2018) conducted a study entitled "Savitribai Phule: Revolutionary work and literature". In this study the important issues are Savitribai's educational thinking is an era promoter. Savitribai Phule can be proudly mentioned as a positive force that shapes the female life of Maharashtra. It is glad to say that Savitribai gave prestige to the woman because of Savitribai, a noble and revolutionary spectator of her personality and activities. This light of innovation is a motivation for women who have worked in various fields and proved their mettle. Savitribai's work was challenging the difficulty of the times, Because Savitribai thought and worked for the freedom of all women and the Shudratishudra society in the world of slavery in the then orthodox society of the nineteenth century. Krantijyoti Savitribai Phule's position as a champion of the downtrodden and a supporter of teaching is inevitable in the wake of India's first teacher women's liberation movement. Phenomenal Education is a instrument for social transformation. He wanted to generate awareness in the society through education. Savitribai Phule was one of the immense educators of India who laid down the basic idea of education for humanity about 175 years before. Savitribai Phule's social and educational work is amazing and phenomenal. At the same time, Savitribai also produced literature. Her literature was enlightening the society. His entire literature was on social awareness. All literature was for the welfare of the citizens.

Jain (2016) carried out a study entitled **"**Caste and Education: The Vision of Mahatma Joti Rao Phule". There major findings are the ideologies the ideologies of the anti-caste movements were geared towards the "emancipation" that all intellectuals needed for Dalits. Phule was the first anti-caste intellectual to think about education for the masses (for Dalits). He fought against Brahmanism, which is "superstition, bag of tricks, weapon of domination" (Omvedt, Dalit Visions 8). Phule is not only considered the main figure of the anti-caste movement, but also a protester for the empowerment of women His wife, Savitribai Phule, is the main contributor to the education mission for oppressed women. According to Jyoti Rao Phule, the education of women and the lower caste deserves priority as their social position and condition in society are greatly degraded.

Somkuwar (2014) discussed in his study on "Dalit Women Poets and New Themes in Poetry". Major issues discussed in this work are as follows Dalit literature in the hands of modern women's writers has gone through a multidimensional revolutionize. Adjudging new themes and concepts it hardly remains the literature of lower classes. These modern poets writing is not only the writing of lamentation, breast-beating, praising or even consideration but also feministic, reflective, and universal. By representing universal themes in their text, they have taken the movement of Dr Ambedkar on a high peak. Their society as well as Dalit Writers from first and second generations has sky-scraping hopes from these Modern Dalit Women poets. Finally, all discussion indicates to the quote Dr Ambedkar who said, "I measure the progress of the community by the degree of progress which women have achieved.

Wolf (2011) conducted a study on Savitribai Phule. It is opined that for present day, every literate woman of India, anywhere in the world, stands as testimony to the influence of the four original and extraordinary ideas shared by Comenius and Savitribai: that education for every child, without exception, must be universally accessible, child sensitive, intellectually critical, and socially reforming. And every girl child, in any school, on any day, in India sitting at the side of boys, reading a book, exploring the Internet, learning new things. It is a

Savitribai-kind of India. Might just such a different arrangement incite a future with a different kind of social structure a world venue learning place different from the detention center house kind of culture within which Savitribai lived? If so, then I don't know the children of India may yet sing in a pleasant house, little canaries freed into a most original and extraordinary future a Comenius and Savitribai kind of future.

Role in Women Education & Empowerment

The first indigenously run school for girls in Pune (at that time Poona) was started by Jyoti Rao and Savitribai in 1848 when the latter was still in her teens. Although they were ostracized by both family and community for this step, the resolute couple was given shelter by a friend Usman Sheikh and his sister Fatima Sheikh, who also gave the Phule couple place in their premises to start the school. Savitribai became the first teacher at the school. Jyoti Rao and Savitribai later started schools for children from the Mang and Mahar castes, who were regarded as untouchables. Three Phule schools were in operation in 1852. On November 16 that year, the British government honored the Phule family for their contributions in the field of education while Savitribai was named the best teacher. That year she also started the Mahila Seva Mandal with the objective of creating awareness among women regarding their rights, dignity, and other social issues. She was successful in organizing a barbers strike in Mumbai and Pune to oppose the prevailing custom of shaving heads of widows.

All the three schools run by the Phule's were closed by 1858. There were many reasons for this, including drying up of private European donations post the Indian Rebellion of 1857, resignation of Jyoti Rao from the school management committee due to difference of opinion on curriculum, and withdrawal of support from the government. Undeterred by the circumstances Jyoti Rao and Savitribai along with Fatima Sheikh, took charge of educating people from the oppressed communities as well. Over the years, Savitribai opened 18 schools and taught children from different castes. Savitribai and Fatima Sheikh began teaching women as well as other people from downtrodden castes. This was not taken well by many, particularly the upper caste of Pune, who were against Dalits education. Savitribai and Fatima Sheikh were threatened by the locals and were also harassed and humiliated socially. Cow dung, mud and stones were thrown at Savitribai when she walked towards the school. However, such atrocities could not discourage the determined Savitribai from her goal, and she would carry two saris. Savitribai and Fatima Sheikh were later joined by Saguna Bai who also eventually became a leader in the education movement. Meanwhile, a night school was also opened by the Phule couple in 1855 for agriculturist and laborer's so that they can work in daytime and attend school at night.

To check the school dropout rate, Savitribai started the practice of giving stipends to children for attending school. She remained an inspiration for the young girls she taught. She encouraged them to take up activities like writing and painting. One of the essays written by a student of Savitribai called Mukta Salve became the face of Dalit feminism and literature during that period. She conducted parent-teacher meetings at regular intervals to create awareness among parents on the significance of education so that they send their children to school regularly.

In 1863, Jyoti Rao and Savitribai also started a care center called 'Balhatya Pratibandhak Griha,' possibly the first ever infanticide prohibition home founded in India. It was set up so that pregnant Brahmin widows and

rape victims can deliver their children in a safe and secure place thus preventing the killing of widows as well as reducing the rate of infanticide. In 1874, Jyoti Rao and Savitribai, who were otherwise issueless, went on to adopt a child from a Brahmin widow called Kashibai thus sending a strong message to the progressive people of the society. The adopted son, Yashavantrao, grew up to become a doctor.

While Jyoti Rao advocated widow remarriage, Savitribai worked tirelessly against social evils like child marriage and sati pratha, two of the most sensitive social issues that were gradually weakening the very existence of women. She also made effort in bringing the child widows into mainstream by educating and empowering them and advocated for their re-marriage. Such pursuits also met with strong resistance from the conservative upper caste society.

Conclusion

Women in India have always been inspiring, whether it is now or during the times of the Indian freedom struggle. Women have always been a source of power and ideal of courage for society. There were several prominent faces in the Indian Freedom Struggle, and the role of women brought a significant change.

Savitribai Phule pursued her education in English which broadened her perspective of principles that contributed for the transformation of society. Savitribai, and her husband, Jyoti Rao was a historic couple who worked together for the empowerment of women and the oppressed classes. The couple did not have any biological child, so when Jyoti Rao was coaxed to remarry, he humbly stated that the defect in having a child may be in myself and not in Savitri. The couple adopted a boy who later became a medical doctor. They considered it their mission to purge society of the evil practices and do away with the misuse of religion as a tool to subordinate the lower castes. India is a nation which is characterized as a *karma Bhoomi,* wherein an individual's merits are a criterion for his social status. A person who is virtuous is superior and one of loose character is inferior. The exploitation of the world under the guise of antiquity must be disapproved because they are trying to gain an advantage for themselves, rather than trying to help other people do what is right. The life of women should not be restricted to her husband and children. The identity of a woman is not restricted only to her husband and children. Today the literacy rate of women is high, but are we really educated or only literate. Feminism outside the academic circle will challenge us in ways, which yet we cannot even foresee. Women must build up their identity by their contribution to society and their lives should not be restricted as being just wives and mothers of great reformers. Savitribai proved herself as a woman of substance and not as an appendage of a man. Even after the death of Jyoti Rao, she continued her mission of empowerment of women. In the famine of 1896, she compelled the British to undertake relief measures. An epidemic of plague swept Pune in 1897. Savitri was personally involved in the relief effort, contracted the disease which resulted in her death on 10th March 1897.

Academic research has given us extremely valuable insights into women's lives in different ages and different cultures. One can get a glimpse of an educated woman through the way she communicates, with other women in society, the women who collect our rubbish, deliver the laundry, and work as domestic helps and in menial jobs. Women empowerment will take new strides, when we teach our sons to treat women in a humane

manner. Savitribai Phule is an inspiration for the students, the parents, and the community at large. In her mission of social resurgence, she encountered several adversities, which she tackled sometimes through discussions and at times with debates. In every era a woman may not be blessed with a liberal minded husband like Jyoti Rao, hence a woman must light up her own life through the medium of education.

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Assessing The Influence Of Savitribai Phule's Social Reforms On The Advancement Of Women In Indian Society: An Analytical Perspective

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Abstract: This study critically assesses the impact of Savitribai Phule's social reforms on the advancement of women in Indian society from an analytical perspective. Savitribai Phule, a prominent figure in the 19th-century Indian social reform movement, dedicated her life to advocating for women's rights, education, and social equality. Through a comprehensive analysis of historical sources, biographical accounts, and scholarly literature, this study examines the multifaceted influence of Savitribai Phule's initiatives on the status and empowerment of women in Indian society. Key areas of focus include the expansion of educational opportunities for women, efforts to challenge patriarchal norms and discriminatory practices, and the promotion of women's participation in social and political spheres. By critically evaluating the legacy of Savitribai Phule, this study aims to shed light on the enduring relevance of her ideals and contributions to the ongoing struggle for gender equality and social justice in India.

Keywords: Savitribai Phule, social reforms, women's advancement, gender equality, Indian society, analytical perspective.

Introduction:

Background information on Savitribai Phule and her socio-cultural context: Savitribai Phule was a pioneering figure in the Indian social reform movement of the 19th century. Born in 1831 in Maharashtra, India, Savitribai faced discrimination and oppression due to her gender and caste. However, despite facing immense societal barriers, she pursued education, becoming one of the first female teachers in India. Savitribai's marriage to Jyoti Rao Phule, a social reformer and thinker, marked the beginning of her involvement in social activism. Together, they challenged prevailing social norms and worked towards the upliftment of marginalized communities, particularly women and lower castes, in Indian society.

During the 19th century, Indian society was deeply entrenched in patriarchal and caste-based hierarchies. Women, especially those from lower castes, faced systemic oppression, denied access to education, subjected to child marriage, and deprived of basic rights. Savitribai Phule emerged as a beacon of hope for these marginalized groups, advocating for their rights and dignity.

Statement of the problem and research objectives: Despite her significant contributions, the impact of Savitribai Phule's social reforms on women's development in Indian society remains underexplored in academic discourse. Therefore, this study seeks to address this gap by conducting an analytical examination of the influence of Savitribai Phule's initiatives on the status and empowerment of women in Indian society.

The primary objectives of this research are as follows:

To critically analyze the key social reforms advocated by Savitribai Phule, including her efforts in promoting female education, challenging gender-based discrimination, and advocating for women's rights to property and inheritance.

To assess the extent to which Savitribai Phule's reforms contributed to the advancement of women's development in Indian society, particularly in terms of educational attainment, socio-economic empowerment, and participation in public life.

To explore the enduring legacy of Savitribai Phule and her relevance in contemporary discussions on gender equality, social justice, and women's rights in India.

Importance of studying the impact of Savitribai Phule's social reforms on women's development in Indian society: The study of Savitribai Phule's social reforms is of paramount importance for several reasons:

Historical significance: Savitribai Phule played a pivotal role in challenging oppressive social norms and advocating for the rights of marginalized communities, particularly women and lower castes, during a critical period in Indian history.

Inspirational legacy: Savitribai's life and work continue to inspire generations of activists, scholars, and policymakers in their quest for gender equality and social justice.

Policy implications: Understanding the impact of Savitribai Phule's reforms can inform contemporary policy initiatives aimed at promoting women's development and empowerment in India.

Academic inquiry: The study of Savitribai Phule's social reforms provides valuable insights into the dynamics of social change and resistance in Indian society, offering lessons for future research and scholarship in the fields of gender studies, social history, and development studies.

Historical Context of Women's Status in 19th Century India:

Overview of the status of women in pre-colonial and colonial India: Pre-colonial India:

In pre-colonial India, women's status varied significantly depending on factors such as region, religion, caste, and socio-economic class.

Women in ancient India were often depicted in scriptures and texts as revered figures, embodying virtues such as wisdom, strength, and devotion. However, this idealized portrayal did not necessarily translate into societal practices.

Despite the presence of powerful female rulers such as Rani Lakshmibai of Jhansi and Ahilyabai Holkar, most women in pre-colonial India were subject to patriarchal norms and restrictions.

The practice of child marriage was prevalent, with girls often married off at a young age, sometimes even before reaching puberty.

Women's access to education was limited, particularly among lower castes and marginalized communities. Formal education was primarily reserved for boys from privileged backgrounds.

Colonial India:

The colonial period brought significant changes to Indian society, including alterations in the status and roles of women.

British colonial policies, while ostensibly aiming to uplift Indian society, often reinforced existing patriarchal structures and stereotypes.

The introduction of English education and Western values led to debates on gender roles and women's rights within Indian reformist circles.

The codification of Hindu personal laws by the British colonial administration further entrenched discriminatory practices against women, particularly in matters of inheritance, marriage, and property rights.

Missionary activities and Christian schools provided education and social welfare services to some Indian women, albeit within a framework that promoted Western cultural values and norms.

The emergence of social reform movements, such as the Brahmo Samaj and the Arya Samaj, brought attention to issues such as widow remarriage, female infanticide, and the status of widows in Indian society.

Social and cultural constraints faced by women in traditional Indian society:

Patriarchal family structures: Indian society was characterized by patriarchal family systems in which male authority was dominant, and women's roles were primarily confined to domestic duties and caregiving.

Child marriage: The practice of child marriage was deeply ingrained in Indian society, perpetuating cycles of early motherhood, limited education, and economic dependence for girls.

Sati and widowhood: The custom of sati, in which widows were expected to immolate themselves on their husbands' funeral pyres, was prevalent in certain regions despite being outlawed by British authorities in the 19th century. Widows often faced social ostracism, economic deprivation, and limited autonomy.

Restrictions on education and mobility: Access to education for girls was restricted, with emphasis placed on domestic skills rather than formal schooling. Women's mobility outside the household was often curtailed, particularly in conservative communities.

Lack of property and inheritance rights: Women had limited rights to property and inheritance, with property ownership and control largely vested in male relatives.

Overall, the 19th century witnessed a complex interplay of continuity and change in the status of women in Indian society. While traditional social norms and cultural practices persisted, the colonial encounter and emerging social reform movements laid the groundwork for shifts in attitudes towards gender roles and women's rights, setting the stage for future struggles for gender equality and empowerment.

Life and Work of Savitribai Phule:

Biography of Savitribai Phule: Early life, education, and marriage to Jyoti Rao Phule:

Early Life: Savitribai Phule was born on January 3, 1831, in Naigaon, Maharashtra, India, into a family belonging to the Mali caste, which was considered low caste at that time. She faced discrimination and social stigma due to her caste and gender from an early age.

Education: Despite societal opposition to female education, Savitribai's father, Khandoji Nevase Patil, recognized the importance of education and arranged for her to receive schooling at an early age. Savitribai showed exceptional academic aptitude and became one of the first women in Maharashtra to receive formal education.

Marriage to Jyoti Rao Phule: At the age of nine, Savitribai was married to Jyoti Rao Phule, who later became a prominent social reformer. Their marriage was unconventional for the time, marked by mutual respect, support, and a shared commitment to social justice. Jyoti Rao played a crucial role in Savitribai's intellectual and personal development, encouraging her to pursue further education and actively participate in social reform activities.

Role of Savitribai Phule in the Satyashodhak Samaj and social reform movements:

Co-founding the Satyashodhak Samaj: In 1873, Jyoti Rao Phule founded the Satyashodhak Samaj (Society for Truth Seekers) as a platform for social reform and the upliftment of marginalized communities, including women, Dalits, and lower castes. Savitribai was an integral part of this movement, actively participating in its activities and advocating for women's rights.

Promotion of Female Education: Savitribai recognized the importance of education in empowering women and challenging social hierarchies. Together with Jyoti Rao, she established the first school for girls in Pune in 1848, breaking new ground in female education in India. Despite facing opposition and hostility from conservative elements, Savitribai remained steadfast in her commitment to providing educational opportunities for girls from all castes and backgrounds.

Campaign against Social Evils: Savitribai Phule was a vocal critic of prevalent social evils such as child marriage, caste discrimination, and the mistreatment of widows. She actively campaigned for the abolition of child marriage and the promotion of widow remarriage, challenging entrenched patriarchal norms and traditions.

Advocacy for Women's Rights: Savitribai played a pioneering role in advocating for women's rights to property, inheritance, and social equality. She supported women in asserting their agency and autonomy, encouraging them to participate in public life and pursue their aspirations.

Literary Contributions: Savitribai was also a prolific writer and poet, using her literary talents to raise awareness about social issues and inspire change. She wrote powerful poems addressing themes of gender equality, caste oppression, and the struggle for justice, which continue to resonate with audiences today.

Overall, Savitribai Phule's life and work exemplify her unwavering commitment to social reform and the empowerment of marginalized communities, particularly women. Her legacy continues to inspire generations of activists and feminists in India and around the world, highlighting the transformative potential of grassroots movements for social change.

Social Reforms Advocated by Savitribai Phule:

Promotion of Female Education and Establishment of Schools for Girls:

Savitribai Phule recognized education as a potent tool for empowering women and challenging entrenched social hierarchies. Alongside her husband, Jyoti Rao Phule, she played a pivotal role in promoting female education in 19th-century Maharashtra.

In 1848, Savitribai and Jyoti Rao established the first school for girls in Pune, breaking new ground in female education in India. The school aimed to provide formal education to girls from all castes and backgrounds, including those from marginalized communities who were traditionally denied access to schooling.

Savitribai's efforts in establishing and running schools for girls were met with resistance f from conservative elements in society who opposed the idea of educating women. She faced various challenges, including social ostracism and threats of violence, but remained steadfast in her commitment to the cause of female education.

Campaign Against Child Marriage and Widow Remarriage:

Savitribai Phule was a staunch critic of prevalent social practices such as child marriage and the mistreatment of widows. She actively campaigned for the abolition of child marriage and the promotion of widow remarriage, which were deeply ingrained customs in Indian society.

Through her writings, speeches, and activism, Savitribai challenged the notion that girls should be married off at a young age, emphasizing the importance of allowing them to pursue education and personal development. She also advocated for the rights of widows to remarry and lead fulfilling lives beyond the confines of widowhood.

Savitribai's advocacy for the rights of women and girls to choose their own destinies and break free from oppressive social norms laid the groundwork for future reforms in India's legal and social systems.

Advocacy for Women's Rights to Property and Inheritance:

Savitribai Phule was a vocal proponent of women's rights to property and inheritance, which were often denied to them under prevailing social and legal norms.

She argued that women should have equal rights to property and inheritance as men, challenging the patriarchal notion that women were inherently inferior and dependent on male relatives for their economic well-being.

Through her activism and writings, Savitribai sought to raise awareness about the injustices faced by women in matters of property ownership and inheritance, advocating for legal reforms to ensure gender equality in these areas.

Efforts to Eradicate Caste-Based Discrimination and Promote Social Equality:

Savitribai Phule was deeply committed to the eradication of caste-based discrimination and the promotion of social equality in Indian society. She believed that caste oppression was one of the most significant barriers to social progress and advocated for the rights of Dalits and lower castes.

Savitribai actively supported inter-caste marriages and social integration, challenging the rigid caste hierarchy that perpetuated inequality and injustice. She worked tirelessly to create a more inclusive and egalitarian society where individuals were judged not by their caste or birth but by their character and abilities.

Through her involvement in social reform movements such as the Satyashodhak Samaj, Savitribai contributed to the broader struggle for social justice and equality, leaving behind a legacy of activism and advocacy that continues to inspire generations of social reformers in India.

Impact of Savitribai Phule's Reforms on Women's Development:

Expansion of Educational Opportunities for Women and its Socio-Economic Implications:

Savitribai Phule's relentless advocacy for female education led to a significant expansion of educational opportunities for women in 19th-century India. Through the establishment of schools for girls and her promotion of female literacy, Savitribai paved the way for thousands of girls to receive formal education, empowering them with knowledge and skills that were previously inaccessible.

The expansion of educational opportunities for women had profound socio-economic implications. Educated women were better equipped to participate in the workforce, contribute to household income, and break the cycle of poverty. They gained access to a wider range of employment opportunities beyond traditional domestic roles, thus enhancing their economic independence and socio-economic status.

Furthermore, educated women were more likely to make informed decisions about their health, family planning, and overall well-being, leading to improvements in maternal and child health outcomes. Education also fostered critical thinking, creativity, and problem-solving skills among women, enabling them to become agents of change in their communities.

Changes in Social Attitudes towards Women's Rights and Gender Roles:

Savitribai Phule's advocacy for women's rights and gender equality challenged deeply ingrained patriarchal attitudes and norms in Indian society. Her efforts contributed to a gradual shift in social attitudes towards women's status and roles, fostering greater recognition of women's rights and capabilities.

By advocating for the abolition of practices such as child marriage and the mistreatment of widows, Savitribai helped raise awareness about the injustices faced by women and inspired broader social reform movements aimed at addressing gender-based discrimination.

Savitribai's emphasis on the importance of women's education challenged prevailing stereotypes about women's intellectual inferiority and their limited role within the household. As more women gained access to education and knowledge, traditional gender roles began to be questioned, paving the way for greater gender equity and opportunities for women in various spheres of life.

Empowerment of Women through Increased Participation in Social and Political Spheres:

Savitribai Phule's reforms played a crucial role in empowering women to actively participate in social and political spheres, thereby amplifying their voices and agency. Through education and awareness-raising initiatives, women gained the confidence and skills necessary to engage in public discourse, advocate for their rights, and challenge oppressive systems of power.

Women who received education under Savitribai's initiatives became leaders and change-makers in their communities, spearheading social reform efforts and championing causes related to women's rights, education, and social justice.

Furthermore, Savitribai's advocacy for women's inclusion in decision-making processes and political activism laid the foundation for future movements advocating for women's suffrage and political representation in India.

Overall, Savitribai Phule's reforms had a transformative impact on women's development by empowering them with education, challenging discriminatory social norms, and fostering their active participation in shaping the socio-political landscape of India. Her legacy continues to inspire generations of women to strive for equality, justice, and empowerment.

Legacy of Savitribai Phule and Contemporary Relevance:

Continuation of her work by subsequent generations of activists and reformers:

Savitribai Phule's pioneering efforts in the field of social reform and women's empowerment laid the groundwork for subsequent generations of activists and reformers in India. Her legacy continues to inspire individuals and organizations dedicated to advancing gender equality, social justice, and human rights.

Many grassroots organizations and non-governmental organizations (NGOs) in India today draw inspiration from Savitribai's commitment to education, social reform, and the empowerment of marginalized communities. These organizations work towards promoting access to education for girls, combating gender-based violence, and advocating for women's rights in various spheres of life.

Savitribai's emphasis on the intersectionality of caste, class, and gender oppression has influenced contemporary social justice movements in India, which seek to address multiple forms of discrimination and inequality.

Women's rights activists and feminists in India continue to invoke Savitribai's name and legacy in their advocacy efforts, highlighting her pioneering role in challenging patriarchal norms and advocating for women's agency and autonomy.

Savitribai's legacy is also evident in the work of educators, scholars, and intellectuals who strive to promote critical thinking, gender-sensitive pedagogy, and inclusive education systems that prioritize the needs and aspirations of all learners, regardless of their gender or social background.

Reflections on the enduring relevance of Savitribai Phule's ideals in the context of contemporary gender issues in India:

Gender-based violence and discrimination: Savitribai Phule's advocacy against practices such as child marriage, widowhood rituals, and caste-based discrimination remains highly relevant in the context of contemporary gender issues in India. Despite legal reforms and social progress, women and girls continue to face various forms of violence, discrimination, and marginalization based on their gender, caste, and socio-economic status.

Education and empowerment: The importance of education as a tool for women's empowerment and social transformation, championed by Savitribai, continues to be a central theme in contemporary debates on gender equality and development. Efforts to promote girls' education, ensure access to

quality schooling, and address gender disparities in education remain key priorities for policymakers and activists alike.

Political participation and representation: Savitribai Phule's advocacy for women's participation in public life and decision-making processes resonates strongly in the contemporary context of efforts to increase women's political representation and leadership. Despite progress in some areas, women remain underrepresented in political institutions and face numerous barriers to meaningful participation in governance and decision-making.

Intersectionality and social justice: Savitribai's recognition of the intersecting nature of caste, class, and gender oppression provides a valuable framework for understanding and addressing contemporary social justice issues. Efforts to combat multiple forms of discrimination and promote inclusivity and equity across various social domains are informed by Savitribai's legacy of intersectional activism and solidarity with marginalized communities.

Struggles for social change: Savitribai Phule's life and work serve as a source of inspiration and resilience for contemporary activists and movements striving for social change and justice. Her commitment to challenging power structures, amplifying marginalized voices, and advocating for the rights and dignity of all individuals continues to guide and motivate those engaged in the ongoing struggle for gender equality and social justice in India and beyond.

Conclusion:

Summary of key findings and insights from the study:

Savitribai Phule emerged as a pioneering figure in the Indian social reform movement of the 19th century, advocating for women's rights, social equality, and education.

Through her relentless efforts, Savitribai promoted female education by establishing schools for girls and challenging prevailing social norms that restricted women's access to learning.

She campaigned against social evils such as child marriage, widowhood rituals, and caste-based discrimination, advocating for the rights and dignity of women from all backgrounds.

Savitribai's advocacy for women's rights to property, inheritance, and social equality laid the groundwork for future reforms in India's legal and social systems.

Her legacy continues to inspire generations of activists, scholars, and policymakers in their quest for gender equality, social justice, and human rights in India and beyond.

Implications for policy and future research directions:

Policy Implications: The study underscores the importance of policies and programs aimed at promoting female education, combating gender-based violence, and ensuring women's participation in decision-making processes.

Educational Reforms: There is a need for comprehensive educational reforms that prioritize gender-sensitive pedagogy, inclusive curricula, and equitable access to quality schooling for all learners, regardless of their gender or social background.

Legal Reforms: Efforts should be made to enact and enforce laws that protect women's rights to property, inheritance, and social equality, in line with the principles advocated by Savitribai Phule.

Future Research Directions: Further research is needed to explore the long-term impacts of Savitribai Phule's reforms on women's development in Indian society, including their effects on education, health, economic empowerment, and political participation.

Intersectionality and Social Justice: Future studies should adopt an intersectional approach to examine the intersecting forms of discrimination faced by women based on factors such as caste, class, religion, ethnicity, and sexual orientation.

Final reflections on the significance of Savitribai Phule's contributions to women's development in Indian society:

Savitribai Phule's contributions to women's development in Indian society are immense and enduring. Her advocacy for education, social reform, and gender equality laid the foundation for subsequent generations of activists and reformers.

She challenged prevailing social norms and fought against systemic injustices, inspiring millions to strive for a more equitable and just society.

Savitribai's legacy serves as a reminder of the transformative power of grassroots movements and the importance of collective action in advancing women's rights and social justice.

Her life and work continue to inspire individuals and organizations dedicated to promoting gender equality, social justice, and human rights, reaffirming her status as a symbol of courage, resilience, and hope for women's empowerment in India and beyond.

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REGIONAL INEQUALITY IN LITERACY ASPECTS IN INDIA: AN ANALYSIS

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Abstract

Literacy forms an important input in overall development of individuals enabling them to comprehend their social, political and cultural environment better and respond to it appropriately. It acts as a catalyst for social upliftment enhancing the returns on investment made in almost every aspect of development effort, be it population control, health, hygiene, environmental degradation control, employment of weaker sections of the society. Literacy rate in India (Census of India, 2011) was found to be 74.04 percent. When compared to the adult literacy rate, the youth literacy rate was about 9 percent higher. During the last decade, the highest improvement in literacy rate was observed among rural females (24 percent). This paper is descriptive in nature and examines the regional inequality in literacy aspects in India based on 75th round of National Sample Survey data. This will be useful in decision support, frame policy measures to improve literacy rate among the regions.

Key Words

Literacy, Education, Region, Inequality, gender and Census of India

Introduction

Educational attainment is the first and foremost step towards improving quality of life, awareness level and also level of skill of people in the society. Considering the importance of education, India has enacted ‘ Right to Education Act,2009’ to ensure free and compulsory Education for children in the age group 6-14 years. Literacy and education are important indicators in a society and play a central role in human development that impacts overall social-economic development milieu. Higher levels of literacy and education lead to better attainment of health and nutritional status, economic growth, population control, empowerment of the weaker sections and community as a whole. Also, higher literacy rates improve

development indicators consistently. Census obtains information on literacy for every individual, as this is recognised as one of the most important social characteristics. In census, a person aged seven years and above who can both read and write in any language, is treated as ‘ literate’ . A person, who can only read but cannot write, is not considered as ‘ literate’ (Census of India, 2011).

Literacy is the main foundation for social and economic growth. Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society (UNESCO, 2018). Generally, literacy also encompasses numeracy, the ability to make simple arithmetic calculations. Literacy and education is also one of the main components of human development index (HDI), as it has direct impact on the per capita income, level of living and ultimately on life expectancy. There is a strong empirical co-relation between literacy and life expectancy (Khan, 2004). In international usages, literacy is defined as the ability to read write and at least a simple message in any language (Hassan, 2005). Education is the single best development investment and a powerful instrument to develop an economically prosperous society. The long term social and economic return from education is enormous. The level of development of any region or any area may be gauged through the socio-economic characteristics of people. Of the various elements of population characteristics, the level of literacy and education gives the best exposition of regional development because of its dual functions as cause and effect of modernization.

Review of literature

Gopala Krishan and Madhav Shyam (1978) describe and interpret the regional aspects of the urban-rural differential in literacy in India in relation to economic, society and educational history different of India on the basis of 1971 census data. Siddiqui Shafiqullah (2011) attempted to analyses the trends of differential in literacy rate, spatial patterns of urban-rural differential and the relationship between differential index and selected variables of development among the districts of Uttar Pradesh, India. Kalyan Sundar Som and Ramesh Prasad Mishra (2014) examined the literacy and their differential in West Bengal, India. Ghanshyam Prasad Jhariya and C.K.Jain (2014) attempted to study the trends and pattern and their differential (Male-female and urbanrural) of literacy in Madhya Pradesh. The male – female and rural – urban differential has been worked out. There are remarkable gaps between male and female and between rural and urban rates in the state. Jangra, Ravinder and Kaushik, Satya (2015) describe and interpret the regional aspects of the urban-rural differentials in female literacy during 1991, 2001 and 2011, identify the correlates of female literacy in an agro-based economy, the total female literacy rate has increased significantly during the study period, and there are wide gaps in urban-rural female literacy. Comparatively, the increase is more remarkable in rural areas and gap is narrowing down. Vachaspati Shukla and Udaya S

Mishra (2020) examined the progress in literacy among the Indian states are evaluated here from an age cohort perspective.

Objectives

1. To examine the inequality in literacy aspects in India, also its states and
2. To suggest measures to improve aspects of literacy

Method and Material

The paper is based on descriptive and data collected from 75th round of National Sample Survey conducted on Household Social Consumption: Education during 1st July 2017 to 30th June 2018. A stratified multi-stage design was adopted for the 75th round survey and covers whole of the Indian Union except the villages in Andaman and Nicobar Islands. In this survey, total number of persons of age 3 to 35 years surveyed was 2, 86,456 (1, 73,397 in rural areas and 1, 13,059 in urban areas). Percentage of literates among persons of age 7 years and above has been defined as literacy rate.

Analysis and Discussion

Literacy rate

Literacy and level of education are basic indicators of the level of development achieved by a society. Spread of literacy is generally associated with important traits of modern civilization such as modernization, urbanization, industrialization, communication and commerce. Literacy forms an important input in overall development of individuals enabling them to comprehend their social, political and cultural environment better and respond to it appropriately. Education is a human right. Education is essential for human emancipation and social development. It contributes to better health, higher productivity, greater income, human freedom, capability and esteemed living, increased participation in community life. Literacy is an important demographic element of human process. It is essential for human character, social and economic development. Education includes new ideas for a better building of the society and their personal life style. Table- 1 gives data on literacy rate (in per cent) among persons of age 7 years and above for different States and regions.

Table-1: Literacy rate (in per cent) among persons of age 7 years and above for different states and regions

State	Rural			Urban **(in per cent)**			Rural+Urban **(in per cent)**		
	Male	Female	Person	Male	Female	Person	Male	Female	Person
Jammu and Kashmir	84.9	66.0	75.8	88.5	75.7	82.6	85.7	68.0	77.3
Himachal Pradesh	92.3	79.2	85.6	97.8	93.0	95.5	92.9	80.5	86.6
Haryana	85.8	66.4	77.0	92.5	81.2	87.3	88.0	71.3	80.4
Punjab	85.5	74.0	80.0	93.8	86.7	90.5	88.5	78.5	83.7
Uttarakhand	93.1	79.0	86.1	97.4	85.9	92.0	94.3	80.7	87.6
Uttar Pradesh	80.5	60.4	70.8	86.8	74.9	81.2	81.8	63.4	73.0
Delhi	-	-	-	94.1	83.4	89.4	93.7	82.4	88.7
Rajasthan	77.6	52.6	65.5	91.1	74.6	83.5	80.8	57.6	69.7
North Region	**85.7**	**68.2**	**77.3**	**92.8**	**81.9**	**87.8**	**88.2**	**72.8**	**80.9**
Gujarat	85.7	68.0	77.0	95.2	86.3	91.1	89.5	74.8	82.4
Maharashtra	87.0	71.4	79.4	95.3	87.6	91.7	90.7	78.4	84.8
West Region	**86.4**	**69.7**	**78.2**	**95.3**	**87.0**	**91.4**	**90.1**	**76.6**	**83.6**
Chhattisgarh	84.0	65.6	75.0	91.8	82.3	87.2	85.4	68.7	77.3
Madhya Pradesh	77.9	61.0	69.8	91.4	79.5	85.8	81.2	65.5	73.7
Central Region	**81.0**	**63.3**	**72.4**	**91.6**	**80.9**	**86.5**	**83.3**	**67.1**	**75.5**
Bihar	78.6	58.7	69.5	89.3	75.9	83.1	79.7	60.5	70.9
Jharkhand	80.6	61.4	71.4	92.6	78.6	86.1	83.0	64.7	74.3
Odisha	82.0	67.3	74.9	94.4	85.9	90.2	84.0	70.3	77.3
West Bengal	82.0	72.6	77.4	91.4	84.7	88.1	84.8	76.1	80.5
East Region	**80.8**	**65.0**	**73.3**	**92.0**	**81.3**	**86.9**	**82.9**	**67.9**	**75.8**
Assam	89.4	79.9	84.9	96.1	91.4	93.8	90.1	81.2	85.9
Northeast Region	**89.4**	**79.9**	**84.9**	**96.1**	**91.4**	**93.8**	**90.1**	**81.2**	**85.9**
Andhra Pradesh	67.5	53.4	60.4	86.3	73.1	79.6	73.4	59.5	66.4
Telangana	70.6	53.7	62.1	91.7	79.0	85.5	80.5	65.1	72.8
Karnataka	78.2	63.1	71.0	92.5	83.7	88.3	83.4	70.5	77.2
Kerala	96.7	94.1	95.4	98.2	96.4	97.3	97.4	95.2	96.2
Tamil Nadu	84.2	70.8	77.5	92.3	85.9	89.0	87.9	77.9	82.9
South Region	**79.4**	**67.0**	**73.3**	**92.2**	**83.6**	**87.9**	**84.5**	**73.6**	**79.1**
All India	**81.5**	**65.0**	**73.5**	**92.2**	**82.8**	**87.7**	**84.7**	**70.3**	**77.7**

Note: Figures for rural Delhi is not presented separately. However, ' rural + urban' for Delhi includes, ' rural' also.
Source: NSS 75th Round, July 2017 – June 2018.

Table-1 depicts that higher literacy rate is found in the region of north-east followed west, north, central, east and south. Central and east region had lower literacy rate than all India level. Among the regions, lowest literacy rate registered Uttar Pradesh in north, Gujarat in west, Madhya Pradesh in Central, Bihar in East and Andhra Pradesh in South in order. In the regions and states, literacy rate was lower for females. The differentials in literacy rate in regions and states can be attributed to disparities in socio-economic, cultures, physical conditions, infrastructure facilities and education related policies.

Years of formal education

Number of years completed in formal education or levels of education and literacy lead to a greater awareness and also contributes in improvement of economic and social conditions. Also better literacy and educational level definitely have a positive impact on the health as well as other sectors that influences level of development. Data on average number of years completed in formal education among persons of age 15 years and above for different states and regions presented in table-2

Table-2: Average number of years completed in formal education among persons of age 15 years and above for different states and regions

State	Rural			Urban			Rural+Urban		
	Male	Female	Person	Male	Female	Person	Male	Female	Person
Jammu and Kashmir	9.9	9.3	9.6	10.8	10.8	10.8	10.1	9.7	9.9
Himachal Pradesh	10.3	10.0	10.1	12.6	11.7	12.2	10.6	10.2	10.4
Haryana	10.0	9.5	9.8	11.7	11.5	11.6	10.6	10.3	10.5
Punjab	9.4	9.2	9.3	11.0	11.1	11.1	10.0	10.0	10.0
Uttarakhand	10.4	9.7	10.0	12.5	11.7	12.1	11.0	10.2	10.6
Uttar Pradesh	9.6	9.2	9.5	11.2	11.0	11.1	10.0	9.7	9.9
Delhi	-	-	-	11.4	11.4	11.4	11.4	11.4	11.4
Rajasthan	9.3	8.5	9.0	11.1	10.5	10.9	9.8	9.1	9.6
North Region	**9.8**	**9.3**	**9.6**	**11.5**	**11.2**	**11.4**	**10.4**	**10.1**	**10.3**
Gujarat	8.9	8.0	8.6	10.8	10.2	10.5	9.8	9.0	9.4
Maharashtra	9.5	8.6	9.1	11.4	10.8	11.2	10.4	9.7	10.1
West Region	**9.2**	**8.3**	**8.9**	**11.1**	**10.5**	**10.9**	**10.1**	**9.4**	**9.8**
Chhattisgarh	8.9	8.0	8.5	11.1	10.6	10.9	9.4	8.7	9.1
Madhya Pradesh	8.7	7.8	8.4	10.9	10.4	10.6	9.4	8.6	9.1
Central Region	**8.8**	**7.9**	**8.5**	**11.0**	**10.5**	**10.8**	**9.4**	**8.7**	**9.1**
Bihar	9.1	8.2	8.8	11.1	10.2	10.7	9.4	8.5	9.0
Jharkhand	8.6	7.7	8.2	10.8	10.3	10.6	9.1	8.4	8.8
Odisha	8.5	8.0	8.3	11.1	10.4	10.8	9.0	8.5	8.8
West Bengal	8.3	7.8	8.1	10.3	9.8	10.1	9.0	8.5	8.7
East Region	**8.6**	**7.9**	**8.4**	**10.8**	**10.2**	**10.6**	**9.1**	**8.5**	**8.8**
Assam	9.1	8.3	8.7	11.5	10.6	11.1	9.4	8.6	9.0
Northeast Region	**9.1**	**8.3**	**8.7**	**11.5**	**10.6**	**11.1**	**9.4**	**8.6**	**9.0**
Andhra Pradesh	9.3	8.6	9.0	10.7	9.9	10.3	9.8	9.1	9.5
Telangana	9.8	9.1	9.5	11.9	11.3	11.7	11.0	10.4	10.7
Karnataka	9.2	8.7	9.0	11.8	11.0	11.4	10.3	9.7	10.1
Kerala	10.2	10.2	10.2	10.6	10.8	10.7	10.4	10.4	10.4
Tamil Nadu	9.6	9.0	9.3	11.0	10.2	10.6	10.3	9.7	10.0
South Region	**9.6**	**9.1**	**9.4**	**11.2**	**10.6**	**10.9**	**10.4**	**9.9**	**10.1**
All India	**9.2**	**8.6**	**9.0**	**11.2**	**10.6**	**10.9**	**9.9**	**9.4**	**9.7**

Note: Figures for rural Delhi is not presented separately. However, ' rural + urban' for Delhi includes, ' rural' also.
Source: NSS 75th Round, July 2017 – June 2018.

Table-2 reveals that the average number of years completed in formal education among persons of age 15 years and above has registered in region of north followed by south, west, north east, west and east region. Enteral and east regions registered lower literacy rate than national level. Among the regions, Uttar Pradesh in north, Andhra Pradesh in south, Gujarat in west, Madhya Pradesh in Central and West Bengal in east in order had lower average number of years completed in formal education among persons of age 15 years and above. Average number of years completed in formal education was lower for females. It is generally influenced by socio-economic status and cultural aspects along with parents' perception on importance of higher education.

Gross Attendance Ratio (GAR)

GAR is one of the important indices of literacy rate. For each level of education, GAR is the ratio of the number of persons attending in the level of education to the number persons in the corresponding official age-group. GAR is calculated as " Number of persons attending in particular Classes/ estimated population in the respective classes' age-group x100. Table-3 furnishes details of Gross Attendance Ratio (GAR).

Table-3: Gross Attendance Ratio (GAR) at different levels of education for different States and region (rural+urban person)

State	Level of education					
	Primary level	Upper primary/ Middle level	Primary and Upper primary/ Middle level	Secondary level	Higher Secondary level	Post higher Secondary level
Jammu and Kashmir	101.9	96.9	100.2	115.7	77.0	33.1
Himachal Pradesh	99.3	92.1	96.1	100.9	110.0	34.1
Haryana	106.3	93.8	101.3	96.7	70.3	25.2
Punjab	101.5	94.9	99.1	95.4	79.4	22.8
Uttarakhand	99.8	111.6	104.0	80.7	98.7	32.8
Uttar Pradesh	98.9	88.8	95.4	64.0	60.4	20.8
Delhi	100.2	90.6	96.8	93.6	86.2	29.6
Rajasthan	110.5	87.0	101.6	82.4	70.1	28.9
North Region	**102.3**	**94.5**	**99.3**	**91.2**	**81.5**	**28.4**
Gujarat	106.0	89.1	99.1	88.3	59.2	15.3
Maharashtra	101.1	96.5	99.5	104.0	74.3	29.3
West Region	**103.6**	**92.8**	**99.3**	**96.2**	**66.8**	**22.3**
Chhattisgarh	102.4	100.4	101.6	90.3	66.9	16.2
Madhya Pradesh	95.3	97.5	96.1	83.9	59.9	17.3
Central Region	**98.9**	**99.0**	**98.9**	**87.1**	**63.4**	**16.8**
Bihar	97.2	98.4	97.6	82.0	65.7	16.2
Jharkhand	112.4	91.4	105.3	90.0	51.3	16.8
Odisha	103.4	91.3	98.8	87.2	53.4	14.5
West Bengal	101.6	105.2	103.0	92.4	59.3	18.7
East Region	**103.7**	**96.6**	**101.2**	**87.9**	**57.4**	**16.6**
Assam	103.6	104.7	104.0	86.6	56.0	16.5
Northeast Region	**103.6**	**104.7**	**104.0**	**86.6**	**56.0**	**16.5**
Andhra Pradesh	99.3	81.9	92.2	114.1	73.0	26.1
Telangana	92.8	106.1	97.7	109.0	96.8	28.9
Karnataka	104.4	90.1	99.3	92.3	73.4	21.7
Kerala	103.6	97.2	100.9	97.3	99.9	37.6

Tamil Nadu	103.2	96.4	100.4	89.8	91.9	35.4
South Region	**100.7**	**94.3**	**98.1**	**100.5**	**87.0**	**29.9**
All India	**101.2**	**94.4**	**98.7**	**86.4**	**68.3**	**22.8**

Note: Figures for rural Delhi is not presented separately. However, ' rural + urban' for Delhi includes, ' rural' also.
Source: NSS 75th Round, July 2017 – June 2018.

Table-3 reveals that the gross attendance ratio in primary level was lower in central region and southern than all India. In upper primary/ middle level, least GAR was recorded in west region. In primary and upper primary/middle level, least GAR recorded in south. In secondary level, least GAR recorded in north-east. In higher secondary level, least GAR recorded in east region. In post higher secondary level, least GAR recorded in east and central region. In primary level, Telangana of south region had least GAR. In Upper primary/Middle level, Rajasthan of north region had lowest GAR. In Primary and Upper primary/Middle level, Andhra Pradesh of south region had lowest GAR. In Secondary level, Uttar Pradesh of north region had lowest GAR. In higher secondary level, Jharkhand of east region had lowest GAR. In post higher Secondary level, Odisha of east region had recorded lowest GAR. Thus, differential in Gross Attendance Ratio (GAR) at different levels of education for different States and region were recorded. It can be due to differential in socio-economic and cultural progress, access of education facilities and other factors.

Net Attendance Ratio (NAR)

Net Attendance Ratio is the better indicator than GAR and shows level progress in literacy rate .It is the ratio of the number of persons in the official age-group attending a particular level of education to the total number of persons in the age-group. NAR is calculated as " Number of persons currently attending in particular Classes/ estimated population in the age-group in those particular classes x100.

Table-4: Net Attendance Ratio (GAR) at different levels of education for different States and regions (rural+urban person)

State	Level of education					
	Primary level	Upper primary/ Middle level	Primary and upper primary/ Middle level	Secondary level	Higher Secondary level	Post higher Secondary level
Jammu and Kashmir	88.1	78.4	91.3	69.6	46.1	29.5
Himachal Pradesh	90.1	80.6	90.7	68.2	67.5	28.1
Haryana	89.9	77.2	90.6	63.2	47.5	20.9
Punjab	88.8	78.1	90.9	65.3	49.7	19.8
Uttarakhand	87.1	80.8	94.0	54.3	56.5	29.2
Uttar Pradesh	79.2	59.7	84.0	38.7	33.1	17.2
Delhi	89.8	73.1	87.3	62.4	54.0	23.4
Rajasthan	89.5	69.1	88.2	48.2	37.8	24.2
North Region	**87.8**	**74.6**	**89.6**	**58.7**	**49.0**	**24.0**
Gujarat	93.7	77.6	91.0	62.9	40.6	13.7
Maharashtra	90.8	79.9	91.6	71.9	54.1	25.9
West Region	92.3	78.8	91.3	67.4	47.4	19.8

Chhattisgarh	91.6	82.1	93.5	64.9	46.6	13.1
Madhya Pradesh	81.6	72.9	86.6	54.1	36.3	13.5
Central Region	**86.6**	**77.5**	**90.05**	**59.5**	**41.45**	**13.3**
Bihar	81.9	70.3	87.8	54.2	35.7	13.2
Jharkhand	87.7	61.3	91.2	50.0	29.0	13.8
Odisha	91.2	77.0	91.5	67.6	37.4	12.0
West Bengal	88.4	77.8	91.9	60.2	36.3	15.8
East Region	**87.3**	**71.6**	**90.6**	**58**	**34.6**	**13.7**
Assam	88.8	77.0	93.0	57.3	36.8	15.2
Northeast Region	**88.8**	**77.0**	**93.0**	**57.3**	**36.8**	**15.2**
Andhra Pradesh	86.5	64.6	84.5	70.7	51.8	22.4
Telangana	82.2	75.8	91.0	76.8	75.2	25.2
Karnataka	95.3	80.7	94.5	75.8	56.5	20.2
Kerala	94.4	86.3	93.6	76.9	78.5	33.2
Tamil Nadu	89.5	81.3	92.3	66.7	61.8	30.4
South Region	**89.6**	**77.7**	**91.2**	**73.4**	**64.8**	**26.3**
All India	**86.1**	**72.2**	**89.0**	**57.6**	**43.4**	**19.4**

Note: Figures for rural Delhi is not presented separately. However, ‘ rural + urban’ for Delhi includes, ‘ rural’ also.
Source: NSS 75th Round, July 2017 – June 2018.

Table-4 reveals that in primary level, a difference in net attendance ratio was meager. However, Uttar Pradesh in North, Madhya Pradesh in Central, Bihar in east, and Telangana in south region recorded lowest net attendance ratio. In upper primary/middle level, lowest net attendance ratio observed in east region. In primary and upper primary/middle level, north region recorded lowest. In secondary level, net attendance ratio was lowest in north-east region. Lowest net attendance ratio found in east region in higher secondary level and central region in post higher secondary level. Among the states, except post higher Secondary level, Uttar Pradesh recorded lowest net attendance ratio.

Dropouts

Inspite of huge expenditure spent by the national and states/UTs on education sector along with several education policies, dropout is still serious issue in India. Parent’ s attitudes, unwillingness of students, distance and lack of facilities, bad school environment and building are the few of causes for dropouts. A Study of Dropout rate of School Children in Punjab by Inderpreet Kaur (2018) highlights the alarming rate of school dropouts, find out the causes of students drop out rates and their impact on Indian economy also report that children within the rural areas drop out of school earlier than those in the urban areas. An ever-enrolled person was considered as dropped out if he/ she did not complete the last level of education for which he/she enrolled and currently not attending any educational institution for reasons other than ‘ completion of the desired level of education’ .

Table-5: Percentage of persons dropped out among ever enrolled persons of age 3 to 35 years for different States

State	Rural			Urban			Rural+Urban		
	Male	Female	Person	Male	Female	Person	Male	Female	Person
Jammu and Kashmir	10.4	13.9	11.9	7.9	10.2	8.9	9.8	13.1	11.3
Himachal Pradesh	5.4	4.8	5.1	3.8	3.9	3.8	5.2	4.7	5.0
Haryana	11.0	10.8	10.9	5.2	4.5	4.9	9.1	8.7	8.9
Punjab	5.3	3.0	4.2	4.6	2.5	3.7	5.0	2.8	4.0
Uttarakhand	3.4	3.2	3.3	4.7	2.4	3.7	3.7	3.0	3.4
Uttar Pradesh	6.8	6.7	6.8	6.1	4.6	5.4	6.7	6.3	6.5
Delhi	-	-	-	6.5	6.1	6.4	6.5	6.0	6.3
Rajasthan	12.3	16.0	13.9	10.0	11.4	10.6	11.7	14.9	13.1
North Region	**7.8**	**8.3**	**8.0**	**6.1**	**5.7**	**5.9**	**7.2**	**7.4**	**7.3**
Gujarat	21.3	19.5	20.5	13.7	13.9	13.8	18.2	17.3	17.8
Maharashtra	16.8	19.9	18.2	12.2	11.6	11.9	14.7	16.1	15.3
West Region	**19.1**	**19.7**	**19.4**	**13.0**	**12.8**	**12.9**	**16.5**	**16.7**	**16.6**
Chhattisgarh	11.3	13.2	12.2	7.7	9.4	8.5	10.7	12.4	11.5
Madhya Pradesh	14.6	14.3	14.5	8.9	10.3	9.5	13.1	13.3	13.2
Central Region	**13.0**	**13.8**	**13.4**	**8.3**	**9.9**	**9.0**	**11.9**	**12.9**	**12.4**
Bihar	9.1	13.1	10.7	4.6	7.3	5.8	8.6	12.4	10.2
Jharkhand	13.5	16.3	14.7	8.7	8.4	8.6	12.5	14.7	13.5
Odisha	22.5	23.5	23.0	10.4	14.1	12.2	20.6	21.9	21.2
West Bengal	24.9	24.7	24.8	19.9	20.4	20.1	23.5	23.5	23.5
East Region	**17.5**	**19.4**	**18.3**	**10.9**	**12.6**	**11.7**	**16.3**	**18.1**	**17.1**
Assam	18.6	23.8	21.0	13.0	15.9	14.3	18.0	23.0	20.3
Northeast Region	18.6	23.8	21.0	13.0	15.9	14.3	18.0	23.0	20.3
Andhra Pradesh	14.4	14.6	14.5	10.4	11.3	10.8	13.1	13.5	13.3
Telangana	11.2	13.9	12.4	6.5	6.3	6.4	8.9	10.3	9.5
Karnataka	15.0	18.4	16.5	7.9	9.2	8.5	12.3	14.7	13.3
Kerala	14.6	14.5	14.5	13.1	11.9	12.5	13.9	13.3	13.6
Tamil Nadu	10.8	9.4	10.1	6.9	6.6	6.7	8.1	9.0	8.5
South Region	**13.2**	**14.2**	**13.6**	**9.0**	**9.1**	**9.0**	**11.3**	**12.2**	**11.6**
All India	**13.2**	**14.7**	**13.8**	**9.5**	**9.7**	**9.6**	**12.1**	**13.2**	**12.6**

Note: Figures for rural Delhi is not presented separately. However, ' rural + urban' for Delhi includes, ' rural' also. Source: NSS 75th Round, July 2017 – June 2018.

Table-5 shows that percentage of persons dropped out among ever enrolled persons of age 3 to 35 years was east and west region. Rural of all regions recorded higher dropped out in rural than urban and higher for females than males. This clearly reveals some of the hurdles like poverty and social norms access to education in rural and for females. In northern region, highest dropout recorded in Rajasthan. Similarly, Gujarat in west region, Madhya Pradesh in central region, West Bengal in east, Assam in north east, and Kerala, Karnataka and Andhra Pradesh states in south recorded higher dropouts. Thus, significant differential in dropouts recorded among the regions, states, rural-urban areas and by gender.

Summary and policy implications

Among the regional and states, inequality in literacy rate, years of formal education, gross attendance ratio, net attendance ratio and dropped out among ever enrolled persons of age 3 to 35 years was found. Hence, tackle the inequality in examined literacy aspects, emphases should be given to special educations of New Education policy 2020 apart from strict implementation of free and compulsory education as per Right to Education Act, 2009 by considering the level of literacy, influencing obstacles such as geographical, socio-economic and cultural apart from other aspects that prevails at regional and states level.

Measures to improve Literacy Rate

- Encouraging every female to study
- Teaching in mother tongue
- Develop love for reading
- Use of technology in teaching and learning
- Encourage learning by doing
- Institutional Social Responsibility (ISR)
- Social Responsibility of every educated and employed citizen

Every citizen should be given a compulsory task to educate children in their own neighbourhoods. Local Governing bodies can target the area to analyse and formulate plan to cover up the population in bringing up the rate of literacy in India.

Limitation

The main limitation of the study is that for north-east region, data related to education aspects available for Assam state only.

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WOMEN WELFARE PROGRAMMES THOURGH SUSTAINABLE DEVELOPMENT OF WOMEN IN ANDHRA PRADESH

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Abstract:

Women's empowerment is a crucial process aimed at granting women access to and control over material and informational resources. This concept, first articulated in 1985 by Development Alternatives with Women for a New Era (DAWN), empowers individuals, groups, and communities to take charge of their circumstances, thereby enhancing their quality of life. Women constitute an essential part of the labor force, and their economic involvement is intricately linked to overall development. The level of women's integration into economic development serves as an indicator of economic independence and social status. Women's empowerment encompasses equipping rural women with the necessary skills to undertake various tasks independently or collectively, granting them improved access to and control over societal resources. Empowerment is recognized as a pivotal strategy for enhancing the well-being of individuals, families, communities, as well as governmental and non-governmental agencies. It is crucial to continually refine women's empowerment strategies to ensure they are effective and yield tangible results. Notably, income earned by impoverished women tends to be prioritized for essential life needs, underscoring the significance of women as focal points in development efforts. When women work together in groups, it fosters a newfound sense of solidarity and cooperation, contributing to their economic independence.

Keywords: Women Empowerment, Economic Independence, Sustainable development, Leadership.

Introduction:

India, with its staggering population of over one billion people, grapples with the complex challenge of poverty and gender inequality. Approximately 26 percent of its populace lives below the poverty line, based on national minimum calorie intake standards of 2,400 calories per person in rural areas and 2,100 calories in urban areas. This poverty is unevenly distributed across the country, with pronounced regional disparities, notably between northern and southern India, where poverty concentrations are more pronounced in the north. Moreover, income inequality has been on the rise, increasing by 10 percent in the 2000s.

Furthermore, considering broader indicators such as education and health, as measured by the UNDP Human Development Index, the poverty rate in India becomes even more distressing, with 32 percent of households experiencing poverty in 2003. However, these statistics alone fail to capture the full extent of vulnerability, including factors contributing to the risk of falling in and out of poverty.

Vulnerability in India emanates from multiple sources, including shock-induced poverty, stemming from factors such as income loss and asset destruction at the household level, and idiosyncratic vulnerability due to elements like disease epidemics, healthcare expenses, death-related costs, theft, violence, and the consequences of globalization, such as job loss and inflation. Entire communities also face covariate vulnerability, encompassing threats like floods and droughts.

The marginalized status of women in Indian society plays a pivotal role in exacerbating these structural issues. In many regions of India, women endure neglect, discrimination, domestic responsibilities, caring for siblings, and often engage in labor outside the home. From a young age, girls face the specter of inadequate attention, nourishment, medical care, and education. As they reach adolescence, they become vulnerable to forced marriage, child labor, or prostitution. Following marriage, their status frequently deteriorates further, subjecting them to institutionalized subservience, loneliness, mental anguish, harassment, and even violence or murder.

This dire situation of women in India contributes to the concept of "missing women," a term coined by Amartya Sen, referring to women who should be alive but aren't due to social disadvantages. Disturbing statistics highlight the extent of gender bias, including women earning only 34 percent of men's wages, adult literacy ratios for women at 70 percent of those for men, and disparities in primary and high school enrollment ratios.

The unequal allocation of resources, lower wage rates, and lack of inheritance rights further compound these disparities, resulting in poorer life outcomes for women compared to men. These gender biases extend beyond the household, affecting women's legal and normative entitlements to land ownership and property exchange, leading to market failures related to the prices they receive for their labor and produce. Additionally, women's social relationships within their households and communities are influenced by these biases, as are their claims on the state for welfare and other benefits.

In addition to these challenges, significant disparities persist between men and women in terms of their access to assets, control over their labor, status, training opportunities, and access to resources for income generation activities. While there have been some improvements in the past decade, overcoming the deeply entrenched institutionalized disadvantages faced by Indian women remains an ongoing struggle.

In this context, women's empowerment and welfare programs play a critical role in addressing these issues, bridging gender disparities, and improving the well-being of women in India. These programs aim to empower women economically, socially, and politically, providing them with the tools and opportunities needed to break free from the cycle of poverty and discrimination. Sustainable development hinges on an equitable distribution of resources for both present and future generations, making gender equality a fundamental component of this pursuit. Women's empowerment is a key driver for achieving sustainable economic growth, social development, and environmental sustainability, as it fosters a balanced approach to development that benefits all segments of society.

NAVARATNALU

Here are the nine Navaratnalu welfare schemes.

1.YSR Rythu Bharosa

The YSRCP promises to offer Rs 50,000 financial assistance to farmers. Starting second year, each farmer family would be given Rs 12,500 per year, in addition to zero-interest loans and free borewells. Cold storages and food processing units in every constituency are among a list of benefits promised to the farmers.

Benefits to the citizens

- Every farmer to be provided Rs 50000 financial assistance. Crop sowing farmers to get Rs 12500 per year.
- Farmers need not worry about crop insurance. Government to pay crop insurance premium on behalf of farmers.
- Interest free Crop loans to be provided to farmers.
- Free bore-wells to be provided to farmers.
- 9 hours Free electricity during day time for agriculture purpose.
- Aqua culture farmers to get electricity @ Rs 1.50 per unit.
- Rs 3000 crores corpus fund allotted to prices stabilization. Rates to be declared before crop sowing.
- Farmers to be assured Minimum support price.
- Rs 4000 crores allotted for Natural disaster Relief fund.
- Every constituency to be provided with cold storages, go-downs. Food processing units to be established where necessary.
- Cooperative sector will be revived during the first year. Every dairy farmer who participates in a cooperative dairy from the second year onwards gets Rs. 4 bonus per liter.
- Toll Tax and Road Tax to be waived off for Agriculture Tractors.
- Rs 7 Lakh YSR Bhima to be provided to the family of farmer for accidental death or suicide. Act will be passed in the assembly to ensure amount does not land into the hands of loaner and government will stand by the deceased farmer family.

In the previous financial year, the government has already deposited Rs. 4.40 lakh crore into 54 lakh farmer's accounts. Other than the financial assistance of Rs 3900 crore spent in the 1st instalment, another Rs 2,000 crore is being provided by the government to the farmers.

2.Fee Reimbursement

Scholarships are of great importance to those students unable to pay their fee due to financial burden, so this scheme provides full fee reimbursement benefits to approximately 14 lakhs students of the state. Also, tuition fees, mess charges, hostel charges will be exempted from all of the students who excel in the studies as per the reports of their academics which will be provided by their hostels or by their college itself. Education expenditure will be borne for poor. Rs. 20,000 per student per annum to be provided in addition to fees reimbursement, boarding and lodging.

As mentioned above, many incentives are provided to all of the beneficiaries who enrolled themselves in the Jagananna Vidya Deevena Scheme as announced by the Chief Minister of Andhra Pradesh state.

1. The students will be given Rs 20,000/- per year.
2. Students studying from Welfare hostels will be exempted from mess charges.
3. Money incentives are as follows-

- Rs 15,000 for Polytechnic students
- Rupee 10,000 for ITI Students
- Rs 20,000 for Graduate Degree and other courses.

This scheme ensures that no student remains inaccessible to education due to his/her financial status and one benefit that has captured all of the good will of Andhra Pradesh people is the free education being provided to all beneficiaries who pass the eligibility criteria of the scheme. Also, monetary incentives are being provided every year to all the beneficiaries.

3.Arogyasri

The Arogyasri scheme would be applicable to all medical treatments of above Rs 1,000. Regardless of the location of the hospital, all medical expenses would be borne by the government.

AP government provides free treatment for specific illness to the eligible patients in any hospital in the state and the country. If the hospital bill is more than Rs.1000, the eligible ArogyaSri card holders can avail their free medical services. The objective of the scheme is to provide good quality medical treatment to BPL People for specific diseases form the renowned hospitals. All the BPL families identified by BPL ration card issued by Civil Supplies Department are eligible. All the people whose photo and name appear on Health Card / BPL (White, Annapurna and Anthyodaya Anna Yojana, RAP and TAP) ration card and suffering from identified diseases are eligible for availing treatment under the scheme.

Benefits of AP Arogyasri Scheme

Health Coverage of Rs 2.5 Lakh will be provided.

- It is a cashless treatment Scheme
- It will reduce death ratio from the state
- 1040 type of diseases will be covered
- It is a 100% government-funded scheme
- 24 hours call centre facility under the scheme (Toll-Free 104)

The Govt. of Andhra Pradesh had given top priority to public health. The annual family income to get the benefit of YSR Arogyasri was pegged at Rs. 5 lakh and the number of treatments covered under it was increased to 2450. As promised, the government had introduced YSR Bima under which poor families will get the insurance benefit if they lose the breadwinner.

Impact on Health Scenario in the State

- Early Recognition of Diseases: As the scheme progressed the pre-existing load of diseases is coming down, particularly in relation to the high-end diseases in cardiology, neurosurgery, gynaecology and obstetrics etc.,
- Improvement in documentation and regulatory effect on Hospitals: The emplacement procedure, defined diagnostic and treatment protocols, capturing of admission notes, daily clinical notes, operation notes, discharge summary and uploading of diagnostic reports including films, WebEx recording of Angio and Laparoscopic procedures and other photographic evidences have resulted in profound improvement of medical documentation in the State and regulatory effect on the hospitals.
- Improvement in quality of services: Continued monitoring of the services both online and in the field by the elaborated field mechanism coupled with disciplinary action against erring hospitals is greatly contributing to the quality of treatment under the scheme.

4.Jalayagnam

Under this scheme, lakhs of families would be benefited by the irrigation projects. Completion of Polavaram project on a war footing is promised.

Jalayagnam or Jala Yagnam, (water worship), is a water management program in India. It has been implemented by Chief Minister of Andhra Pradesh, India, Dr. Y. S. Rajasekhara Reddy as an election promise to the farmers of the state to bring 8.2 million acres (8.2 million acres) under irrigation in five years.

The concept of Jalayagnam was aimed at providing a permanent solution to drought and floods. The Government always feels that if the farmer is happy then the State will flourish. This project has the capacity to redraw the contours of the State itself. Under this scheme, lakhs of families would be benefited by the irrigation projects. Completion of Polavaram project on a war footing is promised.

With the inspiration of his father Y.S.R., Jagan Mohan Reddy promised to the people of Andhra Pradesh, he wants to re-introduce the Jalayagnam Scheme in Andhra Pradesh. Under Navaratnalu, "Jala Kala – Free Borewells" is aimed at utilizing the available groundwater Resources for the improvement of livelihoods of the farmers and thereby improve the GSDP under primary sector.

The scheme is providing free of cost borewells for all of the ranches of the Andhra Pradesh state. A lot of farmers highly depend upon the natural water resources for their irrigation of the field but because there are high draught statistics it is not possible for the farmers to use the natural groundwater resources for their irrigation. Borewells will provide to all of the farmers free of cost so that they can continue their practices and their income is also increase because of the large crop.

5.Ban on Alcohol

The YSRCP promises to put in place a ban on sale of alcohol across the State because Liquor is one of the main reasons for dispute in families due to which human relations are collapsing. Sale of alcohol will be banned in 3 stages and availability of alcohol use to be limited to 5-star hotels only. The plan is to ban its sales totally, but in a phased manner. If all goes to plan, the state should be liquor-free by 2024, well in time for the next legislative assembly election. Andhra Pradesh will join only four other Indian states-Gujarat, Mizoram, Bihar, and Nagaland- in banning the bottle.

Phases of Ban

- Jagan Reddy's plan is to introduce prohibition in a phased manner. In the first step, the Andhra Pradesh government has taken over retail sales, reduced the number of liquors vends from 4,380 to 3,500 across the state and made the state-owned AP State Beverages Corporation the sole supplier from October.
- To gradually cut availability and consumption, liquor shops will stay open from 10 am to 9 pm only, which will be reduced progressively to just a few hours a day. Official estimates of

consumption suggest that liquor sales in the state is already down 18 per cent since Reddy came to power in May end.

- A new bar licensing policy is to come into force from when their number will come down from the current 798--excluding those in star hotels and the micro- breweries. The bars will be allowed to stay open from 11 am and 7 pm. Apart from reducing business hours, the license fee will also see a big hike

6.Amma Vodi

With a view to encourage the families with school-going children, the YSRCP promises to provide Rs 15,000 towards assistance to all the mothers who send their children to school.

Government of A.P has announced "Amma Vodi" for providing financial assistance to each mother who is below poverty line household, irrespective of any differences to enable her to educate her children from class I to XII in all recognized schools/junior colleges. Under this scheme financial assistance of Rs. 15,000/- given to mothers for children education annually. With a view to encourage the families with school going children and to reduce the dropout ratio in schools, the government promises to provide Rs 15,000 towards assistance to all the mothers who send their children to school. Student enrolment has increased by 30% in the 2019-2020 academic year after the announcement of the scheme.

The initial rule of 75% mandatory attendance has been waived to encourage mothers to send their children to school. Orphans and street children studying in schools through voluntary organizations have been covered under the scheme and the money will be given to the organizations. The promised aid of ₹15000 is directly deposited in the beneficiaries' savings bank accounts in January every year until the child completes class 12.

Last year around 42 lakh beneficiaries have got the benefit of Amma Vodi scheme and this year the number has increased to 44.48 lakh. In the fiscal budget, the state government has allocated Rs 22,604 crore to the education sector out of Rs 2,24,789.18 crore. In the year 2020 budget, the government has sanctioned Rs 17,971 crore to the education sector has been increased in the budget for 2021. Out of this amount Rs. 6,107 crores have sanctioned for the Amma Vodi scheme. T

7.YSR Asara

All loans pertaining to the women's co-operative societies would be waived. In addition, zero-interest loans would be Issued YSR Cheyutha Through YSR Cheyutha, the YSRCP intends to support all women from SC, ST, BC and minority communities, who are aged above 45.

AP YSR Cheyutha Scheme being execute under Women government assistance leading body of Andhra Pradesh. Any denied network ladies belonging to these communities of SC, ST, OBC, or Minority and whose age is between 45 to 60 years may profit from the advantages of the AP YSR Cheyutha Scheme. This will be a great initiative for all of the women belonging to the minority community.

Features Of YSR Asara Scheme

- By the implementation of this scheme financial help will be provided to needy women who are living in Andhra Pradesh.
- The Government of Andhra Pradesh is going to give SHG loan to women who belong to the minority community.
- The Government of Andhra Pradesh have decided to spend 25,383 crore for this scheme in the next four years.
- Around 900000 beneficiaries will get benefit from this scheme
  YSR Cheyuta to be provided to BC, SC, ST, Minority women.
- Rs. 75000 to be granted after first year to women above 45 years age of BC, SC, ST and minorities through various corporations as YSR Cheyuta.

8.Pedalandariki illu

In five years, the YSRCP promises to build 25 lakh homes for the poor.

Chief Minister Y.S. Jagan Mohan Reddy's padayatra promise of providing pakka houses to the poor. The Chief Minister has started the construction of Pedalandariki illu vat Komaragiri layout of U Kothapalli mandal in East Godavari district on 25th December 2020. On this programme state government takes initiative to commencement of construction of 15.60 lakh houses in the first phase. In addition to these, the government also distributes sale agreements for 2.60 lakh TIDCO houses.

For the first time in the country, a house site patta is being given for just one rupee and government takes initiative to registered in the name of a woman member of the household. The beneficiaries are given 1.5 cents in rural areas or one cent in urban areas.

So far 30,75,755 beneficiaries have been identified for the scheme, of which 23,37,067 will be given houses in over 17,000 developed 'YSR Jagananna Colonies'. About 4,86,820 people who are already living in unauthorized sites, being legalized and the remaining 2,51,868 will be allocated TIDCO houses.

9.Pensionla Pempu

The eligibility age criteria of 65 years for the pensions would be reduced to 60 years. Senior citizens aged above 60 would be given Rs 2,000 while the physically challenged would be given a pension of Rs 3,000.

Door delivery of pensions under the YSR Pension Kanuka scheme one of the major initiatives of the YS Jagan Mohan Reddy. The idea of delivering pensions at the doorstep of beneficiaries through the village and ward volunteers was mooted by Chief Minister YS Jagan Mohan Reddy. This is another step in the implementation of the Navaratnalu, which were part of the YSRC election manifesto.

Instead of the beneficiaries going to the pension disbursement offices, the volunteers visit the beneficiaries and complete the formalities. The pension has been increased to Rs 2,250 from Rs 1,000 and the volunteers have been equipped with smartphones with biometric information of the beneficiaries to deliver the pension at their doorstep without any hassle. While the government has earmarked Rs 15,675.20 crore for the year towards the program

The existing eligibility criteria for sanction of pensions under the scheme is

- A monthly pension of Rs.2250/- is provided to Toddy Tappers, weavers, Single women, Fishermen, ART (PLHIV) Persons. Traditional Cobblers
- Disabled persons, Transgender and Dappu Artists receive a monthly pension of Rs.3,000/-
- People affected with chronic kidney disease who are undergoing Dialysis in both Government and network hospitals receive Rs.10,000/- per month.
- The enhanced scale of pension came into effect from June, 2019 payable from 1st July, 2019 onwards.

ABOUT DISTRICT

The district derives its name Tirupati is its headquarters town. It is located between the Northern Latitudes of 130 21′ 54″ and 140– 30′ 40″ and between the Eastern Longitudes 790 5′ 42″ and 800 4′ 10″. It is bounded on the east by Bay of Bengal, on the west by Annamayya and Chittoor Districts of Andhra Pradesh, on the North by SPSR Nellore and Annamayya Districts of Andhra Pradesh and on the south by Chittoor District of Andhra Pradesh and Tamilnadu State. In respect of area, it is with an area of 9174 Square Kilometers which accounts for 5.63 percent of the total area of the state. The general elevation of the mountainous part of the district is 2500 feet above sea level. The Chennai & Bangalore cities are located in 150 Kms. and 250 Kms. respectively to Tirupati Town. The district has good business and marketing for Groundnut, Paddy and Other Products.

The Eastern Ghats are pre-dominant in the Western Region and they gradually bend towards the sacred hills of Tirupati, passing through Chandragiri and entering into Nellore District.

Boundaries of the District:

The district is bounded by the following places and features on all the four sides.

East: Bay of Bengal

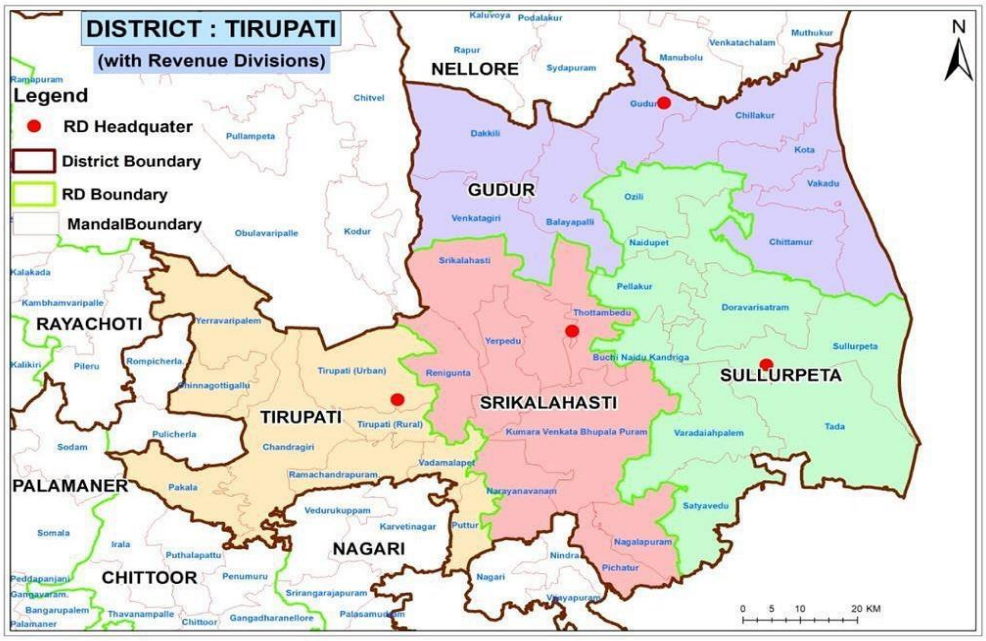
West: Annamayya and Chittoor Districts

North: SPSR Nellore and Annamayya Districts

South: Chittoor District and Tamilnadu State

Administrative Divisions:

There are 4 Revenue Divisions with Divisional headquarters at Tirupati, Srikalahasti, Sullurpet and Gudur and 34 Revenue Mandal's with 33 Mandal Parishads also existing in the district. A total of 784 Gram Panchayats are in position comprising all notified & non – notified Gram Panchayats.



Objectives

The objectives of the present study are:

1. to study the women participation and implementation of Welfare Programmes;
2. benefits from welfare programmes to study the women economic development of the respondents
3. to study the Problem faced by the different programmes;

Data Collection Techniques

Both primary and secondary data were used in the study. Secondary data was collected from publications of Government of India, Government of Andhra Pradesh, Bureau of Economics and Statistics, dailies etc. Primary data was collected through interview schedules and both participant observation and non-participant observation techniques.

Field Area

The field work was conducted in fourteen villages spread over Two Mandal's (Blocks) of Tirupati district in Andhra Pradesh. The villages selected are as follows:

Ramachandra Puram Mandal	:	2 villages
Vadamalapet Mandal	:	2 villages

Sampling

The study was conducted by selecting100 respondents from the two Mandal's as shown below:

Ramachandra. Puram Mandal	-	50
Vadamalapet Mandal	-	50

The sample was selected by following stratified random sampling method. The sample was selected from different Mandal's of the respondents from all the below the poverty line benefitted from welfare programmes.

Table-1

Releasing the Welfare programmes Mandal Wise Composition

Mandal's	frequency	Percentage
Ramachandra Puram Mandal	50	50.0
Vadamalapet Mandal	50	50.0
Total	**100**	**100.0**

After applying for sanction of navaratnalu Govt. Welfare programmes sanction to respondents the particulars. Ramachandhrapuram Mandal 50 (50.0) Repondents and Vadamalapet Mandal 50 (50.0) respondent . It's concluded the each Mandal are equal.

Table-2

Releasing the welfare programmes Village Wise Composition

Villages	frequency	Percentage
Ravillavaripalli	25	25.0
Venkatarama Puram	25	25.0
Tirumanyam	25	25.0
Vemapuram	25	25.0
Total	**100**	**100.0**

After applying for sanction of navaratnalu Govt. Welfare programmes sanction to respondents the particulars. The table shows ravillavaripalli, venkataramapuram, Tirumanyam and Vemapuram. Each villages are 25(25.0)respondents selected.

Table-3

Benefited of Welfare Programmes of respondents

Welfare Programmes	Frequency	Total	Percentage

	Yes	No	100	100.0
1.YSR Rythu Bharosa	60	40	100	100.0
2.Fee Reimbursement	32	68	100	100.0
3.Arogyasri	40	60	100	100.0
4.Jalayagnam	15	85	100	100.0
5.Ban on Alcohol	50	50	100	100.0
6.Amma Vodi	40	60	100	100.0
7.YSR Asara	60	40	100	100.0
8.Paydalandariki Illu	58	42	100	100.0
9.Pensionla Pempu	30	70	100	100.0

The information on the Govt. Welfare programmes being implemented in the Village has been elicited and presented in the Table.

The particulars of the more membership in YSR Rythu Barosa and YSR Asara 60(60.0) respondents, Paydalandariki Illu 58(58.0) respondents Ban on Alcohol 50 (50.0) respondents, Ammavadi and Arogyasri (40.0) respondents, Free Reimbursement 32 (32.0) respondents Pensionla pempu 30 (30.0) respondents and Jalaysgnam 15 (15.0) respondents .

It is Concluded that majority and more benefited of the respondents YSR Rythu Barosa and YSR Asara 60 (60.0) respondents.

Table-4

Problems faced in the Govt. Welfare Programes

Problems	**frequency**	**Percentage**
Non- Cooperation of Govt. Officers	15	15.0
Corruption of Govt. officers	5	5.0
Non - Cooperation of Village officers	20	20.0
No problems	60	60.0
Total	**100**	**100.0**

The respondents while Govt. Welfare Programmes faced many problems and the types of problems are presented in the table.

It is evident from table that 60(60.0) respondents did not faced any problems. But on the non-cooperation of the village officers 20 (20.0) respondents, 15 (15.0) respondents expressed the problems of Non-cooperation of Govt. officers and 5 (5.0) respondents corruption of Govt. Officers

Conclusion

Respondents of Ramachadrapuram and Vadamalapeta Mandals mostly benefited from Govt. Welfare Programmes (Navaratnalu). Majority of the Respondents received and above under Govt. Welfare Programmes (Navaratnalu) providing substantial additional income to the sample respondents. Govt. welfare programmes had some positive impact on the economic conditions of the sample respondents and made the respondents economically empowered. 60 percent respondents did not face any problems at all under the programmes. The high number of respondents who participated in the programmes and increasing saving amount indicate the high impact of the Govt. welfare programmes. The programmes must continue with the pitfalls covered.

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GENDER INEQUALITY IN THE WORKPLACE ITS IMPACT ON SOCIETY

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Abstract: Gender inequality is that people receive different treatment because of gender in this present review, gender in inequality is widespread in the workplace is found including the prevalence of the easier access to promote opportunities for men and women. Gender inequality in the workplace is a pervasive issue with profound implications for individuals, organizations, and society at large. This paper provides a comprehensive analysis of the various dimensions of gender inequality in the workplace and explores its multifaceted impact on society. Drawing on existing literature, statistical data, and real-life examples, the paper examines the root causes of gender inequality, its manifestations in different sectors, and the barriers that perpetuate it. Furthermore, it discusses the detrimental effects of gender inequality on individuals' well-being, organizational performance, and societal progress. Finally, the paper offers recommendations for addressing and mitigating gender inequality in the workplace to foster a more equitable and inclusive society.

Keywords: Gender inequality, workplace, impact, society, gender pay gap, occupational segregation, leadership representation, root causes, stereotypes, biases, structural barriers, economic implications, psychological effects, work-life balance, organizational productivity, talent retention, social cohesion, policy interventions, organizational initiatives, cultural shifts, advocacy efforts.

Introduction

Gender inequality in the workplace remains a significant and persistent issue that has far-reaching implications for individuals, organizations, and society. Society can improve gender inequality and enhance women's awareness of self-worth by adjusting school education. When most women are in society realize that they are important not humble, and begin to say no to inequality, they can change gender inequality in society. Despite advancements in gender equality efforts, disparities in pay, opportunities, and treatment based on gender continue to exist across various industries and sectors. Understanding the complexities of gender inequality in the workplace and its broader impact on society is crucial for developing effective strategies to address and mitigate these disparities. The lack of education on gender equality leads to a lack of timely awareness of gender inequality. Even many women are not thinking they are suffering from gender inequality, which they think is normal.

Overview of Gender Inequality in the Workplace

Gender inequality in the workplace encompasses a wide range of disparities and discriminatory practices that disadvantage individuals based on their gender. One of the most well-documented manifestations of this inequality is the gender pay gap, which persists across industries and occupations, with women earning, on average, less than their male counterparts for comparable work. Additionally, women are often underrepresented in leadership positions and decision-making roles, contributing to a lack of diverse perspectives and voices at the highest levels of organizations. Occupational segregation, wherein certain industries or occupations are dominated by one gender, further perpetuates inequalities by limiting opportunities for career advancement and professional growth.

Importance of Studying its Impact on Society

Understanding the impact of gender inequality in the workplace on society is crucial for several reasons. Firstly, it highlights the broader societal consequences of workplace disparities, including economic ramifications, social cohesion, and the perpetuation of harmful stereotypes and biases. Economic disparities resulting from gender inequality not only affect individual financial stability but also contribute to systemic poverty and inequality within society. Moreover, workplace inequalities can reinforce and perpetuate societal norms and expectations regarding gender roles, further entrenching inequality in various aspects of life.

Purpose and Scope of the Analytical Study

The purpose of this analytical study is to examine the multifaceted impact of gender inequality in the workplace on individuals, organizations, and society. The study will explore the root causes and manifestations of gender inequality in various sectors, including the role of structural barriers, stereotypes, and biases. Additionally, it will analyze the implications of gender inequality for individuals' well-being, organizational performance, and societal progress.

Definition and Concept of Gender Inequality

Gender inequality in the workplace refers to the unequal treatment, opportunities, and outcomes experienced by individuals based on their gender. It encompasses various forms of discrimination and disparities, including but not limited to the gender pay gap, limited access to leadership roles, occupational segregation, and unequal treatment in hiring, promotion, and compensation decisions.

Root Causes and Contributing Factors

Gender gaps are one of the most pressing challenges facing the world of work today. Globally women are substantially less likely than men to participate in the labor market, and once in the workforce, they are also less likely to find jobs than men. Indeed, their access to quality employment opportunities remains restricted. Overall, for example women are more likely to work longer hours than men when both paid and unpaid employment, on average, women work favor ours for pay or profit either because they opt to work part-time or because part- time work is the only option available to them. These gender gaps persist despite the preference of most women worldwide to work in a paid job underlying the fact that women’s choices are constrained by a few factors.

Historical Contest Gender inequality

Gender inequality in the workplace has deep historical roots, stemming from longstanding societal norms and practices that have traditionally assigned different roles and responsibilities to individuals based on their gender. Historical disparities in education, property rights, and legal frameworks have also contributed to the perpetuation of gender inequality.

Societal Norms and Stereotypes: Gender norms and stereotypes play a significant role in perpetuating inequality in the workplace. Societal expectations regarding gender roles often lead to biases in hiring, promotion, and performance evaluations. Stereotypes about women's competence, leadership abilities, and commitment to work can result in limited opportunities for career advancement and leadership roles.

Structural and Institutional Biases: Structural and institutional biases within organizations and industries also contribute to gender inequality in the workplace. These biases may manifest in policies and practices that disadvantage women, such as lack of family-friendly policies, unequal pay practices, and limited opportunities for mentorship and professional development.

Gender Pay Gap: The gender pay gap is one of the most widely recognized manifestations of gender inequality in the workplace. It refers to the disparity in earnings between men and women, with women typically earning less than men for comparable work. Factors contributing to the gender pay gap include occupational segregation, discrimination in pay and promotion decisions, and the undervaluing of women's work.

Occupational Segregation: Occupational segregation refers to the concentration of men and women in different occupations and industries, often based on traditional gender roles and stereotypes. This segregation results in vertical and horizontal gender segregation, with women being underrepresented in leadership positions and overrepresented in lower-paying, less prestigious roles.

Lack of Leadership Representation: Women are often underrepresented in leadership positions across various sectors and industries. This lack of representation can be attributed to various factors, including biases in recruitment and promotion processes, limited access to mentorship and networking opportunities, and the perpetuation of stereotypes about women's leadership abilities.

Economic Impact: Gender inequality in the workplace results in unequal access to opportunities, resources, and compensation. Women, on average, earn less than men for the same work, contributing to the gender pay gap. This economic disparity not only affects individual financial stability but also perpetuates systemic poverty among women and their families.

Career Advancement: Discriminatory practices and biases often hinder women's career progression. Glass ceilings and gender stereotypes limit women's access to leadership roles and decision-making positions. Consequently, there's a loss of diverse perspectives and talents at the managerial and executive levels, impacting organizational performance and innovation.

Work-Life Balance: Gender inequality in the workplace also intersects with challenges related to work-life balance. Women are often expected to fulfill traditional caregiving roles, which can impede their professional growth and opportunities. This imbalance contributes to higher levels of stress and burnout among women, affecting their overall well-being and productivity.

Psychological Impact: Discrimination and bias in the workplace can lead to feelings of marginalization, imposter syndrome, and decreased job satisfaction among women. This psychological toll not only affects individual mental health but also perpetuates a culture of inequality and exclusion within organizations.

Societal Norms and Expectations: Gender inequality in the workplace reflects and reinforces broader societal norms and expectations regarding gender roles. By perpetuating stereotypes and unequal treatment, workplaces contribute to the normalization of gender discrimination in society, which, in turn, perpetuates a cycle of inequality across various domains.

Legal and Policy Implications: Gender inequality in the workplace also highlights gaps in existing legal frameworks and policies designed to promote gender equality. Analyzing these disparities can inform the development of more robust regulations and enforcement mechanisms to address systemic biases and discrimination.

Innovation and Competitiveness: Diverse and inclusive workplaces are more innovative and competitive. Gender inequality limits diversity, stifling creativity and hindering organizations' ability to adapt to changing market dynamics. Addressing gender disparities fosters a more dynamic and resilient workforce, ultimately benefiting organizational performance and societal progress.

Analyzing the Impact on Society: Economic Implications

Gender inequality on society and the economy, namely that there is discrimination between both genders in certain industries, mothers struggle of getting back to an initial position in a job, and a clear understanding of benefits equalized pay. The research has clearly indicated that gender inequality is not necessary, it can be easily avoided by changing the mind set in society, while gender equality gives a Varity of benefits to both society and the economy.

Gender Disparities in Earnings and Wealth: Gender inequality in the workplace contributes to significant disparities in earnings and wealth between men and women. The gender pays gap results in women earning less over their lifetimes compared to their male counterparts, leading to lower levels of wealth accumulation and financial security for women. This disparity in earnings and wealth perpetuates economic inequality between genders and limits women's economic independence and autonomy. **Effects on Poverty Rates and Economic Growth:** Gender inequality in the workplace is also associated with higher poverty rates among women, particularly among single mothers and women in marginalized communities. The gender pays gap and limited access to economic opportunities contribute to higher rates of poverty among women, which, in turn, have broader implications for societal well-being and economic growth. Addressing gender inequality in the workplace is essential for reducing poverty rates and promoting sustainable economic development.

Stress, Anxiety and Mental Health Issues: Gender inequality in the workplace can have significant psychological effects on individuals, particularly women. Discrimination, bias, and unequal treatment based on gender can lead to heightened levels of stress, anxiety, and other mental health issues among women. The constant pressure to prove oneself in a male-dominated workplace environment can take a toll on women's well-being and overall mental health.

Imposter Syndrome and Career Aspirations: Gender inequality in the workplace can also contribute to the development of imposter syndrome among women, leading to self-doubt and diminished confidence in their abilities. Stereotypes and biases about women's competence and leadership capabilities can undermine women's career aspirations and hinder their professional growth and advancement. One of the primary reasons behind workplace gender in equality is the unequal access to career development and progression opportunities for women. Long hours, inflexible work

arrangements inadequate family friendly policies can all contribute to hindering women's career advancement, reinforcing the gender gap in the workplace.

Reinforcement of Gender Stereotypes: Gender inequality in the workplace reinforces and perpetuates harmful gender stereotypes and cultural norms. Biases in hiring, promotion, and leadership decisions based on gender contribute to the normalization of gender discrimination and inequality in society. This reinforcement of gender stereotypes limits opportunities for women and perpetuates rigid gender roles and expectations. Gender stereotypes perpetuate the notion that people of certain gender are naturally suited to specific roles or professions.

Impact on Family Dynamics and Social Relationships: Gender inequality in the workplace also has implications for family dynamics and social relationships. Limited access to economic opportunities and leadership roles for women can strain family dynamics and contribute to unequal distribution of household and caregiving responsibilities. Additionally, workplace discrimination and inequality can negatively impact social relationships and interactions, leading to feelings of isolation and marginalization.

Understanding the multidimensional impact of gender inequality in the workplace on society is essential for addressing systemic barriers and promoting gender equity and inclusion. By addressing economic disparities, prioritizing mental health and well-being, and challenging harmful gender stereotypes, societies can work towards creating more equitable and inclusive environments for all individuals, regardless of gender.

Legal and Policy Interventions: Effective gender inclusive policies may be further supported by reviewing and adhering to legal frameworks that promote gender equality. More recently, some of the states have introduced laws such as pay transparency and minimum wage polices that aim to reduce gender discrimination. By familiarizing themselves with and adhering to these legal frame works, companies can help minimize any disparities that negatively affect women in the workplace.

Gender Equality Legislation: Governments and policymakers have implemented various gender equality laws and regulations aimed at addressing gender inequality in the workplace. These laws prohibit discrimination based on hiring, promotion, and compensation practices and require employers to promote gender equality in their organizations. Examples include the Equal Pay Act, Title VII of the Civil Rights Act, and the Gender Equality Act in different countries.

Affirmative Action Policies: Affirmative action policies are designed to promote equal opportunities for underrepresented groups, including women, in the workplace. These policies may include measures such as quota systems, targeted recruitment efforts, and preferential treatment in hiring and promotion decisions to address historical and systemic barriers to gender equality. Affirmative action aims to level the playing field and increase representation of women in traditionally male-dominated industries and leadership positions.

Diversity and Inclusion Programs: Many organizations have implemented diversity and inclusion programs to promote a more equitable and inclusive workplace culture. These programs aim to foster diversity across various dimensions, including gender, race, ethnicity, and sexual orientation, and create environments where all employees feel valued and respected. Diversity and inclusion initiatives may include training programs, employee resource groups, and mentorship opportunities to support women and other underrepresented groups in the workplace.

Gender-Sensitive HR Policies: Organizations are increasingly adopting gender-sensitive human resources (HR) policies to address gender inequality in the workplace. These policies may include equal pay policies, parental leave, and flexible work arrangements to support work-life balance, and anti-discrimination and harassment policies to ensure a safe and inclusive work environment for all employees. By implementing gender-sensitive HR policies, organizations can promote fairness, equity, and diversity in their workforce.

Awareness Campaigns and Education: Advocacy organizations, non-profits, and grassroots movements play a crucial role in raising awareness about gender inequality in the workplace and advocating for change. These efforts include awareness campaigns, educational programs, and community outreach initiatives aimed at challenging stereotypes, promoting gender equality, and empowering women in the workforce. By raising awareness awareness campaigns, educational programs, and community outreach initiatives aimed at challenging stereotypes, promoting gender equality, and empowering women in the workforce. By raising awareness and educating the public about the importance of gender equality, advocacy organizations contribute to cultural shifts and societal change.

Changing Attitudes and Social Norms: Cultural shifts and changing attitudes towards gender roles and stereotypes are essential for addressing gender inequality in the workplace. This includes challenging traditional gender norms, promoting positive representations of women in leadership and professional roles, and encouraging men to be allies in the fight for gender equality. By challenging harmful stereotypes and promoting more inclusive attitudes towards gender, society can create environments where all individuals have equal opportunities to thrive in the workplace.

Overall, legal and policy interventions, organizational initiatives, and advocacy efforts play complementary roles in addressing gender inequality in the workplace and promoting gender equity and inclusion in society. By working together, governments, organizations, and advocacy groups can create more equitable and inclusive environments where all individuals, regardless of gender, have equal opportunities to succeed.

Implications for Addressing Gender Inequality in the Workplace

Addressing gender inequality in the workplace requires comprehensive strategies that target root causes and promote systemic change. Legal and policy interventions, such as gender equality legislation and affirmative action policies, can help address discrimination and promote equal opportunities for women. Organizational initiatives, including diversity and inclusion programs and gender-sensitive HR policies, are crucial for fostering inclusive workplace cultures and supporting women's advancement.

Advocacy efforts and cultural shifts are also essential for challenging stereotypes and promoting more equitable attitudes towards gender. By raising awareness, educating the public, and challenging traditional gender norms, society can create environments where all individuals have equal opportunities to succeed in the workplace.

Future Directions for Research and Action:

Moving forward, further research is needed to explore emerging trends and innovative strategies for addressing gender inequality in the workplace. Future studies could focus on evaluating the effectiveness of existing interventions, identifying barriers to progress, and exploring the intersectionality of gender with other factors such as race, ethnicity, and sexual orientation. Action is needed at multiple levels to advance gender equality in the workplace. Governments, organizations,

advocacy groups, and individuals all have a role to play in promoting systemic change and fostering inclusive environments where all individuals have equal opportunities to thrive.

Conclusion

Gender inequality in the workplace is a complex and pervasive issue with far-reaching implications for individuals, organizations, and society. Throughout this study, we have explored various dimensions of gender inequality, including its root causes, manifestations, and impact on society.

We found that historical biases, societal norms, and institutional barriers contribute to gender disparities in the workplace, including the gender pay gap, occupational segregation, and lack of representation in leadership roles. These inequalities have significant economic, psychological, and social consequences, affecting individuals' well-being, organizational performance, and societal progress. addressing gender inequality in the workplace is not only a moral imperative but also essential for promoting economic growth, social cohesion, and individual well-being. By working together and implementing evidence-based strategies, we can create workplaces and societies that are more equitable and inclusive for all.

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A Study On Socio-Economic And Demographic Characteristics Of HIV Positive Pregnant Women Attending ART Centre

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Abstract

The women are mostly engaged in the unorganised sector as labourers. They face the problems of job insecurity and exploitation on par with the male workers. In addition, they are subjected to wage discrimination and the nature of work assigned to them is usually drudgery in nature. They are also subjected to sexual exploitation at the work place. In the homes they are expected to do all the domestic chores. Therefore, the women with Human Immunodeficiency Virus (HIV) positive in lower starts of society need urgent and special attention. Moreover, the women in India are characterized by low status, low level of education, low level of health conditions and employment. They are suffering from insecurity, exploitation in addition to poverty. The paper aims at examines the Socio-Economic and Demographic Characteristics and based on primary data collected from HIV positive pregnant women attending Antiretroviral therapy (ART) Centre.

Keywords

Socio-Economic and Demographic Characteristics, Antiretroviral therapy and Human Immunodeficiency Virus

Introduction

India is one such Third World country which is characterized by poverty and unemployment. According to 2001 census 35 per cent of the population is living below poverty line and 25 per cent below poverty line huge are of developmental benefits are going in favour of a small section of the society, who have high socio-economic status. This has been resulting in the widening of income and wealth disparities. Consequently, the intensity of poverty has been rising and as a result, high incidence of poverty has been falling on women. Rural women are mostly engaged in the farms as agricultural labourers. They face the problems of job insecurity and exploitation on par with the male workers. In

addition, they are subjected to wage discrimination and the nature of work assigned to them is usually drudgery in nature. They are also subjected to sexual exploitation at the work place. In the homes they are expected to do all the domestic chores. Therefore, the rural women in lower starts of society need urgent and special attention. Msamanga, G.I et al (2006) examined the Socio-economic and demographic factors associated with prevalence of HIV infection among pregnant women in Dar es Salaam, Tanzania.

The women will face different problems for their existence depending upon the class to which they belonged to. Therefore, treating all the women as one category may not be helpful in proper understanding often phenomenon. The women belonging to the upper strata are relatively at some advantage, while women in poorer sectors are to wage struggles for their existence. The women in the upper strata of the society have the problem of leisure and the problems that go with the leisure, the middle class women are under the stresses and strains of deteriorating living standards. It is the middle class women who compete for the jobs in the organized sector and encounter stiff competition. The third category of women who belong to the poorer classes and are engaged in the basic struggle for existence, particularly in the rural areas face a different type of problems. Chauhan G (2014) HIV positive pregnant women were younger, primi and housewives. HIV positive antenatal women need to be followed rigorously to link them to ART services. Caroline Granberg (2015) found that higher level of education and belonging to a higher level of wealth quintile were significantly associated with having knowledge about PMTCT. All categories for education showed a significant difference.

The rural women are mostly engaged in the farms as agricultural labourers. They face the problems of job insecurity and exploitation on par with the male workers. In addition, they are subjected to wage discrimination and the nature of work assigned to them is usually drudgery in nature. They are also subjected to sexual exploitation at the work place. In the homes they are expected to do all the domestic chores. Therefore, the rural women in lower starts of society need urgent and special attention. The rural women in India are characterized by low status, low level of education, low level of health conditions and employment. They are suffering from insecurity, exploitation in addition to poverty. Socio-economic status (SES) is often measured as a combination of education, income, and occupation. It is commonly conceptualized as the social standing or class of an individual or group. When viewed through a social class lens, privilege, power and control are emphasized. Furthermore, an examination of SES as a gradient or continuous variable reveals inequities in access to and distribution of resources. The SES is relevant to all realms of behavioural and social science including research, practice, education and advocacy. Padmaja Y et al (2017) studied the demographic characteristics among pregnant and postpartum HIV positive women. Social class and educational status play a vital role in establishing awareness and ensuring the antenatal care and compliance. Empathetic, inclusive and responsive by health care providers in convincing women to get tested goes a long way.

Literature Review

Anne WanjaKibera et al (2017) found that HIV infections in Kenya were predominantly among the resourceful newly married,young educated adults. Gender distribution difference was insignificant (2.2%) in the numbers by sex it was at (2%). The youngest participant was 18 years old implying that the

mode of transmission in this population was sexual and or any other but unlikely to be mother to child. Ottop F. Manyi et al (2020) aimed to describe the socio-demographic profiles of naive to antiretroviral therapy (ART) HIV-infected pregnant women. A total of seventy (70) women were enrolled with age range varying between 15 and 40 years, the Muslim religion, education below secondary level and the profession of housewife were significantly associated. Unyime Patrick Udoudo et al (2021) examined the socio-economic characteristics such as age, marital status, employment status, place of residence, level of education. The result showed that the marital status, place of residence and level of education has a negative relationship with the probability of a pregnant woman having a positive HIV status. Feny Deya Virdausi et al (2022) found that women's age, education level, wealth quintile, residential area and region, access to information, owning cell phones and autonomy were significantly associated with positive knowledge and attitudes toward HIV/AIDS.

Objective

To study the Socio-Economic and Demographic Characteristics of HIV positive pregnant women attending ART Centre

Method and material

The paper is based descriptive research design and based on primary data collected with interview scheduled from 250 HIV positive pregnant women coming to Antiretroviral therapy Center at SVRR Government General Hospital, Tirupati, Andhra Pradesh.

Results and discussion

Age

Age is an important factor which determines the physical ability to work. Age is very important factor besides the active participation in innovative activities and risk taking ability. To understand the working age group, it is necessary to classify the respondents according to their age. Age shows understanding nature and shouldering the responsibility. The age of the respondents is presented in the table-1.

Table-1: Age of the Respondents

Sl. No.	Age	No. of Women	Percentage
1	Below 25 years	75	30.0
2	26 - 35 years	101	40.4
3	Above 35 years	74	29.6
	Total	**250**	**100.0**

The table-1 shows that 40.4 per cent of the respondents are in the age group of 26–35 years, 30 per cent are in the age group of below 25 years and 29.6 per cent are in the age group of above 35 years. Above all, it is concluded that more than 40 per cent of the respondents are in the age group of 26–35 years.

Marital Status

The marital status of the respondents is shown in the table-2.

Table-2: Marital status of the respondents

Sl. No.	Marital Status	No. of Women	Percentage
1	Married	248	99.2
2	Unmarried	2	0.8
	Total	**250**	**100.0**

The table-2 shows that 99.2 per cent of the respondents are married and mere 0.8 per cent is spinsters.

Caste

Caste is another variable to analyse and understand the socio-economic characteristics of the respondents. Caste has become very important in India, for meaningful study it is not possible and feasible without taking caste into consideration. The caste composition of the respondents is furnished in the table-3.

Table-3: Caste of the respondents

Sl. No.	Caste	No. of Women	Percentage
1	Forward Caste	52	20.8
2	Backward Caste	120	48.0
3	Scheduled Caste	60	24.0
4	Scheduled Tribe	18	7.2
	Total	**250**	**100.0**

The table-3 portrays that 48 per cent of the respondents belong to Backward Caste, 24 per cent to Scheduled Caste, around 21 per cent to Forward Caste and a little over 7 per cent belong to Scheduled Tribe.

Education

Education plays a very important role to empower women and for development of society. It gives analysing capacity and wisdom to thinking and decision making capacity. Education - formal and informal - improves awareness for better life and generates positive impulses for socio-economic advancement. It controls the attitudes, opinions and behaviour of the people and influences the economic destiny of the family. The educational status of the respondents is presented in the table-4.

Table-4: Literacy of the Respondents

Sl. No.	Education	No. of women	Percentage
1	Illiterate	106	42.4
2	Up to Primary	39	15.6
3	Up to 10th	85	34.0
4	Intermediate	11	4.4
5	Graduation	9	3.6
	Total	**250**	**100.0**

It is quite obvious from the table-4 that 42.4 per cent of the respondents are illiterates, 34 per cent have SSC qualification, around 16 per cent have primary education, 4.4 per cent have Intermediate and around 4 per cent are graduates.

Occupation

It is a common fact that the occupation of the individual determines his position in the society and standard of living. Table-5 reveals the occupational structure of the sample population. Most of the respondents in the sample are doing business and are in employment. Only a few persons are Involved in agriculture. Majority of the respondents from the employment and business categories show higher fertility and higher additional expected family size compared to the cultivators in the sample population.

Table-5: Occupation of the Respondents

Sl. No.	Occupation	No. of Women	Percentage
1	Housewife	128	51.2
2	Coolie	90	36.0
3	Petty business	11	4.4
4	Daily labourers	14	5.6
5	Private jobs	7	2.8
	Total	**250**	**100.0**

The table-5 shows that 51.2 per cent are housewives, 36 per cent are coolies, around 6 per cent are daily labourers, 4.4 per cent have petty business and around 3 per cent are working in private sector.

Financial Support

The financial support the respondents getting is shown in the table-6.

Table-6: Mode of financial support

Sl. No.	Mode of financial support having to live	No. of Women	Percentage
1	Family members	159	63.6
2	Friends	42	16.8
3	Relatives	49	19.6
	Total	**250**	**100.0**

The table-6 shows that around 64 per cent of the respondents have financial support from their family members to live, around 20 per cent have financial support from relatives and around 17 per cent have financial support from friends.

Conclusion

This study showed that as many women as men were equally vulnerable to HIV infections. Risk factors for HIV infections were being young adults, mostly backward and scheduled caste, illiterate or primary education and majority are being housewife, and receiving financial support from family members most are being married or cohabiting couples, a contrast with the notion that marriage was a protective institution against HIV infections. The high prevalence rate of HIV was attributed to low level of sexual health education and condom use. Low risk factors for HIV infections were associated with low level of education. As such, policy makers should review HIV programmes and consider the contribution of socio-economic and demographic factors done so that gaps in the prevention and control of HIV in could be sealed to reduce the negative impact of HIV infections.

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INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

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A Study On Socio-Economic And Demographic Characteristics Of HIV Positive Pregnant Women Attending ART Centre

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Abstract

The women are mostly engaged in the unorganised sector as labourers. They face the problems of job insecurity and exploitation on par with the male workers. In addition, they are subjected to wage discrimination and the nature of work assigned to them is usually drudgery in nature. They are also subjected to sexual exploitation at the work place. In the homes they are expected to do all the domestic chores. Therefore, the women with Human Immunodeficiency Virus (HIV) positive in lower starts of society need urgent and special attention. Moreover, the women in India are characterized by low status, low level of education, low level of health conditions and employment. They are suffering from insecurity, exploitation in addition to poverty. The paper aims at examines the Socio-Economic and Demographic Characteristics and based on primary data collected from HIV positive pregnant women attending Antiretroviral therapy (ART) Centre.

Keywords

Socio-Economic and Demographic Characteristics, Antiretroviral therapy and Human Immunodeficiency Virus

Introduction

India is one such Third World country which is characterized by poverty and unemployment. According to 2001 census 35 per cent of the population is living below poverty line and 25 per cent below poverty line huge are of developmental benefits are going in favour of a small section of the society, who have high socio-economic status. This has been resulting in the widening of income and wealth disparities. Consequently, the intensity of poverty has been rising and as a result, high incidence of poverty has been falling on women. Rural women are mostly engaged in the farms as agricultural labourers. They face the problems of job insecurity and exploitation on par with the male workers. In

addition, they are subjected to wage discrimination and the nature of work assigned to them is usually drudgery in nature. They are also subjected to sexual exploitation at the work place. In the homes they are expected to do all the domestic chores. Therefore, the rural women in lower starts of society need urgent and special attention. Msamanga, G.I et al (2006) examined the Socio-economic and demographic factors associated with prevalence of HIV infection among pregnant women in Dar es Salaam, Tanzania.

The women will face different problems for their existence depending upon the class to which they belonged to. Therefore, treating all the women as one category may not be helpful in proper understanding often phenomenon. The women belonging to the upper strata are relatively at some advantage, while women in poorer sectors are to wage struggles for their existence. The women in the upper strata of the society have the problem of leisure and the problems that go with the leisure, the middle class women are under the stresses and strains of deteriorating living standards. It is the middle class women who compete for the jobs in the organized sector and encounter stiff competition. The third category of women who belong to the poorer classes and are engaged in the basic struggle for existence, particularly in the rural areas face a different type of problems. Chauhan G (2014) HIV positive pregnant women were younger, primi and housewives. HIV positive antenatal women need to be followed rigorously to link them to ART services. Caroline Granberg (2015) found that higher level of education and belonging to a higher level of wealth quintile were significantly associated with having knowledge about PMTCT. All categories for education showed a significant difference.

The rural women are mostly engaged in the farms as agricultural labourers. They face the problems of job insecurity and exploitation on par with the male workers. In addition, they are subjected to wage discrimination and the nature of work assigned to them is usually drudgery in nature. They are also subjected to sexual exploitation at the work place. In the homes they are expected to do all the domestic chores. Therefore, the rural women in lower starts of society need urgent and special attention. The rural women in India are characterized by low status, low level of education, low level of health conditions and employment. They are suffering from insecurity, exploitation in addition to poverty. Socio-economic status (SES) is often measured as a combination of education, income, and occupation. It is commonly conceptualized as the social standing or class of an individual or group. When viewed through a social class lens, privilege, power and control are emphasized. Furthermore, an examination of SES as a gradient or continuous variable reveals inequities in access to and distribution of resources. The SES is relevant to all realms of behavioural and social science including research, practice, education and advocacy. Padmaja Y et al (2017) studied the demographic characteristics among pregnant and postpartum HIV positive women. Social class and educational status play a vital role in establishing awareness and ensuring the antenatal care and compliance. Empathetic, inclusive and responsive by health care providers in convincing women to get tested goes a long way.

Literature Review

Anne WanjaKibera et al (2017) found that HIV infections in Kenya were predominantly among the resourceful newly married,young educated adults. Gender distribution difference was insignificant (2.2%) in the numbers by sex it was at (2%). The youngest participant was 18 years old implying that the

mode of transmission in this population was sexual and or any other but unlikely to be mother to child. Ottop F. Manyi et al (2020) aimed to describe the socio-demographic profiles of naive to antiretroviral therapy (ART) HIV-infected pregnant women. A total of seventy (70) women were enrolled with age range varying between 15 and 40 years, the Muslim religion, education below secondary level and the profession of housewife were significantly associated. Unyime Patrick Udoudo et al (2021) examined the socio-economic characteristics such as age, marital status, employment status, place of residence, level of education. The result showed that the marital status, place of residence and level of education has a negative relationship with the probability of a pregnant woman having a positive HIV status. Feny Deya Virdausi et al (2022) found that women's age, education level, wealth quintile, residential area and region, access to information, owning cell phones and autonomy were significantly associated with positive knowledge and attitudes toward HIV/AIDS.

Objective

To study the Socio-Economic and Demographic Characteristics of HIV positive pregnant women attending ART Centre

Method and material

The paper is based descriptive research design and based on primary data collected with interview scheduled from 250 HIV positive pregnant women coming to Antiretroviral therapy Center at SVRR Government General Hospital, Tirupati, Andhra Pradesh.

Results and discussion

Age

Age is an important factor which determines the physical ability to work. Age is very important factor besides the active participation in innovative activities and risk taking ability. To understand the working age group, it is necessary to classify the respondents according to their age. Age shows understanding nature and shouldering the responsibility. The age of the respondents is presented in the table-1.

Table-1: Age of the Respondents

Sl. No.	Age	No. of Women	Percentage
1	Below 25 years	75	30.0
2	26 - 35 years	101	40.4
3	Above 35 years	74	29.6
	Total	**250**	**100.0**

The table-1 shows that 40.4 per cent of the respondents are in the age group of 26–35 years, 30 per cent are in the age group of below 25 years and 29.6 per cent are in the age group of above 35 years. Above all, it is concluded that more than 40 per cent of the respondents are in the age group of 26–35 years.

Marital Status

The marital status of the respondents is shown in the table-2.

Table-2: Marital status of the respondents

Sl. No.	Marital Status	No. of Women	Percentage
1	Married	248	99.2
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The table-2 shows that 99.2 per cent of the respondents are married and mere 0.8 per cent is spinsters.

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Caste is another variable to analyse and understand the socio-economic characteristics of the respondents. Caste has become very important in India, for meaningful study it is not possible and feasible without taking caste into consideration. The caste composition of the respondents is furnished in the table-3.

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Conclusion

This study showed that as many women as men were equally vulnerable to HIV infections. Risk factors for HIV infections were being young adults, mostly backward and scheduled caste, illiterate or primary education and majority are being housewife, and receiving financial support from family members most are being married or cohabiting couples, a contrast with the notion that marriage was a protective institution against HIV infections. The high prevalence rate of HIV was attributed to low level of sexual health education and condom use. Low risk factors for HIV infections were associated with low level of education. As such, policy makers should review HIV programmes and consider the contribution of socio-economic and demographic factors done so that gaps in the prevention and control of HIV in could be sealed to reduce the negative impact of HIV infections.

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A REVIEW ON CHALENGES AND INNOVATION IN THE ORGANIZATION AND SUPERVISION OF FIELD WORK IN SOCIAL WORK EDUCATION

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Abstract: Field work in social work education serves as a cornerstone for bridging theory with practice, providing students with invaluable experiential learning opportunities. However, the organization and supervision of field work present numerous challenges that impact the effectiveness and quality of students' educational experiences. This article explores these challenges and examines innovative strategies and practices that have emerged to enhance the organization and supervision of field work in social work education. Key topics include placement availability, supervision quality, logistical considerations, and the adaptation of field work to evolving societal needs. By investigating these issues, this article aims to contribute to a deeper understanding of how field work can be optimized to better prepare future social workers for the complexities of professional practice.

Keywords: Field work, Practice, Supervision, Social Work Education, Placements, Challenges Innovative Approaches.

Introduction: Field work, often referred to as practicum or internship, is a fundamental component of social work education, offering students the opportunity to apply classroom learning in real-world settings under the guidance of experienced practitioners. The significance of field work lies in its ability to bridge the gap between academic knowledge and practical skills, preparing students to navigate the complexities and challenges they will encounter in their careers as social workers.

Despite its pivotal role, the organization and supervision of field work in social work education are fraught with challenges that can impact the quality and effectiveness of student learning experiences. One of the primary challenges is securing suitable field placements that align with students' academic interests and professional goals. The availability of placements, especially in specialized fields such as healthcare or child welfare, can be limited, posing logistical hurdles for both students and educational institutions.

Another critical challenge is ensuring the quality of supervision provided to students during their field placements. Effective supervision is essential for nurturing students' professional development, offering guidance, feedback, and support as they navigate complex social work scenarios. However, variations in supervisor qualifications and availability can lead to inconsistencies in the supervision process, affecting students' learning outcomes.

Moreover, logistical considerations such as transportation, scheduling, and administrative tasks add another layer of complexity to the organization of field work placements. These practical challenges can impact the smooth operation of field work programs and require careful coordination and planning from educational institutions.

Furthermore, the landscape of social work practice is constantly evolving, necessitating ongoing adaptation of field work to address emerging societal needs, changes in policy, and advancements in technology. Innovations in field work education, such as the integration of virtual field work experiences and interdisciplinary collaborations, are emerging as strategies to enhance learning opportunities and better prepare students for the dynamic realities of contemporary social work practice.

This article aims to explore challenges innovative approaches and best practices that have been developed to optimize the organization and supervision of field work in social work education. By examining these innovations, educators and practitioners can gain insights into how to effectively navigate the complexities of field work placements and enhance the educational experiences of future social workers.

Challenges

Placement Availability: Challenge Securing appropriate field placements that align with students' academic interests and career goals can be difficult, especially in specialized areas of social work practice (e.g., healthcare, child welfare).

placements may restrict students' opportunities to gain experience in their preferred fields, potentially delaying or compromising their professional development.

Supervision Quality:

Ensuring consistent and effective supervision by qualified professionals throughout the field work experience. Inconsistent or inadequate supervision can hinder students' learning and professional growth, affecting their ability to apply theoretical knowledge to practical situations and develop critical skills.

Logistical Issues:

Managing logistical aspects such as scheduling, transportation, and administrative tasks associated with field placements. Poor logistical coordination can disrupt students' field work

experiences, leading to inefficiencies and logistical challenges that detract from the learning process.

Adapting to Changing Needs:

Field work programs aligned with evolving social work practices, policies, and community needs. Failure to adapt can result in outdated educational experiences that do not adequately prepare students for current professional challenges and opportunities.

Ethical and Professional Boundaries:

Navigating complex ethical dilemmas and maintaining professional boundaries in real-world practice settings. Inadequate preparation or support in handling ethical challenges can jeopardize students' professional development and ethical integrity.

Diversity and Cultural Competence:

Providing field placements that expose students to diverse populations and cultural contexts. Limited exposure to diverse experiences may hinder students' ability to develop cultural competence and sensitivity, essential for effective social work practice in multicultural environments.

Evaluation and Feedback:

Ensuring timely and constructive feedback on students' performance during field placements. Insufficient feedback can impede students' ability to reflect on and improve their practice, limiting their overall learning and professional growth.

These challenges require innovative approaches and collaborative efforts among educators, practitioners, and stakeholders in social work education. By identifying and overcoming these obstacles, institutions can enhance the quality and effectiveness of field work experiences, better preparing students for the complexities of professional social work practice.

Innovations

Virtual Field Work:

Utilizing technology to create virtual field work experiences. Allows students to engage with clients and scenarios remotely, overcoming geographical limitations and enhancing accessibility to diverse practice settings. Virtual platforms can simulate real-world interactions, offering a safe environment for learning and skill development.

Simulation Exercises:

Implementing simulated scenarios that replicate real-life social work challenges. Provides students with opportunities to practice decision-making, critical thinking, and intervention skills in controlled settings. Simulations can be tailored to specific learning objectives and adjusted based on students' progress and feedback. Partnering with other disciplines (e.g., psychology, nursing) to offer joint field work experiences.

Enhances students' understanding of multidisciplinary approaches to client care and strengthens collaborative skills essential for integrated service delivery. Interdisciplinary collaborations broaden students' perspectives and prepare them for team-based practice in diverse healthcare and social service settings.

Reflective Practices:

Incorporating structured reflective supervision and learning activities into field work experiences. Encourages students to critically analyze their experiences, values, and professional development. Reflective practices foster self-awareness, empathy, and ethical decision-making, supporting holistic learning and personal growth as future social workers.

Use of Data and Technology:

Leveraging data analytics and technology tools to enhance supervision and evaluation processes. Enables real-time monitoring of students' progress, identification of learning trends, and personalized feedback. Technology integration facilitates efficient communication between students, supervisors, and field instructors, streamlining administrative tasks and improving overall program management.

Community and Global Engagement:

Offering international or community-based field work placements Exposes students to diverse cultural contexts, global social issues, and alternative service delivery models. Community and global engagement broaden students' perspectives on social justice, advocacy, and human rights, fostering cultural competence and global citizenship in social work practice.

Trauma-Informed Approaches:

Integrating trauma-informed care principles into field work education. Equips students with skills to recognize and respond sensitively to trauma-related issues in client interactions. Trauma-informed approaches promote client empowerment, resilience-building, and the creation of safe, supportive environments in social work practice.

These innovations reflect ongoing efforts to enhance the quality, relevance, and impact of field work experiences in social work education. By adopting and adapting these innovative practices, educational institutions can better prepare future social workers to meet the complex and evolving challenges of the profession.

Importance of Adequate Supervision: Effective supervision is crucial for maximizing the learning outcomes of field work experiences in social work education. Institutions should prioritize ensuring that supervisors are well-trained, experienced, and capable of providing meaningful guidance and support to students.

Need for Diverse Field Placements: Addressing the challenge of securing suitable field placements requires collaboration with a variety of agencies and organizations. Efforts should focus on expanding placement options to include diverse settings that reflect the breadth of social work practice.

Innovative Approaches Enhance Learning: Innovations such as virtual field work, simulation exercises, and interdisciplinary collaborations have demonstrated promise in enriching students' educational experiences. These approaches provide opportunities for immersive learning, skill development, and exposure to new technologies and methodologies.

Integration of Reflective Practices: Incorporating structured reflective practices into field work supervision encourages students to critically analyze their experiences, values, and professional growth. This fosters a deeper understanding of social work practice and promotes ongoing learning and self-improvement.

Challenges in Logistics and Administration: Addressing logistical challenges, such as scheduling, transportation, and administrative tasks associated with field placements, is essential for ensuring the smooth operation of field work programs. Institutions should streamline processes and allocate resources effectively to minimize disruptions.

Adaptation to Evolving Needs: Social work education must adapt to evolving societal needs, technological advancements, and changes in policy and practice. This requires ongoing collaboration between academia and the field to ensure that curricula remain relevant and responsive to current challenges and trends.

Ethical Considerations and Cultural Competence: Emphasizing ethical decision-making and cultural competence is fundamental in preparing social work students for diverse and complex practice environments. Educational programs should prioritize the development of these competencies through rigorous training and exposure to diverse populations.

Future Directions: Continued research and evaluation of field work practices are necessary to identify emerging challenges and refine innovative approaches. Institutions should continue to innovate and adapt to meet the evolving needs of students, practitioners, and the communities they serve.

Conclusion: while challenges in the organization and supervision of field work in social work education are significant, ongoing innovations and strategic approaches can enhance the quality and effectiveness of field work experiences. By addressing these challenges proactively and embracing innovative practices, educational institutions can better prepare future social workers to navigate the complexities of contemporary social work practice and make meaningful contributions to society.

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Women in Politics in India: An Analytical Study

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Department of Sociology,
S.V University, Tirupati,

Abstract

This analytical study provides an overview of women in politics in India, focusing on their representation, challenges faced, and the impact of their involvement. It examines the historical background, highlighting key figures and milestones in women's political empowerment. The study explores the current state of women's representation in Indian politics, identifying factors contributing to their underrepresentation. It discusses the reservation policy and its impact on increasing women's participation at the grassroots level. Additionally, the study investigates the impact of women in politics on policymaking and governance, emphasizing the positive influence they have on various issues.

It delves into the challenges and barriers faced by women in Indian politics, including gender biases, stereotypes, and violence. Furthermore, the study suggests measures to empower women in politics, such as internal party reforms, education, training.

programs, and legal reforms. It highlights success stories of women leaders who have broken barriers and served as role models. The study concludes by emphasizing the need for comprehensive efforts to address gender disparities and create an inclusive and empowering environment for women in Indian politics.

Keywords : political empowerment, women leaders, party reforms, education, training.

Introduction:

The role of women in politics is a subject of profound significance and study in the context of India, a country known for its rich tapestry of culture, diversity, and democratic governance. This analytical study delves into the intricate dynamics surrounding the participation of women in Indian politics. It seeks to shed light on the challenges,

opportunities, and evolving trends that have shaped the landscape of women's political representation in India.

India, the world's largest democracy, has a long and complex history of gender inequality, which has manifested itself in various spheres of society, including politics. Despite the nation's progressive and inclusive constitutional framework, the political arena has traditionally been dominated by men. over the years, significant strides have been made to break down these barriers and encourage greater gender parity in politics.

The study will examine the historical context of women's involvement in politics in India, tracing the journey from the early days of the independence movement to the present day. It will explore the milestones and challenges faced by women in their pursuit of political leadership, highlighting key figures and movements that have played pivotal roles in this journey.

Moreover, the study will delve into the factors that have hindered women's participation in politics, such as socio-cultural norms, economic disparities, and institutional barriers. It will also analyze the impact of reservation policies and affirmative action measures designed to increase women's representation in elected bodies.

In addition to examining the challenges, this study will underscore the importance of women's participation in politics and the potential benefits it brings to the nation's development and governance. It will explore how the inclusion of diverse voices can lead to more equitable policies, improved governance, and greater social justice.

Furthermore, the study will present a contemporary assessment of the current state of women in politics in India, offering insights into recent trends, achievements, and ongoing struggles. It will also consider the role of women in various political parties and their representation in legislative bodies at the national and state levels.

As we embark on this analytical journey, it is important to recognize that the participation of women in politics is not merely a matter of numerical representation but a reflection of a broader struggle for gender equality and social justice. This study aims to contribute to a deeper understanding of the complex dynamics surrounding women's participation in Indian politics and the implications it holds for the nation's democratic future. Through rigorous

analysis and insightful observations, it seeks to provide a comprehensive view of the challenges and opportunities facing women in politics in India.

1.Historical Background:

The historical background of women in politics in India is a complex and multifaceted narrative that spans centuries, marked by significant milestones, movements, and gradual progress towards greater inclusion and representation. To understand the present state of women in Indian politics, it is essential to explore this historical context:

The historical background of women in politics in India reflects a journey marked by progress, challenges, and ongoing struggles. While significant milestones have been achieved, there is still work to be done to ensure greater representation and participation of women in all levels of Indian politics. This historical context provides the foundation for understanding the current state of women in Indian politics and the efforts being made to address gender disparities in the field of governance.

- **Pre-Independence Era (Ancient and Medieval India):** In ancient and medieval India, women often had prominent roles in governance and administration. Examples include the likes of Rani Padmini and Rani Durgavati. However, these were exceptions rather than the norm, and women's political participation remained limited.
- **Women in the Independence Movement:** The struggle for independence from British colonial rule in the early to mid-20th century provided a platform for women to actively participate in politics. Figures like Sarojini Naidu, Annie Besant, and Kamala Nehru played significant roles in the freedom struggle, raising awareness about political issues and advocating for women's rights.
- **Post-Independence Period (1947 onwards):** After gaining independence in 1947, India adopted a democratic constitution that guaranteed equality for all citizens, regardless of gender. The right to vote was extended to women, and women started participating in electoral politics. In 1952, India held its first general election, and several women were elected to the Constituent Assembly.
- **Reservation for Women:** To address the underrepresentation of women in political offices, India introduced reservation policies at the local level in the form of Panchayati Raj Institutions (PRIs). The 73rd and 74th Constitutional Amendments in 1992 mandated that one-third of seats in local rural and urban bodies be reserved for women.
- **Women's Movements:** Throughout the post-independence period, various women's movements and organizations advocated for gender equality and women's political

empowerment. Prominent among them were the All India Women's Conference and the National Federation of Indian Women.

- **Progress in State Politics:** Some Indian states saw women achieving significant political positions. For instance, Mamata Banerjee in West Bengal and Jayalalithaa in Tamil Nadu became prominent political leaders who served as Chief Ministers.
- **National Leadership:** While India has had a few female Presidents (such as Pratibha Patil) and Prime Ministers (Indira Gandhi and her daughter-in-law, Sonia Gandhi, who declined the position but was a powerful political figure), women's representation at the national level remained relatively low.
- **Challenges and Gender Disparities:** Despite advancements, women in Indian politics faced numerous challenges, including patriarchal attitudes, violence, and unequal access to resources and opportunities. The gender gap in political participation persisted.

- **Contemporary Developments:** In recent years, there has been a growing awareness of the need for greater women's participation in politics. Some states have experimented with increasing reservation quotas, and women have assumed leadership roles in major political parties.

2. **Representation and Participation**: Representation and participation of women in Indian politics are crucial aspects of the broader discourse on gender equality and democratic governance. This section of the analytical study explores the dynamics of women's representation and participation in Indian politics, shedding light on the challenges, opportunities, and evolving trends.

- **Numerical Representation:** Despite progress over the years, women's numerical representation in Indian politics still falls short of gender parity. While women constitute nearly half of the country's population, their presence in legislative bodies at the national and state levels remains disproportionately low. This underrepresentation is particularly evident in the Lok Sabha (House of the People) and Rajya Sabha (Council of States), where women's participation hovers around 14-15% and 10-11%, respectively.
- **Reservation Policies:** One significant step towards enhancing women's representation has been the introduction of reservation policies. As mentioned earlier, the 73rd and 74th Constitutional Amendments mandated one-third of seats in Panchayati Raj Institutions (PRIs) and urban local bodies to be reserved for women. These policies have resulted in a considerable increase in women's participation at the grassroots level, with many women serving as Sarpanches (village leaders) and in other leadership roles at the local level.

- **Role of Political Parties:** Political parties play a pivotal role in shaping women's political participation. While some parties have actively promoted women's leadership and representation, others lag behind. Women continue to face significant challenges in securing tickets to contest elections, and party leadership positions are often dominated by men. However, there is a growing recognition of the need for more women in leadership roles within political parties.
- . **Women in State Politics:** Several Indian states have witnessed the rise of women leaders who have assumed the position of Chief Minister. Leaders like Mamata Banerjee (West Bengal), Mayawati (Uttar Pradesh), and Vasundhara Raje (Rajasthan) have demonstrated the potential of women in top executive roles. These instances serve as examples of successful women leaders at the state level.
- **Challenges and Barriers:** Women in Indian politics face numerous challenges, including societal norms, patriarchy, political violence, and unequal access to resources. Women are often viewed as "proxy" candidates for male family members and are subjected to harassment and discrimination within political parties and during campaigns.
- **Women's Movements and Advocacy:** Various women's movements and civil society organizations continue to advocate for gender equality in politics. These groups raise awareness, provide training and support for women candidates, and push for policy changes that promote women's political participation.
- **Media and Public Perception:** The role of media in shaping public perception of women in politics is significant. Positive media coverage can inspire more women to enter politics and counter gender stereotypes. However, negative, or biased reporting can reinforce existing biases and discourage women from participating.
- **Youth and Emerging Trends:** There is a growing trend of young women entering politics, particularly at the local level. This influx of fresh talent brings new perspectives and energy to the political arena, potentially reshaping the landscape of women's participation in the years to come.

3.**Reservation Policy:** Reservation policies have been a critical and transformative component of women's participation in politics in India. These policies were introduced with the intention of addressing the historical underrepresentation of women in political leadership roles. In this section of the analytical study, we delve into the reservation policies for women in Indian politics, their impact, and the ongoing debates surrounding them.

- **Reservation in Panchayati Raj Institutions (PRIs):** The 73rd and 74th Constitutional Amendments in 1992 mandated that one-third of seats in local rural Panchayati Raj bodies (such as Gram Panchayats, Panchayat Samitis, and Zila Parishads) and one-third of seats in urban local bodies (such as Municipalities and Municipal Corporations) should be reserved

for women. These amendments aimed to increase women's participation at the grassroots level and empower them in local governance.

- **Positive Impact at the Local Level:** The reservation policy for women in PRIs has had several positive outcomes. It has led to a substantial increase in the number of women elected as Sarpanches (village heads) and members of local governing bodies. This increased representation has resulted in greater attention to issues related to women, children, and marginalized communities in local governance.
- **Women's Empowerment:** Reservation policies at the local level have empowered women who were previously excluded from political decision-making. It has given them a platform to voice their concerns, participate in developmental initiatives, and challenge traditional power structures.
- **Challenges and Limitations:** While the reservation policy has been successful at the local level, it has not been extended to the state or national levels. Women's representation in state legislatures (Vidhan Sabha's) and the national parliament (Lok Sabha and Rajya Sabha) remains disproportionately low. Critics argue that this limited scope of reservation policies restricts women's political influence to local issues, preventing their participation in shaping broader policies and legislation.
- **Debates on Efficacy:** There is an ongoing debate about the effectiveness of reservation policies in truly empowering women in politics. Some argue that it might lead to tokenism, where women elected through reservations might not have real decision-making power or be taken seriously by their male counterparts. Others contend that these policies are necessary to break the cycle of male-dominated political leadership.
- . **Intersectionality and Marginalized Communities:** Reservation policies have primarily benefited women from dominant caste groups. Women from marginalized and disadvantaged communities still face significant barriers in entering politics. Addressing intersectionality, which considers factors like caste, class, and religion, is a crucial aspect of promoting inclusivity in politics.
- **Need for Comprehensive Reforms:** Many experts and activists advocate for a more comprehensive approach to address women's underrepresentation in politics. This includes not only increasing the number of women in leadership positions but also creating a conducive environment for their active and meaningful participation.
- **Increasing Reservation Quotas:** Some states in India have experimented with increasing reservation quotas for women in local bodies beyond the mandated one-third. This has led to even greater women's participation at the grassroots level.

4.**Impact of Women in Politics:** The impact of women in politics in India is multifaceted and extends across various dimensions of governance, policymaking, and societal transformation. This section of the analytical study examines the influence and consequences of women's participation in Indian politics.

- **Policy Formulation and Prioritization:**
- **Gender-Specific Policies:** Women in politics often advocate for policies that address gender-specific issues, such as healthcare, education, and violence against women. Their presence in decision-making bodies can lead to the prioritization of these concerns.
- **Empowerment Initiatives:** Women leaders frequently champion programs and initiatives aimed at the economic, social, and political empowerment of women, including schemes for financial inclusion, skill development, and political participation.
- **Legislative Impact:**
- **Enacting Pro-Women Legislation:** Women legislators have played pivotal roles in the formulation and passage of legislation aimed at protecting women's rights and promoting gender equality. This includes laws addressing issues like dowry, domestic violence, and sexual harassment.
- **Advancing Social Justice:** Women in politics often advocate for marginalized and vulnerable groups, including women from marginalized communities, tribal populations, and the economically disadvantaged.
- **Influencing Public Discourse:**
- **Changing Perceptions:** The presence of women in politics challenges traditional gender stereotypes and perceptions about women's roles in society. Women leaders can inspire other women and girls to pursue leadership positions.
- **Highlighting Gender Disparities:** Women in politics use their platforms to draw attention to gender disparities, raising awareness about issues like the gender pay gap, lack of representation, and discrimination.
- **Local Governance and Grassroots Impact:**
- **Improved Service Delivery:** Women leaders in local governance often focus on improving basic services like healthcare, sanitation, and education, which can have a direct impact on the quality of life in their communities.
- **Promotion of Civic Engagement:** Women leaders encourage civic engagement and participation, motivating more women to get involved in community decision-making processes.
- **Role Modeling and Aspirations:**
- **Inspiring Future Leaders:** Women in politics serve as role models for future generations of women leaders, demonstrating that women can excel in traditionally male-dominated fields.
- **Encouraging Political Aspirations:** The visibility of women in political leadership positions encourages more women to enter politics and aspire to higher offices.
- **Championing Social and Economic Development:**
- **Economic Empowerment:** Women leaders often advocate for economic opportunities for women, including entrepreneurship, access to credit, and income-generating programs.
- **Social Welfare:** Women in politics work towards improving the welfare of women, children, and families, including measures to reduce maternal and infant mortality rates.
- **Addressing Violence and Discrimination:**
- **Anti-Discrimination Efforts:** Women in politics actively work to combat discrimination and violence against women, pushing for stricter laws and better enforcement.
- **Raising Awareness:** They use their positions to raise awareness about issues like gender-based violence and harassment, contributing to societal change.
- **Global Impact:**

- **International Diplomacy:** Women leaders in India have represented the country on the international stage, contributing to discussions on global issues such as climate change, peacekeeping, and gender equality.

5. **Challenges and Barrier**: The participation of women in politics in India has been significantly influenced by a range of challenges and barriers, both historical and contemporary. This section of the analytical study explores these challenges and barriers, which have limited women's entry into and progress within the political arena.

- **Patriarchal Norms and Stereotypes:**
- **Traditional Gender Roles:** Deep-rooted patriarchal norms assign women primarily domestic roles, making it difficult for them to break into the male-dominated sphere of politics.
- **Stereotypes:** Stereotypes about women's capabilities, leadership, and decision-making abilities persist, undermining their credibility as political leaders.
- **Violence and Harassment:**
- **Physical Threats:** Women politicians often face physical threats and violence, including assault and vandalism, which can deter them from active political participation.
- **Verbal Abuse:** Verbal harassment, character assassination, and derogatory comments are commonly used as tools to silence women in politics.
- **Lack of Access to Resources:**
- **Financial Barriers:** Women often lack access to the financial resources necessary for mounting political campaigns, such as fundraising networks and campaign financing.
- **Educational Disparities:** Gender disparities in education limit women's access to information and knowledge, affecting their ability to engage in informed political discourse.
- **Family and Social Pressure:**
- **Balancing Family and Politics:** Women often find it challenging to balance family responsibilities with political careers, leading to family pressure to prioritize domestic roles.
- **Social Stigma:** The decision to enter politics can be met with social stigma, as women who challenge traditional gender roles may face backlash from their communities.
- **Lack of Representation in Political Parties:**
- **Underrepresentation in Party Leadership:** Women are often underrepresented in leadership positions within political parties, making it difficult to secure party tickets and nominations.
- **Limited Decision-Making Power:** Women within political parties may have limited influence in shaping party policies and strategies.
- **Electoral Challenges:**

- **Electoral Violence:** Elections in India can be marred by violence and intimidation, disproportionately affecting women candidates.
- **Winner-Takes-All System:** The "winner-takes-all" electoral system can discourage women from entering politics because they may perceive it as a high-stakes, winner-centric environment.
- **Reservation Policies and Tokenism:**
- **Token Representation:** Some critics argue that reservation policies can lead to tokenism, where women elected through reservations may not have real decision-making power or be taken seriously by their male counterparts.
- **Limited Scope:** Reservation policies have primarily been implemented at the local level, leaving state and national-level politics with limited gender diversity.
- **Media Bias and Misrepresentation:**
- **Biased Reporting:** The media sometimes portrays women politicians in a biased or negative manner, focusing on their appearance and personal lives rather than their policies and capabilities.
- **Lack of Coverage:** Women politicians may receive less media coverage compared to their male counterparts, making it difficult to build public profiles.
- **Intersectionality and Caste-Based Discrimination:**
- **Caste and Class Barriers:** Women from marginalized communities often face compounded discrimination due to both their gender and caste or class background, limiting their political opportunities.
- **Institutional Barriers:**
- **Lack of Internal Democracy:** Some political parties lack internal democracy, making it difficult for women to rise through party ranks and assert their influence.
- **Ineffective Complaint Mechanisms:** Many institutions lack effective mechanisms to address harassment and discrimination against women in politics.

6**. Empowering Women in Politics:** Empowering women in politics in India is a crucial endeavor that involves a multifaceted approach aimed at addressing the challenges and barriers women face in the political arena. This section of the analytical study explores strategies and initiatives to empower women in Indian politics.

- **Educational Empowerment:**
- **Promote Girls' Education:** Encourage and incentivize the education of girls and women to enhance their knowledge, skills, and confidence, making them more capable and informed political participants.
- **Financial Support and Resources:**
- **Access to Funding:** Facilitate access to campaign financing and financial resources for women candidates, especially those from marginalized backgrounds.

- **Training and Capacity Building:** Provide training programs and workshops to enhance the political and leadership skills of women interested in politics.
- **Legal Reforms and Policy Advocacy:**
- **Gender-Sensitive Legislation:** Advocate for and enact gender-sensitive legislation that promotes women's rights and addresses gender disparities in all spheres, including politics.
- **Reform Election Laws:** Advocate for reforms in election laws to create a more level playing field for women candidates, such as ensuring fair representation in party candidate lists.
- **Reservation Policies:**
- **Expand Reservation Quotas:** Consider expanding reservation quotas beyond local Panchayati Raj bodies to state and national legislatures, allowing for increased representation of women in higher-level politics.
- **Effective Implementation:** Ensure the effective implementation of existing reservation policies and mechanisms for their enforcement.
- **Political Parties and Internal Democracy:**
- **Intra-Party Democracy:** Encourage political parties to adopt and practice internal democracy, ensuring that women have equal opportunities to rise through party ranks and hold leadership positions.
- **Women's Wings:** Strengthen women's wings within political parties to provide support, mentorship, and networking opportunities for women party members.
- **Media and Public Awareness:**
- **Media Sensitization:** Sensitize the media to report on women politicians fairly and substantively, focusing on their policies and accomplishments rather than their appearance or personal lives.
- **Public Awareness Campaigns:** Launch public awareness campaigns to educate the public about the importance of women's participation in politics and the benefits of gender equality in governance.
- **Leadership Development:**
- **Leadership Programs:** Establish leadership development programs that specifically target women, equipping them with the skills and confidence needed to assume leadership roles in politics.
- **Mentorship:** Pair women politicians with experienced mentors who can provide guidance and support throughout their political careers.
- **Gender-Responsive Governance:**
- **Gender Mainstreaming:** Implement gender mainstreaming in policymaking and governance, ensuring that policies and programs address the specific needs and challenges faced by women.

- **Gender Budgeting:** Incorporate gender budgeting practices to allocate resources effectively for gender-sensitive initiatives and projects.
- **Community Engagement:**
- **Community Mobilization:** Engage communities in supporting and promoting women in politics, emphasizing the benefits of diverse political representation.
- **Women's Participation in Local Governance:** Encourage women's participation in local governance and community decision-making processes, providing opportunities for them to gain experience and build political networks.
- **Research and Data Collection:**
- **Collect Data:** Gather and analyze data on women's political participation, representation, and barriers to better inform policy and program design.
- **Research and Studies:** Conduct research and studies on the impact of women in politics, showcasing their contributions to governance and societal development.
- **International Collaboration:**
- **Exchange of Best Practices:** Collaborate with international organizations and countries to exchange best practices and lessons learned in promoting women's political empowerment.
- **Inclusivity and Intersectionality:**
- **Intersectional Approaches:** Recognize and address the intersectionality of gender with other factors like caste, class, and religion to ensure inclusivity in political empowerment efforts.

7. **Success Stories:**

- **Indira Gandhi:** Indira Gandhi was the first woman to serve as the Prime Minister of India. She held this office for four terms, making her one of the most influential political figures in India's history. Her leadership during crucial moments, such as the Bangladesh Liberation War, has left a lasting impact on Indian politics.
- **Pratibha Patil:** Pratibha Patil served as India's first female President from 2007 to 2012. Her election to the highest constitutional office in the country was a significant milestone for women in Indian politics.
- **Mamata Banerjee:** Mamata Banerjee is the Chief Minister of West Bengal and the founder of the All-India Trinamool Congress (AITC). Her leadership has had a significant impact on state politics, and she is known for her grassroots activism.
- **Sushma Swaraj:** Sushma Swaraj was a prominent leader of the Bhartiya Janata Party (BJP) and served as India's Minister of External Affairs. She was known for her diplomatic skills and her ability to connect with people both within and outside India.
- **Mayawati:** Mayawati, a leader from the Bahujan Samaj Party (BSP), has served multiple terms as the Chief Minister of Uttar Pradesh. Her advocacy for the rights of marginalized communities, particularly Dalits, has reshaped caste politics in the state.

- **Jayalalithaa:** J. Jayalalithaa, also known as "Amma," was a charismatic leader and actress who served multiple terms as the Chief Minister of Tamil Nadu. Her leadership was marked by a strong focus on welfare programs and infrastructure development.
- **Nirmala Sitharaman:** Nirmala Sitharaman is the Finance Minister of India and a prominent member of the BJP. She has played a crucial role in shaping India's economic policies and is known for her leadership in finance and commerce.
- **Smriti Irani:** Smriti Irani, a former television actress, is a senior BJP leader who has held significant ministerial portfolios, including Minister of Textiles and Minister of Women and Child Development. She is known for her active role in politics and governance.
- **Maneka Gandhi:** Maneka Gandhi, a member of the Nehru-Gandhi family, has held various ministerial positions in different governments. She is known for her work in animal welfare and environmental protection.
- **Poonam Mahajan:** Poonam Mahajan is a prominent young leader of the BJP and a Member of Parliament. She has actively worked to engage youth and women in politics and has represented her constituency effectively.
- **Nandini Satpathy:** Nandini Satpathy was the first woman Chief Minister of Odisha. Her tenure was marked by a focus on social welfare and development programs.

Conclusion:

In conclusion, the study on women in politics in India reveals a complex and evolving landscape where women have made significant strides, yet numerous challenges and barriers persist. This analytical study has explored various aspects of women's participation in Indian politics, providing insights into their historical background, representation, challenges, empowerment strategies, and success stories.

- India's political landscape has seen notable achievements in women's participation, with women breaking barriers and attaining leadership positions at the local, state, and national levels. Women leaders have played crucial roles in shaping policies, advocating for gender equality, and addressing the unique needs of women and marginalized communities.

- However, challenges such as patriarchal norms, violence, limited access to resources, and underrepresentation in political parties continue to impede women's progress in politics. The study underscores the importance of addressing these challenges through comprehensive reforms, gender-sensitive policies, and grassroots empowerment initiatives.

- Efforts to empower women in politics in India should encompass educational opportunities, financial support, legal reforms, and awareness campaigns that promote gender equality and inclusivity. Expanding reservation policies and promoting women's

leadership within political parties are also vital steps toward achieving greater representation.

- Success stories of women leaders in Indian politics serve as powerful examples of determination, resilience, and the potential for change. These stories inspire future generations of women to pursue leadership roles and actively contribute to the nation's governance.

- In conclusion, the study recognizes that while significant progress has been made, there is still work to be done to ensure equal and meaningful participation of women in Indian politics. Achieving gender equality in politics is not only a matter of justice and democracy but also a means to enhance the effectiveness of governance and address the unique needs and perspectives of all citizens, regardless of gender. By addressing the challenges and building on the successes, India can move closer to a more inclusive and representative political landscape that reflects the diversity and aspirations of its people.

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Empowering Rural Women through Information, Education, and Communication: A Study in Tirupati District, Andhra Pradesh

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Abstract:

This research examines the effectiveness of Information, Education, and Communication (IEC) initiatives among Self-Help Group (SHG) women in rural areas of Tirupati District, Andhra Pradesh. The study aims to assess awareness levels regarding IEC and health issues among SHG women. Adopting purposive stratified random sampling, 500 SHG beneficiaries were selected, with 250 each from Chandragiri Mandal and Ramachandrapuram (RC Puram) Mandal. Data was collected through structured interviews.

The findings reveal that the adoption of new technologies has significantly enhanced income generation among SHG women and increased awareness of health issues such as HIV/AIDS and contraception methods. Furthermore, the study highlights the importance of legal frameworks addressing issues like sexual harassment and domestic violence. The success of IEC initiatives is evidenced by the extensive knowledge and awareness demonstrated by SHG women on various health topics.

Keywords: Information, Education, Communication, Self-Help Group Women, Rural Areas, Tirupati District, Andhra Pradesh, Health Awareness, HIV/AIDS, Contraception, Legal Frameworks, Income Generation

Introduction:

Education and Communication is now rightfully recognized as an integral part of policy making procedure. Over the years, the thrust of the Department has been to place the IEC as an intervention tool to generate demand for the range of services under National Rural Health Mission and various other schemes implemented by this Department. The communication strategy aims to facilitate awareness, disseminate information regarding

availability and access to quality health care within the Government run public health system. The key objective of the IEC strategy is to encourage a health seeking behaviour that is achievable in the context in which people live. The strategy views recipients of health services as not merely users of services but key participants in generating demand for services. During the year under report, the communication strategy has focused on sustaining behaviour changes on key health issues through multimedia tools. The strategy framework thus incorporates a variety of activities involving communities and the various media channels. A judicious mix of the following media channels were used for information, education, and communication during the year. Interpersonal communication, Community mobilization, Mass media, Folk and traditional media, Outdoor media, advocacy, events and exhibitions as also Print media.

In contemporary society, Information, Education, and Communication (IEC) have emerged as indispensable tools in both policy-making and public health interventions. Particularly in rural areas, where access to resources and awareness of health-related issues may be limited, effective IEC initiatives can play a pivotal role in empowering communities and promoting positive behavioral changes. This study directs its focus on assessing the implementation and impact of IEC initiatives among Self-Help Group (SHG) women in Tirupati District, Andhra Pradesh.

Tirupati District, located in the southern state of Andhra Pradesh, represents a typical rural setting where socio-economic challenges intersect with issues related to healthcare access and awareness. Against this backdrop, understanding the efficacy of IEC initiatives becomes imperative, as they serve as crucial channels for disseminating information and facilitating behavior change among marginalized communities.

The primary objective of this study is to evaluate the effectiveness of IEC initiatives in promoting health awareness and education among SHG women in Tirupati District. These women represent a vulnerable yet influential demographic group, as SHGs not only provide them with economic opportunities but also serve as platforms for social and community engagement.

By assessing the impact of IEC initiatives, this study seeks to shed light on the extent to which these interventions have contributed to enhancing awareness levels regarding health issues among SHG women. Additionally, it aims to explore the role of IEC in addressing broader socio-cultural factors such as gender-based violence and legal frameworks related to women's rights.

Given the diverse socio-economic landscape of rural areas, understanding the nuances of IEC implementation and its impact on SHG women can inform policymakers, healthcare practitioners, and development agencies about the most effective strategies for promoting health awareness and education in similar contexts.

In this study delves into the realm of IEC initiatives among SHG women in Tirupati District, aiming to assess their effectiveness in fostering health awareness and education. By examining the implementation processes and outcomes of these initiatives, it seeks to provide valuable insights into enhancing the well-being and empowerment of rural women in Andhra Pradesh and beyond.

Research Objectives:

To assess the awareness levels of Self-Help Group (SHG) women regarding Information, Education, and Communication (IEC) initiatives in Tirupati District, Andhra Pradesh.

To evaluate the effectiveness of IEC initiatives in promoting health awareness among SHG women, with a specific focus on topics such as HIV/AIDS, contraception methods, and reproductive health.

To analyze the impact of IEC initiatives on the knowledge, attitudes, and behaviors of SHG women towards health-related issues in rural areas.

To examine the role of IEC initiatives in addressing broader socio-cultural factors affecting SHG women, including gender-based violence, legal frameworks, and women's rights.

To identify the key sources of information utilized by SHG women for accessing health-related knowledge and resources, including traditional media, community networks, and technological platforms.

To explore the implications of IEC initiatives on income generation, economic empowerment, and social inclusion among SHG women in Tirupati District.

To provide recommendations for improving the design, implementation, and sustainability of IEC initiatives aimed at promoting health awareness and education among SHG women in rural areas.

Methodology:

Sampling Technique: Purposive Stratified Random Sampling was employed to ensure representation from both Chandragiri and RC Puram Mandal's. This method involved dividing the population of SHG beneficiaries into distinct groups (strata) based on geographical location (mandalas). From each stratum, a random sample of SHG beneficiaries was selected to ensure diversity and representativeness in the study sample.

Sample Size: The study aimed to include 500 SHG beneficiaries, with 250 participants from Chandragiri Mandal and 250 from RC Puram Mandal. This sample size was determined to provide adequate statistical power for analyzing the effectiveness of IEC initiatives among SHG women in rural areas.

Data Collection: Data collection was conducted through structured interviews using a pre-designed questionnaire. The questionnaire was developed based on the research objectives and included both closed-ended and open-ended questions to capture quantitative and qualitative data. Trained interviewers administered the questionnaire to the selected SHG beneficiaries, ensuring consistency and reliability in data collection.

Variables: The key variables examined in the study included awareness levels regarding IEC initiatives, knowledge and attitudes towards health issues, sources of information utilized, socio-economic factors, and perceived impact of IEC initiatives on health awareness and empowerment.

Data Analysis: Quantitative data collected through the structured interviews were analyzed using appropriate statistical methods, including descriptive statistics, frequency distributions, and inferential statistics (e.g., chi-square tests) to examine associations and relationships between variables. Qualitative data from open-ended questions were analyzed thematically to identify emerging patterns and themes.

Ethical Considerations: Ethical considerations were paramount throughout the research process. Informed consent was obtained from all participants prior to their inclusion in the study, ensuring voluntary participation and

confidentiality of responses. The study adhered to ethical guidelines and protocols established by relevant institutional review boards and regulatory bodies.

Hypotheses:

SHG women exposed to IEC initiatives will demonstrate higher levels of awareness regarding health issues compared to those not exposed.

There will be a significant association between exposure to IEC initiatives and adoption of positive health behaviors among SHG women.

SHG women who utilize multiple sources of information, including traditional and technological platforms, will exhibit higher levels of health awareness and empowerment.

Socio-economic factors, such as income level and education, will moderate the relationship between exposure to IEC initiatives and health outcomes among SHG women.

The perceived impact of IEC initiatives on health awareness and empowerment will vary based on the effectiveness of implementation strategies and the relevance of content to the target population.

RESULTS AND DISCUSSION

Table No.1: Percentage Distributions of SHG women by current use of Contraceptive Methods

	Chandragiri		**RC Puram**	
Type of method	No	%	No	%
Female sterilization	88	35.2	118	47.2
Male sterilization	3	1.2	1	0.4
Pills	82	32.8	75	30
IUD	3	1.2	6	2.4
Injectables	1	0.4	04	0
Condom/Nirodh	174	69.6	49	19.6

The data reveals extensive knowledge of various contraceptive methods among SHG women in Chandragiri and RC Puram. Female sterilization was the most prevalent method, with 35.2% of Chandragiri and 47.2% of RC Puram SHG women having undergone the procedure. Condom usage was also notable, with 69.6% of Chandragiri and 19.6% of RC Puram SHG women using condoms as a contraceptive method. However, the usage of other methods such as male sterilization, pills, IUD, and injectables was relatively low. This indicates a need for further education and access to a wider range of contraceptive options.

Health Awareness & Education:

Health awareness and education are vital components of community development, particularly in rural areas. The data presented in Table No. 2 highlights the level of awareness among SHG women regarding various health issues and services.

Table No.2: Percentage Distribution of SHG Beneficiaries by Health Awareness & Education

Response	Chandragiri		RC Puram	
	No	%	No	%
HIV awareness	249	99.6	241	95.6
Primary Health center	244	97.6	224	89.6
Leprosy &TB centers	158	63.2	147	58.8
Community health development	112	44.8	113	45.2
Mobile heath unit/visit	84	33.6	77	30.8

The data indicates a high level of awareness among SHG women in both Chandragiri and RC Puram regarding HIV/AIDS, primary health centers, and mobile health units. Over 95% of SHG women in both areas were aware of HIV/AIDS, while more than 89% were aware of primary health centers. However, awareness of other health services such as leprosy & TB centers and community health development was relatively lower, highlighting areas for improvement in health education and outreach programs.

Sources of Information on HIV/AIDS:

Information dissemination plays a crucial role in increasing awareness of HIV/AIDS prevention and treatment.

Table. No.3. Percentage Distribution of SHG women by sources of information on HIV/AIDs

Sources of information on HIV	Chandragiri		RC Puram	
	No	%	No	%t
Radio/Television	50	20	53	20.4
Newspaper/Magazine	34	13.6	72	28.8
friend/relatives	31	12.4	14	5.6
Extension Programmes	83	33.2	61	24.4
SHG	52	20.8	50	20

The data shows that a significant portion of SHG women in both Chandragiri and RC Puram obtained information on HIV/AIDS through extension programs and SHG meetings. Additionally, radio/television and newspapers/magazines served as important sources of information, albeit to a lesser extent. However, there is a need to further explore and utilize newer communication technologies to enhance the reach and effectiveness of HIV/AIDS education programs.

Awareness on HIV Prevention Methods:

Preventive measures are crucial in combating the spread of HIV/AIDS. Table No. 4 presents data on SHG women's awareness of HIV prevention methods.

Table No.4: Percentage Distributions of the respondents by aware HIV prevention methods

Response	Chandragiri		RC Puram	
	No	%	No	%
Using condoms	24	9.6	1	0.4
Limiting sexual intercourse to one uninfected partner	7	2.8	8	3.2
Using condoms and limiting sexual inter course to one uninfected partner	65	26	82	32.8
Abstaining from sexual inter course outside marriage	154	61.6	159	63.6

The data indicates that a majority of SHG women in both Chandragiri and RC Puram recognized the importance of abstaining from sexual intercourse outside of marriage as a key method of HIV prevention. Additionally, a significant portion acknowledged the efficacy of using condoms and limiting sexual intercourse to one uninfected partner. However, there is a need for further education on the consistent and correct use of condoms as a preventive measure.

Overall, the results suggest that while SHG women in rural areas demonstrate substantial knowledge and awareness of health issues, including HIV/AIDS prevention, there are still areas for improvement in terms of access to and utilization of contraceptive methods and broader health services. Effective communication strategies, including the use of newer technologies, tailored educational programs, and community engagement, are essential in addressing these gaps and promoting better health outcomes among rural populations.

Discussion:

The findings of this study underscore the significant impact of Information, Education, and Communication (IEC) initiatives on the empowerment and well-being of Self-Help Group (SHG) women in Tirupati District, Andhra Pradesh. Through targeted interventions aimed at providing information and raising awareness, these initiatives have played a crucial role in improving both health outcomes and socio-economic status among rural women.

Empowerment through Access to Information: One of the key contributions of IEC initiatives is their role in providing SHG women with access to essential information. By disseminating knowledge about health issues, including contraceptive methods, HIV/AIDS prevention, and access to healthcare services, these initiatives have empowered women to make informed decisions about their health and well-being. The high levels of awareness observed in the study, particularly regarding HIV/AIDS and contraceptive methods, highlight the effectiveness of these initiatives in bridging information gaps and empowering women with the knowledge they need to protect their health.

Enhanced Socio-Economic Well-being: Beyond improving health outcomes, IEC initiatives have also contributed to the socio-economic well-being of SHG women. The adoption of new technologies, as evidenced by the increased income generation among SHG women, indicates the economic empowerment facilitated by these initiatives. By equipping women with information and skills necessary for income-generating activities, IEC initiatives have played a pivotal role in enhancing economic opportunities and reducing financial dependency among rural women.

Addressing Legal and Social Issues: Moreover, the study highlights the importance of addressing legal and social issues, such as sexual harassment and domestic violence, within the framework of IEC initiatives. By raising awareness of these issues and providing support mechanisms, these initiatives contribute to the creation of safer and more supportive environments for women. This not only empowers women to assert their rights but also fosters community-level change by challenging harmful social norms and practices.

Challenges and Opportunities: While the findings demonstrate the positive impact of IEC initiatives, several challenges and opportunities remain. For instance, while there is extensive knowledge and awareness among SHG women, particularly regarding HIV/AIDS and contraceptive methods, there is still room for improvement in terms of access to a wider range of contraceptive options and consistent use of preventive measures. Additionally, the study highlights the need for continued efforts to expand access to healthcare services, particularly in remote rural areas where access may be limited.

Conclusion: In conclusion, the findings of this study underscore the transformative potential of IEC initiatives in empowering SHG women in rural areas. By providing access to information, promoting awareness, and addressing socio-economic and legal barriers, these initiatives contribute to improved health outcomes, enhanced socio-economic well-being, and greater empowerment among women. Moving forward, sustained investment in IEC initiatives, coupled with targeted interventions to address existing gaps and challenges, will be essential in advancing the rights and well-being of rural women in Tirupati District and beyond.

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CHILD LABOR, EDUCATION AND CHILDREN'S RIGHTS

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Abstract
This paper reviews the international legal framework relating to child labour as well as access to education and provides a statistical portrait of child labour and education participation. Moreover, it looks at why children work from the perspective of household decision making. Various policy options are also considered, including those which can improve the incentives to education relative to labour, remove constraints to schooling and increase education participation through legislation. Conclusions are drawn in the final section.

Introduction

"Nonetheless, if the fundamental rights behind our cause are not sufficient to move people to act, then let it be the economic and social rationale behind it. Either way, we are going to challenge people to act."

Nelson Mandela

Child Labour (Prohibition and Regulation) Act of India, 1986 defined that the child is a person who has not completed the age of fourteen years. A child of such tender age is expected to play, study and be carefree about his life. But, as a fact of nature, expectations seldom meet reality. Children, by willy-nilly or by force, are employed to work in the harsh conditions and uncongenial atmosphere which become a threat to their precious life. Child labour leads to underdevelopment, incomplete mental and physical development, which in turn, result in stunted growth of children.

Child labour is retribution to the child and is widespread around the world. It is a curse for development of both the individual child and society and economy in which she/he lives. If allowed to persist to the current extent, child labour will prevent the achievement of the Millennium Development Goals of halving poverty and achieving education for all. All of the countries in the world have ratified international human rights conventions which call for the elimination of child labour and the provision of universal primary education. Fulfilling these commitments is of immensely importance for development.

Child labour is a violation of fundamental human rights and has been a stumbling block to children's development, potentially leading to life-long physical or psychological damage. The fundamental ILO standards on child labour are the two legal pillars of global action to combat child labour.

Over 200 million children between the ages of 5 and 14 years are working around the world. This figure represents one-fifth of the total population of girls and boys in this age group. About 111 million children are in "hazardous work" which refers to forms of labour which are likely to have adverse effects on the child's safety, health and moral development. Nearly 10 million of these children are engaged in some form of slave labour, armed conflict, prostitution or pornography, or other illicit activities. Some observers believe that these figures understate the real magnitude of child labour. The hazardous and worst forms of child labour are of universal prime concern, given the obvious harm that they inflict on the lives of these children and their possibilities for a hopeful future. Child labour also has important various economic implications. Among them the most notable are the

substantial future income losses that working children will incur because of the negative consequences working will have on their human capital, including their health and education. Since children are more likely to work and not go to school if their parents worked as children, the economic losses associated with child labour and their implications for poverty are often transmitted across generations (ILO, 2020).

Child labour, of course, has already received ample attention. Most countries have long had prescriptive legislation as well as compulsory education laws. At the international level, child labour has been the focus of various conventions and recommendations. Among them the UN Convention on the Rights of the Child (1989) and two ILO conventions, the Minimum Age Convention (No. 138, 1973) and the Worst Forms of Child Labour Convention (No. 182, 1999) are most significant. In promoting children's rights, each of these instruments – in very different ways -- has been motivated by an interest in protecting children from exploitation through their labour and providing for education as a preferable alternative.

Human Rights Instruments

The principal international legal instruments for addressing child labour include the UN Convention on the Rights of the Child (1989) that covers both child labour and the right to education and two ILO conventions, the Minimum Age Convention (No. 138, 1973) and the Worst Forms of Child Labour Convention (No. 182, 1999). The UN Universal Declaration on Human Rights (1948) and the International Covenant on Economic, Social and Cultural Rights also address the right to education but the above-listed instruments provide more detail and are commonly seen as the key international instruments for addressing children's rights (Table 1). The Convention on the Rights of the Child (CRC) and the ILO child labour conventions have received widespread international support, the former being ratified by 192 countries – all U.N. members, in fact, save the United States and Somalia. ILO Convention 182, prioritizing action against the worst forms of child labour, was the first convention adopted unanimously and has been the most rapidly ratified convention.

Table 1, International Human Rights Instruments Related to Education and Child Labour

Sl. No.	Title	Date	Ratified	Provisions (Articles)
1.	Universal Declaration on Human Rights	1948	N/A	Right to Education (26)
2.	International Covenant on Economic, Social and Cultural Rights (CESCR)	1966	148	Compulsory and free primary education (13)
3.	ILO Convention 138: Minimum Age	1973	131	Compulsory and free primary education (13)
4.	Convention on the Rights of the Child (CRC)	1989	192	Freedom of association (15); primary education; (28) rest and leisure (31); no hazardous child labour (32); protection from sexual exploitation (34) and trafficking (35)
5.	ILO Convention 182: Worst Forms of Child Labour	1999	147	Ban slavery, use in armed conflict, prostitution, drug trade; Work harmful to health safety, morals.

Source: United Nations High Commissioner for Human Rights (http://www.un.org/rights/) and International Labour Organization (www.ilo.org)

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Global and Regional Overview

Child labour remains unacceptably common in the world today. At the start of 2020, prior to the outbreak of the COVID-19 pandemic, 160 million children – 63 million girls and 97 million boys – were in child labour, or 1 in 10 children worldwide. Seventy-nine million children – nearly half of all those in child labour – were in hazardous work directly endangering their health, safety and moral development.

This global estimate masks large variations across regions. Child labour prevalence stands at 24 per cent in sub-Saharan Africa, three times that of Northern Africa and Western Asia, the region with the second highest prevalence. In absolute terms, the nearly 87 million children in child labour in sub-Saharan Africa are more than in the rest of the world combined.

Recent history provides cause for copious concern. In the last four years, for the first time since 2000, the world did not make any progress in reducing child labour. The absolute number of children in child labour was increased by over 8 million to 160 million while the proportion of children in child labour remained still unchanged. Children in hazardous work mirrored these patterns: The share remained almost unchanged but the number rose by 6.5 million to 79 million.

The pace of progress has varied dramatically across regions. The proportion and number of children in child labour have declined consistently since 2008 in Asia and the Pacific and Latin America and the Caribbean. Similar progress has proved elusive in sub-Saharan Africa, where child labour has actually gone up since 2012, a trend especially pronounced over the last four years when the region accounted for much of the global increase.

At present, the world is not on track to eliminate child labour by 2025. For meeting this target, global progress would need to be almost 18 times faster than the rate observed over the past two decades. According to pre-COVID-19 projections based on the pace of change from 2008 to 2016, close to 140 million children will be in child labour by 2025 without an accelerated action. The COVID-19 crisis is making these scenarios even more worrisome, with many more children at risk of being pushed into child labour. Global progress against child labour has stalled since 2016.

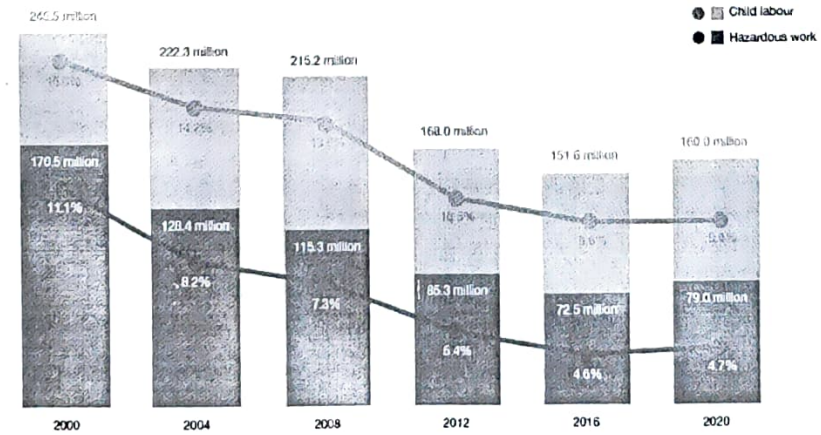


Fig.1. Percentage and number of children aged 5 to 17 years in child labour and hazardous work.

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Child Labour across Ages

The results of the global estimates make clear that child labour remains an important concern across the spectrum of children aged 5 to 17. Of the 160 million children in child labour, 89.3 million are young children aged 5 to 11, 35.6 million are children aged 12 to 14, and 35 million are children aged 15 to 17. Child labour among children aged 12 to 14 and 15 to 17 continued to fall in both absolute and percentage terms over the last four years. By contrast, the 2016-2020 period saw a worrying rise in child labour among young children aged 5 to 11. In 2016, there were signs of slowing progress among young children. Today the trend line is moving in the wrong direction. The reason for backtracking is not clear and direly needs to be investigated as a priority. Hazardous work accounted for about two fifths of the total number of additional children aged 5 to 11 in child labour during the four-year period. While children of all ages must be protected from hazardous work, its persistence and now growth among younger children is a particular concern.

Boys and girls in child labour

Involvement in child labour is more common for boys than girls at all ages. For children aged 5 to 17, child labour prevalence is nearly one third higher for boys. The gender gap grows with age, and boys are roughly twice as likely as girls to be in child labour in the 15 to 17 age range. Comparisons of child labour estimates for boys and girls must be accompanied by an important caveat. The definition of child labour upon which the estimates are based does not include involvement in household chores in children's own homes, an area of work for which girls shoulder a disproportionate burden of the responsibility in most societies.

The 2020 global estimates look for the first time at how the inclusion of household chores affects overall child labour estimates as well as estimates of male child labour relative to female child labour. The results are noteworthy. When the definition of child labour is expanded to include involvement in household chores for 21 hours or more per week, child labour prevalence increases for both sexes, but the rise in female child labour is much larger. As a result, the gender gap in child labour prevalence is reduced by almost half, from 2.8 percentage points to 1.6 percentage points. Child labour is more prevalent among boys than girls at every age

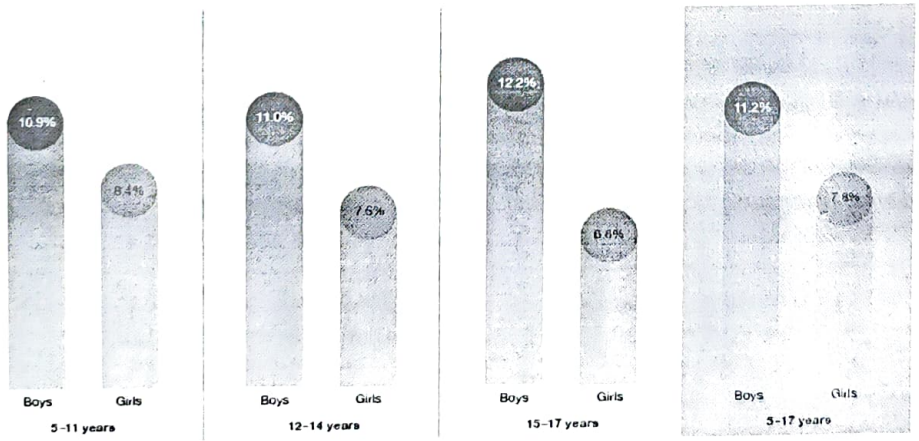


Fig.2. Percentage of children aged 5 to 17 years in child labour, by age and sex

Causes of Child Labour

Major causes of child employment which can be understood keeping in mind the Indian scenario are:

Poverty

In developing countries like India it is quite impossible to control child labour as children have been considered as helping hand to feed their families, to support their families and to feed themselves. Due to poverty, illiteracy and unemployment parents are unable to bear the burden of feeding their children and to run their families. Thus, the poor parents send their children for work in inhuman conditions at lower wages.

Previous Debts

The poor economic conditions of people in India force them to lend money. The illiterate population goes to money lenders and sometimes mortgage their belongings in turn of the debt taken by them. But, due to insufficiency of income, debtors find it quite difficult for paying back the debt and the interest. This vicious circle of poverty drags them towards working day and night for the creditor and then the debtors drag their children too in assisting them so that the debts could be paid off.

Professional Needs

There are some industries such as the 'bangle making' industry, where delicate hands and little fingers are needed to do very minute work with extreme excellence and precision. An adult's hands are usually not so delicate and small, so they require children to work for them and do such a dangerous work with glass. This often resulted in major eye accidents of the children.

Legislation

When in the 20th Century, child labour became so prominent that news of factory hazards and mishappenings taking innocent children's life, flashed all around in the newspapers, then was the time, a need for legislations and statutes were felt to prohibit the malpractice of child labour. Today, there are sufficient statutes condemning and prohibiting child labour such as:

The Factories Act of 1948

The Act prohibits the employment of children below the age of 14 years in any factory. The law also placed rules on whom, when and how long can pre-adults aged 15–18 years be employed in any factory.

The Mines Act of 1952

The Act prohibits the employment of children below 18 years of age in a mine. Mining being one of the most dangerous occupations, which in the past has led to many major accidents taking life of children, is completely banned for them.

The Child Labour (Prohibition and Regulation) Act of 1986

The Act prohibits the employment of children below the age of 14 years in hazardous occupations identified in a list by the law. The list was expanded in 2006, and again in 2008.

The Juvenile Justice (Care and Protection) of Children Act of 2000

This law made it a crime, punishable with a prison term, for anyone to procure or employ a child in any hazardous employment or in bondage. This act provides punishment to those who act in contravention to the previous acts by employing children to work.

The Right of Children to Free and Compulsory Education Act of 2009
The law mandates free and compulsory education to all the children aged 6 to 14 years. This legislation also mandated that 25 per cent of seats in every private school must be allocated for children from disadvantaged groups and physically challenged children.

Conclusion
Child labour is by no means strictly a low income country problem. Three of every five children in child labour live in middle-income countries. For greater national health to translate into reduced child labour, economic growth must be inclusive and its benefits equitably be distributed. The tax revenues it generates must be invested in programmes and services which make a difference for children, above all in education and social protection. The large pockets of child labour persist even in relatively rich countries points to important remaining policy challenges. It is an utmost urgent to put action to end child labour back on track, in line with global commitments and goals.

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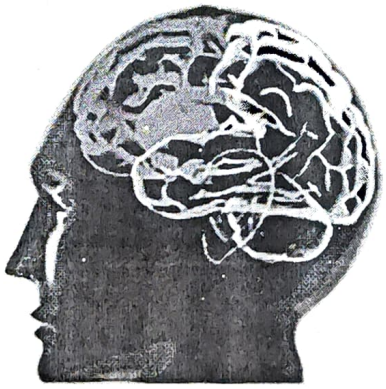
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ENFORCING ENVIRONMENTAL RIGHTS: JUDICIAL RESPONSES TO AIR POLLUTION IN INDIA

Dr.G Adinarayana

ABSTRACT:

Air pollution comes from many sources, depending on location and development. Human actions, like heavy industry, resource overuse, and population growth, are the main culprits. As globalization and industrialization take hold, worsening air quality is a big worry. Protecting the environment from pollution isn't a new idea; it's been crucial for societies forever. Courts, a vital part of our country, play a key role in ensuring environmental justice for those affected by air pollution. They set the rules and hold polluters accountable. This article explores how Indian courts have interpreted laws to control and reduce air pollution, promoting environmental justice in India.

Key words: Air Pollution, resource, globalization, environmental justice, National Green Tribunal.

INTRODUCTION:

When dangerous compounds exist in the Earth's atmosphere and have the potential to negatively impact human health, the environment, and air quality generally, it is referred to as air pollution. These pollutants can come in a variety of forms, such as gases, particles, and chemicals, and they can come from both natural and man-made sources. There are many different effects that air pollution can have, both locally and globally. There have been numerous initiatives in India to address air pollution, such as the adoption of laws, the application of court rulings by the Indian judiciary, the use of cleaner technologies, the promotion of renewable energy sources, the encouragement of sustainable transportation, and the education of the public about the value of clean air. In addition to international agreements and organizations, the judiciary is involved in resolving the problem of transboundary air pollution.

The court, particularly the higher judiciary, has rendered numerous important rulings that have helped to stop the decline in India's air quality. By interpreting and upholding environmental laws, issuing directives, and ensuring that government agencies and businesses take the required steps to lessen the harmful impacts of air pollution, the Indian court plays a critical role in the control of air pollution. The function of the judiciary is especially crucial when environmental rules and regulations are broken.

The enforcement of air pollution control laws, the issuance of guidelines and directives to various governmental agencies and industries, etc., the monitoring and oversight of the implementation of pollution control measures, the provision of compensation and remedies, the dissemination of public awareness and education, and the application of the precautionary principle, which permits preventive action even in the absence of complete scientific certainty about the impacts of air pollution, are just a few of the ways that the Indian judiciary contributes to the mitigation, prevention, or control of air pollution in India. The Supreme Court has rendered several significant rulings in the fight against air pollution, some of which are listed below:

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The Bhopal Gas Leak Disaster, a horrific industrial accident, happened in 1984. A poisonous gas called Methyl Isocyanate leaked from a Union Carbide pesticide plant in Bhopal, India. This tragedy caused thousands of deaths and left hundreds of thousands injured, many with permanent disabilities. The case highlights the plight of the numerous victims and criticizes the lengthy court battle for compensation. It emphasizes the severity of the disaster, calling it the worst industrial accident ever, with a leak of nearly 40 tons of toxic gas. For context, the factory belonged to a US company, Union Carbide Corporation.

The Bhopal gas leak caused a huge number of injuries and deaths, raising a complex legal issue how to get fair compensation for so many victims. There was a risk of countless lawsuits, and the severity of harm suffered by each person varied greatly. To avoid this mess of individual cases, the Indian Parliament passed a law in 1985 . This law gave the Indian government the power to sue on behalf of all the victims. This is based on a legal principle called "parens patriae," which allows the government to act as a parent for those who can't represent themselves in court. The Indian government decided to sue in the United States, where the parent company of the factory that caused the disaster was located. They believed the Indian legal system wasn't developed enough to handle such a big case and get the best possible outcome for the victims. However, the company argued that Indian courts were the most appropriate place for the case. Despite the Indian government's objections, the American court agreed with the company and sent the case back to India.

The Bhopal gas leak case started in Indian courts after US courts refused to hear it. Initially, the Madhya Pradesh High Court lowered the compensation amount from 3.5 billion rupees to 2.5 billion rupees. Both the Indian government and Union Carbide appealed to India's Supreme Court. The Supreme Court ordered a final settlement. Union Carbide would pay $470 million to the Indian government to cover all claims from the disaster. This money had to be paid by the end of March 1989. The Supreme Court also used its special authority to end all legal proceedings related to the disaster, including civil lawsuits, criminal cases, and contempt of court charges. These Supreme Court decisions were criticized for being unusually brief and lacking the detailed reasoning typically expected in such a significant case. Some argued the Court based its choices mainly on compassion for the victims.

The Indian Supreme Court took a significant step to protect historical treasures like the Taj Mahal from air and environmental pollution . They ruled that industries in the TTZ must switch to cleaner burning natural gas or relocate outside the zone if they can't use gas. This decision was based on scientific reports and the idea that polluters should be responsible for the damage they cause and that environmental protection should be a priority . The Court actively championed environmental protection through public interest litigation and relied on various parts of the Indian Constitution that guarantee the right to life and a healthy environment. Additionally, they used environmental laws like the Water and Air Pollution Acts to support their judgement. Delhi Vehicular Pollution Case addressed air pollution in Delhi. The Supreme Court ordered several measures to tackle this issue, such as phasing out leaded petrol, replacing old vehicles, building new bus terminals, and improving air quality monitoring. In Vellore Citizen Welfare Forum v. Union of India , the Court emphasized two key environmental principles: the Pre-

cautionary Principle (taking preventive action) and the Polluter Pays Principle (holding polluters accountable). They directed the Indian government to prioritize supplying cleaner-burning natural gas for vehicles nationwide.

Finally, the Oleum Gas Leak case led the Court to recommend a national policy for locating hazardous industries away from populated areas. They also suggested creating a neutral scientific body to advise courts and government, and establishing specialized environmental courts for pollution cases. The Supreme Court took a stand against secondhand smoke, citing the right to life enshrined in the Indian Constitution . They banned smoking in public places and ordered the government to implement this effectively. This is one example of how the Indian courts have championed environmental protection. They've introduced several principles to combat air pollution. The Precautionary Principle was first used in the Vellore Citizens' Welfare Forum case. The Polluter Pays Principle was applied in the Indian Council for Enviro-Legal Action case. And the Public Trust Doctrine was used in the M.C. Mehta v. Kamal Nath case.

PRINCIPLES ADOPTED BY THE COURTS

India's Supreme Court has significantly advanced environmental law by establishing important principles. These principles, developed mainly by the Supreme Court, are like stepping stones that pave the way for cleaner air in India. The Court has incorporated these principles into its decisions, considering international agreements and conferences . This is a major contribution to India's environmental legal system. Some of the principles are;

1. Polluter pays principle
2. Principle of non-discrimination
3. Precautionary principle
4. Principle of intergenerational equity
5. Doctrine of common but differentiated responsibility
6. Public trust doctrine

India's courts have established key principles to fight air pollution. The Precautionary Principle, explained in the Vellore Citizens' Welfare Forum case , states that preventing environmental damage is a government duty, and scientific uncertainty shouldn't delay action. The Polluter Pays Principle, affirmed in the Indian Council for Enviro-Legal Action case, holds polluters responsible for compensating victims and restoring the environment. Finally, the Intergenerational Equity Principle, implies a duty to future generations to leave them a healthy environment. These principles, along with the Public Trust Doctrine, have led to significant court judgements to control air pollution. However, tackling air pollution requires a combined effort. Laws, regulations, technology, public participation, and commitment from everyone are all necessary for clean air.

NGT , established in 2010, is responsible for handling cases related to urban air pollution in India. It aims to fulfill both the constitutional right to a healthy environment (Article 21) and the goals outlined in the NGT Act itself. This Act empowers the NGT to deal with environmental protection, resource conservation, enforce environmental rights, and provide compensation for damages. However, despite significant air pollution problems, there haven't been many cases brought before the NGT regarding this issue.

The National Green Tribunal Act, passed in 2010, reflects India's commitment to international environmental agreements. This is because India participated in major

conferences like Stockholm in the year 1972 and Rio in the year 1992. The NGT is required to consider these international principles, such as sustainable development, the precautionary principle, and the polluter pays principle, when making decisions on environmental protection cases. These international principles are used alongside Indian laws to effectively enforce environmental rights and responsibilities in India. The NGT primarily focuses on protecting environmental legal rights and addressing problems caused by enforcing environmental laws listed in Schedule 1 of the Act.

Vardhaman Kaushik v. Union of India , the first lawsuit under the previously described category 1, was filed in 2014 and concerned harmful air quality in the National Capital Region. The NGT issued numerous directives over the course of four years through judgments and verdicts, including prohibiting polluting companies, controlling traffic, requesting action plans from the government, and demanding certain measures for waste disposal and dust management, among other things. A suo moto case was filed in 2018 in response to the nation's declining urban air quality, based on a Times of India newspaper piece that examined the National Clean Air Programme's timeframes. The NCAP case required 102 'non-attainment cities', or those that had average annual concentration levels of notified criteria, surpassing certain thresholds for five years in a row, to take corrective action regarding air pollution. This lawsuit sought to address the problem of urban air pollution nationwide and mandated that each state and local government prepare action plans under the NCAP, address vehicle pollution, and conduct thorough carrying capacity evaluations for each city.

In both instances, the Tribunal criticized the federal and state administrations and demanded more vigorous action to reduce air pollution by using Right to Life and the three guiding principles of environmental jurisprudence. As a result, the two cases have emerged as the centerpiece of the Tribunal's urban air pollution intervention. Since then, any cases pertaining to urban air quality that are brought before the Tribunal are handled by subsequent benches utilizing the rulings in the two instances as well as the several directions rendered by the Supreme Court in MC Mehta v. Union of India. For instance, the South Zone bench in Vinay Shivanand Naik v. State of Karnataka , a case concerning urban air pollution in Bengaluru associated with vehicle pollution, requested that the State Government adhere to action plans developed under the National Clean Air Plan, as filed in the NCAP Case. In a related case, LG Sahadevan v. Union of India , for Chennai, the Bench requested that an action plan be created taking into account the directives from the NGT regarding the Vardhaman Kaushik issue.

Concerns about air pollution and other environmental issues have been extensively pursued by the NGT. The NGT contributes significantly to the fight against air pollution in the following ways:

1. The NGT has the authority to consider appeals and cases involving environmental infractions, particularly those involving air pollution. It may decide to take up cases on its own initiative or in response to petitions submitted by people, groups, or governmental entities. The tribunal has the authority to penalize and punish polluters as well as individuals who violate environmental standards.

2. The NGT keeps an eye on how environmental laws and rules-including those pertaining to air quality standards-are being applied. It guarantees that businesses and governmental organizations follow established emission guidelines and pollution prevention techniques. The NGT has the authority to make orders to resolve any infractions.

3. The NGT has the authority to enforce the precautionary principle, which stipulates that the burden of proof rests with those promoting an action if it has the potential to harm the environment or the public, even in the absence of conclusive scientific evidence. This approach permits the NGT to regulate air pollution even in the absence of total scientific knowledge by taking preemptive action.

4. The NGT has the authority to mandate routine air quality monitoring and the application of pollution management strategies. In order to evaluate the status of efforts to reduce air pollution and meet established air quality requirements, it may also request periodic reports from the appropriate authorities.

5. The NGT can help spread knowledge about the negative effects of air pollution and the value of environmental preservation. The public is helped to understand the need of addressing air pollution by the frequent media coverage of its rulings and decisions.

6. In order to stop and manage air pollution, the NGT may publish guidelines and recommendations. A broad range of businesses, including waste management, construction, transportation, and industry, may be covered by these guidelines.

It is noteworthy that there may have been changes in the NGT's function and efficacy since my last report. To obtain up-to-date and precise details regarding the NGT's operations and its function in mitigating air pollution, it is advisable to consult official government resources or recent news stories.

Conclusion :

Even with international agreements and laws to fight air pollution, it's still a major health and environmental threat worldwide. This is due to several reasons: a lack of political commitment to enforce existing laws, poor coordination between government agencies, weak institutions, and limited public awareness. To tackle this urgent crisis, we need stricter controls and better technology transfer from developed to developing countries. Additionally, simplifying environmental laws by merging them into one comprehensive piece of legislation would be beneficial. Courts play a crucial role in controlling air pollution in India. They interpret existing environmental laws broadly to fill any gaps and enforce them when the government fails to do so. This "judicial activism" helps protect the environment, which is especially important because environmental damage is often irreversible. However, to be truly effective, the judiciary needs proper resources and qualified judges specializing in environmental cases. Public participation is also essential. The text doesn't continue about public participation, but the idea is that public awareness and action are necessary alongside legal enforcement. Public awareness and participation are key to tackling air pollution. People need to understand their own responsibility for environmental protection. This can be achieved through environmental education programs targeting everyone, especially young people, women, and students. Mass media

also plays a crucial role in spreading awareness. The fight against air pollution requires a multi-pronged approach. The government and NGOs need to work together. The government, in particular, should provide financial aid and annual awards to recognize and encourage environmental activists at various levels (local, regional, national). This will incentivize public participation and help curb air pollution across the country.

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Taj Trapezium Zone

Polluter Pays Principle

Precautionary Principle

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FOOD SECURITY IN INDIA- JUDICIAL PROSPECTIVE

Dr. G. Adinarayana

Abstract:

Food security is "an economic and social condition of ready access by all members of a household to nutritionally adequate and safe food". In 1974 at The World Food Conference, Rome, it defines food security as "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices. M.S. Swaminathan in 1986 defined food security in terms of "Nutrition Security" as "physical, economic and social access to balanced diet, clean drinking water, environment hygiene, primary health care and nutrition literacy". The activist approach of judiciary through its decisions in various cases gradually paved way for evolving food jurisprudence in India. Some significant verdicts by the Supreme Court of India proclaiming the right to food and allied rights guaranteeing food security of people are discussed hereunder this article. Population explosion, illiteracy, poverty and gender inequality are responsible for food insecurity in India. Effective implementation of the PDS can reduce food insecurity levels and restoration of joint family system to improve food security situation in India. Food security is guaranteed as a statutory right by the enactment of the National Food Security Act, 2013.

Key words: Food security, Nutrition Security, right to food, National Food Security Act, 2013, Judicial activism.

Introduction:

Hunger is not an issue of charity it I an issue of justice. - Jacques Diouf

Since independence India has struggled severely to achieve growth and development. India as a development nation has achieved severely milestones for the promotion of social welfare. In spite of reaching great heights, the nation still faces the basic hurdle of proving the basic necessities of life to its citizens. In spite to its various promises of equality and justice provided under the India constitution either in the form of directive principle of the state policy or the fundamental rights provided to its citizens, the country has failed to take care of the fundamental fights provided to its citizens, the country has failed to take care of the basic right i.e. Right to Food of its millions of citizens even today.

The GHI Report 2019 prepared jointly by Irish aid agency Concern Worldwide and German Organisation Welt Hunger Hilfe termed the level of hunger in India "Serious". India's ranking has dropped from out of 117 countries). India's masses are suffering hunger and malnutrition although there is surplus food grain production and lakhs of tons of food grain stored in FCL godowns. The causes of hunger and malnutrition cannot be attributed to simple natural and manmade disasters but they are enormously complex in nature. The right to food is violated when people suffer hunger and malnutrition. The prominent reasons are discrimination, political economic exclusion and social injustice. 0ften the hungry and malnourished are denied access to sufficient resources as well as adequate incomes such as land, water, livelihoods, etc., which enables them to take care of their families to lead a dignified life.

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Food Security Meaning:

The dictionary meaning of the term "Food security" is "an economic and social condition of ready access by all members of a household to nutritionally adequate and safe food". The Merriam webster dictionary defines it as "the ability to consistently access or afford adequate food".

Food security - definition:

The first and foremost definition of "Food security" evolved in 1974 at The World Food Conference, Rome. It defines food security as "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices"

After a decade later in 1983 it Was and expanded by the Food and Agriculture Organization as "ensuring that all people at all times have physical and economical access to the basic food that they need".

The World Bank in 1986 defined it as "access of all people at all times to enough food for an active and healthy life".

M.S. Swaminathan in 1986 defined food security in terms of "Nutrition Security" as "physical, economic and social access to balanced diet, clean drinking water, environment hygiene, primary health care and nutrition literacy". This definition of food security not only stresses on nutrition security but also on livelihood security to achieve food security in the long run.

Constitutional and legal prospectives:

The progress of identifying the "Right to Food" as part of the right to life under Article 21 may be attributed to India's wholehearted commitment to implement the provisions of international conventions and declarations such as UDHR, ICESCR, CEDAW, CRC and UDEHM, harmonizing the directive principles of state policy and fundamental rights and adopting human- rights based approach to concept of food security on par with countries like Brazil, South Africa, Colombia, Guatemala, Cuba, Ukraine , Ecuador , Srilanka, ete.

Article 39(a) and (d) directs the state to frame policies to secure adequate means of livelihoods and equal pay for equal work to both men and women equally as they play a key role in the availability, accessibility and affordability of food ensuring food security to people.

India also made significant attempts to ensure food security through enactment of various piece- meal legislations. Some of them are

- The Prevention of Food Adulteration Act, 1954
- The Essential Commodities Act, 1955
- The Food Corporation of India Act, 1964
- The Maternity Benefit Act , 1961
- The Disaster Management Act,2005
- The Food Safety and Standards Act, 2006 etc..

However , with the heave by the decision of Super Court in People's Union for Civil Liberties Vs Union of India & others the National Food Security Act was enacted in 2013.

Judicial Prospectives towards ensuring Food Securities in India:

The activist approach of judiciary through its decisions in various cases gradually paved way for evolving food jurisprudence in India. Some significant verdicts by the Supreme Court of India pro-

claiming the right to food and allied rights guaranteeing food security of people are discussed hereunder.

Azad Rickshaw Puller's Union Vs State of Panjab & Ors

In this case the denial of grant of license to petitioners under the Punjab Cycle Rickshaws (Regulation of license) Act was challenged as violative of Article 14,19 (1) (g) and 21 of the Constitution of India. The Indian Judiciary in this case has showed concern to uphold claims of poor and weaker sections of society rather than fasten strictly to provisions of legislation determining their rights to ensure social justice. It also ordered to provide credit facilities for those people to own rickshaws ensuring food security freeing from poverty, hunger and bondage.

Crown Aluminium Works Vs Their Workmen:

The Supreme Court held that it is quite likely that in under -developed countries, where unemployment prevails on a very large scale, unorganized labour may be available on starvation wages; but the employment of labour on starvation wages cannot be encouraged or favored in a modern democratic welfare state. The employer must at least pay minimum wages guaranteeing to a worker who toil for fulfilling his basic necessities such as adequate food shelter and clothing to avoid starvation and poverty.

Sodan Singh Vs New Delhi Municipal Committee:

In this case the Supreme Court held that street trading is an age-old vocation adopted by human beings to earn living. The court observed that the right to fiid and food security of poor cab be realized only when livelihoods are protected.

Shantistar Builders Vs Narayan Khimalal Totame &Ors:

Justice K Ramaswamy held that the right to life would take within its sweep the right ti food, the right to clothing, the right to decent environment and a reasonable accommodation to live in.

P.G Gupta Vs State of Gujarat & Ors

In this case the government resolution excluding certain categories of employees for allotment of houses converted from rental to hire- purchase scheme was challenged as it violates Article 14, 19, and 21 of Indian Constitution. The Apex Court held that the protection of life assured under Article 21 of Indian Constitution includes the right to food, clothing and shelter.

Delhi Transport Corporation Vs D.T.C Mazdoor Corporation

The supreme court held that " employment is not a bounty from the State nor can its survival be at their mercy. Income is the foundation of many Fundamental Rights when work is the sole source of income, the right to work becomes as much fundamental." Food Security of people can be ensured only when their right to work is protected.

People's Union of Civil Liberties (PUCL) Vs Union of India

It is a landmark case in the history of Indian Judiciary realizing the right to food as an integral part of right to life. A PIL was filed highlighting about people going hungry while food grains stored in FCI go-downs were rotting and excessive food storage was there due to maladministration of food grains in these godowns. The court directed to the government to distribute food grains free of costs to starving poor people who cannot afford to purchase them.

It especially recognized the right to food of aged, infirm, disabled, destitute, pregnant and lactating mothers and children as part of right to life.

Inre Problems and Miseries of Migrant Labourers Vs Union of India

The Supreme Court Suo moto motto took cognizance of problems and miseries of migrant labourers during COVID -19 pandamic. The Apex court held that the ' right to life' confers the right to every human being to live a life of dignity with access to at least the bare necessities of life.

Gulshan Khatun & Ors Vs Delhi Urban Shelter Improvement Board & Ors

The Delhi High Court in this case had observed that it was of utmost importance to see that food is provided to the aged , inform , disabled , destitute women , destitute men who are in danger of starvation, pregnant and lactating women and destitute children, especially incases where they or members of their family do not have sufficient funds to provide food for them.

Conclusion:

Man's survival depends indispensably in food. In a narrow sense food is described as anything to fill hungry stomach. In broadest sense food means sufficient quantity and equality in terms of both calories and nutrients necessary for growth and development as well as health and wellbeing of human being. Initially food insecurity is described as physical unavailability of food at national, regional or household levels.

Indian Judiciary is playing an activist prudent role its various decisions incorporated several Directive Principles of State Policy into Fundamental rights and declared the right to food as an integral part of the right to life under Article 21 guaranteeing food security. Population explosion, illiteracy, poverty and gender inequality are responsible for food insecurity in India. Effective implementation of the PDS can reduce food insecurity levels and restoration of joint family system to improve food security situation in India. Food security is guaranteed as a statutory right by the enactment of the National Food Security Act, 2013. The Constitution of India has no expressed provision directly ensuring right to food security does not hold good as other provisions ensured food security in India.

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Article 39- The state shall , I particular , direct its policy towards securing- (a) that the citizens , men and women equally have the right to an adequate means of livelihood

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SRI PADMAVATI MAHILA VISVAVIDYALAYAM
(Women's University), TIRUPATI

R.O.C.No.SPMVV/Acad/C1/2023 Date:14-08-2023

PROCEEDINGS

Sub: Academic- Extension of tenure of Anti – Ragging Cell with Civil & Police Administrators -Reg.

Ref: 1.This office proceedings No. SPMVV/Acad/C1/2023 dated 05-01-2023
2.Letter dated 18-07-2023 received from Prof. J. Katyayani, Dean, Student Affairs, SPMVV
3.Vice Chancellor's orders dated 27-07-2023

*****

In continuation to this office proceedings under reference 1st cited, the tenure of the Anti – Ragging Cell with Civil & Police Administrators is extended for the academic year 2023-24. The following are members of the committee:

1.	The Warden, University Hostels	- Convener
2.	The Dean. Student Affairs	- Member
3.	The Deputy Superintendent of Police, Mahila Police Station, Tirupati	- Member
4.	The Circle Inspector, M.R. Palli Police Station, Tirupati	- Member
5.	The Head, Dept. of. Law, S.V. University, Tirupati	- Member
6.	The Dean, Academic affairs	- Member
7.	The Dean, School of Sciences	- Member
8.	The Dean, School of Social Sciences, Humanities & Management	- Member
9.	The Director, School of Engineering & Technology	- Member
10.	The Principal, College of Nursing	- Member

The Committee shall submit the report to the undersigned quarterly, for forwarding to the University Grants Commission.

REGISTRAR

To
The Committee Members,

Copy to the Director, IQAC, SPMVV, Tirupati
Copy to the office of Vice-Chancellor/Registrar, SPMVV, Tirupati

SRI VENKATESWARA UNIVERSITY:: TIRUPATI

R.O.C.No. B.VII(8)/3-5-LLB/2023 Dated : 18-08-2023

From

M. DAMLA NAICK
CONTROLLER OF EXAMINATIONS,

To

Dr. G. Adinarayana
Head
PG Dept. of Law
S.V.U.College of Arts
TIRUPATI

Sir,

Sub : University Examinations – Sending of Question papers relating to 3 Year LLB IV Sem & 5 Year LL.B IV, VI & VIII Semester (2016-2017 Regulations) (Regular/Supple.) (2009-10-Supply only)Degree examinations of September 2023 – Moderation of Question papers for Verification and Return – Reg.

@@@

I am sending herewith enclosed the Question papers, Syllabus & model question papers relating to 3 Year LLB IV Sem & 5 Year LL.B IV, VI & VIII Semester (2016-2017 Regulations) (Regular/Supple.) (2009-10-Supply only)Degree examinations of September 2023 as per the list of papers for verification and return.

In this connection, I am to request you kindly to verify all the Question papers according to Syllabus & Model question paper pattern in the capacity of Moderator for University examinations for 3/5 Year LL.B courses. This is highly confidential.

Further, you have to confirm whether the question papers are in order. If there are any Omissions, Corrections or Additions in the question papers the same may please be carried out on the question paper itself (Paper wise), so that the same will be go for final printing of the question papers for the above said examinations.

I shall be very much thankful to you if you could kindly return the question papers after your thorough verification and moderation to this office in a **DAY or TWO** after receipt of this letter.

This may be treated as **Most Urgent** please.

Yours faithfully,

CONTROLLER OF EXAMINATIONS

Encl : As above

SRI VENKATESWARA UNIVERSITY:: TIRUPATI

R.O.C.No. B.VII(8)/LLM-I&III SEM/2023

Dated : 12-09-2023

From

M. DAMLA NAICK
CONTROLLER OF EXAMINATIONS,

To

Dr. G. Adinarayana
Head
PG Dept. of Law
S.V.U.College of Arts
TIRUPATI

Sir,

Sub : University Examinations – Sending of Question papers relating to LL.M I&III Semester (2016-2017 Regulations) (Regular/Supple.) Degree examinations of September 2023 – Moderation of Question papers for Verification and Return – Reg.

@@@

I am sending herewith enclosed the Question papers, Syllabus & model question papers relating to LL.M I & III Semester (2016-2017 Regulations) (Regular/Supple.) Degree examinations of September,.2023 as per the list of papers for verification and return.

In this connection, I am to request you kindly to verify all the Question papers according to Syllabus & Model question paper pattern in the capacity of Moderator for University examinations for LL.M. course. This is highly confidential.

Further, you have to confirm whether the question papers are in order. If there are any Omissions, Corrections or Additions in the question papers the same may please be carried out on the question paper itself (Paper wise), so that the same will be go for final printing of the question papers for the above said examinations.

I shall be very much thankful to you if you could kindly return the question papers after your thorough verification and moderation to this office in a **DAY or TWO** after receipt of this letter.

This may be treated as **Most Urgent** please.

Yours faithfully,

CONTROLLER OF EXAMINATIONS

Encl : As above

SRI VENKATESWARA UNIVERSITY COLLEGE OF ARTS :: TIRUPATI

COLLEGE COUNCIL COMMITTEE

Date: 27 – 09 – 2023

From

Principal
S.V.U.College of Arts
Tirupati.

Dear Sir/Madam,

You are appointed as Vice – Chairman and Members of **COLLEGE COUNCIL COMMITTEE** of our College, For the academic Year 2023 – 2024. Please accept the same.

S. No	Name of the Faculty	Mobile Number	Designation
1.	Prof. G. PADMANABHAM Principal	9247328286	**Chairman**
2.	Prof. B.SYAM MOHAN DAVID RAJU Vice - Principal	9000109660	**Vice – Chairman**
3.	Prof.B.V.Muralidhar Head Dept. Of Political Science & Public Administration	9885650540	**Member**
4.	Prof.G.Janakiramaiah Head Dept. Of Education & Sociology	9666665700	**Member**
5.	Prof. K. Sudha Rani Head Dept. Of Centre for Women's Studies	9490049413	**Member**
6.	Dr.M.Sivasankar Reddy Director Physical Education	9441296125	**Member**
7.	Prof.P. Bhaskar Reddy Head Dept. Of Ancient History & Archaeology & History	9440799651	**Member**
8.	Prof.K.Suma Kiran Head Dept. Of English	9963564664	**Member**
9.	Prof.R.Suneetha Head Dept. Of Economics	9866037671	**Member**
10.	Prof.G. Aruna Head Dept. Of Linguistics	9849637993	**Member**
11.	Prof.R. Rajeswaramma Head Dept. Of Telugu	9491420180	**Member**
12.	Prof.R.B.Sathyavathi Head Dept. Of Adult Education & Rural Development	9848616373	**Member**
13.	Dr.JMJ.Vinodini Head Dept. Of Econometrics	998559431	**Member**
14.	Dr.Narayana Head Dept. Of Hindi	9441674830	**Member**
15.	Dr.G. Adinarayana Head Dept. Of L.L.M	9441387344	**Member**

(P.T.O)

16.	Dr.M.Prasantha Kumari Head Dept. Of Master of Library & Information Science (M.L.I.Sc.)	9440669245	**Member**
17.	Dr.M.Chandraiah Head Dept. Of Philosophy	9866331291	**Member**
18.	Dr.T.Chandrasekharayya Head Dept. Of Population Studies & Social Work	9440078579	**Member**
19.	Dr.G.Sireesha Head Dept. Of Sanskrit	7013319905	**Member**
20.	Dr.G.Vijayakumar Reddy Head Dept. Of South East Asian and Pacific Studies & Tourism	9440087753	**Member**
21.	Dr.Md.Nishar Ahemed Head Dept. Of Urdu	9291348511	**Member**
22.	Dr.J.Sankar Ganesh Head Dept. Of Performing Arts	9966609816	**Member**

Thanking you,

(PRINCIPAL)

PRINCIPAL
S.V. UNIVERSITY COLLEGE OF ARTS
TIRUPATI - 517 502

Copy to PS to Vice-Chancellor, S.V.University, Tirupati.

Copy to Rector, S.V.University, Tirupati.

Copy to Registrar, S.V.University, Tirupati.

Copy to Parties concerned.

SRI VENKATESWARA UNIVERSITY:: TIRUPATI

R.O.C.No. B.VII(8)/3-5-LLB/2023

Dated : 26-10-2023

From

M. DAMLA NAICK
CONTROLLER OF EXAMINATIONS,

To

Dr. G. Adinarayana
Head
PG Dept. of Law
S.V.U.College of Arts
TIRUPATI

Sir,

Sub : University Examinations – Sending of Question papers relating to 3/5 Year LLB II Semester (2016-2017 Regulations) (Regular/Supple.) (2009-10-Supply only)Degree examinations of November 2023 – Moderation of Question papers for Verification and Return – Reg.

@@@

I am sending herewith enclosed the Question papers, Syllabus & model question papers relating to 3/5 Year LLB II Semester (2016-2017 Regulations) (Regular/Supple.) (2009-10-Supply only)Degree examinations of November 2023 as per the list of papers for verification and return.

In this connection, I am to request you kindly to verify all the Question papers according to Syllabus & Model question paper pattern in the capacity of Moderator for University examinations for 3/5 Year LL.B courses. This is highly confidential.

Further, you have to confirm whether the question papers are in order. If there are any Omissions, Corrections or Additions in the question papers the same may please be carried out on the question paper itself (Paper wise), so that the same will be go for final printing of the question papers for the above said examinations.

I shall be very much thankful to you if you could kindly return the question papers after your thorough verification and moderation to this office in a **DAY or TWO** after receipt of this letter.

This may be treated as **Most Urgent** please.

Yours faithfully,

CONTROLLER OF EXAMINATIONS

Encl : As above

SRI VENKATESWARA UNIVERSITY:: TIRUPATI

R.O.C.No. B.VII(8)/LLM-II SEM/2024

Dated : 02-04-2024

From

M. DAMLA NAICK
CONTROLLER OF EXAMINATIONS.

To

Dr. G. Adinarayana
Head
PG Dept. of Law
S.V.U. College of Arts
TIRUPATI

Sir,

Sub : University Examinations - Sending of Question papers relating to LL.M II Semester (2016-2017 Regulations) (Regular/Supple.) Degree examinations of April 2024 - Moderation of Question papers for Verification and Return – Reg.

I am sending herewith enclosed the Question papers. Syllabus & model question papers relating to LL.M II Semester (2016-2017 Regulations) (Regular/Supple.) Degree examinations of April 2024 as per the list of papers for verification and return.

In this connection, I am to request you kindly to verify all the Question papers according to Syllabus & Model question paper pattern in the capacity of Moderator for University examinations for LL.M. course. This is highly confidential.

Further, you have to confirm whether the question papers are in order. If there are any Omissions, Corrections or Additions in the question papers the same may please be carried out on the question paper itself (Paper wise), so that the same will be go for final printing of the question papers for the above said examinations.

I shall be very much thankful to you if you could kindly return the question papers after your thorough verification and moderation to this office in a **DAY** after receipt of this letter.

This may be treated as **Most Urgent** please.

Yours faithfully,

M D Naick

CONTROLLER OF EXAMINATIONS

Encl : As above

SRI VENKATESWARA UNIVERSITY :: TIRUPATI

No. B.VI(1)/LLM/2024 Dated. 25.06.2024

From

The Controller of Examinations
S.V.University,
Tirupati.

To

Dr.G.Adinarayana,
Asso.Prof.,
PG Dept. of Law,
S.V.University,
Tirupati.

Sir,

Sub:- SVU – LLM I Semester Examinations held in April – 2024 –
Appointment of Internal Examiner for Valuation of answer scripts – Regarding.

Ref:- Registrar's Orders dated. 22.05.2024.

@@@@@

I am by direction, to appoint you as an Internal Examiner for evaluation of Dissertation Books and answer scripts relating to LLM I Semester Examinations held in April – 2024.

In this connection, I am to request you to kindly attend for valuation and to staff for about 3 days i.e. from 26.06.2024 to 28.06.2024 in the office of the undersigned from 9.00 am to 6.00 pm and to complete the valuation.

This receipt of this letter may kindly be acknowledged.

Yours faithfully,

CONTROLLER OF EXAMINATIONS

Copy to file.

INVITATION

SRI VENKATESWARA UNIVERSITY : TIRUPATI

P.G. DEPARTMENT OF LAW

Cordially invite for you

Indian Constitution and New Challenges - present Scenario

Chief Guest

Prof. A. Raghunatha Reddy (Rtd.)
Dr. B.R. Ambedkar Law University, Chennai

President

Dr. G. Adinarayana
Head I/C P.G. Department of Law,
S.V. University, Tirupati

Venue : P.G. Dept. of Law Seminar Hall, S.V. University, Tirupati
Date : 19-08-2023
Time : 11:00 AM

Organized by
Dr. G. Adinarayana
Head I/C, P.G. Department of Law,
S.V. University, Tirupati

F – 26

SRI VENKATESWARA UNIVERSITY, TIRUPATI

NOTIFICATION

It is hereby notified that on the recommendations of the Board of Examiners duly appointed to adjudicate the thesis entitled **"FOOD SECURITY IN INDIA: A SOCIO-LEGAL STUDY"** submitted by **Ms. Srilakshmi K** and the University has decided to accept the report of the Board of Examiners and declared that **Ms. Srilakshmi K** is eligible for the award of the degree of Doctor of **Philosophy in Law, S.V. University, Tirupati.**

(BY ORDER)

NEELAM SANJIVA REDDY BHAVAN
TIRUPATI – 517 502.

M. DAMLA NAICK
CONTROLLER OF EXAMINATIONS

DATED :18-07-2023

ENDORSEMENT No.: B7(1)/Ph.D/Law/21/2021, dated:22-07-2023.

Forwarded to the Commissioner of Printing, Stationery and Stores Purchases (Printing Wing Dept.) Government Regional Press, Muthyalammapadu, Satyanarayana Puram S.O., Vijayawada, Andhra Pradesh – 520 011, for favor of Publication in the next issue of the Andhra Pradesh Gazette and send the bill along with TEN spare copies of the Notification.

CONTROLLER OF EXAMINATIONS

Copy to the Candidate:
Ms. Srilakshmi K
Research Scholar,
Department of Law,
S.V.U. College of Arts, Tirupati.

Copy to the Research Supervisor :
Dr. G. Adinarayana
Dept. of Law,
S.V.U. College of Arts, Tirupati.

Copy to the Head, Department of Law, S.V.U. College of Arts, Tirupati.
Copy to the Secretary to the Vice-Chancellor, S.V. University, Tirupati.
Copy to the Editor, University News, Association of Indian Universities, House Avenue, New Delhi-1 with a request to publish the contents of the Notification as News Item.
Copy to the Editors of All the Dailies through their local correspondents with a request to Publish the contents of the Notification as a News Item
Copy to the Co-Ordinator, Internal Quality Assurance Cell, S.V.Univesity, Tirupati.
Copy to the Director, SVU Computer Centre, Tirupati, with a request to place the same in the University Web site.

MULTI-DISCIPLINARY ONE DAY INTERNATIONAL E-CONFERENCE

On

WOMEN EMPOWERMENT : ROLE OF LAWS, SOCIETY, CULTURE, POLITICS, LITERATURE AND MEDIA

Organized by

IQAC, Dr. Babasaheb Ambedkar College of Arts, Commerce and Science, Bramhapuri, Dist. Chandrapur, Maharashtra, India - 441206

• CERTIFICATE •

This is to certify that ~~Prof.~~/Dr./Mr./~~Mrs./Ms~~ Dr. G. Adinarayana, Associate Professor of P. G. Department of Law, S V University, Tirupati has successfully participated in INTERNATIONAL E-CONFERENCE ON " **WOMEN EMPOWERMENT : ROLE OF LAWS, SOCIETY, CULTURE, POLITICS, LITERATURE AND MEDIA**" organized by IQAC, Dr. Babasaheb Ambedkar College of Arts, Commerce and Science, Bramhapuri, Dist. Chandrapur, Maharashtra, India on 17th August 2023.

~~She~~/He has Presented/Published Paper entitled Women Laws in India - A Social Legal Dimention in 21st century.

in the Conference / UGC Care Listed Journal / Peer Reviewed Journal.

Convener	Co-Convener	Principal
Dr. Snigdha R. Kamble	**Dr. Dharmapal B. Fulzele**	**Dr. Devesh M. Kamble**

CONCEPT BHARATH

National Workshop o Fund Raising & NGO Management - 2023

Role of NGO's in Nation Building

In Association with Dept. of Population Studies & Social Work, Dept. of Human Rights & Social Development. S.V.University, Tirupati, Andhra Pradesh

CERTIFICATE OF APPRECIATION

This is to certify that Mr./~~Ms~~/Dr. G. Adinarayana, Associate professor P.G. Dept of Law, S.V. university, Tirupathi.

For your highly esteemed contribution/Presence as a Guest Speaker/ Resource Person for a "**National Workshop on Fund Raising & NGO Management**", on the Role of NGOs in Nation Building, held at Arts Block Auditorium, S.V.University, Tirupathi, Andhra Pradesh. on11th&12th September' 2023,In Association with Dept of Population Studies & Social Work, Dept of Human Rights and Social Development. In recognition of your Efforts, Dedication, Sincerity made his event successful with your participation. We thank and we wish you all the best and success in your future endeavors.

ILA ESWARAIAH
RIDO- Gurramkonda, A.P

DR. T.CHANDRA SEKHARAYYA
Associate Prof : & HOD Dept of Population Studies and Social Work S.V.U.Tirupati.

P. MEGHARAJU
SARWC-Mulbagal, Karnataka

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Coimbatore 641043

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Re-accredited with 'A++' Grade by NAAC.CGPA 3.65/4, Category I by UGC)

International Seminar
on
Exploring Research Literacy and Navigating the Path to Publication

CERTIFICATE OF PARTICIPATION

This is to certify that **Prof./Dr./Mr./Ms. Gujjala.Adinarayana, Associate professor, PG Department of Law, S.V.UNIVERSITY, TIRUPATI** has **participated** in the **International Seminar on "Exploring Research Literacy and Navigating the Path to Publication"** organized by the School of Home Science, School of Biosciences, and Research and Development Cell, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, Tamil Nadu, India on 17.10.2023.

Dr. K.S.Santhy	**Dr. C.A.Kalpana**	**Dr. P.Lalitha**	**Dr. S. Kowsalya**
Deputy Dean, School of Biosciences	Deputy Dean School of Home Science	Director (i/c) Research & Development Cell	Registrar
Organizing Secretaries		**Convenor**	

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NEP 2020 ORIENTATION & SENSITIZATION PROGRAMME

This is to certify that Dr. G. Adinarayana, Associate Professor, Dept. of Law, Sri Venkateswara University, Tirupati. has completed the NEP 2020 Orientation & Sensitization Programme under Malaviya Mission Teacher Training Programme (MM-TTP) of University Grants Commission (UGC) Organized by UGC – MMTTC, Sri Venkateswara University, Tirupati from 21-11-2023 to 29-11-2023.

Director/Coordinator (MM-TTC)

THE KERALA LAW ACADEMY LAW COLLEGE
TRIVANDRUM

(AFFILIATED TO UNIVERSITY OF KERALA)

IN ASSOCIATION WITH CENTRE FOR ADVANCED LEGAL STUDIES AND RESEARCH (CALSAR)
KLA CENTRE FOR ENVIRONMENTAL SCIENCE AND LAW AND IQAC KLA

CERTIFICATE

This is to certify that .....

DR GUJJALA ADINARAYANA ..... *has actively participated in the 20th INTERNATIONAL SEMINAR ON* ***CLIMATE CHANGE: RIGHTS, ISSUES AND CHALLENGES*** *organized by The Kerala Law Academy Law College in association with Centre for Advanced Legal Studies and Research (CALSAR), KLA Centre For Environmental Science And Law And IQAC KLA on* ***25th April 2024*** *at The Kerala Law Academy Law College Campus, Thiruvananthapuram.*

Adv. Nagaraj Narayanan
Director,
Kerala Law Academy

Prof. Anil Kumar K.
Director, Administration,
Students and Faculty Affairs,
Kerala Law Academy

Prof.Hareendran K.
Principal,
Kerala Law Academy

Adv. Renjini Ponnan Sheela
Assistant Professor,
Kerala Law Academy

SRI VENKATESWARA UNIVERSITY : TIRUPATI

(Accredited by NAAC with 'A+' Grade)

S.V.U. COLLEGE OF CM & CS

DEPARTMENT OF COMPUTER SCIENCE

National Conference

Certificate

This is to certify that Prof./ Dr./ Mr./ Ms. Dr. G. Adinarayana, P.G. Dept. of Law has participated 2 days National Conference on "Artificial Intelligence, Cyber Security & Research" held at Department of Computer Science, S.V. University, Tirupati on 14th & 15th June, 2024.

Title of the Paper ~~Artificial~~ Artificial Intellegence and Cyber Security in India-A-Legal Study.

J.C.V.

Co-Convener

M.S

Convener

Dept. of Population Studies & Social Work
and
Dept. of Library and Information Science,
S.V.U. College of Arts,
Sri Venkateswara University, Tirupati, A.P.

Certificate of Participation

Certify that Dr. G. Adinarayana Designation Associate Professor Department of P.G. Dept. of Law has participated in one day workshop on **"Research papers publications in UGC Care / Web of Science / Scopus Indexed Journals in Humanities / Social Sciences"** organized by the Department of Population Studies & Social Work, S.V.U. College of Arts, Tirupati in collaboration with Department of Library and Information Science, S.V.U. College of Arts, Tirupati held on 19th June 2024 at Arts Block Auditorium. S.V.University, Tirupati, A.P.

CO-ORDINATOR
Master of Social Work
Department of Population Studies
S.V.U. College of Arts, Tirupati,

HEAD
Department of Population Studies
S.V. UNIVERSITY COLLEGE OF ARTS
TIRUPATI-517 502

HEAD
ASST. PROFESSOR & I/C HEAD
DEPT. OF LIBRARY AND INFORMATION SCIENCE
SRI VENKATESWARA UNIVERSITY
TIRUPATI 517 502

DEPARTMENT OF PHILOSOPHY
S.V. UNIVERSITY, TIRUPATI.

INTERNATIONAL YOGA DAY

21st June 2024

UNITED NATIONS

One Day Seminar on

YOGA FOR WOMEN EMPOWERMENT

Organized by the Department of Philosophy, SRI VENKATESWARA UNIVERSITY, TIRUPATI to Honour United Nations General Assembly Resolution and UNESCO. United Nations Educational Scientific and Cultural Organization Implementation.

Certificate

This is to certify that ~~Prof~~/Dr/Sri/Smt Dr. Adinarayana, Associate professor, P.G. Dept of Law, SVU

has participated / Presented a paper entitled Yoga related Laws in India

In the Seminar on 'Yoga for Women Empowerment' held on 21st June 2024.

Dr. B. Sreenivasulu Naik
Co-Director

Dr. M. Chandraiah
Seminar Director, Head & BOS

International Journal of Research (IJR)

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 09
September 2023

Parental Awareness of Child Labor Laws and Welfare Schemes for Female Child Labor: A Study in Kurnool District

Dr. A. Kusuma
Assistant Professor,
Department Sociology, S.V. University, Tirupati.
Email: drsumasvu20@gmail.com
drsumavsu09@gmail.com

K. Chinna Veeranna
Research Scholar.

Abstract

Child labor remains a pervasive violation of human rights, drawing global attention to the welfare of children. The 20th century marked a significant turning point in the advancement of child welfare, leading to heightened awareness of children's rights as distinct individuals. This study aims to assess the level of parental awareness regarding government welfare schemes designed to support female child laborers. Our findings reveal that 46.3% of respondents acknowledge that child labor forces children into premature adulthood, leaving them vulnerable to exploitation due to their vulnerability. Furthermore, 33.5% of respondents recognize that a sense of inferiority among child laborers stifles their courage and creativity. The creation of additional employment opportunities for unskilled and unemployed individuals in rural areas can contribute to economic growth. Implementing awareness generation programs focusing on child labor laws and involving various stakeholders such as government departments, youth associations, self-help groups (SHGs), and civil society members is crucial for reducing the prevalence of child labor.

Keywords: Child Labor, Welfare, Female Child Labor, Economic Development, Legislation, Parental Awareness

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September 2023

Introduction

Child labor remains a pressing concern in India, with a pronounced presence in rural areas. Although legislative measures have been introduced worldwide to restrict the employment of children below a certain age and define acceptable conditions for minors working in various professions, the effectiveness of laws designed to protect children from hazardous labor is often lacking. In many instances, children find themselves aiding family members in agricultural endeavors, working as part of contractual family labor arrangements, or participating in plantation work. Rural India witnesses a common practice of school-aged children engaging in agricultural work as part of their family responsibilities. Regrettably, the implementation of Child Labor Laws at the state and district levels has been inadequate.

This study seeks to shed light on the perspectives of parents and employers regarding child labor issues, aiming to enhance their awareness, knowledge, and understanding of the prevalence and conditions of child labor within the study area. The situation of female child laborers is especially distressing due to gender discrimination prevalent in many Indian societies. Agriculture, which contributes three-fourths of the national income and supports over 75 percent of the population for subsistence, is heavily intertwined with child labor. Poverty and the absence of social security remain primary drivers of child labor, trapping children in work that offers limited opportunities for physical, social, and mental development. Both girls and boys are ensnared in the worst forms of child labor, but societal expectations, duties, and responsibilities imposed on girls often render them more susceptible to exploitation. Addressing the issue of female child labor is a complex challenge, compounded by the fact that the labor of female children is often unacknowledged or underrepresented in formal labor statistics. The absence of quality universal education further contributes to children dropping out of school and entering the labor force, making it difficult to accurately detect the true extent of child labor.

Welfare schemes for female child labor are essential in combating this pervasive violation of human rights. Child welfare has garnered global attention,

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particularly in the 20th century, with growing awareness of children's rights as independent entities. Article 18 of the United Nations Convention on the Rights of the Child in 1989 emphasizes the need to protect children from economic exploitation and hazardous work that interferes with their education, health, or overall development. The International Labor Organization (ILO) also opposes child labor, particularly in situations where children face educational and social disadvantages or work in exploitative conditions harmful to their well-being.

The Indian Government recognizes child labor because of poverty and has taken steps to address it through legislative measures. In 1986, the

Child Labor (Prohibition and Regulation) Act was enacted, replacing the Employment of Children Act of 1938. While the 1986 Act does not completely ban child labor, it focuses on "projecting" working children. The government has established unique schools to rehabilitate children engaged in dangerous or hazardous occupations, offering them education, vocational training, monthly stipends, and nutrition and health services.

The commitment of the Government of India to eradicate child labor is enshrined in the Constitution, which provides for the protection of children from engaging in economic activities unsuitable for their age. The Directive Principles of State Policy in the Constitution reinforce this commitment. The Central Labor Service (CLS), established in 1987, aims to improve industrial relations, labor welfare, and the enforcement of labor laws. Various schemes offering medical, housing, educational, recreational, water supply, and family welfare benefits are implemented for workers as part of the government's ongoing efforts to safeguard the welfare of children and laborers.

Material and Methodology

Objectives

The present study broadly aims at studying the socio-economic and social participation, employment support and knowledge on welfare schemes available to female child labors. The following are the main objectives of the present study:

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- To study the level of knowledge on welfare schemes provided by the Government for girl child labor.
- To study the level of knowledge on girl child rights
- To examine the economic and social conditions of female child labor in the sample district.

Sample design and study area

The researcher has purposively selected the Kurnool district due to its proximity and familiarity. Stratified random sampling method was used in selection of study sample. The study has conducted in six Mandal's of three revenue divisions of the Kurnool district. Four villages from each Mandal were selected. 20 respondents each were selected at random in 24 villages and the total sample is comprises of 480 female child labor residing in agricultural families in the Kurnool district for the present study.

Results

Socio-Demographic Characteristics of the respondents

A study of the background characteristics of sampled population is an important task in the study. Several studies have been shown that there is a strong relationship between socio-economic status and Girl Child Labor in Agriculture Families.

Table No.1: Percentage Distribution of the respondents by their Socio-Demographic Characteristics (N=480)

Socio-Demographic Characteristics of the respondents	Frequency	Percent
Age of the Respondent		
5-8 Year	47	9.8
9-11 Years	115	24.0
12-14 Years	318	66.2
Religion		
Hindu	242	50.4
Muslim	59	12.3
Christian	146	30.4

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Others	33	6.9
Education		
pre-school	137	28.5
Primary	98	20.4
Upper-Primary	177	36.9
High School	68	14.2
Work Experience (Years)		
≤ 2 Years	151	31.5
2- 4Years	223	46.5
≥ 4 Years	106	22.1
Girl Child Income		
≤ 5000	16	3.3
5001 and above	464	96.7
Source of Family Income		
Agriculture	177	36.9
Allied Labor	155	32.3
Business	45	9.4
Others	103	21.5

Age plays an important role in measuring the respondent's perception on their present working condition. Data has been collected on the girls who involved in the agriculture labor to analyze the girl's working condition in the agriculture field. In the study area nearly two-thirds (66.3 %) of the respondents were in 12-14 years age group. One-fourth (24.0 %) of them were in 9-11 years and the remaining (9.8 %) were in the age group of 5-9 years. One half (50.4 %) of the respondents were Hindus, less than one-third (30.4 %) of them were Christians, 12.3 percent were Muslims and 6.9 percent belong to other religions. It is observed from the above table that more than one third (36.9 %) of the respondents have completed upper-primary education in the study area. More than one-fourth (28.5%) the girls had pre-school education and two-fifth (20.4 %) had primary education and 14.2 percent of the respondents had high school education. More than two-fourth (46.5 %) of the respondents were having ≤ 2 years of experience in the agriculture field, less than one-third (31.5 %) of them were working experience of 2-4 years and more than one-fifth (22.1 %) of them were working 4 years and above in the agriculture field. Almost all (96.7 %) of the respondents were getting a monthly income Rs. 5000 and above the study area. More than one-third (36.9 %) of the respondents' parents were having agriculture background, followed by allied labor (32.3%) and other types of activities (21.5 %).

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The data was collected on parents opinion on child labor, sociological and economical aspects of the girl child labors in agricultural families namely on 1) fulfillment of social obligation 2) prone to habits like smoking, gambling and extravagancy 3) loss of potential intellectuals and thinkers in 4) prone to exploitation 5) violation of human rights 6) enforcement of laws 7) punishment under child labor laws 8) parents knowledge on girl child welfare schemes etc.

Table No. 3: Percentage distribution of the respondents by Parents opinion on Sociological and economical aspects of female child labor

Sociological aspects		Agree	Disagree	Un-Decided	Total
GCs need proper nurture and nourishment to make them best fits in future life	N	355	71	54	480
	P	74	14.8	11.3	100
CL has no rationale as it is the decision of the parent who are second to none as well wishes of children	N	256	160	64	480
	P	53.3	33.3	13.3	100
CL is not unethical rather fulfillment of social obligation by employers towards poor of whom government fails to take care of	N	199	173	108	480
	P	41.5	36	22.5	100
CL keeps children away from education and breeds illiteracy in a society	N	209	187	84	480
	P	43.5	39	17.5	100
Working children are prone to the habits of smoking, gambling, and extravagancy	N	209	200	71	480
	P	43.5	41.7	14.8	100
Child labor compels children to lead pre-mature adults' lives	N	222	161	97	480
	P	46.3	33.5	20.2	100
	N	225	188	67	480

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CL has high opportunity cost as it leads to loss of potential intellectuals and thinkers	P	46.9	39.2	14	100
Inferiority complex suppresses courage and creativity of children	N	161	95	224	480
	P	33.5	19.8	46.7	100
Children as workers are prone to exploitation by reason of their docility	N	164	157	159	480
	P	34.2	32.7	33.1	100
Child labor is an off school of poverty which is the result of unequal distribution of wealth	N	288	141	51	480
	P	60	29.4	106	100

In the table no.3 shows that 33.5 percent of the respondents agreed that inferiority complex among the children will suppress their courage and creativity. 46.3% of the respondents agreed that child labor compels children to lead premature adults and there is a chance to exploit by reason of their docility. 43.5 percent of the respondents agreed that child labor leads to children keep away from education and breeds illiteracy in society. 46.9 percent of the respondents agreed that child labor is one of the opportunities to forego the potential intellectuals and thinkers of nation. Nearly three-fifth (60 %) of the respondent's parents opinioned that unequal distribution of wealth is one of the reasons for child labor as it leads to more dropouts. Nearly three-fourth (74 %) of the parents agreed that girl child require proper nurture and nourishment to make them best fits in future life.

Table No 4: Percentage distribution of the respondents by Parents opinion on Sociological and economical aspects of female child labor

Knowledge on Legal aspects		**Agree**	**Disagree**	**Un-Decided**	**Total**
Employing CL is a violation of human rights	N	235	211	34	480
	P	49	44	7.1	100
Employment of children in hazardous work is a crime	N	201	200	79	480
	P	41.9	41.7	16.5	100

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Child labor is a moral crime against humanity	N	217	183	80	480
	P	45.2	38.1	16.7	100
Hazardous nature of job coupled with excessive workload and long hours of work are so heinous crime	N	138	226	116	480
	P	28.8	47.1	24.2	100
Child labor is a punishment to tender hands for no fault of theirs	N	111	267	102	480
	P	23.1	55.6	21.3	100
CL laws fail as these are unacceptable to people with unsound financial position	N	148	251	81	480
	P	30.8	52.3	16.9	100
Weak enforcement of laws leads to child labor with impunity	N	141	209	130	480
	P	29.4	43.5	27.1	100
The parents of child workers shall be booked under the relevant laws	N	144	166	170	480
	P	30	34.6	35.4	100
Child labor shall be completely banned in all aspects	N	202	205	73	480
	P	42.1	42.7	15.2	100
The employers of CL shall be dealt with stringent punitive measures	N	136	243	101	480
	P	28.3	50.6	21	100
Enforcement of child labor laws shall be strictly observed	N	155	275	50	480
	P	32.3	57.3	10.4	100
Child labor is subject to punishment under child labor laws.	N	167	112	201	480
	P	34.8	23.3	41.9	100

In this study an attempt is made to assess the parents' opinion on the sociological and economical aspect of the child labors related aspects. Nearly one-half (49 %) of the respondent's agreed that working as a child labor is violation of human rights. 45.2 percent of respondents accepted that child labor is moral crime against humanity and 41.9 percent of the respondents agreed that employment of child in hazardous work is

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crime and 28.8 percent of respondent's expressed that excessive workload and long hours of work in hazardous Work is heinous crime. Only one-third (29.4 %) of the parents were having knowledge on child labor laws as they expressed that the Child labor laws are failed in implementation and weak enforcement of law were the causes of child labor. Nearly one-third (32.3 %) of parents expressed that they have observed strict enforcement of child labor laws. 30% of the respondents were agreed that parents of the child labor should be punished under the child labor laws. More than one-third (34.8 %) of the respondents were aware that child labor is subject punishment under child labor laws. 42.1 percent of the respondents agreed that child labor shall be banned in all aspects. It is interesting to note that more than two-fifth (41.5 %) of the parents agreed that child labor is not an unethical and the employers of the child labor were giving an opportunity to get the financial source for those who are neglected by the governments.

The findings from the above table shows that majority of the parents were aware of the ill effects of the child labor and the laws and functioning of law enforcement authorities related to child labor.

Parent's knowledge on various welfare schemes implemented by the government to avoid Child Labor is presented in the table no. 5. Cent percent of the respondents (100 %) in the study area agreed that free education for girls up to higher education will help to eradicate the child labor. Higher proportion (85 %) of the respondent's expressed that Balika Sam Rakshana scheme is very useful to balance sex ratio and prevent gender discrimination and the scheme is also encouraging employment skills, opportunities and creates awareness on health and family life education to girl Child. More than one-half (51.7 %) of the respondents felt that Apana Beti Apne desh scheme is providing rehabilitation services for those who were rescued from child labor and brothel home. Similar percentage (62.5 %) of the respondents agreed that strict implementation of prenatal diagnostic technique act helps in reducing female feticides and the gender discrimination. The girl child agreed that implementing the constitutional provisions and human rights for girl child reduces gender discrimination (60 %) and welfare measures are sufficient to improve the girl child status provided by the government and non-government organizations (60.2 %). More than one-half (52.5 %) of the respondents agreed that national policy for children and legal enactment facilitates the development of girl child.

Table No. 5: Percentage distribution of the respondents by Parents knowledge on welfare schemes for female child labor

Parents knowledge on welfare schemes		Agree	Disagree	Total

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Free education for girls up to degree level is very beneficial for girl education	N	480	0	480
	P	100	0.0	100.0
Balika samrakshna pathakam is very useful to balance sex ratio and prevent gender discrimination	N	408	72	480
	P	85	15	100
The KB scheme is encouraging employment skills, opportunities, and health awareness of girl children	N	290	190	480
	P	60.4	39.6	100
KB scheme is providing awareness on family life education to girl children	N	290	190	480
	P	60.4	39.6	100.0
ABAD programmer is very useful to rehabilitate the girls who are rescued from CL and brothel home	N	248	232	480
	P	51.7	48.3	100.0
Strict implementation of pre –natal diagnostic technique Act, 1994 helps in reducing female feticides	N	300	180	480
	P	62.5	37.5	100.0
Constitutional provision and human rights for GC reduces gender discrimination	N	288	192	480
	P	60	40	100.0
National policy for children and legal enactments facilitates development of GC	N	252	228	480
	P	52.5	47.5	100.0
The present welfare measures taken by govt; NGOs are sufficient to improve the girl child status	N	289	191	480
	P	60.2	39.8	100.0

Conclusion

Equality of opportunities is the foundation of modern welfare states. The crucial role that education can play in the reduction of girl child labor and improvement in the economic wellbeing of individuals can go a long way in achieving such ends. In India, poverty remains the key determinant of children not being sent to school. Most of the parents are not able to afford to send them to school. The path to progress in terms reducing the number of girl child laborer's by taking into consideration the cultural and economic measures, their future will continue to remain bleak. The study suggests that promotions of non-agricultural economic activities like micro and small industries and

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self-employment with the support of SHG groups (Women Groups) are the best alternatives to improve employment and income generation for the rural poor. Creation of more employment opportunities to the unskilled Unemployed will help to economic growth in rural areas. Through awareness generation programmes related to the Child Labor Laws with involvement of convergent departments, youth associations, SHGs, Civil Society members will be helping to decrease the number of child labors. Educate the parents of girl child on importance of sufficient nutritious food and proper education for the growth of girl child and its impact on future generations.

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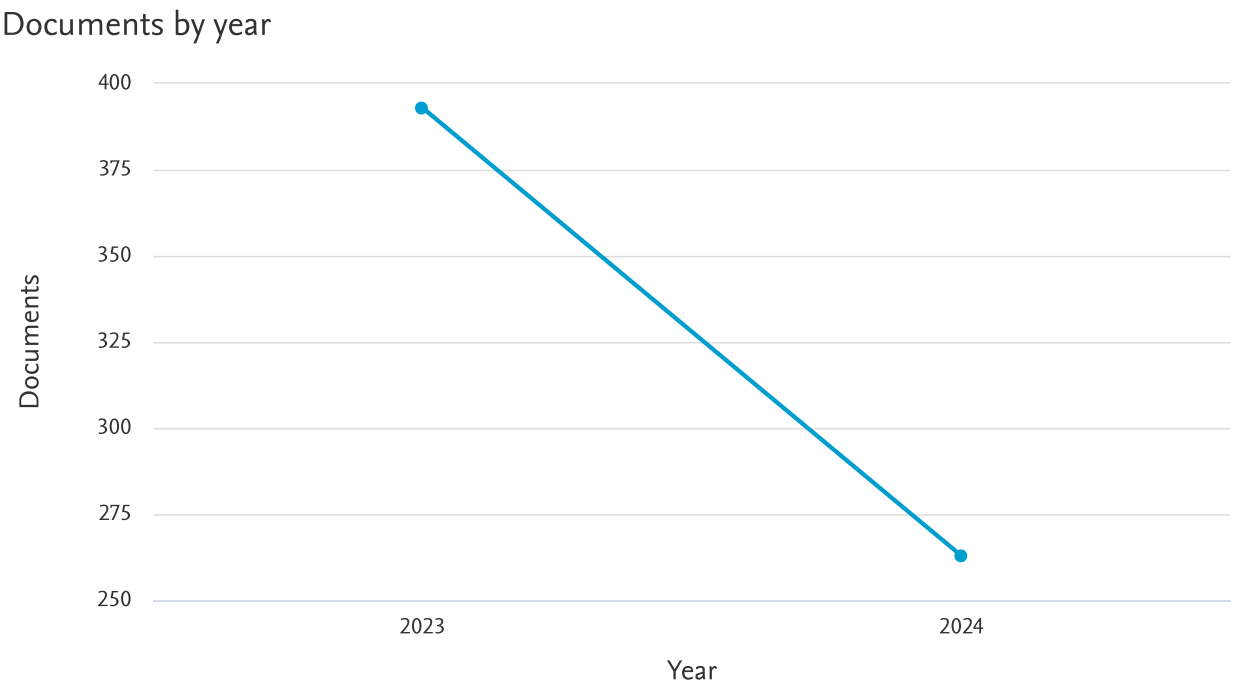
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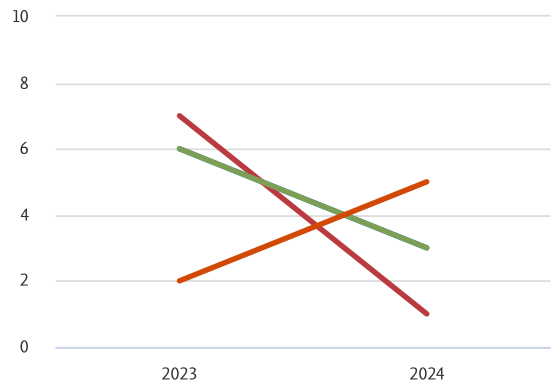
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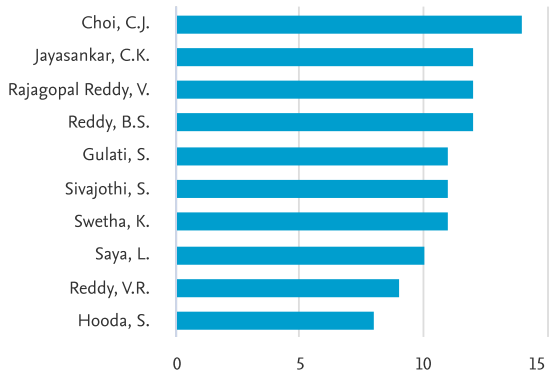
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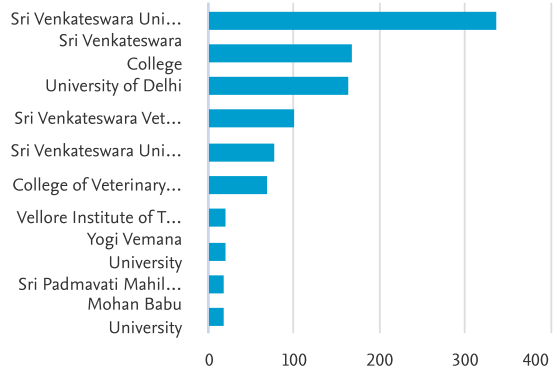
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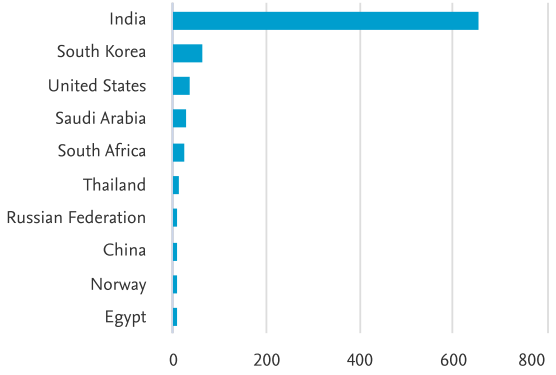
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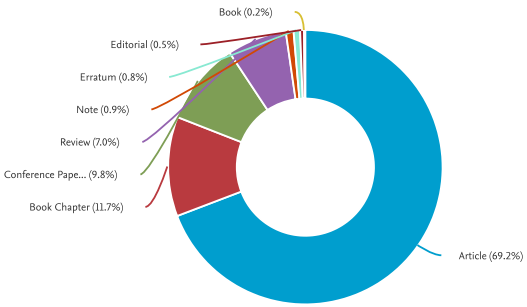
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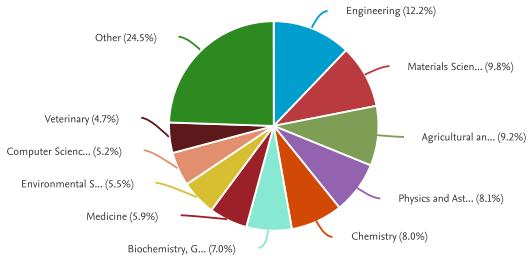
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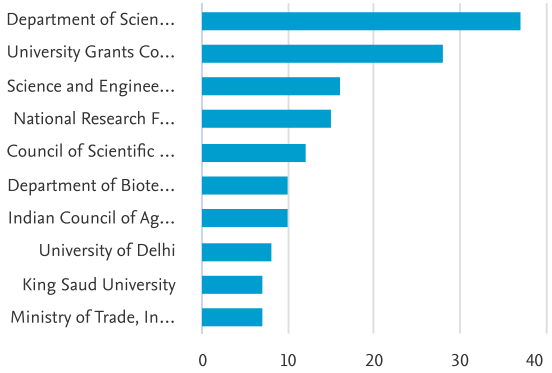
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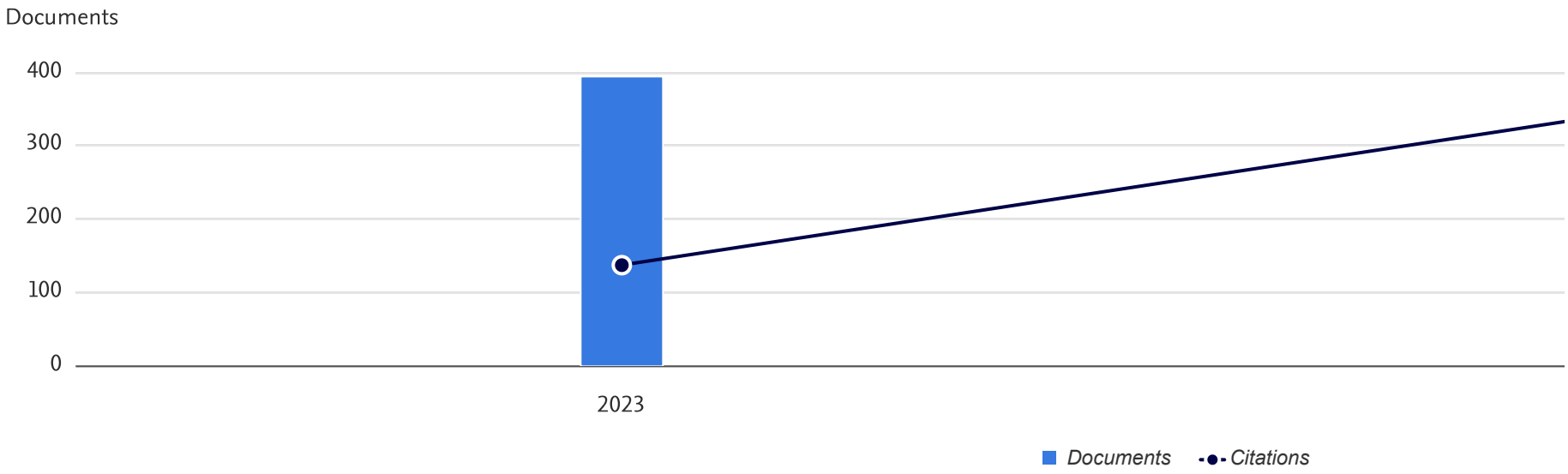
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DESIGN AND IMPLEMENTATION OF TYPE-2 FUZZY LOGIC CONTROLLER FOR ANN BASED MPPT APPLIED TO SPVWPS USING BLDC MOTOR

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ABSTRACT:

Renewable energy sources are being used to lessen reliance on fossil fuels, which are deteriorating at an alarming rate. Renewable energy sources are therefore being prioritized in order to fulfill the increasing demand for power caused by the expanding human population. The goal is to create a novel solar-powered water pumping system that makes use of a Type-2 Fuzzy Logic Controller (T2FLC) to regulate a Brush Less DC (BLDC) motor. The torque ripples and noise of the BLDC motor are eliminated and the system's performance is enhanced with efficient and dependable water pumping under varied environmental circumstances by integrating a T2FLC into the current system. The device in question is a Voltage Source Inverter (VSI) that has a built-in decoder and a DC link voltage controller, also known as a PWM controller. The BLDC (Brush Less DC) motor's characteristics are controlled by the decoder, which executes electronic commutation by Hall signal detection. The system's performance is further confirmed using Proportional-Integral (PI), FLC/Type-1 FLC controllers. When tested in a MATLAB/SIMULINK setting, the suggested Type-2 FLC outperforms the other two controllers. In this study, we evaluated the BLDC motor's torque under static and dynamic irradiance circumstances to those of PI, Type-1, and Type-2 fuzzy logic controllers.

Keywords: ANN, type-2 Fuzzy, BLDC, VSI, SPV, irradiance, MPPT, Efficient operation, DC-DC converter.

I INTRODUCTION

As the world's population rises, so does the need for energy, putting a strain on our current conventional energy sources. As a consequence the focus is shifting from fossil fuel based energy generation to clean and green sources of energy generation.

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Connecting solar photovoltaic systems on a larger scale also demonstrates a suitable alternative to conventional water pumps powered by non-renewable energy sources like oil and coal [1, 2]. To fulfill the water requirement, one option is to install a Solar Photovoltaic Water Pumping System (SPVWPS) that operates independently [1]. Irrigation, home usage, and industrial automation are some of the many areas that are giving this technology high marks. Keeping the DC connection voltage at its rated value allows the BLDC (Brush Less DC) motor to adjust its speed, which in turn is affected by changes in solar irradiation [2]. The ideal duty cycle is achieved by means of a DC-DC boost converter that runs in Continuous Conduction Mode (CCM) and is controlled by Maximum Power Point Tracking (MPPT) based on Artificial Neural Networks (ANNs) [4].

The literature discusses several Maximum Power Point Tracking (MPPT) approaches. When thinking about the water pumping system, two popular Maximum Power Point Tracking (MPPT) algorithms are Incremental Conductance (INC) and Perturb and Observe (P&O) [3, 5]. However, the control characteristics of a standalone SPVWPS (Solar Photovoltaic Water Pumping System) are heavily influenced by the step size of the MPPT (Maximum Power Point Tracking) approach [6, 9]. The literature discusses a number of DC-DC conversion strategies, including Boost, Boost Buck, Luo, and Landsman converter [7, 8, 10, 11]. A Boost Converter is used because of its excellent switching characteristics and the fact that its inductor acts as a ripple filter [1].

A water pumping system that uses SPV (Solar Photovoltaic) arrays with induction motors, synchronous reluctance motors, and switching reluctance motors also created [12][13]. The permanent magnet of a BLDC (Brush Less DC) motor allows it to outperform similarly sized motors in terms of torque-speed proportion, making it ideal for tasks where space and weight are paramount. It outperforms competing motors in terms of speed, torque, and expanded speed ranges [1][2][14]. Many industries rely on traditional P-I (Proportional Integral) controllers for controlling systems[15]. These controllers have a few drawbacks, such as being sensitive to controller gains, slow to respond to sudden disturbances (noise), and

having a hard time getting complex nonlinear systems with uncertainties to perform satisfactorily under control.

Type 1 fuzzy logic controllers are known as FLCs [16]. To handle the uncertainties of several complicated nonlinear systems, FLC, first suggested by Zadeh in 1965, may draw on human knowledge and experience. One of the main draws of FLC is simple to construct, doesn't need precise mathematical formulae, and may perform well depending on things like rules and membership functions [16, 17]. A torque ripple reduction mechanism called FLC has been developed and put into use for BLDC motors [17][18]. However, type-2 fuzzy logic controllers were introduced by Zadeh in 1975 as an expansion of type-1 fuzzy logic control (type-1 FLC) [18], as type-1 FLC was unable to manage greater uncertainties [18][19]. Type-2 fuzzy logic controllers combine the Upper and Lower membership functions of type-1 FLCs, and they have three dimensions, whereas type-1 FLCs only have two. This is the main difference between type-2 and type-1 fuzzy logic controllers [20]. A type-2 FLC was developed and put into operation to remove torque ripples from BLDC motors in the system.

II LITERATURE SURVEY

By including a DC-DC boost converter as an intermediary power conditioning unit into a Solar Photovoltaic (SPV) array fed Brushless DC (BLDC) motor powered water pump, Rajan Kumar and Bhim Singh [1] created a system that is economical, efficient, dependable, and environmentally friendly.

Brushless DC (BLDC) motor powered water pumps that use solar photovoltaic (SPV) electricity were first proposed by Bhim Singh and Ranjan Kumar, [2]. The pulse width modulation (PWM) control of the voltage source inverter (VSI) via the DC link voltage regulator is what allows the BLDC motor's speed to be adjusted.

In their extensive study, B. Subudhi and R. Pradhan [3] covered every method for maximum power point tracking (MPPT) in a PV power system. The advantages and disadvantages of each MPPT method are unique. Therefore, it is crucial to conduct a thorough evaluation of these methods.

For the purpose of improving efficiency and maximum power point tracking (MPPT) of PV arrays, ANN based MPPT was presented by M. Elobaid et.al. [4].

Although there is a simpler framework offered by standard MPPT approaches.

Since PV arrays have a nonlinear voltage-current characteristic with a distinct point where the power generated is maximized, MPPT algorithms are deemed required by Najet Rebei et.al. [5]. Solar irradiation, temperature, and load all have a role in the electricity that a solar panel produces. Various photovoltaic (PV) water pumping system performances were shown.

Water pumping for irrigation and drinking water may be accomplished using a cost-effective standalone Photovoltaic (PV) system that does not need batteries, as proposed by S.G. Malla et.al. [6]. Connected to this system is a Maximum Power Point Tracker (MPPT) algorithm-based perturb and observe (P&O) system with the aim of boosting system efficiency.

An efficient, simple, and inexpensive brushless DC (BLDC) motor drive for a water pumping system that is supplied by solar photovoltaic (SPV) arrays was suggested by B. Singh and R. Kumar [7]. No further control circuitry is needed for speed control of the BLDC motor since they used a DC Link converter in conjunction with fundamental frequency switching of the voltage source inverter (VSI).4

Researchers Rajan Kumar and Bhim Singh[8] examined a Solar Photovoltaic (SPV) array-based water pump powered by a permanent magnet brushless DC (BLDC) motor and how a Landsman converter may be used to detect the highest power point. In addition to providing a gentle and secure start for the BLDC motor, it maximizes the power output of the SPV array.

In their proposal for an independent solar pumping system, Songbai Zhang et al.[9] noted that the stability and dynamics of the system are significantly impacted by the step size in maximum power point tracking (MPPT) algorithms. The pump in this system is powered by an induction motor.

A boost-buck (BB) DC-DC converter was presented by Rajan Kumar et.al., [10], for use in water pumping systems that are supplied by solar photovoltaic (SPV) arrays and driven by permanent magnet brushless DC (BLDC) motors. Designing it with a cascade of DC-DC boost and buck converters allows it to soft start the BLDC motor and achieve maximum power point tracking (MPPT).

III PROPOSED SYSTEM

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The BLDC motor's rotor has permanent magnets, while the stator is equipped with windings. This rotor flux is created by permanent magnets. The rotor is attracted to and rotated by the stator windings, which generate electromagnetic poles. The problems associated with connecting electricity to the moving armature are eliminated with BLDC motors because the permanent magnets revolve around an immovable armature [1, 2]. Electronic controllers in BLDC motors cycle the winding phases many times. Instead of a brush and commentator combo, a solid-state circuit may be used to provide similarly timed power distribution from the controller. There are several stages to a BLDC motor's operation; the three-phase motor is the most common and well-liked because of its precise control, low torque output, and great efficiency [5, 6].

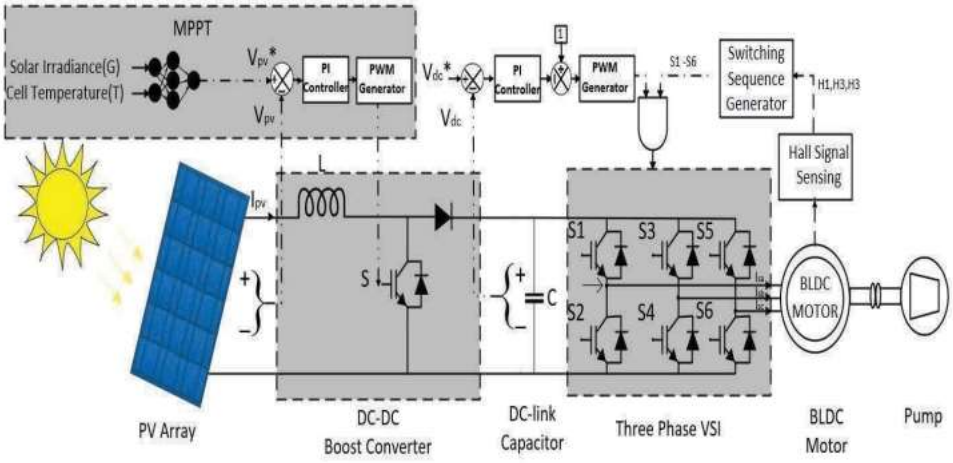


Fig.1. Topology of SPVWPS using PI Controller and BLDC motor

The methodology shown in Fig.1. is the most efficient way to control a Brushless Direct Current Motor (BLDC). Managing the bridge converter's input DC voltage is the foundation of the suggested approach. The motor windings generate a magnetic field, which controls the rotation of the motor, and the input DC voltage of the bridge converter is regulated in the same way [17]. The artificial neural network (ANN) with fuzzy controllers regulates the DC voltage input to the bridge converter. The integral and proportional gain parameters, which are the primary gains, are crucial [18]. All aspects of the ANN's performance while using fuzzy controllers are impacted by them. In this case, we use artificial neural networks (ANNs) with fuzzy controllers to get the same result—a non-integration output—from the input we provided [4]. The error computation for artificial neural networks (ANNs) with fuzzy

controllers is done by using and logic in the Sugeno FIS-Fuzzy Inference System Editor of T2FLC.

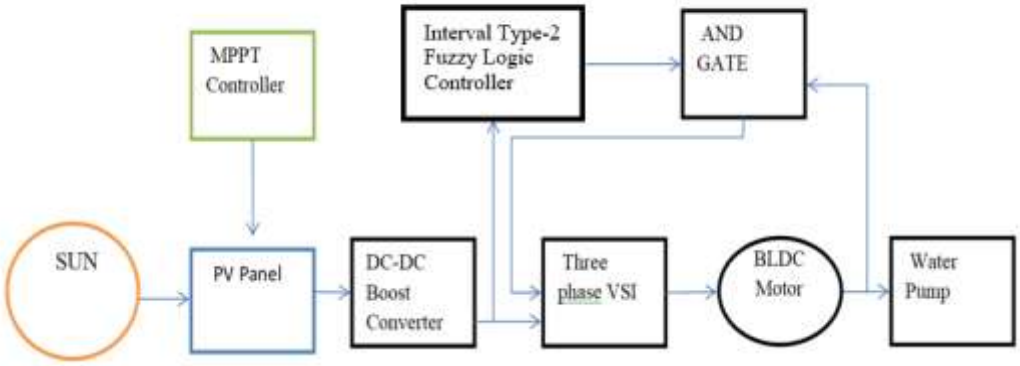


Fig.2. Proposed block diagram of SPVWPS using T2FLC with ANN

A PV array, an ANN-based MPPT driven DC-DC Boost converter, and a DC link capacitor are all components of the system shown in fig.2. The VSI and pump system are controlled by a PWM signal created via electronic commutation. For the DC-DC boost converter to function optimally and with CCM, the SPV array must be properly chosen [1, 2].

Controller being suggested:

Lotfi Zadeh invented the Type 2 Fuzzy Logic Controller (T2FLC) in the early 2000s [18], it is an upgraded version of the standard Fuzzy Logic Controller (FLC). Its introduction allowed for greater leeway in operating complicated systems and helped FLC overcome its shortcomings when dealing with uncertainty. A well-liked control system, fuzzy logic controllers (FLCs) employ fuzzy logic to convert inputs into outputs. Mathematically, fuzzy logic makes use of linguistic variables and fuzzy sets to describe information that is either imprecise or uncertain. A number of applications make use of FLC, including process control in manufacturing, temperature management, and speed control of electric motors [20].

Type 2 Fuzzy Logic Controllers (T2FLCs) basically work the same way as regular FLCs. On the other hand, T2FLC represents the uncertainty related to the input and output variables' membership functions using type 2 fuzzy sets. The fundamental procedures for operating a T2FLC are as follows.

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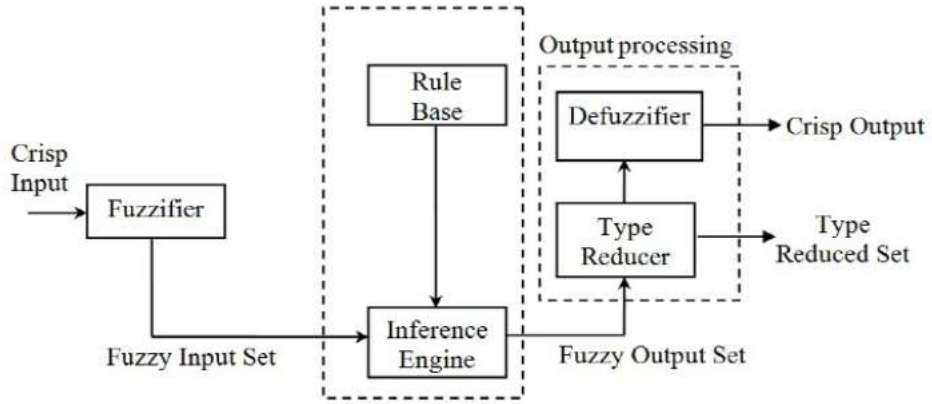


Fig.3. Type -2 Fuzzy Controller model.

Proposed controller methodology:

PI controller with ANN:

An innovative approach to solar-powered water pumping utilizing a brushless DC (BLDC) motor is introduced in this project maximum power point tracking (MPPT), which is based on artificial neural networks (ANNs) and does not need electrical input. We want to use neural networks to create a step-size independent maximum power point tracking (MPPT) for use in water pumping. To get the most juice out of the solar photovoltaic (SPV) array and to soft start the BLDC motor, we're using a DC-DC boost converter that's powered by an ANN-based MPPT. The BLDC motor's speed is controlled by pulse width modulation (PWM) of the voltage source inverter (VSI) using a DC link voltage controller. To carry out electrical commutation by hall signal detection, a pulse width modulation (PWM) signal is produced by means of the built-in encoder. The total system's efficiency is determined under different irradiation conditions after a BLDC motor driving pump system undergoes performance analysis in the MATLAB/Simulink environment.

FUZZY and ANN controller:

A water pumping system utilizes solar PV panels to keep costs down, The brushless dc motors used in this system are preferred over BDC motors due to their ease of maintenance, long lifespan, reduced noise, and high efficiency. The system is also easier to build [16][17]. Therefore a Fuzzy Logic Controller is used to overcome the drawbacks of PI Controller. The fuzzy logic control system is a mathematical framework for analyzing analogue input values and converting them into logic variables with continuous values between 1 and 0. These variables are used to control

the BLDC parameters using the boost converter's gate driver circuit. The boost converters used here are really just DCDC converters, and their purpose is to increase the amount of electricity consumed by the solar panels. Maximum power point tracking (MPPT) is used to manage the boost converters.

Type -2 Fuzzy controller with ANN:

To enhance the BLDC motor performance by eliminating torque ripples and to to get rated speed of BLDC motor, a Type-2 fuzzy logic controller (T2FLC) is integrated into the system. T2FLC handles with more uncertainty than FLC with its two dimensional membership functions and upper and lower limits. Therefore T2FLC reduced noise and energy consumption of BLDC motor. Optimal performance of BLDC motor has been achieved with T2FLC.

Table-1: Rules of T2FLC

e	**Δe**		
	D	N	A
D	D	D	N
N	D	N	A
A	N	A	A

The inputs of T2FLC in the system are e- error and **Δe-** delerror or change in error and the membership functions of the inputs are D-Depreciation, N-neutral, A-appreciation shown in Table-1.

IV SIMULATION & RESULTS

The models used for simulation are created using MATLAB/Simulink 2021a shown in fig.4. The input temperature is 25^{o}C and the first model is run with an irradiance constant of 1000W/m^2. An irradiance step signal of 1000W/m^2 and an input

temperature of 25ºC are used to run the second model. The building components and functioning of both simulation models are identical. The inputs used to train the models are the only differentiating factor. A constant input is used by the first simulation model. The inputs to the second simulation model are variable. By comparing its output with the voltage produced by the solar panel, V_{pv}, and using the non-electrical inputs of irradiance and temperature, ANN-MPPT supplies voltage to the boost converter. Inverters that are based on voltage sources are fed by boost converters. In addition, the Type-2 FLC (Fuzzy Logic Controller) and PWM (Pulse Width Modulator) are notified of the results after comparing them to the rated voltage of the BLDC motor. To power the BLDC motor, a voltage source based inverter (VSI) is used. A hall effect sensor determines the rotational position of BLDC motors. The Hall sensor output can be deciphered by the decoder. The AND block receives pulse width modulator (PWM) pulses and decoder output. For the BLDC motor to run smoothly, the AND block's output is sent to the VSI (Voltage Source based Inverter).

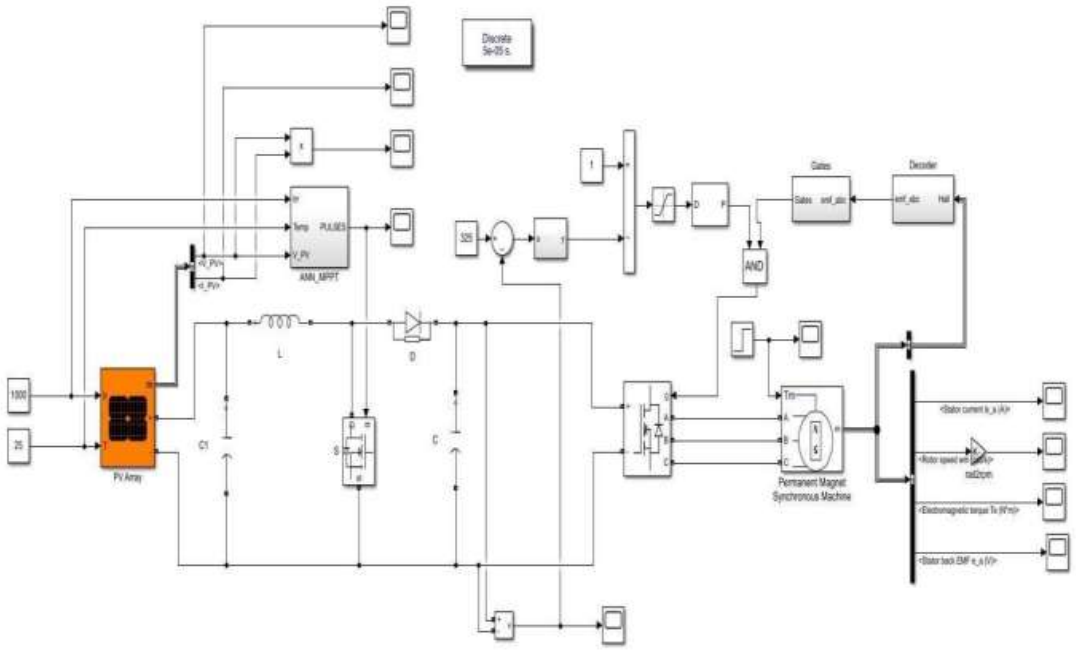


Fig.4. Simulation diagram

Fig.5 to Fig.9 displays the system-wide performance curve obtained from the simulation conducted in MATLAB/Simulink 2021a. As seen in the figure below, the SPV array performed well under STC conditions, with an ANN-based MPPT approach capable of tracking a maximum power of 2809 W, 270 V, and 10.38 A. Not only that, but the suggested MPPT has top-notch tracking efficiency. Boost converter

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performance while Vdc is held constant at 325 V. It is shown that CCM has favourable duty cycles. With the proposed Type-2 FLC Controller, the water pump may be driven by the BLDC motor at full load, which increases the rated speed and electromagnetic torque, Te. The speed and torque ~ time curves also show that the BLDC motor starts smoothly.

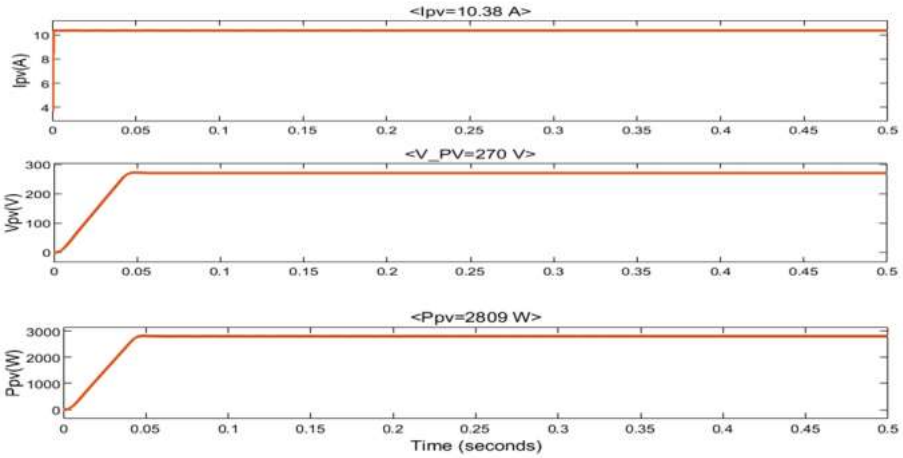


Fig.5. Performances of SPV Array under STC

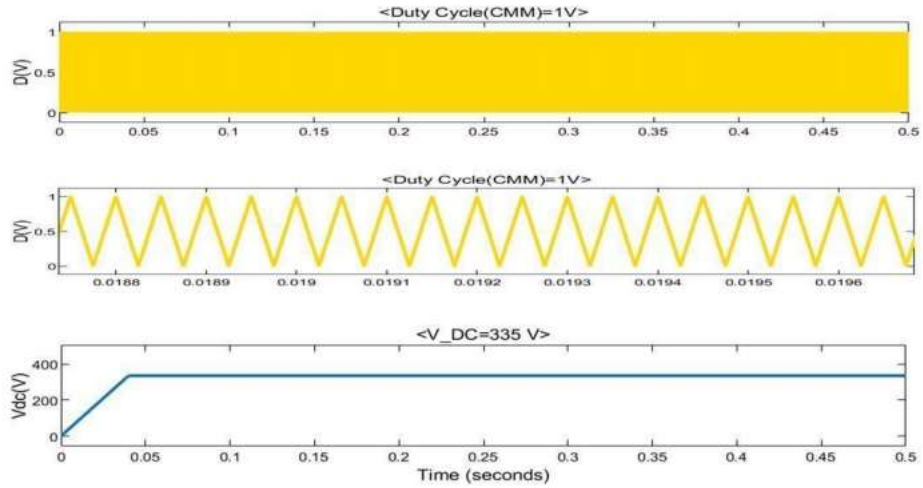


Fig.6. Performances of DC-DC Boost converter under STC of SPV Array

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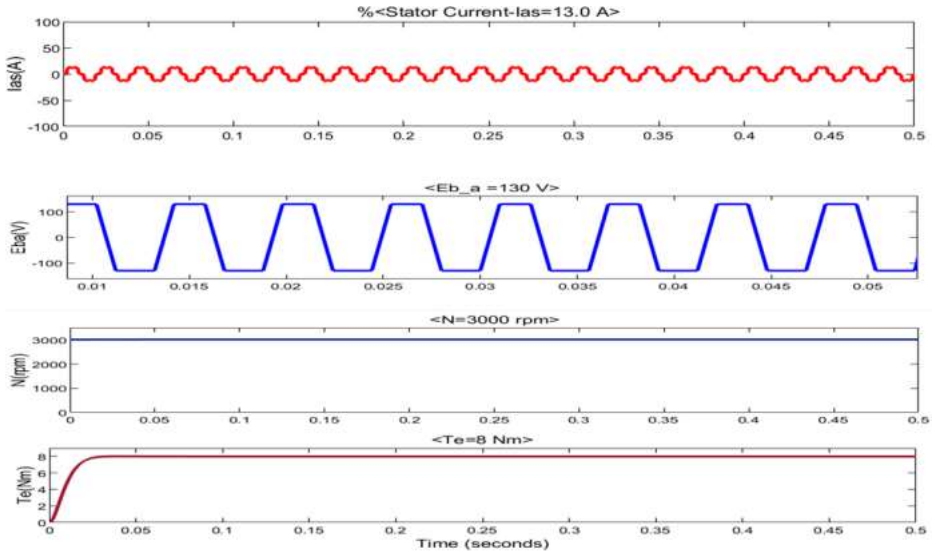


Fig.7. Performances of BLDC motor under STC of SPV Array

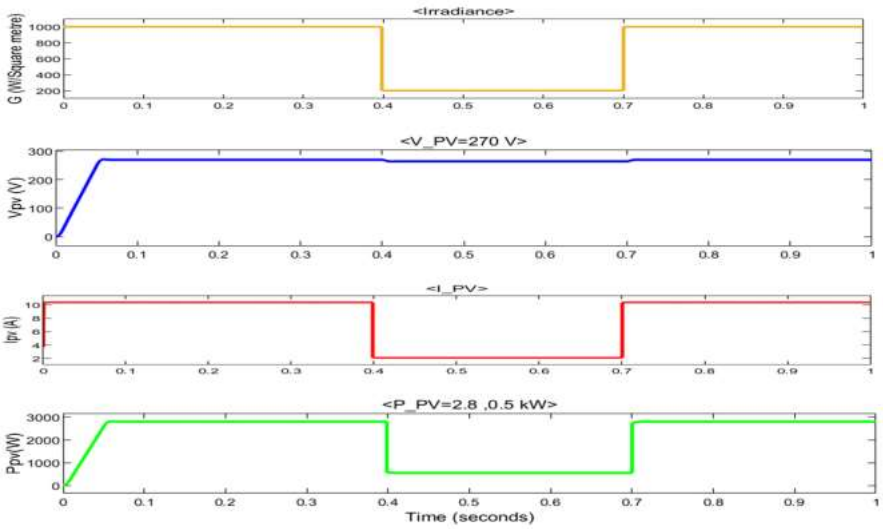
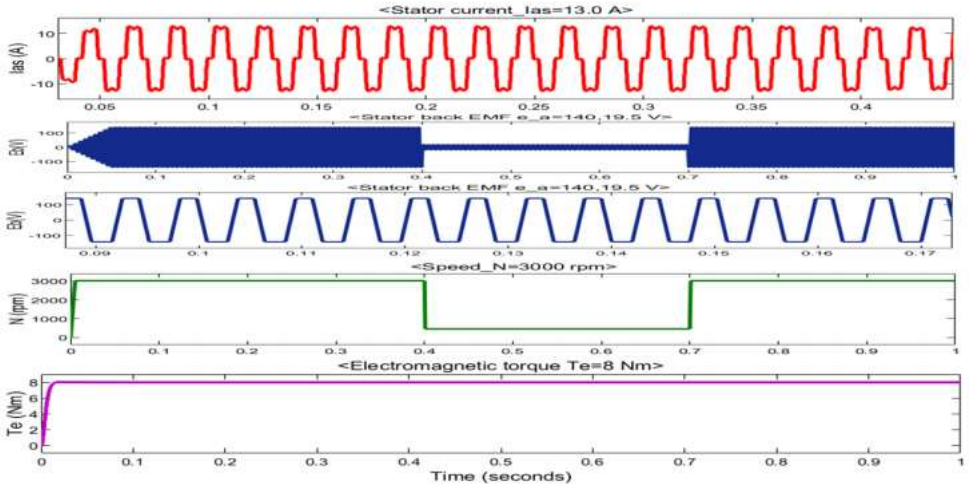


Fig.8. Dynamic Performances of SPV Array



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Fig.9.Dynamic Performance of BLDC Motor

Comparison Of Torques of BLDC Motor with FLC And Type-2 FLC Under Static And Dynamic Conditions

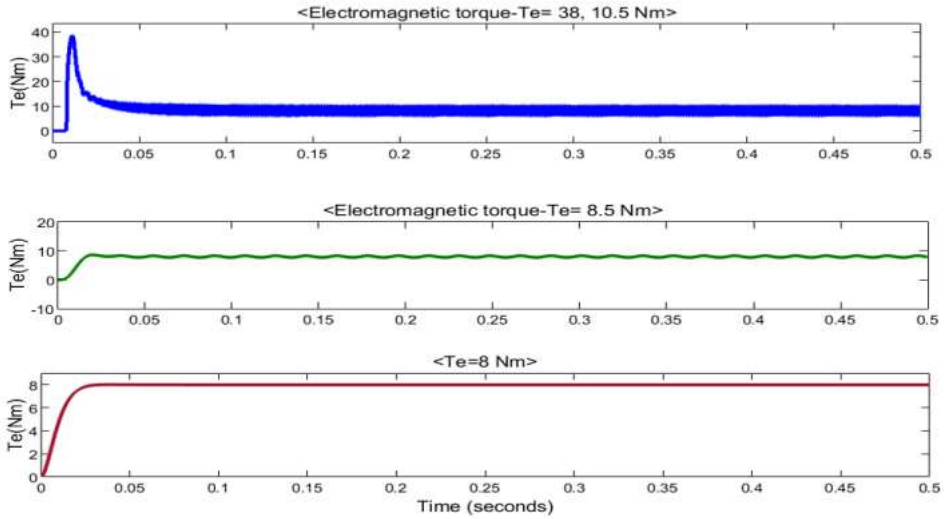


Fig.10 Torques of BLDC motor with PI, FLC, T2FLC under static condition with ANN

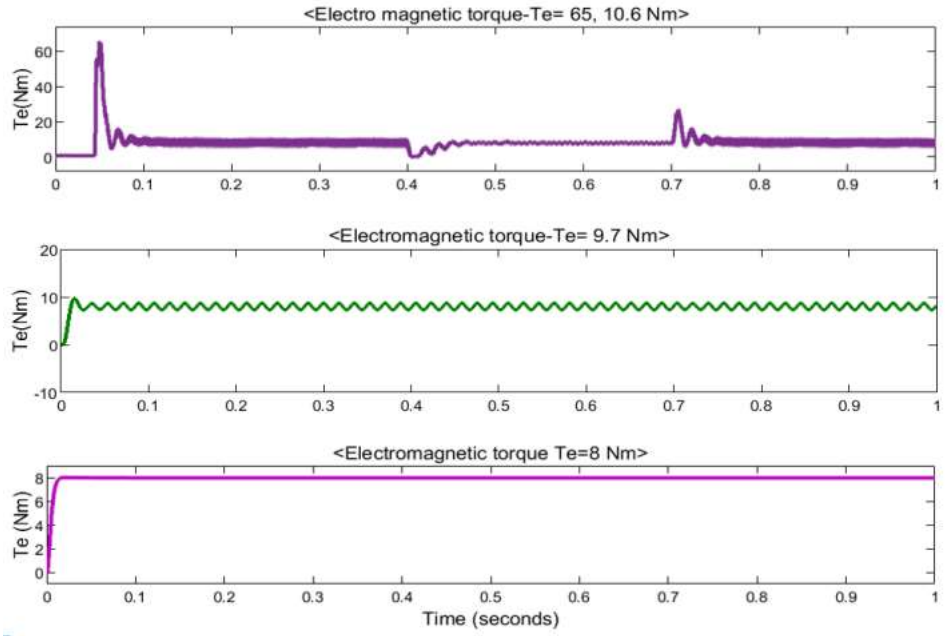


Fig.11 Torques of BLDC motor with PI, FLC, T2FLC under dynamic condition with ANN

Under dynamic conditions, ANN measures the torques of BLDC motors with PI, FLC, and T2FLC. Applying an ANN-based maximum power point tracking (MPPT) controller with PI, FLC, and T2FLC for a solar photovoltaic water pumping system with a BLDC motor produces good simulation results in both steady-state and transient scenarios shown in fig.10 to fig.11. Additionally, it is less complicated than existing controllers for reducing torque ripple in BLDC motors. Using a Fuzzy Logic Controller (FLC) instead of a Proportional Integral (PI) Controller has decreased ripples in the torque waveform. By switching to Type-2 FLC from FLC/T1FLC (Type-1 FLC), torque ripples have been eradicated.

TABLE-2: Specifications of BLDC motor [15]

BLDC Motor Specifications	
Power, P (kW)	2.38
Speed, Nr (rpm)	3000
DC voltage, V_{dc}(V)	325
Current, I(A)	7.35
Poles, p	2
Inertia, J (kg cm2)	7.05
Voltage constant, k_e (V peak L-L/K rpm)	88.86
Torque constant, k_t (Nm/A peak)	0.85
Phase to Phase resistance, R_s (Ohm)	0.957
Phase to Phase inductance, L_s (mH)	3.8

TABLE-3: Comparison of parameters of BLDC motor with PI, FLC & T2FLC

Irradiation	Static Condition (constant Irradiation)			Dynamic Condition (changing Irradiation)		
BLDC Motor Parameters/Controllers	PI Controller	Fuzzy Controller	Type-2 Fuzzy Controller	PI Controller	Fuzzy Controller	Type-2 Fuzzy Controller
E_b (V)	130	130	130	130	140	140
I_s (A)	12.4	13.0	13.0	12.7	13.0	13.0
Speed-N(rpm)	2960	3008	3000	2987	3008	3000
Torque-T(N-m)	38 |10.5	8.5	8.0	65 |10.6	9.7| 8.7	8.0

CONCLUSION

For BLDC motor-powered solar water pumping systems, we provide an ANN MPPT that does not rely on electrical inputs. Using a PI controller, the system exhibits poor transient and steady-state performance over a broad spectrum of irradiances. Applying a Fuzzy Logic Controller (FLC) to the current setup lessens the swells in the system's output waveforms. The current system's torque output from the BLDC motor was smoothed out by adding a Type-2 Fuzzy Logic Controller (T2FLC) shown in table-2&3. As a result, the BLDC motor's jerky motions and vibrations will be lessened. The BLDC motor's noise level drops. The system's performance will be enhanced. The BLDC motor has a longer lifespan. Energy savings are achieved by reducing the power consumption of BLDC motors. The results show that the system is performing optimally and can keep water flowing continuously even when the irradiance is quite low. The suggested approach also accomplishes soft starting of BLDC motors, which is ideal for motor pump set smooth operation.

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NEURAL NETWORK BASED SOLAR POWERED ELECTRIC VEHICLE CHARGING STATION

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Abstract
This paper presents an overview about charging of electric vehicles by neural network based solar PV. Solar power is a clean, renewable and infinite energy source and doesn't produce any greenhouse gas emissions. The output of solar panels can be altered by using neural network. Here the power output of solar panels is increased by ANFIS MPPT which generates maximum power. This way sufficient power is generated to charge electric vehicles even on cloudy days. The development of electric vehicles is creating awareness on using pollution free vehicles which cause no harm to the environment. The rise in the use of electric vehicles has led to the increase in the electric vehicle charging stations. Though the electric vehicles produce zero emissions the charging of electric vehicle batteries are from the conventional energy sources which causes harm to the environment. This led to the development of solar PV powered electric vehicle charging stations. Solar powered electric vehicle charging station and a battery energy storage system with grid assistance is used to ensure that the charging station has uninterrupted power without putting additional burden on the grid. Adaptive Neuro-Fuzzy inference system with neural network technique is designed and evaluated in MATLAB/Simulink.
Keywords: EVCS- Electric vehicle charging station, battery energy storage system, Adaptive Neuro Fuzzy inference system, MPPT, neural network, alternative charging, grid connected, Electric vehicle battery charging, PV.

I. Introduction

The use of renewable energy resources has grown drastically due to the need to preserve fossil fuel reserves for future generations. They cause zero damage to the environment and are ecofriendly which are abundantly available in nature. The use of solar panels for energy generation is increasing rapidly due to its ease of operation and can even be used in remote places where the access to the grid is not possible. Solar cells absorb the light energy from the sun and converts it into electrical energy. The size of the solar panel will affect the energy generated from it. By 2050, solar power is predicted to be become the world's leading source of electricity, with solar photo voltaic along with concentrated solar Power contributing 16 and 11% respectively [1]. When compared to other non-conventional energy sources solar energy serves the best in charging electric vehicles. Due to the increase in the awareness towards clean environment the use of electric vehicles is also increasing as it does not cause harm to the environment by releasing harmful gases as in case of fuel powered vehicles. Due to the technological advancement in the field of solar energy, solar powered chargers are developed to charge electric vehicle batteries which also contribute to green environmental effect and also reduces the burden on the grid. MPPT is used to generate the maximum energy which supplies the demand even on cloudy days. Electric vehicles are expected to increase from 2% of global share in 2016 to 22% in 2030[2]. Electric vehicles have more efficient electric motors than internal combustion engines. So, this saves energy when compared to ICE vehicles. They can also be used to reduce transportation's reliance on oil as long as the electricity is supplied using non-oil fuels [3,4]. A neural network uses solar power output and state of charge of BESS parameters to control the power output of AC grid. During maximum irradiance, PV supplies power to charge EV and excess power is given to AC grid as well as to charge BESS. To ensure an uninterrupted power supply, sometimes the power will be drawn from the AC grid to charge EV and BESS. The proposed system has been simulated in MATLAB/Simulink.

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II. Literature

The recent developments in electric vehicle have led to the development of different electric vehicle charging stations and various charging methods. This neural network based solar powered charging station is one among them. Global market outlook, EPIA[1], predicted solar power to be become the world's leading source of electricity, with solar photovoltaics along with concentrated solar Power contributing 16% and 11% respectively. Solar power generation is the fastest growing power generation method among the renewable energy sources that let to the advanced developments in solar power generation.

The standards of electric vehicle, battery charger and battery charging station was reviewed by Afida ayobet All[2]. The different types of charges used and their ratings are discussed for different types of electric vehicles. The type of charging will effect the charging time, efficiency of charging, performance of electric vehicles and the life span of electrical vehicles being charged. So, the type of charging should also be considered in electric vehicle charging station.

To increase the usage of electric vehicles as an alternative to diesel or petrol-powered vehicles R. Irle[3] concluded the global EV sales for the 1st half year of 2019. The electric vehicle sales and fuel powered vehicle sales are considered and compared to track the sales of electric vehicles.

A comprehensive review of DC fast charging stations with energy storage method was proposed by M. A H. Rafi, J. A. Bauman[5] which gives an overview of the charging stations which uses power converters for the conversion of energy. The electric vehicles are charging time is reduced by using different charging methods. DC charging methods are fast when compared to AC charging methods as the electric vehicle battery is a DC storage device.

III. Modelling of EV charging station

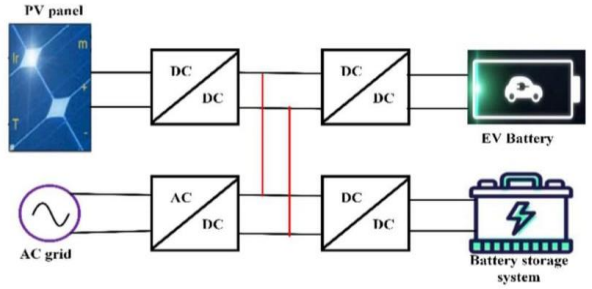


Figure 1: Representation of EV charging station.

Solar energy generation

When the sun light falls on the solar panel, the PV cells in the solar panel absorbs the sunlight and create the charges to move in response to the internal electrical field in the cell causing the flow of electricity. Here the solar photovoltaics are used to generate electricity to charge electric vehicles. However solar energy is highly dependent on temperature and climatic conditions. For higher voltages PV cells are connected in series and for higher currents PV cells are connected in parallel. The total amount of light that falls on the solar panel will not be converted into electrical energy as some light will be reflected back into the atmosphere due to the glass cover and frame of the solar panel. The output of the solar panel will be DC supply. A basic solar cell is the combination of current source and an inverted diode connected in parallel to it with its own shunt and series resistance. The series resistance is the diode resistance and the shunt resistance is due to the electron hole combination before it reaches load. Shading also effects the amount of power generated by the solar panel. The more the shading the less the energy generated. Shading is a phenomenon in which a part or complete solar panel is covered which reduces the amount of sunlight that fall on the solar panel.

PV array with boost converter

The charging station is designed using A 2000W PV panel with an open circuit voltage of 298.4V. Boost converter is used to step up the PV array voltage and to acquire the DC bus voltage of 400V. To

extract maximum power output from the PV array ANFIS voltage controller with Proportional-Integral controller is used.

Electric vehicle

All electric vehicles are generally referred to battery electric vehicles which have an electric motor instead of internal combustion engine. as it runs on electricity it uses a battery pack to power the electric motor and must be charged using a wall outlet or plugins. It does not contain any liquid fuel components such as fuel pump, fuel tank or fuel line and it does not emits from tailpipe. The power of electric vehicles motor is measured in kilowatts(kW). They deliver their maximum torque over wide RPM range.

Key components of electric vehicles

Battery:

All electric vehicles consist of a battery that provide electricity to power vehicle accessories.

Charge port:

It consists of a charge port that allows to connect to external power supply in order to charge the vehicle battery.

DC to DC converter:

It converts the high voltage DC from the battery charging port to the low voltage DC required to charge electric vehicle battery.

Electric traction motor:

This motor drives the vehicle wheels using power from the battery pack. Some vehicles have both drive and regeneration functions for motor operations.

Power electronics controller:

It controls the flow of electricity delivered by the traction battery controlling the speed and torque of electric motor.

Electric transmission:

It transforms mechanical power from the electric traction motor to drive wheels.

Electric vehicle battery

Electric vehicle battery is also called as traction battery. It is a rechargeable battery. These batteries are usually lithium-ion batteries and are designed for high power to weight ratio and energy density. These batteries are smaller, lighter, desirable and will have high performance. Lithium-ion batteries can be charged and recharged daily at any state of charge. The other type of rechargeable batteries used in electric vehicles include lead-acid battery, nickel-cadmium battery, nickel-metal hydride etc. lithium-ion batteries are used in electric vehicles due to their high energy density and long life cycle. For EV charging station a 240V, 7Ah battery is considered and it is charged from a 400V DC bus supply using a PI controller for DC-DC boost converter. For simulation purposes the incoming EV's battery is expected to have a minimum of 10% of SOC. The energy required for charging of EV battery (E_{ev}) can be calculated from the nominal voltage(V_n), ampere-hour rating of battery(Ah), %state of charge(SOC_r).

$$E_{ev}=\frac{V_n*SOC_r*Ah}{100}$$

Battery energy storage system (BESS) with bi-directional dc-dc boost converter

This battery storage is used to collect the extra energy generated from the PV array which is used to charge electric vehicles at night. The bi-directional DC-DC boost converter controls the charging and discharging of BESS. A BESS that can operate as a buffer between the EV charging station and the utility is another preferable approach [5-8].

Grid with inverter

A 230V, 50Hz AC grid is connected to the charging station for additional power requirements. In MATLAB/Simulink 230V AC source is used as grid. It is connected to a 400V DC bus using an

inverter. By taking output power of PV and %soc of BESS as input to BESS pulses are generated for inverter switches neural network Simulink model.

Table 1: Charging station data

Module Data	
Number of cells	60
Open circuit voltage	37.3 V
Short-circuit current	8.66 A
Voltage at MPPT	30.7 V
Current at MPPT	8.15 A
Array Data	
Parallel cells	1
Series connected modules per string	8
BESS Data	
Nominal voltage	240 V
Rated capacity	40 Ah
Battery type	Lithium-ion
EV Battery Data	
Nominal voltage	240 V
Rated capacity	7 Ah
The initial state of charge	9 %
Battery type	Lithium-ion
Boost Converter Data	
Switching frequency	10 kHz
Capacitance	4.0704 µF
Inductance	0.0153 H

Control methodology

ANFIS

An adaptive neuro fuzzy interface system is a network that mimics the behaviour of the neural and fuzzy inference systems. This doesn't have synaptic weights and will have only adaptive and non-adaptive nodes. It is simply converted into typical feed forward neural network and hence the name adaptive network[9]. Its structure is similar to the adaptive Takaji-Sugeno fuzzy network emulator. The input and output parameters of the ANFIS network are referred as linear and non-linear parameters.

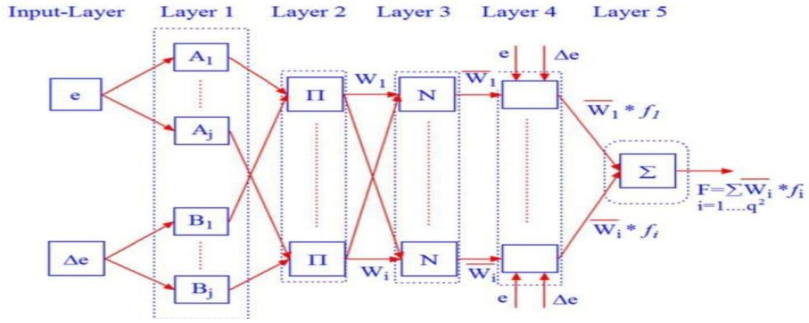


Figure 2: Five-layer ANFIS structure

Figure 2 depicts the five-layer ANFIS structure. The antecedent and succeeding parts are the two primary sections of the neural network.

Layer 1: Node 1 in this layer is called adaptive node and non-linear parameters of ANFIS network are the parameters of this layer. Here e and delta e are the layer 1 inputs. A_i and B_i are the membership functions of each node. Generally, the input variables are distributed using gaussian member ship function for each node.

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Layer 2: It contains a fixed node with the nodes output coming from the product of layer 1 node signals. The output of each layer 2 node determines the rule base's firing strength.
Layer 3: This layer node is denoted by letter "N" and is referred to as fixed node. Its output is calculated by dividing each nodes value by the sum of all node values.
Layer 4: This node is flexible. During the learning phase the parameters of this layer are modified using least square approach.
Layer 5: This layer has a fixed node and is called as output layer. The output of this layer is calculated using weighted average technique.
A hybrid technique is used to update the non-linear and linear parameters of layer 2 and layer 4. This hybrid approach converges significantly faster than conventional back propagation algorithms[10,11].

Maximum power point tracking with ANFIS PI controller:

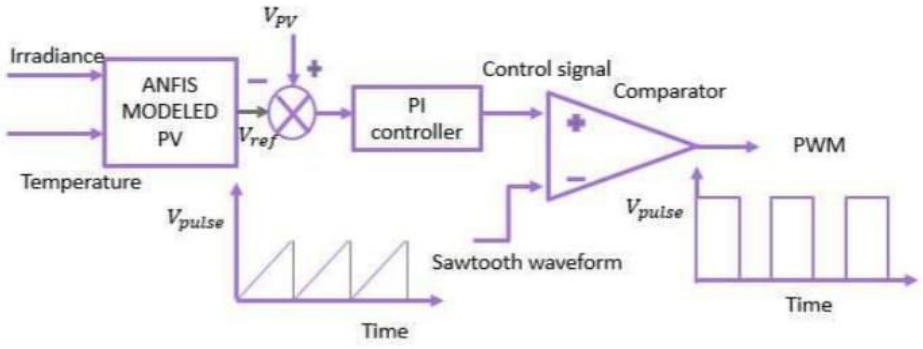


Figure 3: ANFIS voltage control MPPT

ANFIS is used to create a solar PV system model which is identical to the original MPPT structure. ANFIS is trained with two inputs (irradiance and temperature) and a single output voltage. The ANFIS systems output is taken as reference output and is compared with real PV voltage to generate error. The PI controller processes the error voltage and duty cycle is produced for PWM generator. Later PWM generator generates pulse for DC-DC boost converter to extract maximum power from solar array.

Neural network based AC grid:

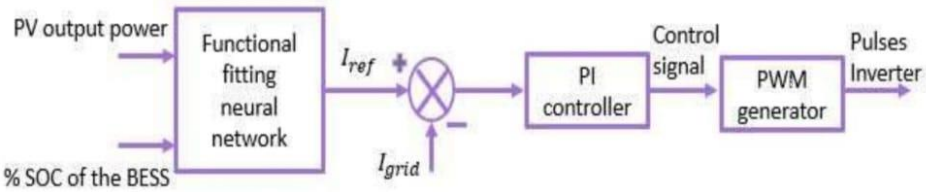


Figure 4: Block diagram of neural network

Figure 4 shows the trained neural network model for AC grid. The output power of PV array and SOC of the BESS are taken as inputs to build functional fitting neural network. The reference current is taken from neural network and is compared to grid current to produce error. The PI controller processes the error and gives a control signal to PWM generator to produce duty cycle for inverter.

Operating modes of charging station

The five modes of operation of neural network based electric vehicle charging station is detailed below:
Mode 1: in this mode EV battery is charged by PV array. Here the temperature is kept constant and the panels irradiance is changed and ANFIS voltage control method is used to extract maximum voltage.
Mode 2 : EV battery and BESS are charged using solar power by operating PV panel at MPPT by ANFIS and when BESS is connected to a DC bus.

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Mode 3: both solar power and BESS are used to charge EV battery with a variation in irradiance. ANFIS ensures the highest amount of power extracted from solar array.
Mode 4: when the output of the PV array is zero during night, EV battery and BESS are charged using AC grid. The power flow from the AC grid is controlled by functional fitting neural network.
Mode 5: charging the EV battery by connecting BESS, AC grid and solar PV array and irradiance and temperature of the PV array is varied. Excess electricity is fed to AC grid.

Simulation diagram

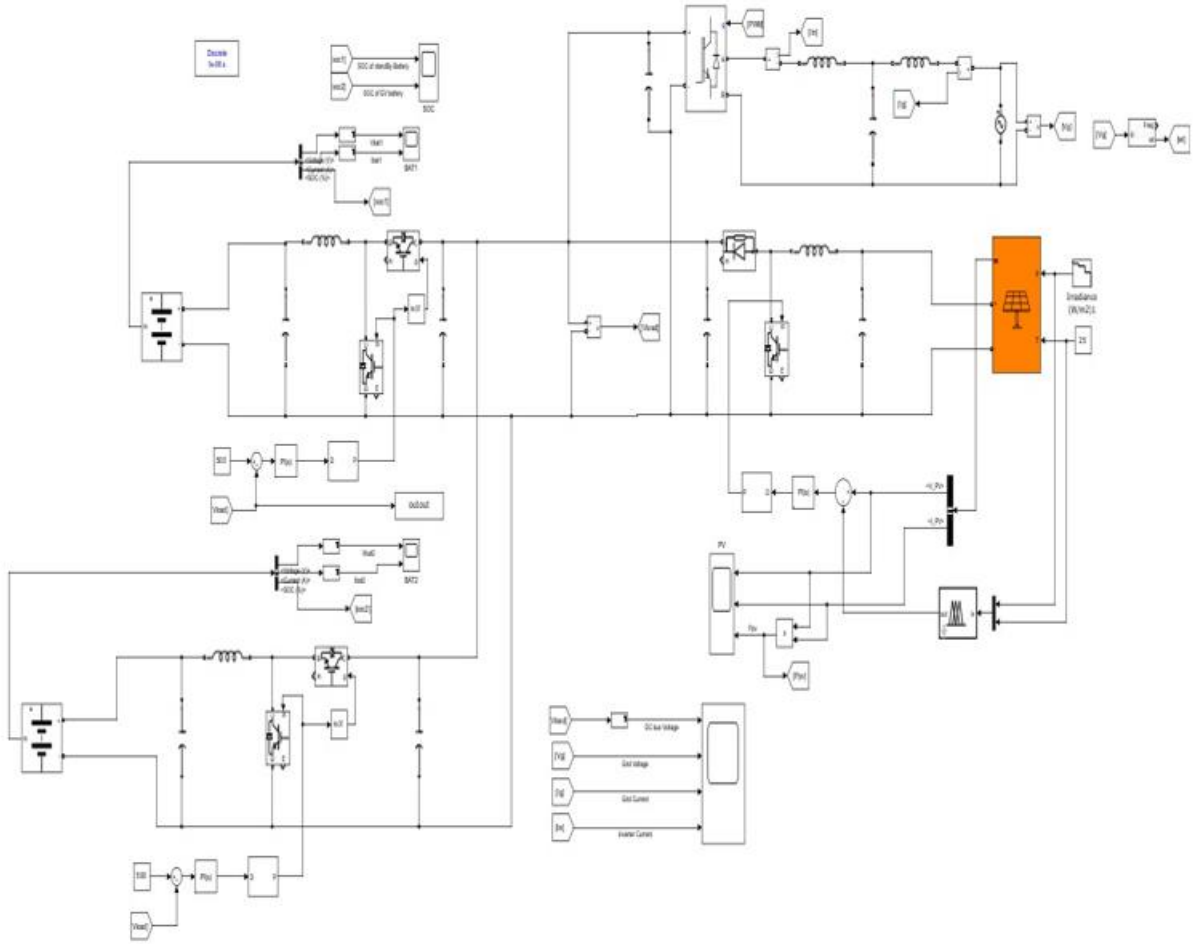


Figure 5: Simulation diagram of neural network based solar powered EV charging station.

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Simulation results

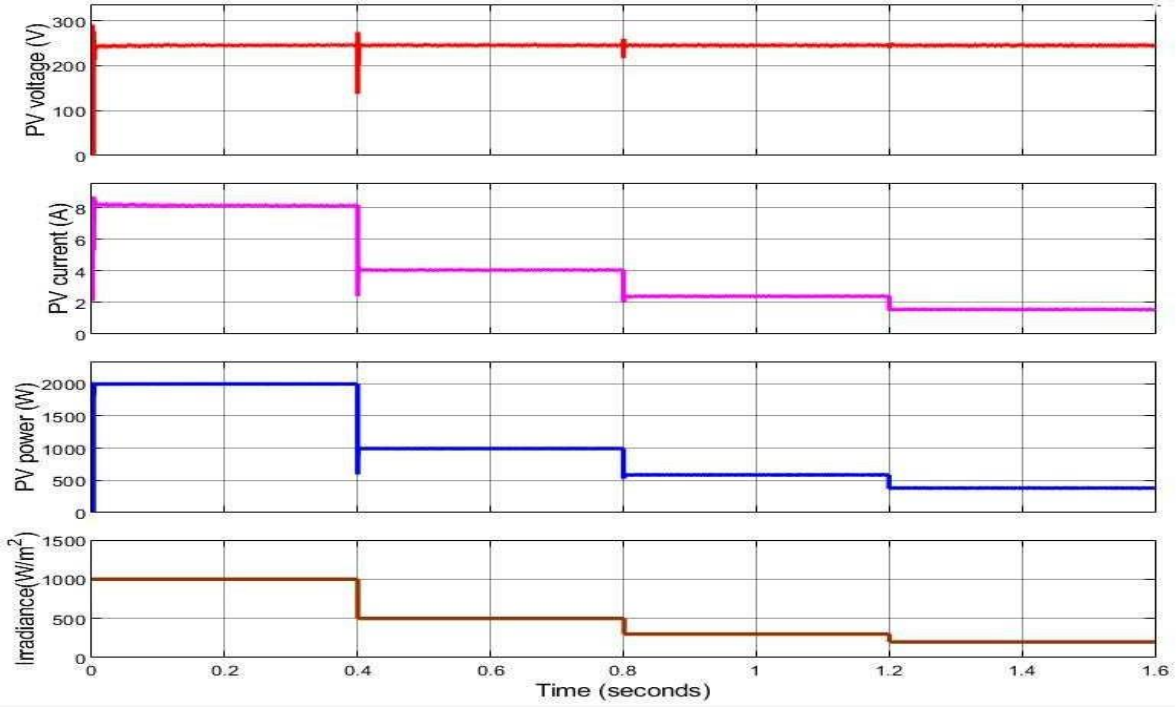


Figure 6: PV voltage, current and power waveforms with a variation of irradiance.

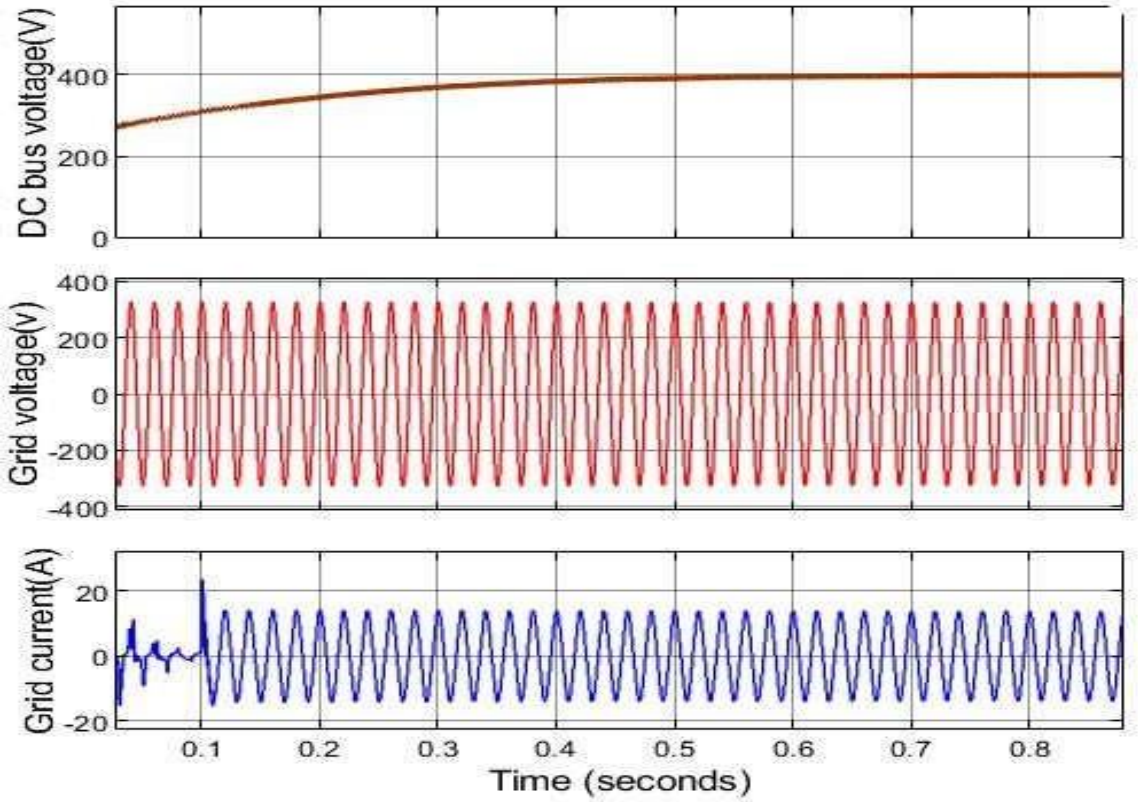


Figure 7: DC bus voltage, grid voltage, grid current and inverter current waveforms

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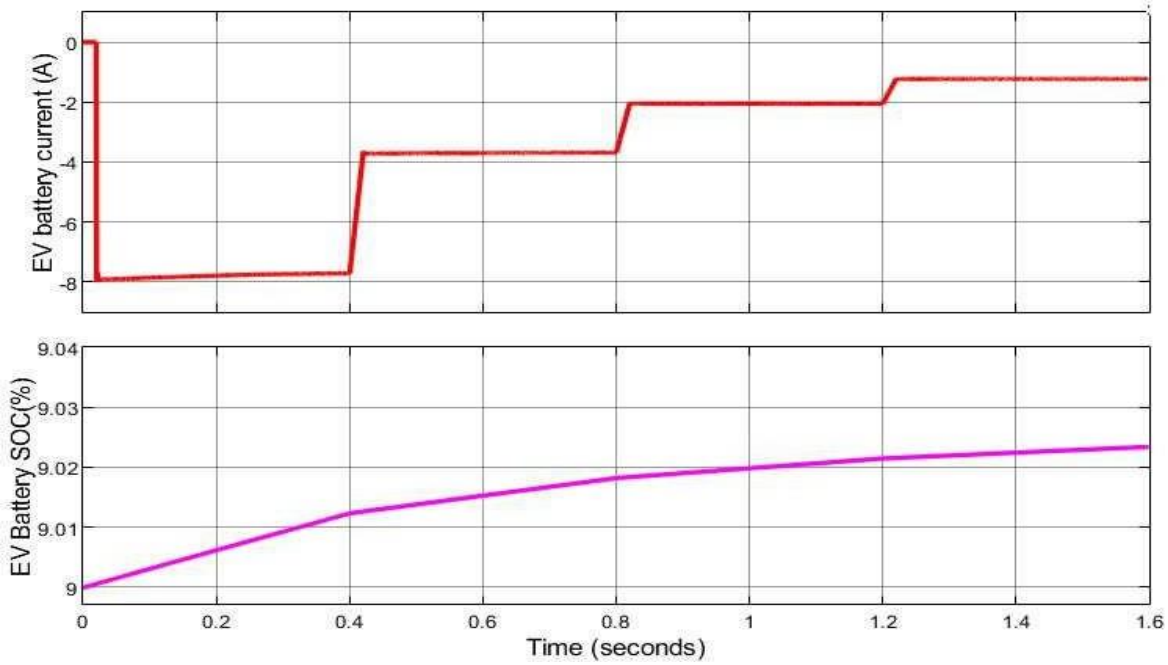


Figure 8: EV battery charging current and %SOC.

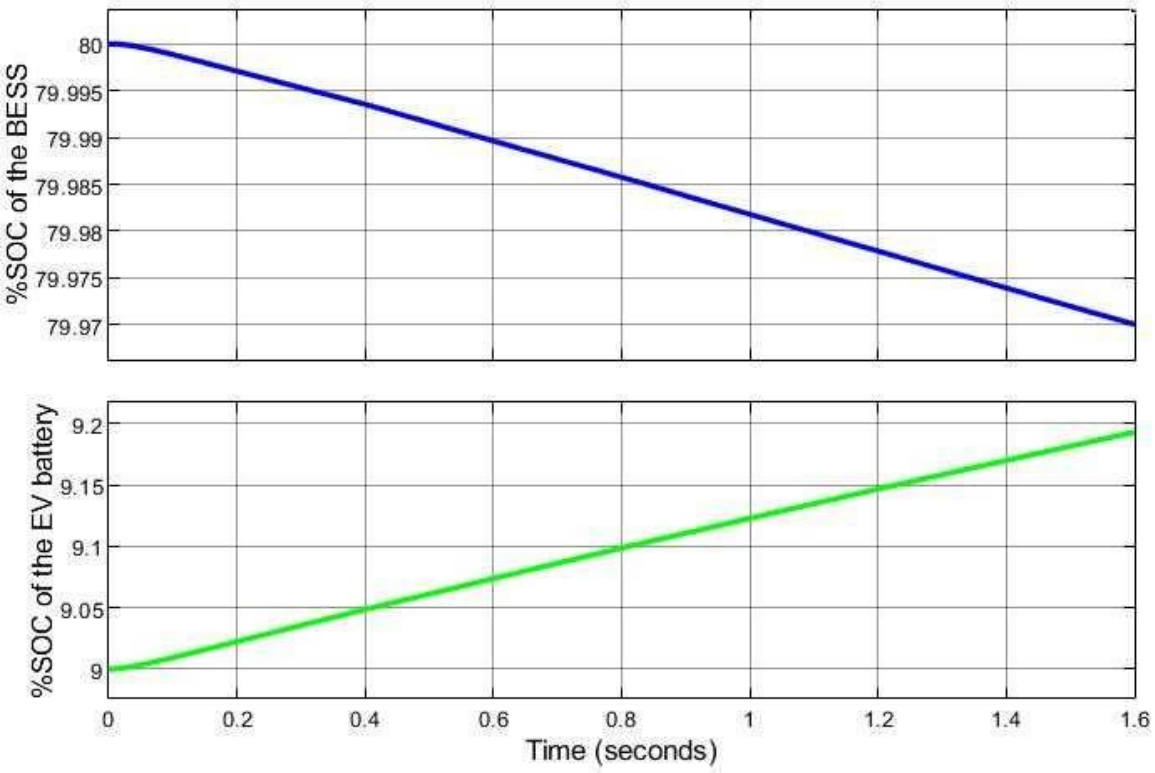


Figure 9: %SOC of standby battery and EV battery

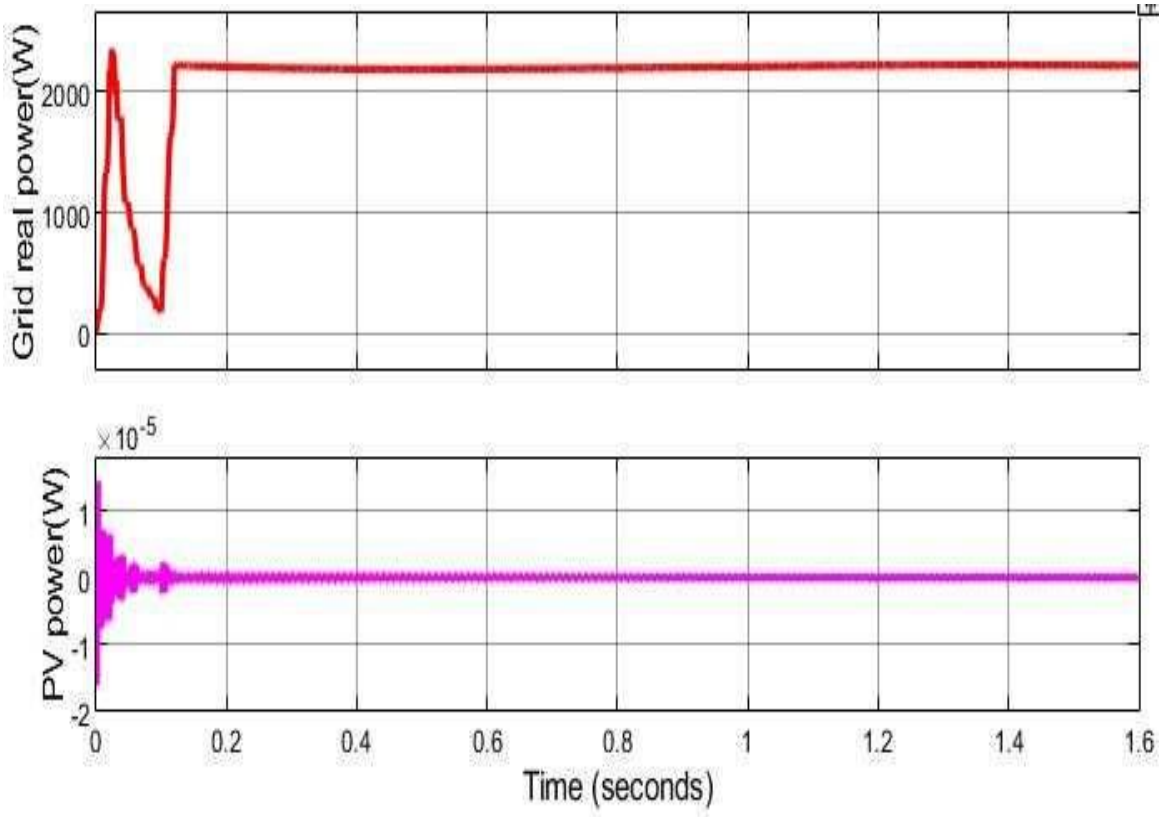


Figure 10: Grid supplied power when PV output is zero

IV. CONCLUSIONS

Many people are switching to solar since a solar system reduces electricity costs and protects the environment from carbon emissions. The grid-connected solar system is widely used for its various benefits. Although it has a few disadvantages, its benefits outweigh the cons. The solar power system enables the power system to provide electric grid with clean power that meets the utility grid power requirements and can be used for electric vehicle charging. PV cell, module and array are simulated and effect of environmental conditions on their characteristics is studied. Solar PV energy system with three phase grid connected electrical vehicle charging station has been studied and simulated. Both the systems are integrated and the solar PV system is used for battery charging and discharging. Number of expected vehicles doubling on the road in the near future increase the need for this alternative energy with evident and promising returns. This will lower our toxic emissions and localize greenhouse effects and increases the overall energy efficiency of vehicles. With the growing number of electric vehicles on the road, EV charging has become major issue. A charging station powered by PV array combined with a (BESS) battery energy storage system and a promising approach is enhanced by a grid support. By maintaining a steady DC bus voltage, the desired power can be obtained. The proposed station's power management is discussed and validated using MATLAB/Simulink in five distinct modes. This can be implemented with a significant power rating and capacity of power supply EV charging station at work.

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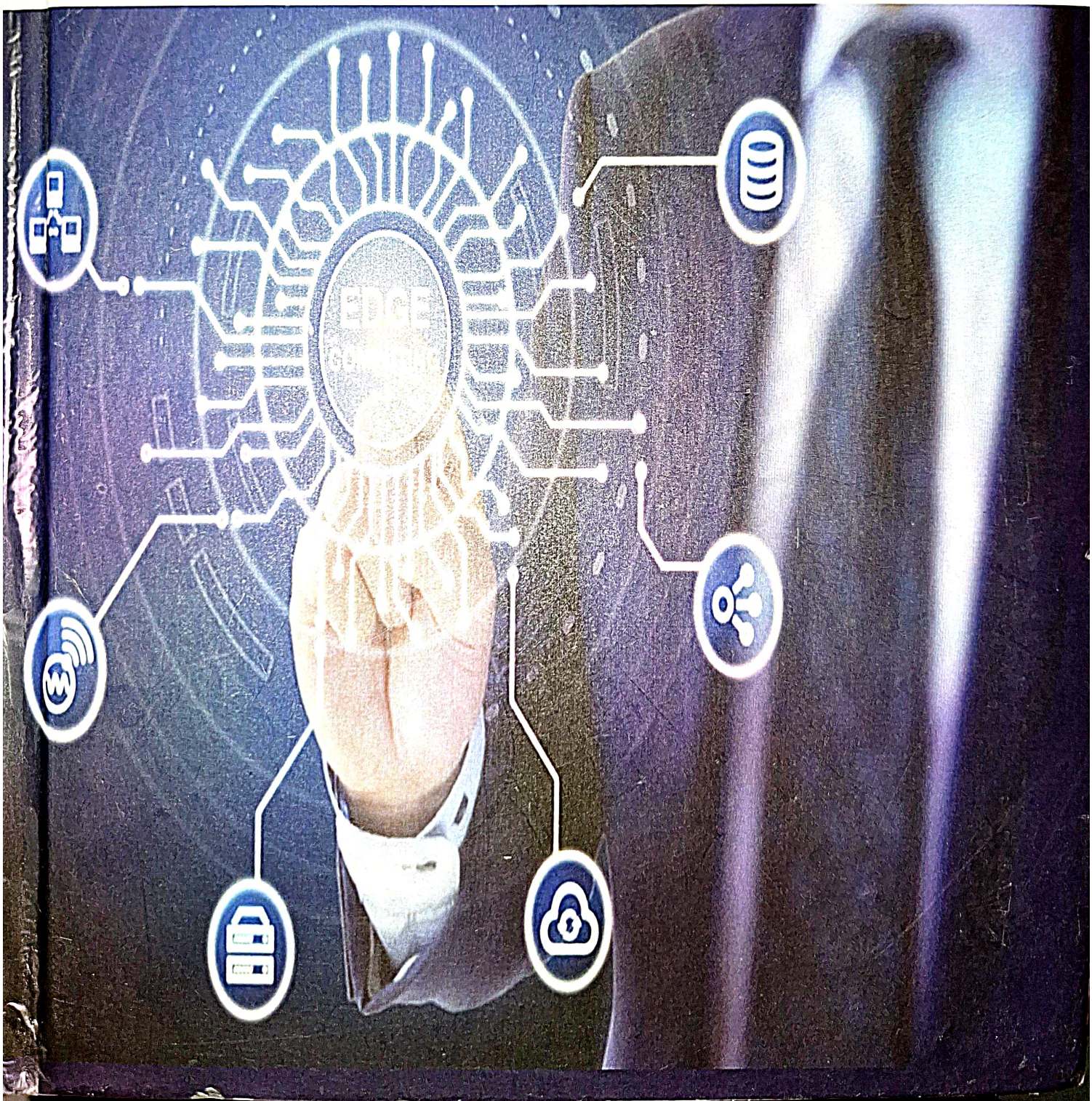
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EFFICIENT TECHNIQUES TO MITIGATE PACKET LOSS IN MANETs

Mr. B. Purushotham
Dr. Ch. D. V. Subba Rao



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Immune Landscape of Pancreatic Cancer Development and Drug Resistance



CHAPTER

12

Enigmatic role of T cells in pancreatic ductal adenocarcinoma: An introspective study

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Abstract

By 2030, pancreatic ductal adenocarcinoma is predicted to be the second most common cause of cancer deaths. In pancreatic cancers, T-cell numbers are limited in the tumor microenvironment without eliciting any anti-tumor activity. Recent studies showed that triggering T-cells to elicit anti-tumor activity may provide better outcomes in immunologically cold cancers like pancreatic cancer. To improve the outcome in a 5-year survival period of a pancreatic cancer patient, the identification of factors downregulating T cell activity in the tumor microenvironment plays an important role in the development of effective translational therapy. In this review, we summarized the role of T cells and their phenotypes in pancreatic cancer progression and pathogenesis, mechanisms behind T-cell exhaustion, and T-cell-based immunotherapies to understand the factors involved in T cell inactivation are crucial for the development of effective translational therapies.

Abbreviations

APC	antigen-presenting cells
CAFs	cancer-associated fibroblasts
CAR T cell	chimeric antigen receptor T cells
CDKN2A	cyclin-dependent kinase inhibitor 2A
CTLA-4	CTL-associated antigen 4
CTLs	cytotoxic T-lymphocytes
EGFR	epidermal growth factor receptor
ERK	extracellular receptor kinases

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	Dr.G.Narasimha	Copper Nanostructures: Next-Generation of Agrochemicals for Sustainable Agroecosystems	Chapter 3 - Biosynthesis and characterization methods of copper nanoparticles and their applications in the agricultural sector	
	Dr.G.Narasimha	Physica E: Low-dimensional Systems and Nanostructures	Synthesis of Frankincense gum stabilized AgNPs by microwave irradiation and their catalytic, antioxidant, and antibacterial properties	

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	Prof. P.Mohan Reddy	Financial inclusion of the marginalised selections in India- emerging issues and challenges	A study on financial inclusion and economic growth in rural areas	
	Prof. P.Mohan Reddy	Financial inclusion of the marginalised selections in India- emerging issues and challenges	Financial inclusion-a key driver for sustainable social development	
	Prof. P.Mohan Reddy	Corporate accounting (second year B.Com)		

	Prof. P.V. Narasaiah	Advanced Accounting (second year B.Com)		
	Prof. M. Venkateswarlu	Digital Economy in India: Trends Challenges and Opportunities	Protentional of GIG Technology in the Indian Education Sector	Digital Economy in India: Trends Challenges and Opportunities
	Prof. M. Venkateswarlu	Digital Economy in India: Trends Challenges and Opportunities	The Role of GIG Technology on Hospitality, Travel and Tourism, Banking, Insurance, Health care, Logistics Education	Digital Economy in India: Trends Challenges and Opportunities
	Prof. M. Venkateswarlu	Financial Inclusion of the Marginalised Sections in India: Emerging Issues and Challenges	Atmanirbhar Bharat: Implementation of Financial Inclusion Under Azadi ka Amrit Mahotsav. pp39-43	Financial inclusion of the marginalized sections in India: Emerging issues and challenges
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	Dr.E.Kesavulu Reddy		"Implementing Gated Recurrent Units and Generative Adversarial Networks to Enhance Effectiveness in Human Resource Management and Organizational Efficiency"	International Conference on Intelligent Computing and Communication Techniques (ICICC T-2024)

	Dr.E.Kesavulu Reddy		Securing multi-party computation using elliptic curve cryptography and neural networks	Abstracts published in Souvenir
	Dr.E.Kesavulu Reddy		Artificial Intelligence for Automated anomally detection in cyber security	Abstracts published in Souvenir
	Dr. Mooramreddy Sreedevi	Introduction to Internet Technologies		
	Dr. Mooramreddy Sreedevi	Handbook of Research on Advancements in AI and IoT Convergence Technologies	Performance Evaluation and Analysis of different Association Rule Mining ARM Algorithms	
	Dr. Mooramreddy Sreedevi		CNAIS: Performance Analysis of the Clustering of Non-Associated Items Set Techniques	International Conference on Recent Advances on Science and Engineering, Dubai, United Arab Emirates
	Dr. Mooramreddy Sreedevi		DDCATF: Deep Learning Approach for Detection of Cyber Crime Activities based on Temporal features.	2023 International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS)
	Dr. Mooramreddy Sreedevi		CADAE: Cybercrime Attack Detection using Autoencoders based on Temporal features	Proceedings of the 2024 Sixth IEEE Sponsored International Conference on Electrical, Computer and Communication Technologies (IEEE ICECCT 2024)
	Dr. MooramreddySreedevi		Artificial Intellegence, Cyber Security and Research	

	Dr. MooramreddySreedevi		DDCATF: Deep Learning Approach for Detection of Cyber Crime Activities based on Temporal features.	2023 International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS)

	Dr.B.Madhusudana Reddy	Effect of Heavy Metals Present in water used for cement mix with partial replacement of Cement by Microsilica	Effect of Heavy Metals Present in water used for cement mix with partial replacement of Cement by Microsilica	IIP, Iterative International Publishers
	Dr. N. MUNILAKSHMI	Author for the book titled "Waste Management-A case study"A Case Study	Author for the book titled "Waste Management-A case study"A Case Study	paramount publishing house
	Prof Ch D V Subba Rao	Recent Advances in Information Technology		
	Prof M Humera Khanam	Paper Presented	Improving The Performance Of IoT Devices Using Fog Computing And Communication Protocols	ICTACC'23
	Dr D Vivekananda Reddy	Novel Approaches for Test Case Prioritization		
	Dr D Vivekananda Reddy	Redefining Business Strategies: New Age Business Models	Cutting Edge Computational Technologies Influence in Human Health Care Applications	Redefining Business Strategies: New Age Business Models
	Deepthi Rapeti, Dr D Vivekananda Reddy	IEEE Xplore	A Brief Review on Melanoa Diagnosis Models using Machine Learning Techniques	Proceedings of the InConference on Automation, Computing and Renewable Systems (ICACRS 2022)"
	Prof.M. Damodar Reddy	Optimal Placement of DG Units and EVCS in Distribution Systems		

	Prof.M. Damodar Reddy	Loss Reduction Methods in Electrical Distribution Systems		
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	Prof.Ch. Chengaiah		Solar-Wind fed EV Charger at Variable Irradiance and Wind Speeds	4th IEEE International Conference on Innovations in Power and Advanced Computing Technologies
	Prof.Ch. Chengaiah		Power Quality In Microgrids: A Critical Examination of Principles, Guidelines, and Case Studies	5th International Conference on Engineering Science Technology and Management (ICESTM-2024)
	Prof.Ch. Chengaiah		An Intelligent Control Strategy to Enhance the Power Quality in a Microgrid with Integrated Solar Power Using Cascade Multilevel Inverter	5th International Conference on Engineering and Advancement in Technology (ICEAT 2024)
	Prof.Ch. Chengaiah	Simulation and Analysis of Solar-Wind System for EV Charging		
	Prof.Ch. Chengaiah	A Novel FSD Reconfiguration Technique for Dynamic Shading in Photovoltaic Systems		

	Prof.Ch. Chengaiah	Power enhancement in solar PV configurations under partial irradiation scenarios using Futo-Sumdoku method	Proceedings of 2nd International Conference (RAMMML-23)	
	Dr.V. Usha Reddy	Solar PV system analysis in different configurations		
	Prof.T.Ramashri	Integration of Artificial Intelligence In Leo Satellite Constellations: A Comprehensive Study		
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	Dr. P Hema			Experimental investigations on process parameters of stainless steel 410 alloy by plasma arc machining process using grey relational analysis with entropy measurement
	Dr.V Diwakar Reddy			Study on Mechanical behaviour of arhar based reinforced filled composite using taguchi approach

ational conference-proceedings during the year

Name of the conference	National / International	Year of publication	ISBN/ISSN number of the proceeding	Affiliating Institute at the time of publication	Name of the publisher	Departments
	National	2022	978-93-91400-12-5	CSEAPS	CSEAPS	CSEAP Studies
	National	2023	978-92-93402-14-1	CSEAPS	Uday Publishing House, New Delhi	CSEAP Studies
			978-93-91400-12-5			CSEAP Studies
	National	2022	978-93-5406-152-3.			CSEAP Studies
Environment Sustainability :Role of women, centre for women studies , s.v.u., Tirupati	National	2023	Chaired session, 5th Oct, 2023			CSEAP Studies
Environment Sustainability :Role of women, centre for women studies , s.v.u., Tirupati	National	2023	Paper presentation, 4th oct,2023			CSEAP Studies
	IN	Jun-24	ISBN: 978-620-6-77270-5	S. V. University	Scholar's Press	Centre for Women's Studies
	IN	Jun-24	ISBN:978-620-6-77287-3	S. V. University	Scholar's Press	Centre for Women's Studies
	IN	Jul-24	ISBN:978-620-7-80588-4	S. V. University	Lambert Academic Publishing	Centre for Women's Studies

	IN	August 2024	ISBN:978-620-7-99776-4	S. V. University	Lambert Academic Publishing	Centre for Women's Studies
						Econometrics
Digital Economy in India	National	May-22	978-93-5406-152-3	S,G. GOvt. Degree & PG College, Piler affiliated to S.V. U	Dr. Venkataramanaiah, Malepati	Economics
Organized by Dept. Of Veterinary & Animal Husbandry Extension Education College of Veterinary Scienc, Tirupati	National Conferenc e	14th & 15th Septembe r 2023				Education
The Gandhigram Rural Institute-Deemed to be University	National Seminar	26th & 27th March 2024				Education
The Gandhigram Rural Institute-Deemed to be University.	National Seminar	26th & 27th March 2024				Education
Tien Giang University,Mytho, Vietnam.	Internatio nal Conferenc e	17th & 19th October				Education
Department of Sociology, Osmania University, Hyderabad, TS, India	National Conferenc e	26th & 28th February 2024				Education
Department of Sociology Dr. B.R. Ambedkar Open University, Hyderabad	National Seminar	28th & 29th January 2024				Education
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	National	Jul-22	ISBN : 978-81-956242-0-1	SVU	Department of Indian Music,University of Madras	Performing Arts
	National	Jul-22	ISBN : 978-81-956242-0-1	SVU	Department of Indian Music,University of Madras	Performing Arts
						Philosophy
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	IN	2024	978-620-6-77287-3		Scholar's Press	Population Studies
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						Telugu Studies
	National	July,2023			Published by Karnataka State Open University, Mysore	Urdu
		October,2023	ISBN 9-788196-647200		Published by C. Abdul Hakeem College, Melvisharam, T.N.	Urdu
llege of Sciences						

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		2023	ISBN: 978-93-90471-19-5,		Volume 2, Integrated Publications	Home Science

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	National	Nov. 2023	ISBN :978-81-967685-5-3	S.V. University	INFINITE RESEARCH	Mathematics
	In	2022	978-0-323-90590-9		Elsivier	Microbiology
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Digital Economy in India: Trends Challenges and Opportunities	National	August, 2022	ISBN : 978-93-5679-949-3	S.G. Govt. Degree & PG College, Piler		Commerce
Digital Economy in India: Trends Challenges and Opportunities	National	August, 2022	ISBN : 978-93-5679-949-3	S.G. Govt. Degree & PG College, Piler		Commerce
Financial inclusion of the marginalized sections in India: Emerging issues and challenges	National	March, 2023	ISBN No.978-93-94293-16-8.	Department of Commerce, Sri Venkateswara University, Tirupati		Commerce
Financial inclusion of the marginalized sections in India: Emerging issues and challenges	National	2023	ISBN No.978-93-94293-16-8.	Department of Commerce, Sri Venkateswara University, Tirupati		Commerce
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International Conference on Intelligent Computing and Communication Techniques (ICICC T-2024)	In	2024		Jawaharlal Nehru University, New Delhi	Jawaharlal Nehru University, New Delhi	Computer Science

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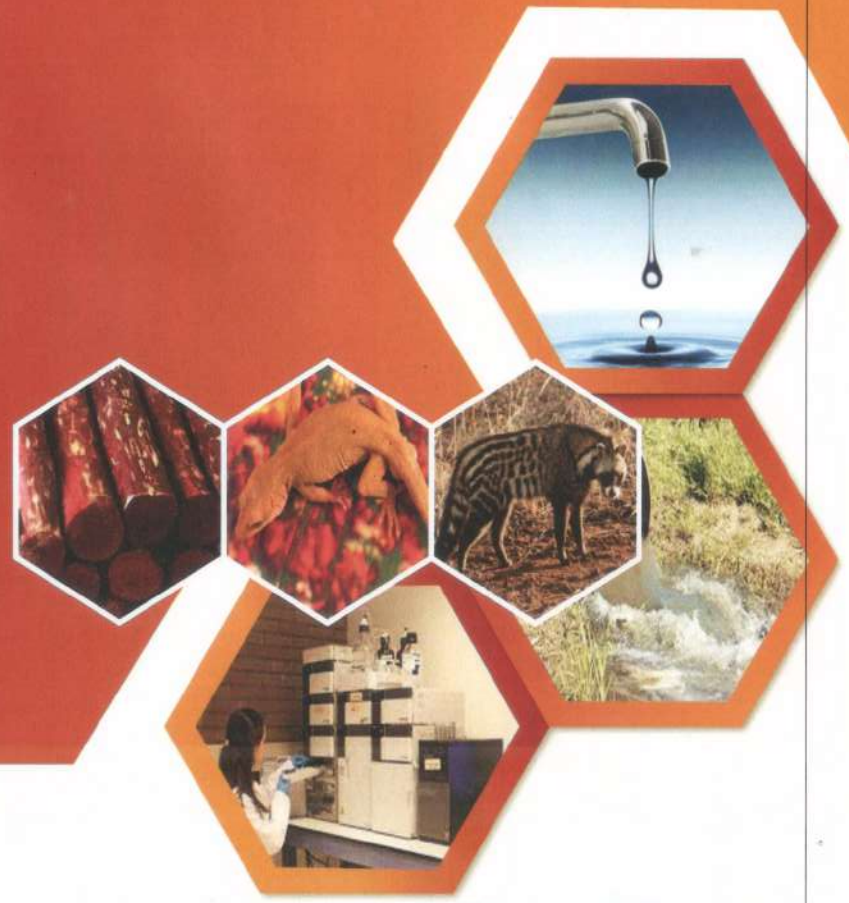
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Prof. T. Damodharam, joined the University service as Assistant Professor in Environmental Science in 1999 and promoted as Associate Professor in the year 2008 then promoted as Professor in the year 2014. At present heading the Department of Environmental Sciences. Research areas pollution monitoring, biodiversity conservation, environmental impact assessment and environmental toxicology and specialized in plant physiology. Published 61 research articles in reputed journals and authored one book and two book chapters. Guided six students for M. Phil., and sixteen students for Ph.D. Completed two MRP projects funded by UGC-New Delhi and one BRNS-DAE Collaborative project. Visited Srilanka for attending a seminar and awarded with Doctor of Science (DSC) from University of Colombo in 1997. Organized three National Seminars, one National Workshop, two Regional Seminars and one Webinar. Co-ordinator for two Refreshers courses in environmental studies in 2018 and 2019. Member of the Directorate of Community Development Cell of the University and Life member in ISCA, Kolkata. Presently acting as NSS Programme Co-ordinator for Sri Venkateswara University, Tirupati.

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Prof. T. Damodharam

Hand Book of Water Quality Assessment

By

Dr. Prof. T. Damodharam,
M.Sc., B.Ed., M.Phil., Ph.D., D.Sc



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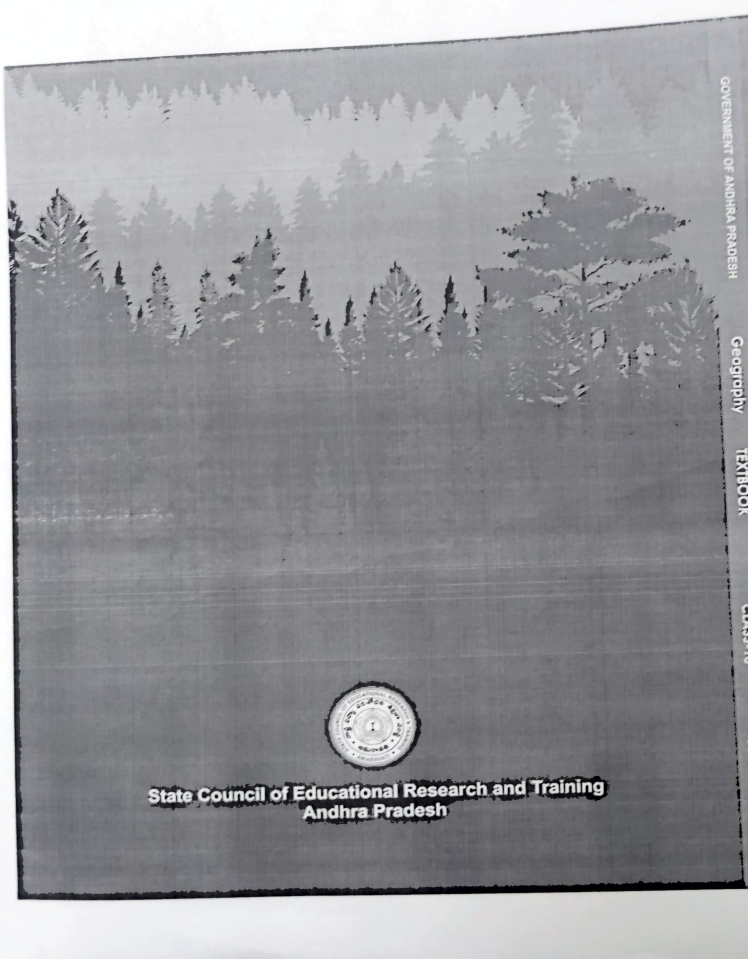
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DIGITAL ECONOMY IN INDIA OPPORTUNITIES AND CHALLENGES: A STUDY

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Abstract

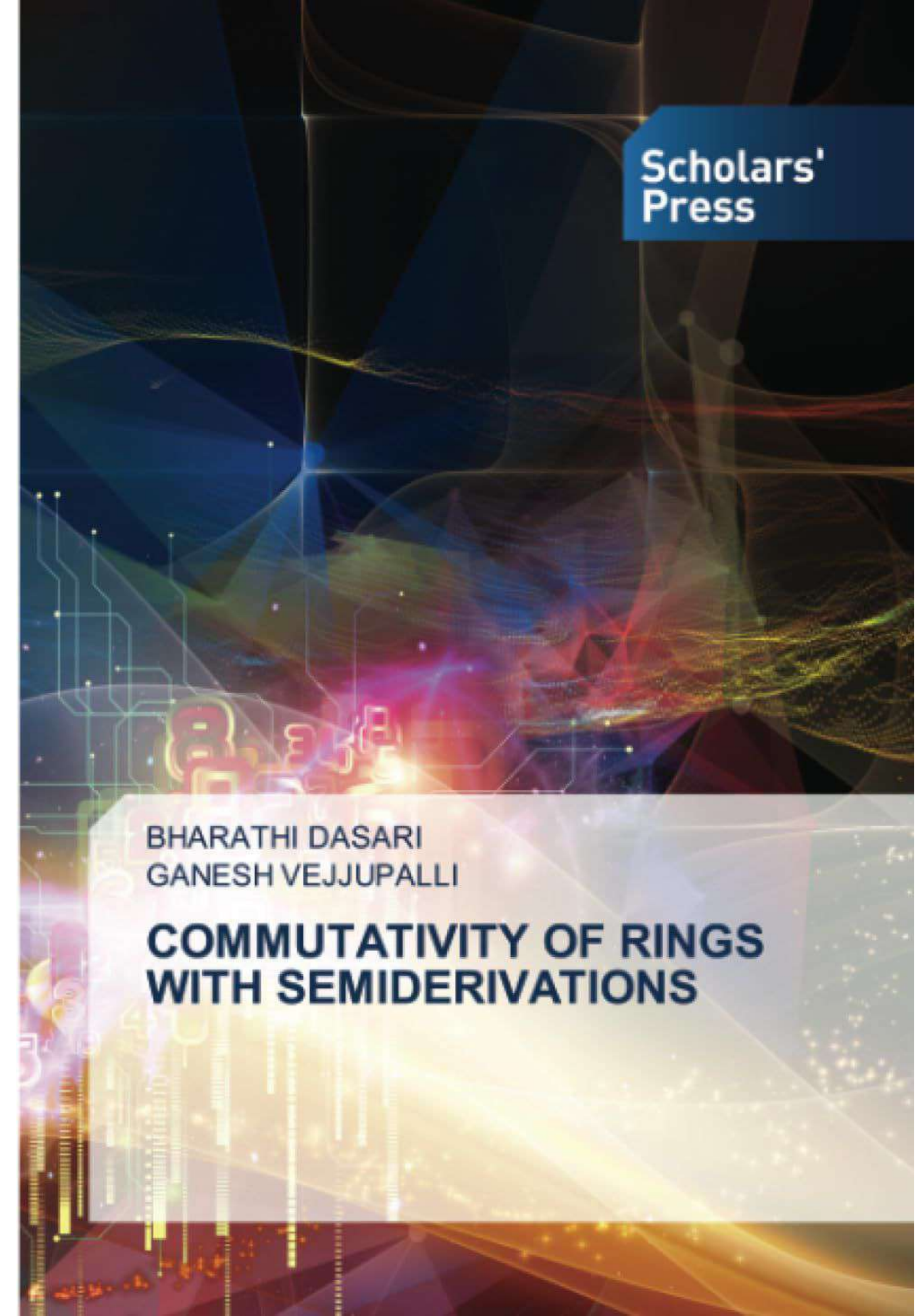
India can create over $1 trillion of economic value from the digital economy in 2025, with half the opportunity originating in new digital ecosystems that can spring up in diverse sectors, says a report from Ministry of Electronics and Information Technology, in partnership with McKinsey. "The trillion dollar economy report is the symbol of opportunity that India offers," said Ravi Shankar Prasad, Minister of Information Technology. "Digital India is also an opportunity for people in digital space to do business in India. The size and scale that India offers is a big business opportunity for global companies," he added. 'Digitization' and 'digitalization' are two conceptual terms that are closely associated and often used interchangeably in a broad range of literatures. Digitization refers to "the action or process of digitizing; the conversion of analogue data into digital form." Digitalization, by contrast, refers to "the adoption or increase in use of digital or computer technology by an organization, industry, country. "Digital India is the beginning of digital revolution. It is a dream which is created by the Government of India to ensure that government services are made available to citizens electronically, even in remote areas, by improving online infrastructure and by increasing Internet connectivity. The programme have one mission and one target that is to take nation forward digitally and economically. The initiative will enable people to get engaged in the innovation process which is needed by the economy to move forward. If implemented properly, it will open various new opportunities for the citizens of the country. Currently, India's digital economy generates about $200 billion of economic value annually 8 per cent of India's GVA in 2017-18 largely from existing digital ecosystem comprising information technology and business process management (IT-BPM), digital communication services, e-commerce, domestic electronics manufacturing, digital payments, and direct subsidy transfers, the report said. "By 2025, India could create a digital economy of $800 billion to $1 trillion. The existing digital ecosystem could

COMMUTATIVITY OF RINGS WITH SEMIDERIVATIONS

In the theory of rings, the study of commutative rings has evoked great interest and assumed importance. In particular, the study of derivations, generalized derivations, semiderivations in rings has yielded many interesting results. These results have applications in other branches of algebra. Throughout this work a ring R is a synonym for an associative ring. In this work we present some properties of semiprime rings, prime rings, semiprime rings, 2 – prime rings which admit semiderivations and Generalized semiderivations. Prime rings with Left Generalized semiderivation We prove the commutativity of rings using the semiderivations and also we use symmetric bi-derivation or permuting tri-derivation instead of derivation in addition of Jordan generalized derivation.

Dr. D Bharathi, Professor is working in the department of Mathematics, Sri Venkateswara University, Tirupati, A.P. Dr. D.Bharathi is teaching Algebra, Commutative Algebra, Partial Differential Equations, Functional Analysis and Graph Theory to Post Graduate students and guiding research work to Ph.D students on Algebra, Graph Theory.

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COMMUTATIVITY OF RINGS WITH SEMIDERIVATIONS

AQUACULTURE ADVANCES IN NANOTECHNOLOGY

Dr. P. Nagajyoti
Department of Aquaculture
S.V. University, Tirupati

Abstract

Aquaculture is one of the fastest rising sectors in the world today. An Aquaculture system is diversified as fresh, brackish and marine water culture systems. The growth of aquaculture as an industry has accelerated over the past decades, this has resulted in environmental damages and low productivity of various crops .The need for increased disease resistance, growth of aquatic organisms, and feed efficiency has brought about the use of probiotics in aquaculture practices. The first application of probiotics occurred in 1986, to less their ability to increase growth of hydrobionts (organisms that live in water). Probiotics were used to improve water quality and control of bacterial infections. Now a day there is documented evidence that probiotics can improve the digestibility of nutrients, increase tolerance to stress, and encourage reproduction. Currently, there are commercial probiotic products prepared from various bacterial species such as Bacillus sp., Lactobacillus sp., Enterococcus sp., Carnobacterium sp., and the yeast Saccharomyces cerevisiae among others, and their use is regulated by careful management recommendations. The present paper shows the current knowledge of the use of probiotics in aquaculture, its antecedents, and safety measures to be carried out and discusses the prospects for the study in this field.

Keywords: *Aquaculture, Probiotics, water quality, Disease Control, Growth promoters, reproduction.*

Introduction

"Nanotechnology is dealing with specific size dependent functional properties of the individual sub-units or of a system of those". Nanotechnology is the future big excitement in the field of Science and Technology.

Nanotechnology manipulates matter at the nanoscale (1-100 nm) (Moore, 2006 and Nel *et al.*, 2006) producing nanoproducts and nanomaterials (NMs) that can have novel and size-related physico-chemical properties differing

significantly from those from larger particles. Recently, anthropogenic sources have also produced nano-sized materials unintentionally from combustion by- products and intentionally as manufactured nanomaterials. Nanotechnology is undoubtedly one of the most important technologies of the 21st century. With an estimated $147 billion worth of so-called 'nano-enabled' commercial and consumer products sold in 2007 and a projected value of $3.1 trillion by 2015. Nanotechnology has been referred to as the next industrial revolution (Schmidt, 2009). This technology promises scientific advancement for many sectors such as medicine, consumer products, and energy. Governments and investors around the world are therefore keen to explore and exploit the exceptional properties of nanomaterials opportunities which exist within nearly every industrial and technological sector.

Nano–Concept and History

Nanotechnology is defined as the "design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale" (Williams *et al.*, 2005). In principle, therefore, any product using compounds that exist as, or are manufactured to, these specifications can be considered as nanomaterials.

Table 1: Comparison of sizes of biological molecules and structures in nanometers (Gupta and Kompella, 2006)

Object	Size (nm)
Carbon atom	0.1
DNA double helix (diameter)	3
Ribosome	10
Virus	100
Bacterium	1,000
Red blood cell	7,000
Human hair (diameter)	80,000

Radiation and Mass Transfer Effects on MHD Convective Flows



Dr. R.L.V. Renuka Devi
Dr. A. Neeraja

RADIATION AND MASS TRANSFER EFFECTS ON MHD CONVECTIVE FLOWS



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RADIATION AND MASS TRANSFER EFFECTS ON MHD CONVECTIVE FLOWS

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Vo Nguyen Giap

Vietnamese Iconic General

M. Prayaga



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Vo Nguyen Giap: Vietnamese Iconic General

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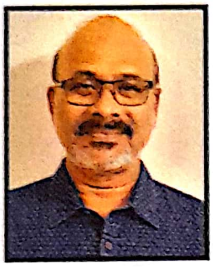
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General Vo Nguyen Giap renowned for the victories, over France and the United States, in the heroic national struggle for liberation and unification of the country. He was a self-trained military commander, who went on to become one of the Vietnamese heroes and great personalities of the World. General Giap adopted both unconventional and guerrilla warfare tactics in which he preferred to lay new organizational policies and strategies. Taking an experimental approach, he blended local talent and resources and used his practical insight and patriotism to bring triumph to the country as a brilliant military strategist and savvy leader. It was his military genius as well as his gradual plan to bring liberation, paved the way for the reunification of Vietnam.



Dr. M. Prayaga is Director and Associate Professor, Centre for Southeast Asian and Pacific Studies, Sri Venkateswara University, Tirupati. He was the recipient of Prof. Saiyid Nurul Hassan's Prize in 1989 for his First Rank in M.A. History. He qualified the UGC- Junior Research Fellow & UGC-Lectureship. In addition to securing M.Phil. and Ph.D. degrees on topics concerning the contemporary Vietnam, his areas of research include International Relations, Indo-Pacific, India-ASEAN relations and India-Vietnam Studies. He has been teaching Southeast Asian History, Politics and Tourism to the Post-Graduate students. Dr. Prayaga has Two books and 28 articles to his credit and attended more than forty five National and International Conferences/ Seminars. Dr. M. Prayaga visited Malaysia, Singapore, Thailand, Indonesia and Vietnam for his field work, attending conferences and to deliver lectures. Institute of Strategic and International Studies (ISIS), Malaysia, had granted Internship to conduct research. He is the Editor for the periodical, *Area Studies: A Journal of International Studies and Analyses*. He is also a reviewer for journals. He is a member of BOS in S.V. University and Rashtriya Sanskrit Vidyapeetha, Tirupati, University of Madras as well as member in a number of professional bodies.

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Azadi Ka Amrit Mahotsav

GIG ECONOMY & ATMANIRBHAR BHARAT

Challenges & Opportunities

Editor
Lt. Dr. M.Venkataramanaiah



About the Editor

Lt. Dr. Venkataramanaiah Malepati is a top- notch academician, presently working as an Assistant Professor in Commerce at S.G.Government Degree and PG College, Piler. He has obtained his M.Com, MBA, M.Phil and Ph.D. from S.V .University, Tirupati and MBA from Pondicherry University. He has got through National Eligibility Test (NET) in Commerce and Management and SET in Commerce with distinction. He has bagged National Merit Scholarship in Graduation and Gold Medal in M.Com. He has also bagged Centrally Administrated Doctoral Fellowship from ICSSR, New Delhi for his research during 2010-13. Dr. Malepati has the rich experience of 18 years in both teaching and research. Being the passionate researcher and teacher, he traveled widely and tried out his wings in various positions in teaching across the countries. Dr. Malepati started his career as a lecturer in Dravidian University. Later he rendered his services in various capacities in the Premier Institutions like University of Gondar, Ethiopia, KMM Group of Institutions, Tirupati, Vignanasudha Institute of Management and Technology, Chittoor, University of Kurdistan, Iraq and Golden Valley Group of Institutions, Madanapalli. Being the top-notch researcher, he contributed significantly to the areas of Capital Markets, Agri Finance, MSMEs and Micro-finance. To his credit, there are 41 research papers published in National and International Journals listed in UGC Care List, Scopus Indexed and Web of Sciences. He has also been credited with four chapters in Edited Books. In addition to these, he has also 10 completed Edited Books and one edited book in the pipeline to his credit.

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POTENTIAL OF GIG TECHNOLOGY IN THE INDIAN EDUCATION SECTOR

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ABSTRACT

Gig Economy is identified as a pattern of work engagement where there is a consumer or service speaker, on one hand, reflecting demand for a particular task while on the other end is a gig worker who can work for a specific period and provide the required work. The development of the tech-enabled platforms contributes to connecting the consumer to the gig worker wherein the former can hire services from the latter based on a fixed period. The gig workers include people of different categories like self-employed, freelancers, part-time workers and also independent contributors. India's gig economy has fundamentally changed the perception of education today. The idea of continuing education is not just to get a degree or certificate that will only add weight to your resume, but to acquire the various industry skills you need to get a job. The growth of social commerce in the country is positively impacting employment opportunities for millions of gig workers. According to a 2019 World Bank report, digital platforms are scaling faster and cheaper than traditional businesses. The penetration of online retail in the report's year was 4.7%. It is expected to reach 10.7% by 2024. India has emerged as one of the largest flexible staffing countries in the world. Simply put, gig jobs have simplified the country's employment landscape and changed its structure for the better. However, in the gig economy, freelancers have to be self-sufficient in their learning. They have to decide what knowledge they lack, where to get it, how to fit their day, and how to pay for it. Free options (as in MOOCs and other online opportunities) are growing in popularity. The flexibility, availability, and constraints of scheduled courses appeal to motivated learners. Gig workers earn money based on their performance on specific tasks rather than focusing on earning a set salary.

Keywords: *Gig economy, Gig workers, Education, and Startups.*

Introduction

Gig employment is considered to be the major source of income in markets like the United States, Germany, Sweden, the United Kingdom, and Spain, however, it is considered to be a secondary or alternative source of income in nations like India and Brazil. Future gig economy developments in the latter will include the introduction of new occupations and skills, expanding talent gaps, adjustments to legal requirements, and shifting attitudes concerning labour itself.

Over three million successful gig workers, such as contract workers in transportation, logistics, construction, and home-based services, are employed informally in India, but COVID-19 has sparked an increase in this industry. The country's gig economy, which ASSOCHAM-India estimates will grow at a compound annual rate of 17% to reach $455 billion by 2023, has the potential to support up to 90 million jobs in India's non-farm sectors (roughly 30%), transact over $250 billion in a volume of work, and contribute 1.25% to the country's gross domestic product (GDP) over the long term. Nearly 24 million employments in skilled, semi-skilled, and shared services professions can be created in the short- to medium term, according to studies by BCG and the Michael & Susan

THE ROLE OF GIG TECHNOLOGY ON HOSPITALITY, TRAVEL AND TOURISM, BANKING, INSURANCE, HEALTH CARE, LOGISTICS, EDUCATION

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Abstract

The words "gig economy" has attracted wide attention from both scholars and the popular media. Much of this attention has been devoted to jobs worked through various online platforms. The new technology is producing an accelerated pace of change in the organization of work which has developed interest to know how these changes might affect both workers and firms. Gig economy is an approach in the labour market which is characterized by the prevalence of short-term contracts or freelance work in contrast to permanent jobs. The gig workers are independent workers or temporary contract workers who enter into formal/informal agreements with on-demand companies to provide their services. Rather than employing full-time/permanent employee's companies may utilize gig workers as per the demand and work burden, which can minimize the costs incurred in managing permanent employees. However,this paper provides a technology of work arrangements and reviews how different arrangements, and especially role of gig technology in hospitality, travel and tourism, banking, insurance, health care, logistics, education etc are captured in existing data.

Purpose:The purpose of this study is to identify role,Prospects and importance of gig technology on hospitality, travel and tourism, banking, insurance, health care, logistics, education and leadershipetc., and the issues involved.

Keywords: Hospitality, travel and tourism, banking insurance, health care, logistics and education, Prospects, gig economy.

I. INTRODUCTION

By upgrading or augmenting skills, equipping modern tools for better efficiency, people at gig jobs can earn more, some becoming even micro-entrepreneurs.India is experiencing a seismic shift in its work culture today. Young people don't want to be stuck in jobs where they have to work long hours for minimal pay. These individuals are finding sustainable employment opportunities in the country's rapidly growing gig economy. Some more aspirational are becoming micro-entrepreneurs.India has always had a large reserve of informal gig workers. The pandemic pushed a lot of them out of work. Just between March and April 2020, CMIE data showed that a whopping 113.6 million people lost their jobs.As people went searching for new jobs, with many industries being down in the doldrums, the gig

FINANCIAL INCLUSION OF THE MARGINALIZED SELECTIONS IN INDIA: EMERGING ISSUES AND CHALLENGES



Editor
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ATMANIRBHAR BHARAT: IMPLEMENTATION OF FINANCIAL INCLUSION UNDER AZADI KA AMRIT MAHOTSAV

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ABSTRACT

The financial addition of women is particularly important for gender equivalency and women's profitable commission. With lesser control over their financial lives, women can help themselves and their families to come out of poverty; reduce their threat of falling into poverty; exclude their exploitation from the informal sector; and increase their capability to completely engage in measurable and productive profitable conditioning. Social Justice remains a vital foundation of our constitution. Within the contradiction of development and justice, one shouldn't ignore the core liabilities of the state. As far as development is solely concerned, on- state actors are sufficiently equipped with the coffers and wherewithal to carry out experimental conditioning, still more sustainable addition can only be realized with the intervention of the state.A practicable policy armed with inclusive growth is the need of the hour and the present government is successfully executing several schemes and programmes on this premise.India has traditionally defended colourful chops and crafts similar to shoe timber, embroidery, polishing, handlooms, etc. In the area of Skill Development, one must evolve ways to match the chops sets amongst citizens with the ever-adding demands of the globalized world.National Strategy for Financial Addition for India 2019- 2024 has been prepared by RBI under the aegis of the financial Addition Advisory Committee and is grounded on the inputs and suggestions from the Government of India, other Financial Sector Controllersviz., Securities Exchange Board of India (SEBI), Insurance Regulatory and Development Authority of India (IRDAI) and Pension Fund Regulatory and Development Authority of India (PFRDA).

FINANCIAL INCLUSION

Financial inclusion is decreasingly being honoured as a crucial motorist of profitable growthand poverty relief the world over. Access to formal finance can boost job creation, reduce vulnerability to profitable shocks and increase investments in mortal capital. Without acceptable access to formal financial services, individuals and enterprises need to calculate on their limited coffers or calculate on expensive informal sources of finance to meet their financial requirements and pursue growth openings. At a macro position, lesser financial addition can support sustainable and inclusive socio-profitable growth for all. There has been a growing substantiation of how financial addition has a multiplier effect in boosting overall profitable.

A STUDY ON INITIATIVES TAKEN BY THE CENTRAL GOVERNMENT TO ACHIEVE FINANCIAL INCLUSION

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ABSTRACT

Being a welfare country, one of the prime objectives of government policy in India has been to enable financial inclusion and to reduce poverty through interventionist public policies. One such approach is the Direct Benefits Transfer (DBT) initiative. Various government programmes such as loans at low interest rates, subsidies and other various incentives for startup entities entitlements, student scholarships, and wages for MGNREGA workers fall under the DBT initiative where the money is transferred to the respective beneficiaries' bank accounts. However, the beneficiaries face many hurdles in accessing their money. For example, in rural areas, beneficiaries have to travel miles and wait for several hours to make one banking transaction. These hurdles are broadly referred to as "last mile challenges". These challenges have widened the distance between the rights holder and their entitlements, which must be urgently resolved. An all-inclusive financial system is essential because it enhances efficiency and welfare by providing scope for secure and safe saving practices and by facilitating a wide range of efficient financial services. The present study will focus on the opportunities of financial inclusion in India.

KEYWORDS: Finance, banking habits, rural areas, financial inclusion.

INTRODUCTION - LENDING POLICIES AND GUIDELINES (LPG)

BACKGROUND

National Safai Karamcharis Finance & Development Corporation (NSKFDC) is a wholly owned Govt. of India Undertaking under the Ministry of Social Justice & Empowerment, set up on 24th January 1997 as a Company "Not for Profit" under Section 8 of the Companies Act, 2013. It is in opera the all round socio-economic upliftment of the Safai Karamcharis (including wastepickers), Manual Scavengers and their dependants throughout the Country through its various loan and non implemented through State Channelizing Agencies (SCAs) nominated by the State Governments & Regional Rural Banks (RRBs)/Public Sector Banks (PSBs) and the Skill Development Training Programmes (SDTP) are implemented through Govt. Sector Training Institutions across the Country.

OBJECTIVES

The major objectives of the Corporation as per Memorandum and Articles of Association are as under:-

FINANCIAL INCLUSION OF THE MARGINALIZED SELECTIONS IN INDIA: EMERGING ISSUES AND CHALLENGES



Editor
Prof. M.Venkateswarlu

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Financial Inclusion of the Marginalized Selections in India: Emerging Issues and Challenges

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A STUDY ON FINANCIAL INCLUSION AND ECONOMIC GROWTH IN RURAL AREAS

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Abstract

The Indian government and the Reserve Bank of India combinedly making concerted efforts to promoting the one of the national important objective of India is financial inclusion.Since five decades, the major efforts made in the Indian Economy. Overall in India all nationalization of banks,cooperative bank, regional rural banks and commercial banks are introduction the at most priority of formation of self help groups, sector lending targets, lead bank scheme and appointed more employees by the banks to provide door step delivery of banking services and also people financial beneficially offering zero balance accounts system etc. The primary objectives all these are have to reach the largest population of India. The main objective of the study is providing basic financial services to all, to create the opportunities to access the universal financial services and enhancing the financial literacy and education. The present study is analysed the government and banking schemes performance in county, so that these allpolicies are enhance the people in economically.

Keywords: Financial Inclusion, Economic Growth, Banking System, Financial Services

Introduction

The Indian government and the Reserve Bank of India combinedly making concerted efforts topromoting the one of the national important objective of India is financial inclusion. Since five decades,the major efforts made in the Indian Economy. Overall in India all nationalization of banks,cooperative bank, regional rural banks and commercial banks are introduction the at most priority of formation of self help groups, sector lending targets, lead bank scheme and appointed more employees by the banks to provide door step delivery of banking services and also people financial beneficially offering zero balance accounts system etc. The primary objectives all these are have to reach the largest population of India. The main objective of the study is providing basic financial services to all, to create the opportunities to access the universal financial services and enhancing the financial literacy and education. The present study is analysed the government and banking schemes performance in county, so that these allpolicies are enhance the people in economically.

RBI -Statement on Developmental and Regulatory Policies

Since 2016 the Reserve Bank of India (RBI) has been organized the Financial Literacy Week for financial education messages to the particularly to Indian population. The Reserve Bank ofIndia was selected the current year as financial literacy week and the theme of these year is " Good Financial Behaviour – Your Saviour". This year financial literacy week organized between February 13 and 17, 2023. The Reserve bank of India overall

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Performance of
INDIAN LIFE INSURANCE INDUSTRY
A PERSPECTIVE



Dr. V. Vasavi

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V Vasavi is working at present as an Assistant professor of Commerce at Government Degree College, Puttur which is affiliated to Sri Venkateswara University, Tirupati. She has entered into the field of teaching in the year 2002, by getting through the exam conducted by the Andhra Pradesh Public Service Commission. She has been awarded M.Phil degree in the year 2009 and Ph.D degree in the year 2021. She qualified National Eligibility Test (UGC NET) being conducted by the UGC and State Eligibility Test (AP SET) conducted by the Andhra Pradesh state government in the year 2012. She is a life member of Indian Commerce Association. She attended a number of national and international seminars and presented articles which got published with ISBN.

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FINANCIAL INCLUSION OF THE MARGINALIZED SELECTIONS IN INDIA: EMERGING ISSUES AND CHALLENGES



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Prof. M.Venkateswarlu

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A TWO DAY NATIONAL SEMINAR ON

FINANCIAL INCLUSION OF THE MARGINALIZED SELECTIONS IN INDIA: EMERGING ISSUES AND CHALLENGES

Editor

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FINANCIAL INCLUSION – A KEY DRIVER FOR SUSTAINABLE SOCIAL DEVELOPMENT

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Abstract

The concept of Financial inclusion started in 2005 in India by RBI, presently its importance is rapidly increasing in making India to be one of the best growing economies of the World.

Financial inclusion is essential for sustainable social development as it provides individuals and communities access to formal financial services, such as savings accounts, pensions, micro credit and insurance in an affordable manner.This enables them to manage their money effectively, build assets, and protect themselves against risks. Financial inclusion also promotes economic growth by increasing productivity and employment generation. This paperconcentrates on the importance of role of financial inclusion in sustainable social development and the challenges that need to be addressed to achieve it. This paper also providesan insight on therole of technology in promoting financial inclusion and the potential of innovative solutions, such as digital finance and mobile money, to reach underserved populations. Ultimately, financial inclusion is crucial to creating a more equitable and just society, where everyone has the opportunity to participate in and benefit from economic growth.

Keywords: Financial inclusion, Sustainable social development, Economic growth, Productivity, Job creation, Mobile money, Underserved.

INTRODUCTION

Financial inclusion is a critical component of sustainable social development. Financial inclusion is a key enabler in reducing poverty and boosting prosperity. Access to basic financial services enables the less fortunate and more vulnerable in the society to step out of the vicious cycle of poverty and empower themselves and their families.

Despite of the benefits of financial inclusion, however, millions of people worldwide remain excluded from formal financial systems. The lack of access to financial services often results in lower incomes, reduced economic opportunities, and limited ability to save and invest ineducation, healthcare, and other critical needs.

Few schemes such as SWABHIMAN, Atal Pension Scheme, Pradhan Mantri Mudra Yojana, Pradhan Mantri Jan Dhan Yojana, Ayushman Bharat were launched as a part of contributionand meeting the Sustainable Social Development in India.This paper will explore the importance of financial inclusion for sustainable social development, highlighting the benefits and challenges in achieving it.Finally, this paper deals with the potential of financial

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About the Editor



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Chapter 3
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Effect of Ultrasound in the enhancement of Protein Metabolism and Enzyme Activities in the Fat body of Fifth Instar Silkworm, *Bombyx mori L*.

P. Naga Jyothi [a*]

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ABSTRACT

Under the influence of ultrasound, protein metabolism parameters such as total, soluble proteins, free amino acids, and activity levels of protease, glutamate dehydrogenase, aspartate amino transferase, and alanine aminotransferase were measured in the fat body of the fifth instar larva of the silkworm, Bombyx mori. On these parameters, ultrasonography generally has an elevating effect. The events of histogenesis and histolysis connected to the metamorphosis of the silkworm are correlated with changes in the levels of certain biochemical components. Under the impact of ultrasound, the metabolism of proteins is accelerated, resulting in increased spinning activity, increased protein turnover in silk, and increased sericultural production. Enhancement of proteins by ultrasound clearly documented the induction of severe proteolysis and transamination of amino acids.

Keywords: Amino acids; aminotransferases; glutamate dehydrogenase; protease.

1. INTRODUCTION

All living cells require proteins as a fundamental building block. Protein metabolism is a representation of life itself if carbohydrate metabolism is life's energy source. In essence, proteins are in charge of preserving the structural and functional structure of cells. They are essential for breathing, enzyme catalysis, material transport, and the control of metabolism, mobility, and body defence. The total protein content of the cell includes both structural and soluble portions, of which the former plays main role in cellular architecture and the latter in cellular metabolism.

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Proteins have always been an interesting biochemical tool for insect biochemists because of their prominent role in development, morphogenesis and the intermediary metabolic pathways in insects. Mihaeslu et al. [1] observed biochemical difference in the eggs of *Bombyx mori* and *Philosamia ricini* with regard to their total proteins and amino acids. The first ever observation on insect haemolymph proteins was made by Lauffer [2] in the silkworm *B. mori.* Subsequently a series of detailed physico-chemical studies on haemolymph proteins of B*. mori* appeared [3].

Tojo et al. [4] made a detailed account of storage proteins while Sasaki et al. [5] investigated the intracellular transport and secretion of fibroin in the posterior fat body of *B. mori.* A novel approach in silkworm research is the manipulation of biochemical machinery through exogenous modulators that could boost the silk production. The development of the worm is depending on metamorphosis process which is a dynamic biochemical process [6]. The growth of silkworm during metamorphosis is accompanied by the increase in the bodyweight and accumulation of various biochemical constituents like proteins, aminoacids and enzymes like proteases, glutamate dehydrogenase and aminotransferases [7]. Since, the silkworm is an economically important insect, several insect physiologists attempted to elucidate the role of biochemical constituents in silk protein synthesis and egg formation [8]. More importantly, the parameters of protein metabolism have been extensively examined because of their role in development, morphogenesis and in the intermediary metabolism [9,10]. A novel approach in silkworm research is the manipulation of biochemical machinery through exogenous modulators that could boost the silk production. This obviously, included the administration of certain neuro-humoral factors, vertebrate hormones and various other chemicals like cyclic AMP and prostaglandins, which could have a profound influence on the growth rate, larval life cycle and fecundity [11,12]. Significantly, the positive impact of vertebrate thyroxine on silkworm biology, especially in improving the pre- and post cocoon parameters is well documented [13]. Another vertebrate hormone, namely prolactin induced improvement in the growth and reproductive potential of silkworms [12]. The dietary administration of vertebrate sex hormones like ethynyl estradiol and norethindrone to the silkworm increased the larval weight, cocoon and shell weights, female pupal and adult weights, but the larval, pupal periods and the egghatchability were significantly reduced [14]. Studies on protein metabolism are considered most important in silkworm physiology because of its vital role in the determination of chemical characteristics of silk proteins [15,16].

These investigations opened up alternative strategies for improving the economic parameters of the sericulture industry by regulating the biochemical machinery. One such option is the ultrasound, whose impact on larval life in Drosophila has been reported [17]. Further, it was reported that ultrasound irradiation does not cause any detectable deterioration in behavioral responses such as mating, oviposition, larval development and pupation in insects [18]. In view of its harmless nature, ultrasound has been used as an exogenous modulator in the present investigation for the manipulation of protein metabolism in the fat body

silkworm and to examine the possibility of its utility in sericulture [19]. The silkworm, Bombyx mori L, secretes silk, a continuous and lustrous fibre having high value. The larval development and silk secreting ability of silkworm depend on the nutritional composition of food, the mulberry (Morus spp.) [20,21]. Generally, the mulberry leaves contain the required amount of nutrients essential for the optimal growth and development of silkworms.

2. MATERIALS AND METHODS

Multivoltine x bivoltine hybrid variety of the silkworm, (Pure Mysore x NB_4D_2) *Bombyx mori* L used in the present investigation were obtained from the Central Seed Farm at Tondavada, a suburb of Tirupati, A.P., India.

2.1 Ultrasound Treatment

Silkworm eggs were irradiated with ultrasound waves, 10-12 h after hatching (blue-egg stage) by water bag method used as experimental samples while those not exposed to Ultrasound waves were treated as Controls. Prior to exposure, the eggs were kept in a sealed, water-filled polythene cover, smeared with gel so as to prevent the diversion of ultrasonic waves by water bag method. The larvae that emerged from the exposed (experimental) and unexposed (control) eggs were used for the experiment. Biochemical assays were carried out on the fifth instar larvae because of their large size and easy isolation of tissues in adequate quantities since it is the stage that culminates in cocoon- spinning. The duration of exposure was standardized by exposing the eggs to varying intensities of ultrasound weaves, at different time intervals, viz. 2, 5, 10, 15, 20, 25, and 30 minutes. Promising results were obtained at 1 MHz, continuous wave of ultrasound at an intensity of $9W/Cm^2$ for 2 minutes. The larvae that emerged from the exposed (experimental) and unexposed (control) eggs were used in the investigation.

2.2 Tissue Separation

Fat body was isolated by dissecting the larvae in icecold silkworm Ringer [22] were used for the biochemical assay.

2.3 Analysis of Protein Metabolism and Enzyme Assay

Day-to-day changes in biochemical parameters of protein metabolism such as total, soluble proteins and free amino acid, the activity levels of protease, aminotransferases, and glutamate dehydrogenase were examined in the fifth instar larvae. The protein content was estimated by the method of Lowry *et al.* [23], the free amino acid content by the method of Moore and Stein [24] as described by Colowick and Kaplan [25] and the protease activity by the method of Davis and Smith [26]. The activities levels of aminotransferases, viz, aspartate aminotransferase (AAT) and alanine aminotransferase (AlAT) were estimated by the method of Reitman and Frankel [27] as described by Bergmeyer and Bruns

[28] and the activity of Glutamate dehydrogenase (GDH) was assayed by the method of Lee and Lardy [29].

2.4 Statistical Analysis

Standard deviation was calculated using the following formula:

$$\frac{\sum x1^2 - [\sum x1]^2 n}{n - 1}$$

Where,
$\sum$ x = individual observation n = total number of observations Student's 'T' test was calculated by using the following formula:

$$t = \frac{X_1 - X_2}{\sqrt{s^2\,[1/n_1+1/n_2]}}$$

$$S_2 = \frac{1}{n_1+n_2-2}[n_1s_1^2+n_2s_2^2]$$

Where,
X_1 = mean of the first set of observations
X_2 = mean of the second set of observations S_1 = standard deviation of the first set of observations
S_2 = standard deviation of the second set of observations
n_1 = number of observations of the first set n_2 = number of observations of the second set

3. RESULTS AND DISCUSSION

The levels of total and soluble proteins recorded an increasing trend in the fat body from day 1 to day 6 during the development of fifth instar larvae. The levels of total proteins increased from 43.48 mg to 81.07 mg in fat body (26% rise). Ultrasound has an elevatory effect on total protein content (Table 1). The levels of soluble proteins increased from about 27.77 mg to 60.04 mg. Ultrasound in general caused an elevation in the levels of soluble proteins also, with varying intensities (Table 1). The levels of free amino acids showed a similar trend during fifth instar. The impact of ultrasound on free amino acid levels is positive (Fig. 1).
The activity levels of protease recorded an upward trend through out the fifth instar. The elevation is more pronounced in the fat body (0.053 to 0.08 µmoles). Ultrasound caused an elevation in the enzyme activity in the selected tissue (Table 2). The activity levels of aspertate aminotransferase enzyme activity decreased in fat body (0.58 to 0.46 µmoles of pyruvate formed/mg protein/h). The impact of ultrasound is elevatory (Table 2). Alanine aminotransferase activity showed a similar trend during fifth instar development. The enzyme activity decreased from 2.33 to 1.96 µmoles of pyruvate formed/mg protein/h in the fat body. Ultrasound caused an elevation in the activity not withstanding its minor fluctuations in controls. The glutamate dehydrogenase (GDH) activity was

decreased in the fat body (0.44 to 0.22 µmoles of formazon formed/mg protein/h) during the fifth instar development. Ultrasound caused an elevation in GDH activity levels (Fig. 2).

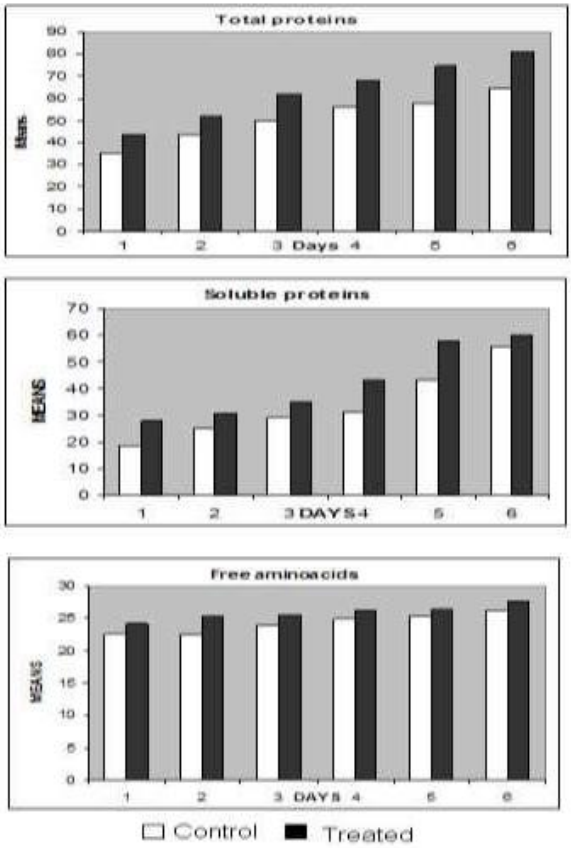


Fig. 1. Impact of ultrasound (9W/Cm^2 for 2 minutes) on fatbody protein metabolism in the silkworm *Bombyx mori* during fifth instar development

The impact of ultrasound on protein metabolism is profound as evidenced by upsurge in the levels of all the biochemical parameters examined. Though, increased levels of proteins were observed in silkworm tissue, these parameters were not analyzed with reference to ultrasound. However, some earlier investigations [30] attempted to elucidate the effect of ultrasound on protein synthesis. Obviously, the intensification of these two behaviors is of paramount importance for the fifth instar larvae. In fat body, the proteins are used for the synthesis of silk proteins, viz, fibroin and sericin [31]. The Increased levels of total, soluble and structural proteins in silkworm tissue indicates the growth-

promoting nature of ultrasound when applied in lower dosages and indicate a promising future for the sericultural industry. Apparently, ultrasound seems to enhance the protein synthesis in general, with a bias towards the silk proteins in fatbody. Amino acids are the building blocks of the proteins. Ultrasound irradiation caused an elevation in the levels of free amino acids. The silkworm and other lepidopteran insects are known to contain unusually large amounts of free amino acids [32]. Insect metamorphosis is a dynamic process involving both histogenesis and histolysis [33]. Obviously, the amino acid pool in silkworm is derived both from proteins through histolysis and from nonprotein sources like carbohydrates and lipids through *de novo* synthesis. Continuous increase in the levels of free amino acids following ultrasound-treatment is attributable to the synthesis of amino acids from nonprotein sources like glucose and fatty acids [34]. Protease activity levels recorded a continuous increase throughout the fifth instar development as reported earlier in silkworm and other insects [35]. The positive impact of ultrasound on enzyme activity indicates its ability to degrade proteins by activating proteolytic enzymes. Histolysis seems to be more pronounced in fat body as evidenced by increased turn over of amino acids. This could probably bring about the degeneration of fat body during pupal stage,

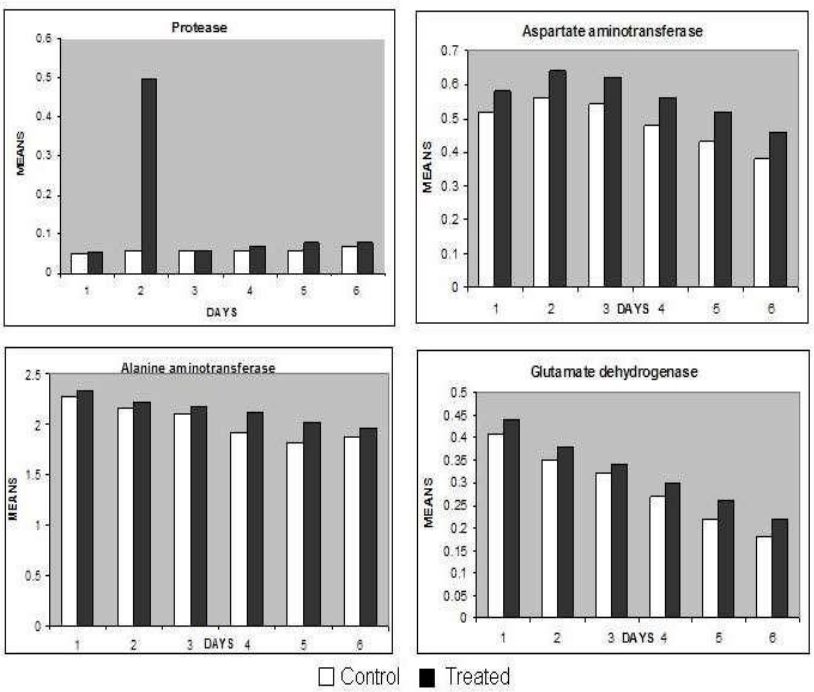


Fig. 2. Impact of ultrasound (9W/Cm^2 for 2 minutes) on fatbody enzyme activities in the silkworm *Bombyx mori* during fifth instar development

Table 1. Day-to-day changes in fatbody protein metabolism during the 5th instar of *Bombyx mori* under the impact of ultrasound (9W/Cm^2 for 2 minutes). Each value is the mean ± Standard Deviation (SD) of six separate observations. For each observation, tissue from at least 10 larvae was pooled. The percent changes for all days were calculated taking control as the reference

		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Total	Control	35.19 ±9.49	43.48 ± 6.21	49.69 ± 6.21	55.9 ± 6.21	57.97 ± 9.48	64.54 ± 10.0
Protein	Treated	43.48 ±6.21	51.76 ±9.48	62.11 ± 6.21	68.32 ± 6.21	74.53 ± 6.21	81.07 ±5.73
(mg proteins/g wet	% Change	23.6	19.0	24.9	22.2	28.6	26.6
weight)	t-Test	1.2849 NS	1.2649 ^{NS}	2.4494 ^{NS}	2.4494 ^{NS}	2.5297 ^{NS}	2.4812 ^{NS}
Soluble	Control	18.63 ±6.21	24.84 ± 6.21	28.98 ± 9.49	31.06 ± 6.21	43.48 ± 5.07	55.9 ± 6.21
Proteins	Treated	27.77 ±9.49	30.98 ±6.11	35.19 ±15.63	43.47 ± 6.21	57.97 ± 9.48	60.04 ±15.62
(mg proteins/g wet	% Change	49.1	24.7	21.4	39.9	33.3	7.4
weight)	t-Test	0.6327 ^{NS}	1.2208 ^{NS}	0.5681 ^{NS}	2.4491 ^{NS}	2.2141 NS	0.4264 ^{NS}
Free amino acids	Control	22.51 ± 0.94	22.50 ±0.94	23.91 ± 0.46	24.85 ± 0.38	25.32 ± 0.38	25.32 ± 0.38
(mg of tyrosine	Treated	24.22 ±0.71	25.32 ±1.23	25.47 ± 0.97	26.26 ± 0.38	26.38 ± 0.96	27.67 ±0.47
equi/g wet weight)	% Change	7.6	12.5	6.5	5.7	4.2	5.4
	t-Test	2.5208 ^{NS}	3.1387*	2.4943 ^{NS}	3.6742*	1.7173 ^{NS}	3.6742*

Table 2. Day-to-day changes in fatbody enzyme contents during the 5th instar of *Bombyx mori* under the impact of ultrasound (9W/Cm^2 for 2 minutes). Each value is the mean ± Standard Deviation (SD) of six separate observations. For each observation, tissue from at least 10 larvae was pooled. The percent changes for all days were calculated taking control as the reference

Enzyme activity		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Protease	Control	0.05 ±0.001	0.055 ±0.002	0.059±0.003	0.06 ±0.002	0.06 ± 0.002	0.07 ±0.002
(µmoles of tyrosine	Treated	0.053 ±0.002	0.05 ±0.002	0.06 ±0.005	0.07 ±0.003	0.078 ±0.002	0.08 ±0.004
equivalents/mg	% Change	6.0	-9.1	1.7	16.7	30.0	14.3
protein/h)	t-Test	2.6726^{NS}	1.2629 ^{NS}	1.9706 ^{NS}	4.1109*	7.1118**	5.0000**
Aspartate	Control	0.52 ±0.02	0.56 ± 0.02	0.54 ±0.02	0.48 ±0.02	0.43 ± 0.03	0.38 ± 0.02
aminotransferase	Treated	0.58 ±0.04	0.64 ± 0.02	0.62 ±0.02	0.56 ±0.02	0.52 ± 0.02	0.46 ± 0.02
(µmoles of pyruvate	% Change	11.5	14.3	14.8	16.7	20.9	21.1
formed/mg rotein/h)	t-Test	2.3237^{NS}	4.8989**	4.8989**	4.8989**	4.1109*	4.8989**
Alanine	Control	2.28 ±0.02	2.16 ± 0.05	2.10 ±0.09	1.92 ±0.06	1.82 ± 0.02	1.74 ± 0.04
aminotransferase	Treated	2.33 ±0.03	2.22 ± 0.02	2.17 ±0.01	2.12 ±0.02	2.02 ± 0.06	1.96 ± 0.02
(µmoles of pyruvate	% Change	2.2	2.8	3.3	10.4	10.9	12.6
formed/mg	t-Test	2.5298^{NS}	1.8371 ^{NS}	1.3804 ^{NS}	4.9734**	5.3164**	8.5205**
protein/h)							
Glutamate	Control	0.41 ±0.02	0.35 ± 0.02	0.32 ±0.02	0.27 ±0.02	0.22 ± 0.02	0.18 ± 0.02
dehydrogenase	Treated	0.44 ±0.02	0.38 ± 0.02	0.34 ±0.02	0.3 ± 0.02	0.26 ± 0.02	0.22 ± 0.02
(µmoles of ormazon	% Change	7.3	8.6	6.3	11.1	18.2	22.2
formed/mg rotein/h)	t-Test	1.7960 ^{NS}	1.8371 ^{NS}	1.2247 ^{NS}	1.8371 ^{NS}	1.9756 ^{NS}	2.4494 ^{NS}

*NS - Not significant at 0.05 level; * Significant at 0.05 level; ** Significant at 0.01 level*

leaving the fatbody that forms the bulk of pupal weight. The presence of aspartate (AAT) and alanine (AlAT) aminotransferase activity was detected in fat body of silkworm as reported in earlier investigations [36]. Ultrasound caused an elevation in the activity levels of both AAT and AlAT in silkworm tissues (Table 2), indicating the increased turnover of amino acids and glutamate formation during metamorphosis in silkworm. The higher levels of free amino acids observed in the present investigation (Table 1) support this assumption. Ultrasound has an elevatory effect on GDH activity in all the tissue of silkworm (Table 2). Some reports are available on GDH activity in silkworm, *Bombyx mori* [36]. The enhanced activity of GDH in fat body is indicative of increased oxidation of glutamate in this tissue. The α-ketoglutarate generated by this enzyme is probably used-up in ensuring sperm mobility in silkworm [37]. The actual mechanism of ultrasound irradiation on protein metabolism is not clear.

4. CONCLUSION

The role of ultrasound in protein metabolism needs special mention in economically viable insects like the silkworm, in view of its profound and positive impact on biochemical parameters. Under its influence entire biochemical machinery in silkworm is geared up to synthesise silk proteins in fat body during fifth instar development. While the former are used up as the raw materials for the cocoon, the latter are used for generating a muscular mechanism necessary for spinning the cocoon at the end of fifth instar. The increase in the concentration of amino acids with concomitant increase in the levels of total and soluble proteins in fat body under the impact of ultrasound reflects this fact. Metabolically fat body seems to occupy a pre-eminent position during metamorphosis in silkworm. It may be concluded that under the impact of ultrasound protein metabolism is stimulated to achieve greater turnover of silk proteins, greater spinning activity, and consequently greater sericultural output.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Chapter 3
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Effect of Ultrasound in the enhancement of Protein Metabolism and Enzyme Activities in the Fat body of Fifth Instar Silkworm, *Bombyx mori L*.

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ABSTRACT

Under the influence of ultrasound, protein metabolism parameters such as total, soluble proteins, free amino acids, and activity levels of protease, glutamate dehydrogenase, aspartate amino transferase, and alanine aminotransferase were measured in the fat body of the fifth instar larva of the silkworm, Bombyx mori. On these parameters, ultrasonography generally has an elevating effect. The events of histogenesis and histolysis connected to the metamorphosis of the silkworm are correlated with changes in the levels of certain biochemical components. Under the impact of ultrasound, the metabolism of proteins is accelerated, resulting in increased spinning activity, increased protein turnover in silk, and increased sericultural production. Enhancement of proteins by ultrasound clearly documented the induction of severe proteolysis and transamination of amino acids.

Keywords: Amino acids; aminotransferases; glutamate dehydrogenase; protease.

1. INTRODUCTION

All living cells require proteins as a fundamental building block. Protein metabolism is a representation of life itself if carbohydrate metabolism is life's energy source. In essence, proteins are in charge of preserving the structural and functional structure of cells. They are essential for breathing, enzyme catalysis, material transport, and the control of metabolism, mobility, and body defence. The total protein content of the cell includes both structural and soluble portions, of which the former plays main role in cellular architecture and the latter in cellular metabolism.

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Proteins have always been an interesting biochemical tool for insect biochemists because of their prominent role in development, morphogenesis and the intermediary metabolic pathways in insects. Mihaeslu et al. [1] observed biochemical difference in the eggs of *Bombyx mori* and *Philosamia ricini* with regard to their total proteins and amino acids. The first ever observation on insect haemolymph proteins was made by Lauffer [2] in the silkworm *B. mori.* Subsequently a series of detailed physico-chemical studies on haemolymph proteins of B*. mori* appeared [3].

Tojo et al. [4] made a detailed account of storage proteins while Sasaki et al. [5] investigated the intracellular transport and secretion of fibroin in the posterior fat body of *B. mori.* A novel approach in silkworm research is the manipulation of biochemical machinery through exogenous modulators that could boost the silk production. The development of the worm is depending on metamorphosis process which is a dynamic biochemical process [6]. The growth of silkworm during metamorphosis is accompanied by the increase in the bodyweight and accumulation of various biochemical constituents like proteins, aminoacids and enzymes like proteases, glutamate dehydrogenase and aminotransferases [7]. Since, the silkworm is an economically important insect, several insect physiologists attempted to elucidate the role of biochemical constituents in silk protein synthesis and egg formation [8]. More importantly, the parameters of protein metabolism have been extensively examined because of their role in development, morphogenesis and in the intermediary metabolism [9,10]. A novel approach in silkworm research is the manipulation of biochemical machinery through exogenous modulators that could boost the silk production. This obviously, included the administration of certain neuro-humoral factors, vertebrate hormones and various other chemicals like cyclic AMP and prostaglandins, which could have a profound influence on the growth rate, larval life cycle and fecundity [11,12]. Significantly, the positive impact of vertebrate thyroxine on silkworm biology, especially in improving the pre- and post cocoon parameters is well documented [13]. Another vertebrate hormone, namely prolactin induced improvement in the growth and reproductive potential of silkworms [12]. The dietary administration of vertebrate sex hormones like ethynyl estradiol and norethindrone to the silkworm increased the larval weight, cocoon and shell weights, female pupal and adult weights, but the larval, pupal periods and the egghatchability were significantly reduced [14]. Studies on protein metabolism are considered most important in silkworm physiology because of its vital role in the determination of chemical characteristics of silk proteins [15,16].

These investigations opened up alternative strategies for improving the economic parameters of the sericulture industry by regulating the biochemical machinery. One such option is the ultrasound, whose impact on larval life in Drosophila has been reported [17]. Further, it was reported that ultrasound irradiation does not cause any detectable deterioration in behavioral responses such as mating, oviposition, larval development and pupation in insects [18]. In view of its harmless nature, ultrasound has been used as an exogenous modulator in the present investigation for the manipulation of protein metabolism in the fat body

silkworm and to examine the possibility of its utility in sericulture [19]. The silkworm, Bombyx mori L, secretes silk, a continuous and lustrous fibre having high value. The larval development and silk secreting ability of silkworm depend on the nutritional composition of food, the mulberry (Morus spp.) [20,21]. Generally, the mulberry leaves contain the required amount of nutrients essential for the optimal growth and development of silkworms.

2. MATERIALS AND METHODS

Multivoltine x bivoltine hybrid variety of the silkworm, (Pure Mysore x NB_4D_2) *Bombyx mori* L used in the present investigation were obtained from the Central Seed Farm at Tondavada, a suburb of Tirupati, A.P., India.

2.1 Ultrasound Treatment

Silkworm eggs were irradiated with ultrasound waves, 10-12 h after hatching (blue-egg stage) by water bag method used as experimental samples while those not exposed to Ultrasound waves were treated as Controls. Prior to exposure, the eggs were kept in a sealed, water-filled polythene cover, smeared with gel so as to prevent the diversion of ultrasonic waves by water bag method. The larvae that emerged from the exposed (experimental) and unexposed (control) eggs were used for the experiment. Biochemical assays were carried out on the fifth instar larvae because of their large size and easy isolation of tissues in adequate quantities since it is the stage that culminates in cocoon- spinning. The duration of exposure was standardized by exposing the eggs to varying intensities of ultrasound weaves, at different time intervals, viz. 2, 5, 10, 15, 20, 25, and 30 minutes. Promising results were obtained at 1 MHz, continuous wave of ultrasound at an intensity of $9W/Cm^2$ for 2 minutes. The larvae that emerged from the exposed (experimental) and unexposed (control) eggs were used in the investigation.

2.2 Tissue Separation

Fat body was isolated by dissecting the larvae in icecold silkworm Ringer [22] were used for the biochemical assay.

2.3 Analysis of Protein Metabolism and Enzyme Assay

Day-to-day changes in biochemical parameters of protein metabolism such as total, soluble proteins and free amino acid, the activity levels of protease, aminotransferases, and glutamate dehydrogenase were examined in the fifth instar larvae. The protein content was estimated by the method of Lowry *et al.* [23], the free amino acid content by the method of Moore and Stein [24] as described by Colowick and Kaplan [25] and the protease activity by the method of Davis and Smith [26]. The activities levels of aminotransferases, viz, aspartate aminotransferase (AAT) and alanine aminotransferase (AlAT) were estimated by the method of Reitman and Frankel [27] as described by Bergmeyer and Bruns

[28] and the activity of Glutamate dehydrogenase (GDH) was assayed by the method of Lee and Lardy [29].

2.4 Statistical Analysis

Standard deviation was calculated using the following formula:

$$\frac{\sum x1^2 - [\sum x1]^2 n}{n - 1}$$

Where,
$\sum$ x = individual observation n = total number of observations Student's 'T' test was calculated by using the following formula:

$$t = \frac{X_1 - X_2}{\sqrt{s^2\,[1/n_1+1/n_2]}}$$

$$S_2 = \frac{1}{n_1+n_2-2}[n_1s_1^2+n_2s_2^2]$$

Where,
X_1 = mean of the first set of observations
X_2 = mean of the second set of observations S_1 = standard deviation of the first set of observations
S_2 = standard deviation of the second set of observations
n_1 = number of observations of the first set n_2 = number of observations of the second set

3. RESULTS AND DISCUSSION

The levels of total and soluble proteins recorded an increasing trend in the fat body from day 1 to day 6 during the development of fifth instar larvae. The levels of total proteins increased from 43.48 mg to 81.07 mg in fat body (26% rise). Ultrasound has an elevatory effect on total protein content (Table 1). The levels of soluble proteins increased from about 27.77 mg to 60.04 mg. Ultrasound in general caused an elevation in the levels of soluble proteins also, with varying intensities (Table 1). The levels of free amino acids showed a similar trend during fifth instar. The impact of ultrasound on free amino acid levels is positive (Fig. 1).
The activity levels of protease recorded an upward trend through out the fifth instar. The elevation is more pronounced in the fat body (0.053 to 0.08 µmoles). Ultrasound caused an elevation in the enzyme activity in the selected tissue (Table 2). The activity levels of aspertate aminotransferase enzyme activity decreased in fat body (0.58 to 0.46 µmoles of pyruvate formed/mg protein/h). The impact of ultrasound is elevatory (Table 2). Alanine aminotransferase activity showed a similar trend during fifth instar development. The enzyme activity decreased from 2.33 to 1.96 µmoles of pyruvate formed/mg protein/h in the fat body. Ultrasound caused an elevation in the activity not withstanding its minor fluctuations in controls. The glutamate dehydrogenase (GDH) activity was

decreased in the fat body (0.44 to 0.22 µmoles of formazon formed/mg protein/h) during the fifth instar development. Ultrasound caused an elevation in GDH activity levels (Fig. 2).

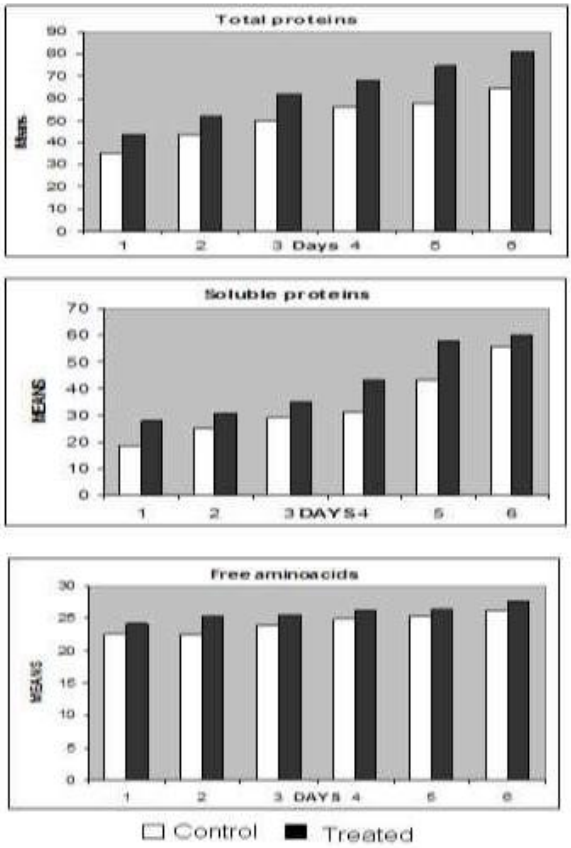


Fig. 1. Impact of ultrasound (9W/Cm^2 for 2 minutes) on fatbody protein metabolism in the silkworm *Bombyx mori* during fifth instar development

The impact of ultrasound on protein metabolism is profound as evidenced by upsurge in the levels of all the biochemical parameters examined. Though, increased levels of proteins were observed in silkworm tissue, these parameters were not analyzed with reference to ultrasound. However, some earlier investigations [30] attempted to elucidate the effect of ultrasound on protein synthesis. Obviously, the intensification of these two behaviors is of paramount importance for the fifth instar larvae. In fat body, the proteins are used for the synthesis of silk proteins, viz, fibroin and sericin [31]. The Increased levels of total, soluble and structural proteins in silkworm tissue indicates the growth-

promoting nature of ultrasound when applied in lower dosages and indicate a promising future for the sericultural industry. Apparently, ultrasound seems to enhance the protein synthesis in general, with a bias towards the silk proteins in fatbody. Amino acids are the building blocks of the proteins. Ultrasound irradiation caused an elevation in the levels of free amino acids. The silkworm and other lepidopteran insects are known to contain unusually large amounts of free amino acids [32]. Insect metamorphosis is a dynamic process involving both histogenesis and histolysis [33]. Obviously, the amino acid pool in silkworm is derived both from proteins through histolysis and from nonprotein sources like carbohydrates and lipids through *de novo* synthesis. Continuous increase in the levels of free amino acids following ultrasound-treatment is attributable to the synthesis of amino acids from nonprotein sources like glucose and fatty acids [34]. Protease activity levels recorded a continuous increase throughout the fifth instar development as reported earlier in silkworm and other insects [35]. The positive impact of ultrasound on enzyme activity indicates its ability to degrade proteins by activating proteolytic enzymes. Histolysis seems to be more pronounced in fat body as evidenced by increased turn over of amino acids. This could probably bring about the degeneration of fat body during pupal stage,

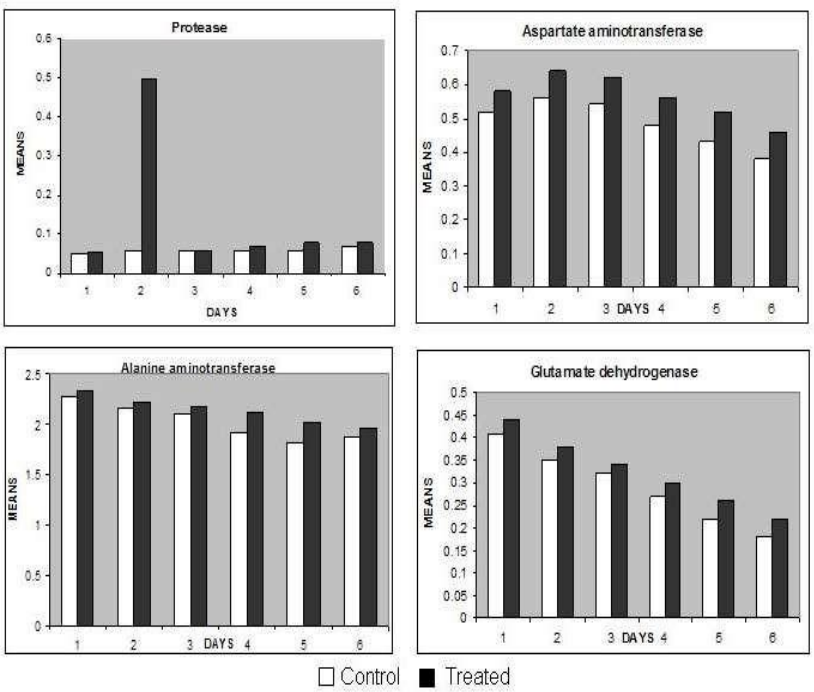


Fig. 2. Impact of ultrasound (9W/Cm^2 for 2 minutes) on fatbody enzyme activities in the silkworm *Bombyx mori* during fifth instar development

Table 1. Day-to-day changes in fatbody protein metabolism during the 5th instar of *Bombyx mori* under the impact of ultrasound (9W/Cm^2 for 2 minutes). Each value is the mean ± Standard Deviation (SD) of six separate observations. For each observation, tissue from at least 10 larvae was pooled. The percent changes for all days were calculated taking control as the reference

		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Total	Control	35.19 ±9.49	43.48 ± 6.21	49.69 ± 6.21	55.9 ± 6.21	57.97 ± 9.48	64.54 ± 10.0
Protein	Treated	43.48 ±6.21	51.76 ±9.48	62.11 ± 6.21	68.32 ± 6.21	74.53 ± 6.21	81.07 ±5.73
(mg proteins/g wet	% Change	23.6	19.0	24.9	22.2	28.6	26.6
weight)	t-Test	1.2849 NS	1.2649 ^{NS}	2.4494 ^{NS}	2.4494 ^{NS}	2.5297 ^{NS}	2.4812 ^{NS}
Soluble	Control	18.63 ±6.21	24.84 ± 6.21	28.98 ± 9.49	31.06 ± 6.21	43.48 ± 5.07	55.9 ± 6.21
Proteins	Treated	27.77 ±9.49	30.98 ±6.11	35.19 ±15.63	43.47 ± 6.21	57.97 ± 9.48	60.04 ±15.62
(mg proteins/g wet	% Change	49.1	24.7	21.4	39.9	33.3	7.4
weight)	t-Test	0.6327 ^{NS}	1.2208 ^{NS}	0.5681 ^{NS}	2.4491 ^{NS}	2.2141 NS	0.4264 ^{NS}
Free amino acids	Control	22.51 ± 0.94	22.50 ±0.94	23.91 ± 0.46	24.85 ± 0.38	25.32 ± 0.38	25.32 ± 0.38
(mg of tyrosine	Treated	24.22 ±0.71	25.32 ±1.23	25.47 ± 0.97	26.26 ± 0.38	26.38 ± 0.96	27.67 ±0.47
equi/g wet weight)	% Change	7.6	12.5	6.5	5.7	4.2	5.4
	t-Test	2.5208 ^{NS}	3.1387*	2.4943 ^{NS}	3.6742*	1.7173 ^{NS}	3.6742*

Table 2. Day-to-day changes in fatbody enzyme contents during the 5th instar of *Bombyx mori* under the impact of ultrasound (9W/Cm^2 for 2 minutes). Each value is the mean ± Standard Deviation (SD) of six separate observations. For each observation, tissue from at least 10 larvae was pooled. The percent changes for all days were calculated taking control as the reference

Enzyme activity		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Protease	Control	0.05 ±0.001	0.055 ±0.002	0.059±0.003	0.06 ±0.002	0.06 ± 0.002	0.07 ±0.002
(µmoles of tyrosine	Treated	0.053 ±0.002	0.05 ±0.002	0.06 ±0.005	0.07 ±0.003	0.078 ±0.002	0.08 ±0.004
equivalents/mg	% Change	6.0	-9.1	1.7	16.7	30.0	14.3
protein/h)	t-Test	2.6726^{NS}	1.2629 ^{NS}	1.9706 ^{NS}	4.1109*	7.1118**	5.0000**
Aspartate	Control	0.52 ±0.02	0.56 ± 0.02	0.54 ±0.02	0.48 ±0.02	0.43 ± 0.03	0.38 ± 0.02
aminotransferase	Treated	0.58 ±0.04	0.64 ± 0.02	0.62 ±0.02	0.56 ±0.02	0.52 ± 0.02	0.46 ± 0.02
(µmoles of pyruvate	% Change	11.5	14.3	14.8	16.7	20.9	21.1
formed/mg rotein/h)	t-Test	2.3237^{NS}	4.8989**	4.8989**	4.8989**	4.1109*	4.8989**
Alanine	Control	2.28 ±0.02	2.16 ± 0.05	2.10 ±0.09	1.92 ±0.06	1.82 ± 0.02	1.74 ± 0.04
aminotransferase	Treated	2.33 ±0.03	2.22 ± 0.02	2.17 ±0.01	2.12 ±0.02	2.02 ± 0.06	1.96 ± 0.02
(µmoles of pyruvate	% Change	2.2	2.8	3.3	10.4	10.9	12.6
formed/mg	t-Test	2.5298^{NS}	1.8371 ^{NS}	1.3804 ^{NS}	4.9734**	5.3164**	8.5205**
protein/h)							
Glutamate	Control	0.41 ±0.02	0.35 ± 0.02	0.32 ±0.02	0.27 ±0.02	0.22 ± 0.02	0.18 ± 0.02
dehydrogenase	Treated	0.44 ±0.02	0.38 ± 0.02	0.34 ±0.02	0.3 ± 0.02	0.26 ± 0.02	0.22 ± 0.02
(µmoles of ormazon	% Change	7.3	8.6	6.3	11.1	18.2	22.2
formed/mg rotein/h)	t-Test	1.7960 ^{NS}	1.8371 ^{NS}	1.2247 ^{NS}	1.8371 ^{NS}	1.9756 ^{NS}	2.4494 ^{NS}

*NS - Not significant at 0.05 level; * Significant at 0.05 level; ** Significant at 0.01 level*

leaving the fatbody that forms the bulk of pupal weight. The presence of aspartate (AAT) and alanine (AlAT) aminotransferase activity was detected in fat body of silkworm as reported in earlier investigations [36]. Ultrasound caused an elevation in the activity levels of both AAT and AlAT in silkworm tissues (Table 2), indicating the increased turnover of amino acids and glutamate formation during metamorphosis in silkworm. The higher levels of free amino acids observed in the present investigation (Table 1) support this assumption. Ultrasound has an elevatory effect on GDH activity in all the tissue of silkworm (Table 2). Some reports are available on GDH activity in silkworm, *Bombyx mori* [36]. The enhanced activity of GDH in fat body is indicative of increased oxidation of glutamate in this tissue. The α-ketoglutarate generated by this enzyme is probably used-up in ensuring sperm mobility in silkworm [37]. The actual mechanism of ultrasound irradiation on protein metabolism is not clear.

4. CONCLUSION

The role of ultrasound in protein metabolism needs special mention in economically viable insects like the silkworm, in view of its profound and positive impact on biochemical parameters. Under its influence entire biochemical machinery in silkworm is geared up to synthesise silk proteins in fat body during fifth instar development. While the former are used up as the raw materials for the cocoon, the latter are used for generating a muscular mechanism necessary for spinning the cocoon at the end of fifth instar. The increase in the concentration of amino acids with concomitant increase in the levels of total and soluble proteins in fat body under the impact of ultrasound reflects this fact. Metabolically fat body seems to occupy a pre-eminent position during metamorphosis in silkworm. It may be concluded that under the impact of ultrasound protein metabolism is stimulated to achieve greater turnover of silk proteins, greater spinning activity, and consequently greater sericultural output.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Antioxidants: Structure-activity of plant polyphenolics

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Affiliations + expand

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Abstract

The excessive accumulation of reactive oxygen species (ROS)/free radicals can lead to abnormal oxidation of biomolecules such as proteins, lipids, fats, carbohydrates and nucleic acids in human organisms. Accordingly, endogenous oxidative stress induces the progressive development of various chronic diseases like rheumatoid arthritis, cancers, cardiovascular risks, diabetes, digestive ulcers, hypertension, obesity, neurological disorders, and age-related complications. Therefore, anti-oxidant defense mechanisms are needed to control/prevent the unbalanced molecular oxidative damage. Indeed, the oxidative stress arises from both endogenous and exogenous factors such as smoking, alcohol, medications, air pollution, sunlight, lifestyle disorders, and metabolic processes. Therefore, consumption of fruits, vegetables, grains, beverages, and leafy vegetables rich in antioxidants may inhibit or treat oxidative damage accompanying diseases. From this aspect, dietary foods are rich in various antioxidant metabolites such as flavonoids, vitamin A, C, E, phenolic acids, curcumin, stilbenes, anthocyanins, etc., which promote healthy life and nutritional benefits. Additionally, various studies have also proven that foods rich in antioxidants interact with reactive species to prevent cell damage(s) or therapeutic pathways for diseases. Although, there are various myths about the antioxidant mechanism(s), the optimal dosage of antioxidants can show beneficial pharmacological activities against various molecular oxidation paths.

Keywords: Antioxidant; Cancer; Diabetes mellitus; Dietary agents; Flavonoids; Oxidative stress;

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Gamma Irradiation of Mushrooms and its Impact on Bioactive Components

Kalyani Bandi [a*] and Manjula Kola [a]

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ABSTRACT

Mushrooms are widely recognized as a high-nutritional food and are gaining popularity as a functional food. For vegetarians, mushrooms are the only natural source of vitamin D. Radiation is a novel and promising food processing technology. Irradiating mushrooms can be a safe and cost-effective way to increase shelf life while also ensuring hygienic and sensory quality. Mushrooms are well-known purposeful foods because of the presence of a large amount of nutraceutical components. These are well recognized as organic foods importance to high protein, low fat and low energy contents. These are made in minerals such as iron, phosphorus, also as in vitamins like riboflavin, thiamine, ergosterol, niacin, and ascorbic acid. They also contain bioactive constituents like secondary metabolites (terpenoids, acids, alkaloids, sesquiterpenes, polyphenolic compounds, lactones, sterols, ester analogues, vitamins, and metal chelating agents) and polysaccharides in the main β-glucans and glycoproteins. Since, the incidences of biologically active substances like hepatoprotective, immune-potentiating, anti-cancer, antiviral, hypocholesterolemic agents and natural antioxidants helpful in reducing aerophilous damages. However, mushrooms remained underutilized, despite their wide organic process and bioactive potential [1,2,3]. Novel inexperienced techniques are being explored for the extraction of bioactive elements from edible mushrooms. Main objectives of the study were to know the impact of gamma irradiation, shelf life and bioactive components of mushrooms. In the current study low dose of gamma irradiation i.e., 0.25 and 0.75 kGy was employed for mushrooms. Vitamin-D content was estimated in irradiated mushrooms at 0.75 kGy, was 3.92 µg, at 0.25 kGy was, 1.44µg and 2.77µg non-irradiated mushrooms. Other bioactive components, such as antioxidant activity, were increased during storage, and irradiated mushrooms retained more vitamin C and folic acid than non-irradiated mushrooms. The gamma irradiation process increases the bioavailability of vitamin-D, making it a good source of vitamin-D while also extending the shelf life of the mushroom. Gamma irradiation boosts vitamin D levels in mushrooms by converting endogenous ergosterol to ergocalciferol (Vitamin D2).

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Keywords: Mushrooms; irradiation; bioactive components; vitamin-D.

1. INTRODUCTION

The most popular variety, button mushroom (Agaricusbisporus), commands a high price and continues to dominate the Indian and international markets. It accounts for approximately 90% of total country output and approximately 40% of global output. Furthermore, macrofungi have a long history of use in oriental therapies, and modern clinical practices still rely on mushroom-derived preparations. Mushrooms are potential sources of protein, essential amino acids, minerals and fiber are really valuable, excellent sources of most B-vitamins, key natural sources of ergosterol or pro-vitamin-D, antioxidant and anticancer components, and they are used as food, food additives and as supplements. They accumulate a variety of bioactive metabolites e.g. phenolic compounds, polyketides, terpenes, steroids and polysaccharides. Presently, mushroom has been recognized universally as a highly nutritive food and is getting more importance as medicinal/functional food [4,5].

Mushrooms are the only non-animal-based food containing vitamin D in the form of pro-vitamin D_2 (ergosterol), hence natural vitamin D sources for vegetarians was mushrooms. Vitamin D consists of two different compounds, vitamin D_2 from ergosterol and vitamin D_3 from 7-dehydrocholesterol. Vitamin D present in mushrooms converts the endogenous ergosterol to ergocalciferol (vitamin D_2) enhances through the use of artificial or exposure to UV light can increase vitamin D_2 content in mushrooms.

$$\text{Ergosterol} \longrightarrow \text{Pre-vitamin } D_2 \longrightarrow \text{Vitamin } D_2 \text{ (ergocalciferol)}$$

Vitamin D_2 is the form of vitamin D that could be provided from mushrooms, and this form has some remarkable advantages over vitamin D_3. Vitamin D_2 is more effective for bone mineralization than vitamin D_3, and vitamin D_2 is less toxic compared with vitamin D_3 [6]. Vitamin D is one of the important vitamins; it plays a key role in muscle function and immune system. The active form of Vitamin D is known as vitamin D_3, or 1,25-dihydroxycholecalciferol. This is derived either from diet or ultraviolet B (UVB) light conversion of 7-dehydrocholesterol in the skin, which is then hydroxylated to 25-hydroxyvitamin D in the liver, and then further hydroxylated to 1,25-dihydroxycholecalciferol in the kidneys. The main dietary source of vitamin D has long been thought to be cod liver oil and oily fish. Edible mushrooms have been shown to be abundant in ergocalciferol, which can then be hydroxylated to 25-hydroxyvitamin D in the liver. This can be further hydroxylated to the active form, 1,25dihydroxyvitamin D, in the kidneys. It is known that ingestion of edible mushrooms can result in an increase in serum vitamin D levels in humans, and it is also known that irradiating mushrooms with UVB light leads to an increase in their vitamin D content. Furthermore, in vivo studies in rats have shown an increase in both serum 25-hydroxyvitamin D levels and bone mineral density following ingestion of UVB-irradiated mushrooms [7].

Mushrooms are internationally regarded as poor man's meat because they are good substitute for meat which peasants cannot afford. The demand for

mushrooms is growing day by day. But due to their perishable nature they spoiled very quickly. The maximum shelf life of mushrooms is 2-6 days at refrigeration (4^0c) temperature [8]. Their shelf-life is short due to postharvest changes, such as browning, cap opening, strip elongation, cap diameter increase, weight loss and texture changes, to their high respiration rate and lack of physical protection to avoid water loss or microbial attack. Thus prolonging postharvest storage, while preserving their quality, would benefit the mushroom industry as well as consumers. Based on the mushrooms nutritional importance and medicinal value, there is a need to increase the shelf life of mushrooms by using advanced technology without affecting the functional components [9].

There has been extensive research on finding the most appropriate technology for mushrooms preservation. Chemical treatments, refrigeration, coating, modified/controlled atmosphere packaging, use of humectants, use of tyrosine inhibitors and ozone treatment are frequently applied methods. Moreover, the majority of food preservation techniques operate by slowing down or inhibiting the growth of microorganisms. In contrast, Gamma, electron-beam and UV irradiation have been shown to be potential tools in extending the postharvest shelf-life of fresh mushrooms, inhibit or inactivate microbial growth completely, resulting in commercially sterile and shelf-stable food.

Food irradiation technology has unique merits over conventional methods of preservation as this process does not lead to loss of flavor, odor, texture, and freshness. Unlike chemical fumigants, irradiation does not leave any harmful toxic residues in food and is more effective. It is efficient and can be used to treat pre-packed commodities. Export development authorities, commodity boards, food industry, farmers, traders, and exporters of agricultural commodities can be benefited from the use of radiation processing technology.

Now a day's people are showing more interest on fresh fruits and vegetable consumption due to the presence of functional components which helps in treating/reducing the risk of diseases, and they act as functional foods. By irradiation processes the valuable functional components can be retained in natural form and also extend the shelf life of mushrooms. Gamma-irradiation alone or in combination with refrigeration has been shown to prolong shelf-life through reducing moisture loss and improving color and appearance [10].

As Food irradiation is one of the best and safest food preservation techniques designed to ensure the provision of better quality with an extended shelf life. Keeping in view of the above points, the present study carried out to study the effect of radiation processing on functional components and shelf life of Mushrooms.

2. METHODOLOGY

2.1 Sample Collection

Freshly harvested, mature mushrooms (*Agaricusbisporus)* of similar size and free from physical defects were obtained from commercial mushroom growers.

Immediately after harvesting, mushrooms were cleaned and then packed in high density polyethylene covers each with 200 g due to light weight and also to avoid the damage of mushrooms during storage and processing.

2.2 Irradiation of Mushrooms

The irradiation was done in gamma irradiation plant at food irradiation unit at Quality control lab, Acharya N.G. Ranga Agricultural University; Hyderabad. The equipment used for radiation processing was Gamma (δ) Irradiation chamber, Model- GC-5000. The source for the radiation processing was cobalt -60. In the present work low dose levels were used for radiation processing i.e., 0.25 kGy and 0.75 kGy.

2.3 Functional Components

The functional parameters were analyzed for non-irradiated and irradiated mushrooms. The predominant functional components such as vitamin-C, folic acid, vitamin-D and total antioxidants activity of mushrooms were analyzed. Vitamin-C and folic acid was estimated by procedure followed by Ranganna [11]. Total Antioxidant Activity in mushrooms was estimated by using TBARS method. Vitamin-D content in the mushrooms was estimated by using Ultra-High-Performance Liquid Chromatography/Tandem Mass Spectrometry First Action 2011, AOAC method No.2011.11 (LC-MS/MS).

2.4 Experimental Period

The irradiated mushrooms at 0.25 kGy (I_1), 0.75 kGy (I_2) and non-irradiated mushrooms (NI) was stored for a period of 21 days. The analysis was done at initially (Initial phase) and at the end of the experimental period (Final phase). The results of the experiment was compared between the initial and final phase of the study and discussed in results and discussion.

3. RESULTS AND DISCUSSION

Proximate components did not alter or typically not much dissimilarity was observed during processing, by this reason this study was majorly focused on functional components. Vitamin-C, folic acid, vitamin-D and total antioxidants activity of Mushrooms were analysed in the present study and the results were discussed in following heads.

3.1 Vitamin-C

Vitamin-C (mg/100 g) in vegetables has varietal and functional factors. The vitamin-C of Mushrooms was analysed in non-irradiated and irradiated samples during initial and final phase of the experimental period. A sharp decrease in vitamin-C content was observed in non-irradiated Mushrooms (6.42 mg to 5.67 mg) and irradiated mushrooms at 0.25 (5.20 mg to 4.87mg) and 0.75 kGy (4.58 mg to 4.00 mg) from initial to final phase of the experimental period. The difference in vitamin-C content between and among irradiated samples (0.25 and 0.75 kGy) and non-irradiated samples was significant ($p<0.05$) from initial to final phase of the experimental period.

Vitamin-C was in the form of ascorbic acid. The reason for accelerated decrease of Vitamin-C in irradiated and non-irradiated samples might be enhanced respiration result in increased enzymatic activity causing rapid degradation of ascorbic acid. The changes in reduced ascorbic acid are due to its role as a radical scavenger. Thayer and Rajjkowski (1999), revealed that irradiation oxidized a portion of total ascorbic acid to dehydro form and both of these forms of vitamins are biologically active, suggesting minimal nutritional impact.

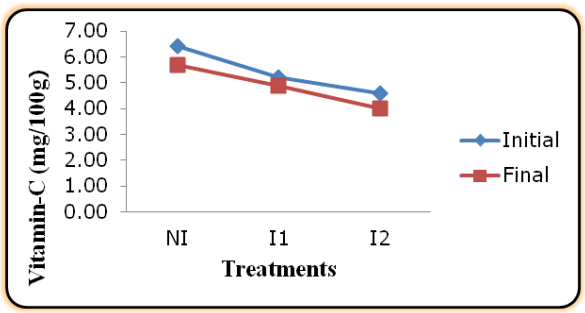


Fig. 1. Effect of gamma irradiation on vitamin-C content of mushrooms

Similar trend was observed by Hajara et al. [12], in their study on radiation processing of minimally processed carrot and cucumber. The minimally processed carrot and cucumber at a dose of 2 kGy was carried out over a storage period of 16 days at 8^0C and 10^0C. During storage both the control as well as the irradiated samples showed significant decrease in vitamin-C content.

The vitamin-C content decreased in all the samples on storage. Loss of vitamin-C was more in non-irradiated samples and even though the loss of vitamin-C was observed in irradiated Mushrooms it was comparatively less when compared to non-irradiated Mushrooms. The stability and variation of ascorbic acid not only depends on the irradiation treatment and doses, but also environmental factors such as storage, temperature etc.

Vitamin-C (ascorbic acid) exhibits a high degree of sensitivity to ionizing radiation. Furthermore, it is known to be readily oxidized to dehydro ascorbic acid on irradiation [13,14].

3.2 Folic Acid

The folic acid (µg/100g) of Mushrooms was estimated in non-irradiated and irradiated samples.Folic acid content of Mushrooms was estimated at initial and final phase of the experimental period and the results. The decrease in folic acid content of Mushrooms was observed in all the treated and non-treated samples from initial to final phase of the experimental period (Fig. 2) and it was statistically significant ($p<0.01$) in non-irradiated Mushrooms, whereas in irradiated Mushrooms it was not significant. At the end of the experimental period no significant difference was observed in folic acid content of Mushrooms irrespective of the treatments.

Table 1. Effect of gamma irradiation on functional components of mushrooms

Treatments	Vitamin-C (mg/100g)			Folic acid (µg/100g)			Vitamin-D (µg/100g)			Total Antioxidant activity %		
	Initial Phase	Final Phase	t-value (p-value)	Initial Phase	Final Phase	t-value (p-value)	Initial Phase	Final Phase	t-value (p-value)	Initial Phase	Final Phase	t-value (p-value)
NI	6.42 ±0.03	5.67±0.05	18.01** (0.003)	14.56 ±0.07	14.26 ±0.04	6.03* (0.024)	2.77 ±0.05	1.97 ±0.05	79.99** (0.000)	43.02 ±0.19	45.60 ±0.044	-10.12** (0.010)
I_1	5.20 ±0.04	4.87±0.06	16.11** (0.04)	14.48 ±0.18	14.26 ±0.06	3.097@ (0.090)	1.44 ±0.02	1.28 ±0.03	48.99** (0.000)	35.80 ±0.09	52.02 ±0.18	-103.98** (0.000)
I_2	4.58±0.04	4.00±0.02	48.53** (0.000)	14.32 ±0.09	14.25 ±0.04	1.424@ (0.291)	3.92 ±0.02	3.02 ±0.02	77.94** (0.000)	41.73 ±0.343	52.05 ±0.17	-181.86** (0.000)
F-value (p-value)	2065.62** (0.000)	891.49** (0.000)	---	6.80* (0.029)	0.110@ (0.898)	---	4780.24** (0.000)	2212.86** (0.000)	---	3084.7** (0.000)	1614.5** (0.000)	---

** - Significant at 1% level,*
***- Significant at 5% level,*
@- Not Significant

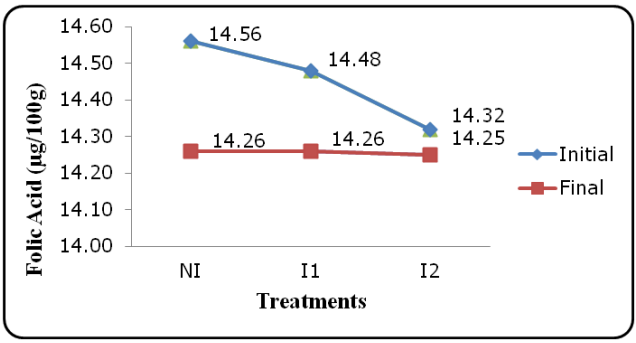


Fig. 2. Effect of Gamma Irradiation on Folic acid content of Mushrooms

These findings are in support with the results of Lester et al. [15], in his study on the effect of gamma-irradiation on ascorbic acid, carotenoids, folate, α-tocopherol and phylloquinone concentrations of baby-leaf spinach. There is no evidence in the literature that transient sunlight exposure increases folate levels in Mushrooms or other plants. However, all folates are to various degrees unstable and are particularly sensitive to oxidation. Despite the fact that folates are good absorbers of UVB and UVA light, these compounds are believed to be relatively stable to UV light exposure, but degradation of 5-methyltetrahydrofolate in the presence of UV light has been reported in the presence of photo sensitizers such as riboflavin [16].

In the present study, folic acid content of Mushrooms is not affected by irradiation processing. Initially slight decrease in irradiated Mushrooms was noticed and at final phase the maximum retention of folic acid was observed in irradiated Mushrooms.

3.3 Vitamin-D

Mushrooms are the only vegetative source of vitamin-D. Immediately after irradiation, significant difference was showed between non-irradiated and irradiated samples of Mushrooms. The Vitamin-D analysis was done at initial and final phase of the experimental period as indicated in Table 1 for both irradiated and non-irradiated Mushroom. The decrease of vitamin-D was more in non-irradiated (2.77µg to 1.97µg) when compared to irradiated Mushrooms at 0.25(1.44µg to 1.28µg) and 0.75 kGy (3.92µg to 3.02µg) from initial to final phase of the experimental period. Statistically a significant difference was observed in vitamin-D content of both non-irradiated and irradiated Mushrooms during the experimental period from initial to final phase. At the end of experimental period significant difference ($p<0.01$) was observed in vitamin-D content of Mushrooms between the treatments [17,18].

The increasing trend of vitamin-D was observed with the increase of dosage in Mushrooms. The increase of vitamin-D was more in Mushrooms irradiated at 0.75 kGy followed by 0.25 kGy and non-irradiated Mushrooms (Fig. 3).

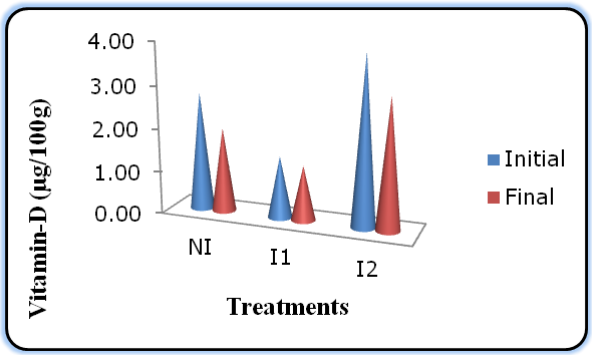


Fig. 3. Effect of Gamma Irradiation on Vitamin-D content of Mushrooms

The temperature and exposure time of irradiation plays an important role in the conversion and this may be one of the reasons. Irradiation also contributes to an oxidative atmosphere and prolonged exposure of vitamin-D to UV radiation may result in photo-degradation at vitamin-D_2. Another important factor is moisture, at low moisture levels, the specific surface area of the tissue is increased, results in the oxidation of vitamin-D_2. Furthermore, irradiation also contributes to oxidative atmosphere, and photo–degradation of vitamin-D_2 may occur.

These findings are in support with the results of Jasinghe and Perera [6]. They conducted a study on Distribution of ergosterol in different tissues of Mushrooms and its effect on the conversion of ergosterol to vitamin-D_2 by UV irradiation. In this study, highest ergosterol content was found in button Mushrooms (7.80 mg/g DM) while the lowest was in enoki Mushrooms (0.68 mg/g DM). The conversion of ergosterol to vitamin D_2 was about four times higher when gills were exposed to UV-A irradiation than when the outer caps were exposed to the same.

Kalaras et al. [19], carried out a study on Effects of Postharvest Pulsed UV Light treatment of White Button Mushrooms (Agaricusbisporus) on Vitamin D_2 Content and Quality Attributes. In this study, dose-response suggests a non-linear relationship between PUV irradiation dose and vitamin-D_2 content of fresh Mushrooms. The initial levels of vitamin D_2 in untreated Mushrooms were less than 0.005 µg/g DW, and rapidly increased to 12.6 µg/g DW after 3 pulses. The D_2 produced with 3 pulses decreased after 3 days of storage.

Souci et al. [20], reported that ergosterol contents and the conversion rate of ergosterol to vitamin D_2 in different types of Mushrooms were varied. Button Mushrooms have lower vitamin D_2 content compared to other types of edible Mushrooms. This may be due to the gill was not exposed. The gill of sliced

button Mushroom was exposed to UV-B; therefore, Vitamin-D_2 concentration of sliced button Mushrooms was higher than that of whole Mushroom [21].

Irradiation shows significant effect on vitamin-D content in Mushrooms. The increase of vitamin-D was more in irradiated Mushrooms at 0.75 kGy than other samples. The conversion of vitamin-D was more in 0.75 kGy irradiated Mushroom. A slight decrease was observed during the experimental period. The conversion was affected by many factors. Exposure time, temperature, dosage of Irradiation and type or mode of raw material significantly affected the vitamin-D content in Mushrooms.

3.4 Total Antioxidant Activity

The antioxidants are recognized as bio-active compounds that act against possible ill effects of free-radical damages in humans. The antioxidant activity of a compound has been attributed to various mechanisms.

At initial and final phase of the experimental period total antioxidant activity was estimated in Mushrooms and given in Table 1. The high increasing trend of total antioxidant activity was observed in irradiated Mushrooms at 0.25 kGy (35.80% to 52.02%), whereas a very minute increase was there in irradiated Mushrooms at 0.75 kGy (41.73% to 52.05%) when compared with the non-irradiated (43.02% to 45.60%) from initial to final phase of experiment. The significant difference was observed among all the samples of Mushrooms during the experimental period at initial and final phases.

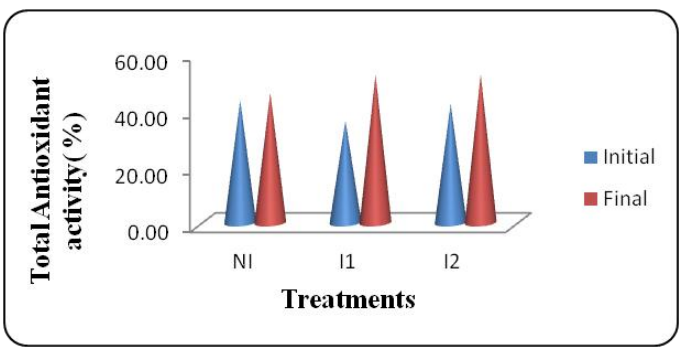


Fig. 4. Effect of Gamma Irradiation on Total Antioxidant activity of Mushrooms

Irradiation increased the antioxidant activity during the experimental period (Fig 4), it is also possible that the increased antioxidant capacity is related to tissue browning. Another reason for improved antioxidant activity could be due to formation of novel compounds having antioxidant activity during processing. Non-enzymatic browning reaction products might be formed during prolonged exposure with the improvement of antioxidant activity in Mushrooms.

An another reason for the increase of total antioxidant activity might be due to the fact that the irradiation disrupt the cell wall and liberate antioxidant compounds from insoluble portion of Mushroom, which in turn, increase the pool of bio accessible antioxidant compounds.

Song et al. [14], reported that the total phenols analyzed in irradiated Kale Juice immediately after the irradiation, was significantly lower than the control. However, the phenolic compound level of the irradiated sample becomes higher after one day than that of the control. The phenomenon was attributed to the immediate oxidation of the phenolic compounds, thus playing an antioxidant role by reducing the free radicals and the reactive oxygen species induced by irradiation.

Adamo et al. [22], have opined that the destructive processes of oxidation and γ-irradiation are capable of breaking the chemical bonds of polyphenols, thereby releasing soluble phenols of low molecular weights, leading to an increase of antioxidant-rich phenolics. The decrease of antioxidants is attributed to the formation of radiation-induced degradation products or the formation of free radicals.

Mami et al. [23], carried out a study on Improvement of shelf-life and postharvest quality of white button Mushroom by ^{60}Co γ-ray irradiation. Five different doses of gamma irradiation, including: 0 as control, 0.5, 1, 1.5 and 2 kGy were used. Irradiation increased both phenolics content and antioxidant capacity, suggesting the increased phenolics synthesis contributed to the total antioxidant capacity. It is also possible that the increased antioxidant capacity is related to tissue browning. It is well known that irradiation inactivates food borne pathogens in various vegetables, resulting in improved microbial food safety of fresh-cut vegetables.

In the current study irradiation has significant effect on total antioxidant activity of Mushrooms. The decrease of total antioxidant activity was observed initially in irradiated Mushrooms which might be due to immediate oxidation of the phenolic compounds. On storage the total antioxidant activity was increased more in irradiated Mushrooms than non-irradiated Mushrooms. A reason for improved antioxidant activity could be due to pool of bio accessible antioxidant compounds.

The mushrooms have extensive potential to be used in the diet for taking advantage of the nutraceutical properties of the bioactive compounds. Edible mushrooms, due to lower fat and higher protein contents, need to be used for the preparation of low-calorie and high protein diets. Besides, their use as therapeutic foods can be helpful in the preclusion of lifestyle diseases, such as diabetes, hypertension, cancer, hypercholesterolemia, and cardiovascular diseases [24,25]. Functional characteristics of these edible mushrooms are primarily due to the occurrence of antioxidants, dietary fibres, lectins, anti-microbial agents, and other bioactive components. Due to their richness in immune-modulating polysaccharides, these can be incorporated into health-promoting supplements. The approach for extraction of secondary metabolites

from edible mushrooms is yet to be discovered. The exploration of new edible mushrooms and extraction of their valuable bioactive and their further incorporation for the preparation of value-added functional foods and their use in prevention, as well as the treatment of various lifestyle diseases, will continue to be the major attention of research into future prospects. Therefore, more research efforts are required to enhance resource efficiency, minimize waste generation, and avoid resource over-exploitation. Further studies are required to improve the biological properties of the existing nutritional components of several mushroom varieties through structural modifications, as recently it has been reported that a few naturally present nutrients show minimal biological activity, however, it can be improved by certain chemical modifications. Also, mushroomderived prebiotics is the other recent attention of researchers worldwide, particularly for the relationship between the regulation of gut microbiota and host health, including gut-immune function, gut inflammation, obesity, colonic cancer, and neurological diseases.

4. CONCLUSION

The current study reveals that the effect of gamma irradiation at low doses of functional components of mushrooms was analyzed at initial and final phases of experiment. Mushrooms irradiated at 0.75 kGy was more optimum in improving the vitamin-D and total antioxidant activity, no vast discrepancy or loss was noticed in vitamin-C and folic acid content of mushrooms when compared with initial to final phase of experiment. They were least affected by irradiation and retention of nutrients was observed during storage period. It was quite evident that gamma irradiation improves the shelf life of the vegetables as well as improves their quality in terms of physical, nutritional, functional and safety aspects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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INVESTIGATION OF JORDAN REVERSE GENERALIZED DERIVATIONS AND COMMUTATIVITY IN PRIME AND SEMIPRIME RINGS

DR. A. SIVA KAMESHSWARA KUMAR
DR. K. SUBBARAYUDU
DR. C. JAYA SUBBA REDDY

a2+b2=c2

This work investigates various types of derivations in prime and semi prime associative rings, particularly focusing on Jordan generalized reverse derivations and left generalized derivations. Notable contributions from mathematicians like E.C. Posner and I.N. Herstein and C. Jaya Subba Reddy have advanced the field significantly. The research presents new findings on lie ideals, symmetric reverse bi-derivations, and the commutativity of left generalized derivations. Specific results include demonstrating conditions under which Jordan generalized reverse derivations become generalized reverse derivations, and proving commutativity in rings with certain derivation properties. The study also explores the properties of prime and semi prime rings under these derivations, providing detailed proofs and extending previous results in the literature. Definitions of key terms such as commutator, anti-commutator, prime ring, semi prime ring, and various types of derivations are included to clarify the theoretical framework.



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CURRENT PROSPECTS AND APPLICATIONS OF NANOTECHNOLOGY

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AQUACULTURE ADVANCES IN NANOTECHNOLOGY

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Abstract

Aquaculture is one of the fastest rising sectors in the world today. An Aquaculture system is diversified as fresh, brackish and marine water culture systems. The growth of aquaculture as an industry has accelerated over the past decades, this has resulted in environmental damages and low productivity of various crops .The need for increased disease resistance, growth of aquatic organisms, and feed efficiency has brought about the use of probiotics in aquaculture practices. The first application of probiotics occurred in 1986, to less their ability to increase growth of hydrobionts (organisms that live in water). Probiotics were used to improve water quality and control of bacterial infections. Now a day there is documented evidence that probiotics can improve the digestibility of nutrients, increase tolerance to stress, and encourage reproduction. Currently, there are commercial probiotic products prepared from various bacterial species such as Bacillus sp., Lactobacillus sp., Enterococcus sp., Carnobacterium sp., and the yeast Saccharomyces cerevisiae among others, and their use is regulated by careful management recommendations. The present paper shows the current knowledge of the use of probiotics in aquaculture, its antecedents, and safety measures to be carried out and discusses the prospects for the study in this field.

Keywords: *Aquaculture, Probiotics, water quality, Disease Control, Growth promoters, reproduction.*

Introduction

"Nanotechnology is dealing with specific size dependent functional properties of the individual sub-units or of a system of those". Nanotechnology is the future big excitement in the field of Science and Technology.

Nanotechnology manipulates matter at the nanoscale (1-100 nm) (Moore, 2006 and Nel *et al.*, 2006) producing nanoproducts and nanomaterials (NMs) that can have novel and size-related physico-chemical properties differing

significantly from those from larger particles. Recently, anthropogenic sources have also produced nano-sized materials unintentionally from combustion by- products and intentionally as manufactured nanomaterials. Nanotechnology is undoubtedly one of the most important technologies of the 21st century. With an estimated $147 billion worth of so-called 'nano-enabled' commercial and consumer products sold in 2007 and a projected value of $3.1 trillion by 2015. Nanotechnology has been referred to as the next industrial revolution (Schmidt, 2009). This technology promises scientific advancement for many sectors such as medicine, consumer products, and energy. Governments and investors around the world are therefore keen to explore and exploit the exceptional properties of nanomaterials opportunities which exist within nearly every industrial and technological sector.

Nano–Concept and History

Nanotechnology is defined as the "design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale" (Williams *et al.*, 2005). In principle, therefore, any product using compounds that exist as, or are manufactured to, these specifications can be considered as nanomaterials.

Table 1: Comparison of sizes of biological molecules and structures in nanometers (Gupta and Kompella, 2006)

Object	Size (nm)
Carbon atom	0.1
DNA double helix (diameter)	3
Ribosome	10
Virus	100
Bacterium	1,000
Red blood cell	7,000
Human hair (diameter)	80,000

Table 2: Percentage surface molecules in particles of different diameters (Gupta and Kompella, 2006).

Particle Size (nm)	Surface Molecules %
1	100
10	27.1
100	2.97
1,000	0.3
10,000	0.03

Furthermore, as the size of a particle decreases to the nanoscale, the physical properties of the particle are altered, rules of quantum mechanics, which determine the behavior of matter and light at the atomic and subatomic level, begin to dominate as particles shrink to the nanoscale.

Oxide Nanoparticles in the Aquatic Environment

Nanotechnology has grows with the number of nanomaterial types and applications increase, so does the likelihood that they will be released into the environment, and in significant quantities, a fact that has been met with increasing concern over their safety in terms of human health and the environment (Dowling *et al.*, 2004; Williams *et al.*, 2005). Sources to the aquatic environment include waste water discharges, accidental release from factories, and the degradation and wear of products containing oxide nanomaterials. Due to their extremely small size and unique physical properties the behaviour of oxide nanomaterials in the environment, their uptake, distribution and effects within the bodies of living organisms are likely to be different when compared to conventional xenobiotics. To date, however, there is a lack of data and understanding about their environmental fate, bioavailability and biological effects. Therefore an urgent need to fill the gaps in our understanding

and for research and regulatory activities to ensure these compounds do not pose any significant hazard to human and environmental health. This type of study form vital to ensure the sustainability of the industry.

Nanotoxicology

Nanotoxicology is a branch of bionanoscience, which deals with the study and application of the toxicity of nanomaterials. Nanotoxicological studies are used to determine whether and to what extent these properties may pose a threat to the environment and to human health. Nanoparticles play a remarkable role in toxicity, which is important for the toxicologists.

The rapid development of the nanotechnology industry has been fueled by the unusual properties that materials possess at the nanoscale. However it is also these properties that are in part fuelling concern regarding their potential toxicity and ecotoxicology. In addition, their small size means they may be able to bypass barriers that usually prohibit the entry of other xenobiotics and enter the cells of living organisms, passing through membranes and junctions between cells. This coupled with their improved reativity may mean oxide nanomaterials have the potential to induce adverse cellular effects and harm to living organisms. To date however, there are relatively few studies investigating the effects of exposure to oxide nanomaterials on living organisms, especially those living in aquatic environments. Nanotoxicology would expected to make an important and timely contribution to the development of a sustainable and safer use of nanotechnology for the welfare of mankind. Nanotoxicology research not only provide data for safety evaluation of synthetic nanoparticles, and devices but also will help to advance the field of nanomedicine by providing information about their undesirable properties and means to avoid them.

The history of development of nanomaterials started at 1959 with an exciting lecture of **Richard Feynman** - the scientist engaged in construction of atomic bomb, teacher, raconteur, and musician - entitled "**There is a plenty of room at the bottom**". However, it has been only an idea of creating any object by putting together single atoms or molecules. The word "nanoscience" was coined by Dr. Eric Drexier, a famous American engineer. The term nanotechnology was first adopted by Professor Norio Taniguchi of the Tokyo Science University in his paper, "On the Basic Concept of 'Nanotechnology'", presented at a meeting of the Japan Society of Precision Engineering in 1974.

The advent of cluster science (the study of aggregates of molecules and how their properties contribute to the characteristics of a bulk solid) and the invention of the scanning tunnelling microscope (STM) in the 1980s and later the atomic force microscope, heralded the beginning of practical nanoscience and led to the discovery of fullerenes in 1985 (Kroto *et al.*, 1985) Since then, nanotechnology has grown into the multi-billion dollar industry, with a seemingly limitless array of particle types being developed with potential applications within all industrial sectors.

Nanoparticles

Nanoparticles include ultrafine particles of metals, metal oxides, non- metals and ceramics. They can be spherical, tubular, or irregularly shaped and can exist in fused, aggregated or agglomerated forms. Nano-sized materials are naturally present from forest fires and volcanoes, viral particles, biogenic magnetite, and even protein molecules such as ferritin. Oxide nanoparticles such as zinc oxide (ZnO), titanium dioxide (TiO_2) and silicon dioxide (SiO_2) are some of the common industrial additives and have various

applications. The behaviour of nanoparticles in surface waters will therefore be dominated by the same physicochemical principles as those that determine the behaviour of natural colloids in soil. The aquatic environment is a sink for pollutants from both the atmosphere and lithosphere entering the water system besides autochthonous sources. All suggests that the aquatic environment is particularly vulnerable to contamination due to the extensive use/applications of oxide nanoparticles.

Properties of Nanoparticles

In recent years, nanomaterials have become increasingly important in various fields because they exhibit better optical, mechanical, physical, chemical, thermal and electrical properties and magnetic susceptibility than its microcrystalline materials. There are obvious advantages associated with being able to scale down the size of various technologies and products and they include saving space and reducing production and transportation costs. Nanotechnology, involving the manipulation and creation of molecules to exact specifications, also allows for the creation of novel materials that function more effectively and can perform new roles. This is primarily because various physical qualities set nanoparticles apart from larger materials of the same chemical composition. These qualities have largely fuelled the interest in their potential uses. Due to their small size, nanoparticles have a very large surface area to volume ratio. Therefore an increasing number of the atoms that make up the particle are present on the particle's surface compared with a larger particle of the same chemical composition (Table -2). Nanosized particles are therefore be chemically more reactive per unit mass than their bulk sized counterparts.

Conclusion

Nanotechnology is considered as an innovative and highly promising revolution in science and technology. The application of nanotechnology in biomedical science, electronics, cosmetics, and pharmaceutical industry has potential to increase the release of nanoparticles into environment. Environmental release of nanoparticles may pose a significant risk to life within the aquatic ecosystem. Thus nanotoxicology is the study of the toxicity of nanomaterials on biologicals. Because of quantum size effects and large surface area, nanomaterials have unique properties compared with their larger counterparts.

Nanotoxicological studies are intended to determine whether and to what extent these may pose a threat to the environment and to human.

An understanding of the underlying biological mechanisms responsible for the consequences of exposure observed is also required in order to provide information that will allow the informed design of future nanomaterials, ensuring their biocompatibility and minimising potential adverse health risks. This information may prove critical in aiding the progression of the nanotechnology industry, so that it is able to realise the great benefits it promises.

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A Study on Flora and Fauna of Sheshachalam Hill Range, Tirupati, Tirupati Distirct, Andhra Pradesh

Prof. T. Damodharam



A STUDY ON FLORA AND FAUNA OF SHESHACHALAM HILL RANGE, TIRUPATI, TIRUPATI DISTIRCT, ANDHRA PRADESH.

By

Dr. Prof. T. Damodharam,
M.Sc., B.Ed., M.Phil., Ph.D., D.Sc



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Azadi Ka Amrit Mahotsav

DIGITAL ECONOMY IN INDIA

- TRENDS
- CHALLENGES
- OPPORTUNITIES

Editor
Lt. Dr. M.Venkataramanaiah



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DIGITAL ECONOMY IN INDIA OPPORTUNITIES AND CHALLENGES: A STUDY

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Abstract

India can create over $1 trillion of economic value from the digital economy in 2025, with half the opportunity originating in new digital ecosystems that can spring up in diverse sectors, says a report from Ministry of Electronics and Information Technology, in partnership with McKinsey. "The trillion dollar economy report is the symbol of opportunity that India offers," said Ravi Shankar Prasad, Minister of Information Technology. "Digital India is also an opportunity for people in digital space to do business in India. The size and scale that India offers is a big business opportunity for global companies," he added. 'Digitization' and 'digitalization' are two conceptual terms that are closely associated and often used interchangeably in a broad range of literatures. Digitization refers to "the action or process of digitizing; the conversion of analogue data into digital form." Digitalization, by contrast, refers to "the adoption or increase in use of digital or computer technology by an organization, industry, country. "Digital India is the beginning of digital revolution. It is a dream which is created by the Government of India to ensure that government services are made available to citizens electronically, even in remote areas, by improving online infrastructure and by increasing Internet connectivity. The programme have one mission and one target that is to take nation forward digitally and economically. The initiative will enable people to get engaged in the innovation process which is needed by the economy to move forward. If implemented properly, it will open various new opportunities for the citizens of the country. Currently, India's digital economy generates about $200 billion of economic value annually 8 per cent of India's GVA in 2017-18 largely from existing digital ecosystem comprising information technology and business process management (IT-BPM), digital communication services, e-commerce, domestic electronics manufacturing, digital payments, and direct subsidy transfers, the report said. "By 2025, India could create a digital economy of $800 billion to $1 trillion. The existing digital ecosystem could



About the Editor

Lt. Dr. Venkataramanaiah Malepati is a top- notch academician, presently working as an Assistant Professor in Commerce at S.G.Government Degree and PG College, Piler. He has obtained his M.Com, MBA, M.Phil and Ph.D. from S.V .University, Tirupati and MBA from Pondicherry University. He has got through National Eligibility Test (NET) in Commerce and Management and SET in Commerce with distinction. He has bagged National Merit Scholarship in Graduation and Gold Medal in M.Com. He has also bagged Centrally Administrated Doctoral Fellowship from ICSSR, New Delhi for his research during 2010-13. Dr. Malepati has the rich experience of 18 years in both teaching and research. Being the passionate researcher and teacher, he traveled widely and tried out his wings in various positions in teaching across the countries. Dr. Malepati started his career as a lecturer in Dravidian University. Later he rendered his services in various capacities in the Premier Institutions like University of Gondar, Ethiopia, KMM Group of Institutions, Tirupati, Vignanasudha Institute of Management and Technology, Chittoor, University of Kurdistan, Iraq and Golden Valley Group of Institutions, Madanapalli. Being the top-notch researcher, he contributed significantly to the areas of Capital Markets, Agri Finance, MSMEs and Micro-finance. To his credit, there are 41 research papers published in National and International Journals listed in UGC Care List, Scopus Indexed and Web of Sciences. He has also been credited with four chapters in Edited Books. In addition to these, he has also 10 completed Edited Books and one edited book in the pipeline to his credit.

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ROLE OF WOMEN IN CONSERVATION OF NATURAL RESOURCES

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Abstract

Growing population and technological advancement are continuously putting a strain on the environment and on a country's natural resources. Over-exploitation of the country's natural resources like land, water, air, fuel etc. has resulted in degradation of natural resources mainly due to industrial wastes, soil erosion, cutting of forests (deforestation) and migration from rural to urban (urbanization). Hence, it is most important to conserve and promote natural resources and the environment. Women have an important role for direct contact with natural resources like fuel, food and fodder, flora, water, air and land especially in rural areas where 73% of Indian population reside and directly dependent upon natural resources. Women are also responsible for using these resources to satisfy the basic needs of their families. Before 18th and 19th century, it was considered that women have no role in natural resources protection and promotion, as well as they were avoided in all major aspects of social life. After spreading awareness about their rights and duties and taking cognizance of their surroundings they consciously tried to raise voice against environment degradation. Women play an important role in managing natural resources on family and community levels and are most affected by environmental degradation. This paper focuses on how women participated in conservation of natural resources for preserving them for the future generations.

Key Words: Environment, Natural Resources, Over Exploitation, Deforestation, Urbanization.

Introduction

Since time immemorial, women are traditionally involved in protecting and conserving their natural resources in hilly areas. With their extraordinary skills and traditional knowledge, women have proved how land, water, forest, air and other natural resources can be used and managed. Besides, that woman even played a leadership role for conservation and enhancement of environment. In communities around the world, women manage water, sources for fuel, and food, as well as both forests and agricultural terrain. From the high level to the grassroots, the 1992 UN Earth Summit, India's Chipko movement and Kenya's

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Non-Formal Education- An Alternate System to Eliminate Analphabetism

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(2) Dr. V. Jagadeeswari, Academic Consultant, Centre for Women's Studies, S. V. University, Tirupati

Abstract

Education plays a pivotal role in all our lives and paves the way for all of us to reach our highest potential. When we talk about the importance of education in life, it is extremely important to understand what education is. In this blog, we explore the importance of education in life, the significance of contemporary learning and its many aspects. The stakeholders of education, namely, governments, organizations and students themselves agree on its multidimensional essentiality. High-quality education, particularly tertiary education is a major catalyst of development in families across the income spectrum. Further, with the integration of multidimensional goals, the importance of education has been accentuated and individuals have grown more conscious towards the environment and society developing an awareness lacking in previous generations. Published on the World Bank blog, the article "Education is Fundamental to Development and Growth" appropriately summarizes the fact that education, through various methods, carries the potential to transform people's lives. On the other side, illiteracy affects an individual in all areas of their life. An illiterate individual cannot read and write, and thus cannot join the workforce or may work as unskilled labour, lack awareness to make an informed decision which affects them and their community. So there is a need to promote alternative ways to eradicate illiteracy.

Key Words: Education, Development, Multi- Dimensional Development, Illiteracy.

Introduction:

Article 26 of the Universal Declaration of Human Rights, proclaimed by the General Assembly of the United Nations in 1948, states in its opening paragraph: "Everyone has the right to education. Education shall be free, at least in the elementary and fundamental stages. Elementary education shall be compulsory. Technical and professional education shall be made generally available and higher education shall be equally accessible to all based on merit."

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Health Care Programmes for Children in Andhra Pradesh- A Study

*- Dr. V. Jagadeeswari **

Abstract

Health influences all activities and shapes the destiny of the people. Without health, there is no foundation for man's happiness. Since "Good health leads long life", traditionally it has been prized as goals of the mankind and health information flew from generation to generation. Information of health has a great social, political and economic importance. Information of health should reach the people in right time, to prevent the damage to human life. To have relevant information, it means to have basis for timely reporting, basis for action, and prerequisites for success. The purpose is to produce and use adequately appropriate information about health status, health risks and health outcomes in order to establish priorities. Health information should be useful and easily accessible to all potential users at every moment i.e., from health care providers to the public. Health indicators, as aggregated health statistical data, present measure instruments in this process. Basic set of relevant and measurable indicators should be found on different aspects of health and health care viz. health promotion, diseases prevention, clinical treatment, rehabilitation, monitoring and evaluation as a part of every day's routine in health sector. It should be a continuous process with the involvement of not only health and medical staff but also para medical staff including lab technicians. Governments are executing different health promotion programmes.

Keywords : Health, human life, health status, health risks, health indicators, health promotion programmes.

Introduction

According to World Health Organization (1948) health is 'A condition or quality of the human organisms expressing the adequate functioning of the organism in given conditions, genetic (or) environmental".

The Millennium Development Goals placed health at the heart of development and represent enrichment by the governments throughout the world. This is to reduce poverty, to tackle ill health, access to clean water and so on. Andhra Pradesh Government is implementing several health awareness and health promotion programmes to people especially to downtrodden communities including women and children. Health is the fundamental right of every human being. Health is related deeply to life style. Ideal health will however, always remains an illusion, because everything in our life is subject to change. Health is a dynamic

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A Study on the Significance of Property Rights to Women

Dr. V. Jagadeeswari

Abstract

In a country like India where 73.2% of rural women workers are engaged in agriculture, women own only 12.8% of land holdings. Land serves as security and shelter. The land ownership changes the position of women as decision maker thus whole family will be benefited. Children will be much safer, healthier, educated. Anita Pagare, a women's rights activist based in Nashik said 'Land acts as a bargaining tool for women'. "With no land to their name, women are completely at the mercy of their husbands or their family." The 2005 Hindu Succession Act was legislated to protect women's rights to an equal share in ancestral property, including land. But in reality, land is not at all registered in the name of women.

KeyWords: *Women Workers, Agriculture, Land Ownership, Bargaining Tool, De Jure and De Facto, etc.*

Introduction

Land ownership acts as a bargaining tool for women. Findings of different studies established that women who own land have better economic and social security. According to United Nations Report 2013 "By diminishing the threat of forced eviction or poverty, direct and secure land rights boost women's bargaining power in the home and improve their levels of public participation". "With no land to their name, women are completely at the mercy of their husbands or their family." The 2005 Hindu Succession Act was legislated to protect women's rights to an equal share in ancestral property, including land. But in reality, land is not at all registered in the name of women. That means De Jure of women's property rights.

There is a view which is widely prevalent that, inequality between the sexes never existed in the age of hunting, in the period of domestication of animals, in the times of fruit gathering and even during the centuries of agriculture with weed. But a look at various socio-economic indicators

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Savitribai Phule- the First Generation Modern Indian Feminists: Case Study

Dr. V. Jagadeeswari

Abstract

Savitribai Phule, the first female teacher in India and a pioneering social reformer of the 19th century, passionately championed the rights of women and lower castes while challenging the oppressive social systems of Pune, advocating for truth, equality, and humanity. Savitribai Phule, born on January 3, 1831, in Maharashtra, emerged as an influential social reformer and women's rights activist, using her education to combat the deeply entrenched patriarchy and caste system in Pune alongside her husband, Jyotirao Phule. On the third of January 1831, she was born in Naigaon, Satara, Maharashtra. Her parents were from the Bamako Community, which is currently classified as one of the Other Backward Classes (OBC). She was schooled by Jyotirao Phule, her husband, after they were married at the age of nine. She subsequently used this education to combat social injustice, inequality, and graded patriarchy that were common in Maharashtra, particularly Pune. This paper discusses about her contributions to the welfare of backward community.

Keywords: First female teacher, Social reformer, Women's rights activist, Equality and humanity.

Introduction

At that time, the caste system and patriarchy defined Pune. Savitribai Phule became determined after reading about Jyotirao Phule's

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Government Support for Emancipation of Women and Girls - An Overview

Dr. V. Jagadeeswari
Dr. K. Kishore Kumar Reddy
Dr. K. Vijaya Kumari

Abstract

The women population add more than 49% of the country. Enabling women free in decision making is important as they are alike chief of the ship and having the responsibility of the family viz. balancing the economic condition of the family and educating the children. Nations, businesses, communities and groups may benefit from the implementation of programs and policies accomplished for women empowerment. Empowerment of women not only enhances the quantity of workforce but also their quality which is needed for the growth of any country.

Since children will be the nation's future citizens, empowering them is also necessary for the country's wealth. The welfare of the youth is crucial to the country's future. The only people who can influence the leadership are those who are in good physical and mental health. The concept of women's and children's empowerment also encompasses social and economic advancement, which is a key driver of national development. Since, India is primarily an agricultural nation, it stands to reason that women's and children's empowerment should be given top priority. 50% of the population is made up of women and children, and by supporting other women in their endeavors, women make up the workforce.

Keywords : Empowerment, Development, Leadership, Endeavors, Welfare of the youth.

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11. Empowerment of Women and Girls through Sustainable Development Goals

Dr. V. Jagadeeswari and

Mrs. D. Jahnavi

Abstract

Globalization should lead to the promotion of shared understanding, values and cooperative actions on a transnational and trans-societal level. It would be a movement that recognizes and respects the diversity, variety and richness of local discourses, codes and practices, while developing viewpoints and the understanding that facilitates cooperation and coordination to achieve gender equality which is very important for sustainable development. It is a process that continues life long and therefore takes place in global environments. The ultimate objective is 'a better future for all irrespective of gender'.

One of the challenges of sustainable development is gender inequality and gender discrimination. There have been several recent initiatives designed to foster the gender equality at home and workplace in different fields for sustainable development. Education as a qualitative attribute of the population is one of the most important indicators of achieving gender equality through socio-economic and political development of a society. It is a major component of human resource development and is thus basic to any programme of social and economic progress. The role of education in the life cycle of an individual affirms and enables the individuals to adapt to and deal with new challenges and changes in their lives and their surrounding environment. It supports all forms of experiences which can help prepare or engage individuals in purposeful interaction with their own environment by developing their knowledge, skills and their critical thinking

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MGNREGA- A Source of Employment Generation in Rural Areas

V. Jagadeeswari
D. Sai Sujatha

MGNREGA- A Source of Employment Generation in Rural Areas

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MGNREGA- A Source of Employment Generation in Rural Areas

The Indian Government over the years has executed and implemented several Rural Employment generation programmes viz. National Rural Employment Programme (NREP) in 1980, Rural Landless Employment Guarantee Programme (RLEGP) in 1983, Jawahar Rozgar Yojana (JRY) in the last year of 7th Five Year Plan, Employment Assurance Scheme (EAS) in 1993, Jawahar Gram Samridhi Yojana (JGSY) in 1999, Sampoorna Grameen Rozgar Yojana (SGRY) in 2001, National Food for Work Programme (NFFWP) 2004, Mahatma Gandhi National Rural Employment Guarantee Act(MGNREGA) in 2005 which is known as National Rural Employment Guarantee Act (NREGA), etc. MGNREGA implemented Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) which is an envisaged template modification from all precedent Wage Employment Programmes (WEP) operating in the country since 1980. With this locale the authors attempted to study MGNREGA and MGNREGS as source of employment to rural people, its impact on the lives and creation of assets in rural areas. The data collected from the beneficiaries has been documented by the authors with the title "MGNREGA- A Source of Employment Generation in Rural Areas"- A Study.

Dr. V. Jagadeeswari working as Academic Consultant in the Centre for Women's Studies, Sri Venkateswara University, Tirupati obtained M.A. (Gold Medal), M. Phil and Ph.D. degrees in Adult Education, M.A.W.G.S., M.Com, M.L., M.Ed., B.L.I.Sc., P.G. Dip. in G&C and COBOL Certificate and also qualified APSET.

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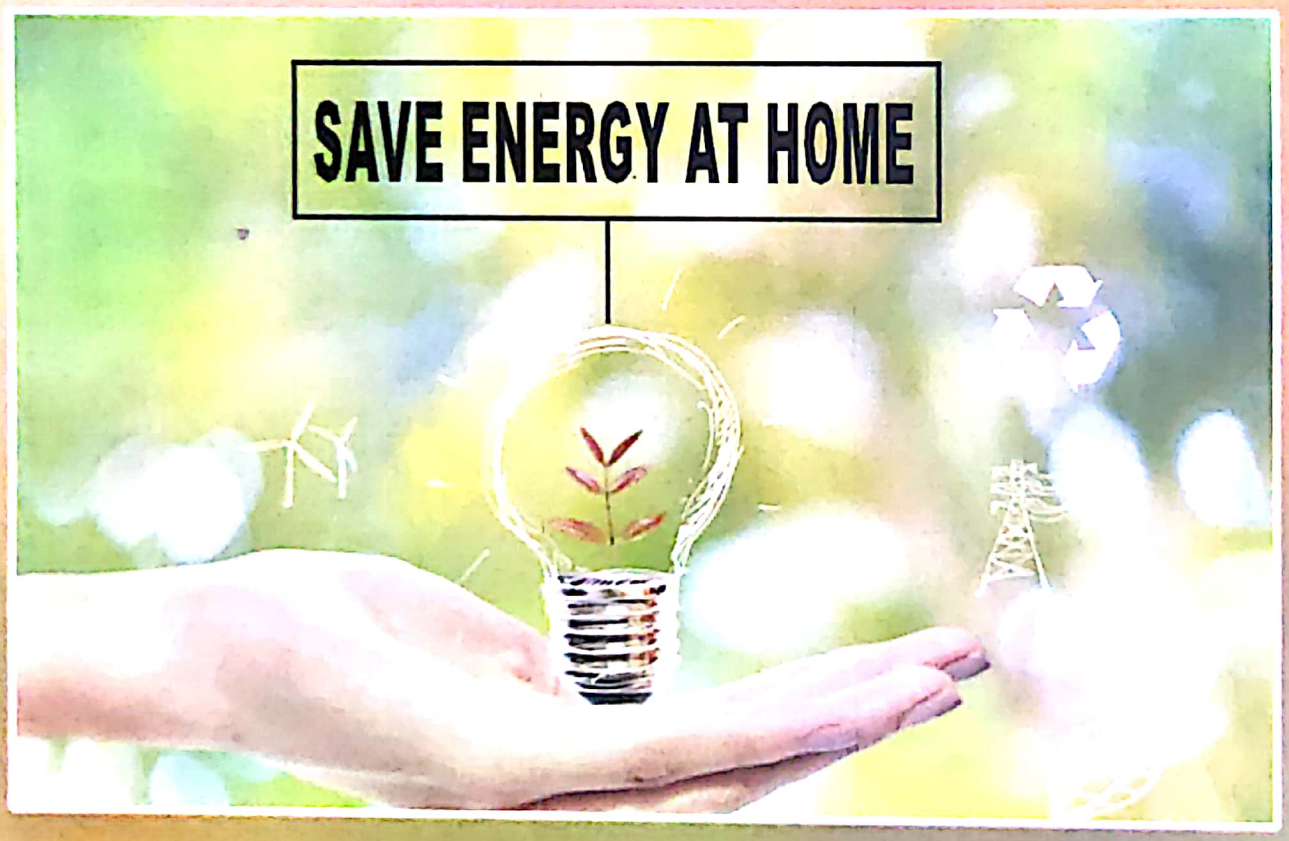
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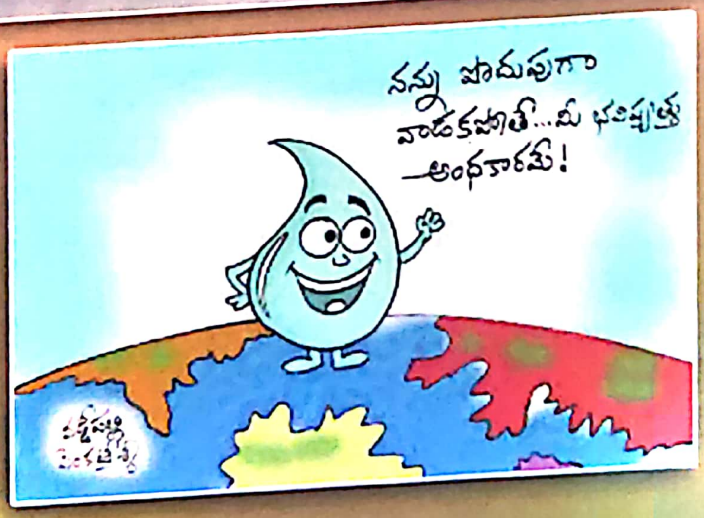
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AP HRD Institute.

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This is to certify that **Dr.V.Jagadeeswari** has extended her valuable services as a Resource Person on 02nd & 03rd Nov, 2023 and delivered expert lecture on the following session at APHRDI RC, Srikalahasti, Tirupathi Dist.

Name of the programme & Date	Subject of session
Three Days Residential Capacity Building Training Programme to Women Ward Members on "**She is a Change Maker**" from 02nd to 04th, Nov 2023 in association with National Commission for Women, Govt of India, New Delhi at APHRDI Regional Centre, Srikalahasti	1. Anti Human Trafficking and Laws relating to Protection of Women 2. Marriage, Divorce and inheritance of property Act & Women welfare related Government of India schemes. 3. Protection of Children: POCSO Act and Cyber Crime

The Participants interacted well with the Resource Person and she clarified their doubts well and they satisfied very well.

AO.
02/11/23

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APHRD Institute.

APHRDI REGIONAL CENTRE ★ SRIKALAHASTI
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NATIONAL SEMINAR ON

National Education Policy 2020 : Pathway for the Transformation of Higher Education – Status, Challenges and Strategies

Certificate

This is to certify that Prof./Dr./Mr./Ms. V. Jagadeeswari has participated in the National Seminar on National Education Policy 2020 : Pathway for the Transformation of Higher Education – Status, Challenges and Strategies organized at the Women's Studies Centre, Sri Padmavati Mahila Visvavidyalayam, Tirupati from 17th - 18th July, 2024 and presented paper on NEP2020- Indorsing Gender Equality in Higher Education: prospects and challenges.

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A STUDY ON KNOWLEDGE REGARDING THE EFFECT OF JUNK FOOD ON HEALTH AMONG ADOLESCENT GIRLS

***Dr. D. Raja Rajeswari**, Academic Consultant, Centre for Women's Studies, S.V. University, Tirupati, Andhra Pradesh.

****Dr. D. Ramana**, Academic Consultant, Centre for Women's Studies, S.V. University, Tirupati, Andhra Pradesh.

Abstract

Food is necessary for energy, for growth, for repair, and for health. Our health depends on what we eat daily. These days, most people like junk food, which is very popular among adults as well as children. Socio-economic trends, such as longer work hours, more women employed outside the home, and a high number of single-parent households, have changed the way families obtain their meals. In today's world scenario, junk food has become a prominent feature of diets for adolescents. The rapidly changing food consumption pattern and diet transition are emerging in society due to economic growth and new lifestyle choices. Today, many adolescents like to eat junk food, but they do not know about the harmful effects of junk food on their health. People have forgotten that the primary reason for eating is nourishment. Lifestyle changes have compelled us so much that we have so little time to really think about whether what we are eating is right! Junk foods are quick, tasty, convenient, and fashionable. Objectives of the study to study the socio-economic demographic profile of the respondents to assess the knowledge regarding the effects of junk food on health. Among adolescent girls The present investigation was carried out in the Tirupati urban area of Chittoor, Andhra Pradesh. The sampling unit for the study was adolescent girls of the same age. Group of 13 to 14 years. A total of 50 samples were selected for the study, 50 from 8^{th} and 9^{th} grade adolescent girls. Sri Padmavathi Girls High School in Tirupati. A random sampling procedure was followed in the selection of the respondents.

Keywords: Knowledge, Junk Food, Health, Adolescent Girls

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WOMEN'S PARTICIPATION IN GREEN JOBS FOR DEVELOPMENT OF GREEN ECONOMY IN INDIA

Dr. D. Ramana

Academic Consultant, Centre for Women's Studies, S. V. University, Tirupati

ABSTRACT

India's G20 presidency, the country has introduced the 'LiFE' (Lifestyle for Environment) Mission to promote responsible consumption. India emerging as one of the world leaders, has the potential to create 35 million green jobs by 2047. The green jobs help to protect ecosystems by reducing energy, materials, and water consumption through high-efficiency strategies. Reduce all forms of waste and pollution for sustainable development. This mechanism helps to create an efficient green economy through the creation of green jobs.

Green occupations for women could be such a solution, but there are several hurdles to overcome first. Green jobs for women can combat the climate crisis and boost equality. Women are underrepresented in high-potential climate-friendly sectors Women continue to be underrepresented, underpaid, undervalued, and sometimes completely unseen in the labor market. Women may be excluded from the green economy due to gender-segregated employment, discrimination, and traditional attitudes. The lack of gender equality is decreasing the access of women to green positions in the primary, secondary, and tertiary sectors. Although they are the foundation of sustainable households, women agricultural workers in poor countries are a marginalized group. Most green jobs are expected to be in the secondary sectors of construction, manufacturing, and energy production, where women are significantly underrepresented. Women may fare better in the tertiary division where most are now employed. However, men dominate the better-paid jobs in engineering, financial, and business services, where the bulk of green service positions are likely to be created.

Achieving sustainability depends on equal attention to economic, environmental, and social factors and their integration through sustainable development strategies. Green economy initiatives that aim at creating more environmentally sound economies may not fully incorporate fundamental social requirements such as income equity, job quality, and gender equality. If they do not take account of these social factors, they may maintain or even aggravate the negative social and distributive trends of the traditional economy including existing inequalities and gender gaps. Upward environmental awareness and economy-linked

Political Participation of Women in Rayalaseema Region in Andhra Pradesh: A Brief Analysis of 2004 to 2019 State Legislative Assembly Elections

Dr. D. Ramana

Abstract

Empowerment of women takes place through structural changes in women's lives such as provision of land rights, promotion of non-farm employment, self-employment and support to unleash their potential of leadership abilities and their input in decision making at various levels. The Political inequalities prevalent within the semi-feudal and rural societies are balance the power structure ultimately (Agarwal, 2018). Political representation is a tool to achieve the social equality and personal privileges of women in elsewhere the society.

The current study aimed to analyse of the Women's Political participation in Rayalaseema region of Andhra Pradesh. Secondary source of data method was followed to collect the data produced from 2004, 2009, 2014 and 2019 Legislative Assembly Elections.

***Key words** : Political Participation, Women Empowerment, Political inequalities*

Introduction

The days have changed women from which they have arrested by four parapets of the kitchen and to look after the members of the family to the days where women are showing their talent in all fields. Veracious from the origin of the Andhra Pradesh Legislative Assembly, women as

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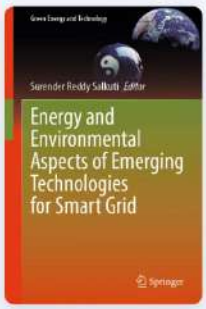
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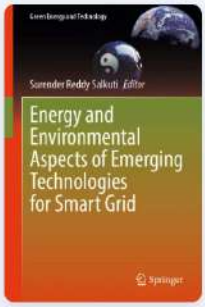
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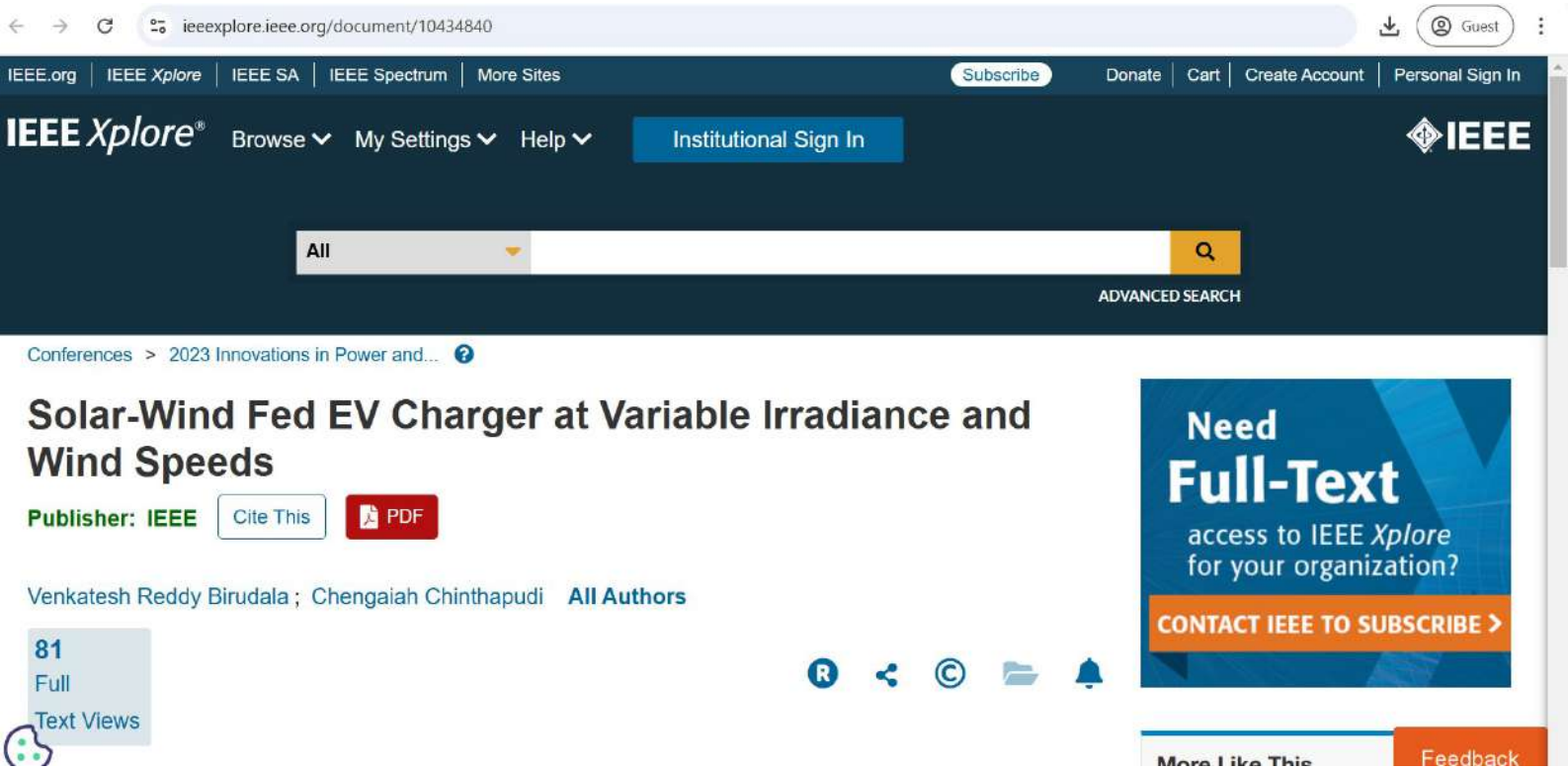
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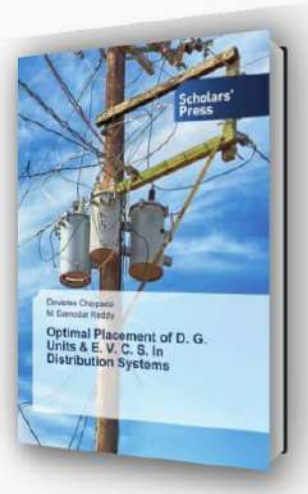
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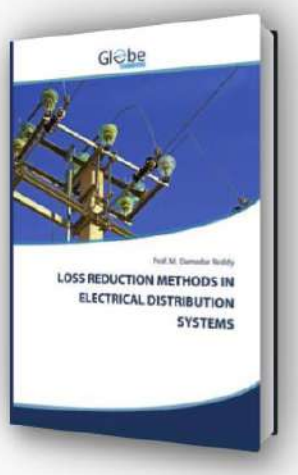
Optimal Placement of D. G. Units & E. V. C. S. In Distribution Systems

978-620-6-76883-8

The primary objective of this book is to introduce various methods for the optimal placement of Distributed Generation (D.G.) Units and Electric Vehicle (E.V.) Charging Stations within radial distribution systems. This book explores the impact of Electric Vehicle Charging Stations (EVCS) on distribution systems and delves into the optimal placement of multiple DG units of different types, along with EV charging stations. The operations of these units in both Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) modes are investigated, focusing on loss reduction and voltage profile improvement within radial distribution systems. The book comprises six chapters.

Authors	Devisree Chippada M. Damodar Reddy
Book language	English
Published on	2023-08-29
Publishing house	Scholars' Press
Number of pages	268
Price (EUR)	€104.90

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LOSS REDUCTION METHODS IN ELECTRICAL DISTRIBUTION SYSTEMS

978-620-6-17677-0

The main objective of this book is to present some of the loss reduction methods in Electrical distribution systems. There are many different ways to reduce the losses and improve the performance of the distribution systems. Within the scope of this book, optimal capacitor placement, network reconfiguration and the two hybrid methods are presented. The introductory aspects related to Electrical distribution systems, factors affecting distribution system losses, loss reduction methods and literature survey in this area are presented in Chapter-1. Chapter-2 introduces an efficient branch current method to obtain the load flow solution of radial distribution systems. The findings of the proposed branch current load flow method tested on different static load models namely constant power load model, constant current load model, constant impedance load model and exponential load model are reported. Load growth is also considered. Chapter-3 presents different methods developed for the optimal capacitor placement problem. A two-stage methodology is used for the optimal capacitor placement.

Authors	Prof. M. Damodar Reddy
Book language	English
Published on	2023-10-13
Publishing house	GlobeEdit
Number of pages	252
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OPTIMAL U.P.Q.C. PLACEMENT IN RADIAL DISTRIBUTION SYSTEMS

OPTIMAL UNIFIED POWER QUALITY CONDITIONER PLACEMENT IN RADIAL DISTRIBUTION SYSTEMS

978-620-6-76894-4

The main objective of this book is to present some of the Optimal Placement methods of Unified Power Quality Conditioner (U.P.Q.C.) in Radial Distribution Systems. Within the scope of this book, the optimal UPQC placement problem is solved for the objective of Power Loss Minimization (PLM) and Voltage Deviation Minimization (VDM) and analyzed with various optimization methods. This book is divided into five chapters.

Authors	MULE LAXMIDEVI RAMANAIAH M. Damodar Reddy
Book language	English
Published on	2024-03-18
Publishing house	Scholars' Press
Number of pages	148
Price (EUR)	€74.90

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This is to certify that **Dr. M. Damodar Reddy** of SVUCE, Tirupati has presented a paper titled *Enhancing Voltage Stability Assessment Through Phasor Measurement Based Voltage Estimation* in "**1st International Conference on Intelligent and Sustainable Power and Energy Systems (ICISPES-2023)**" on 26th & 27th September, 2023 organized by **Dept. of Electrical & Electronics Engineering**, Dayananda Sagar College Of Engineering, Bengaluru, India.

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Experimental study on flexural strength of slurry infiltrated fibrous concrete (SIFCON) produced with various percentages of waste steel fibers recovered from used tires

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Abstract. Slurry Infiltrated Fibrous Concrete (SIFCON), a modified version of Fiber Reinforced Concrete (FRC), addresses the challenge of increased fiber volume fractions. Commercially produced steel fibers are typically used in FRC and SIFCON. Efforts to reduce energy use in making commercial steel fibers have led to seeking alternative sources. Vehicular tires are typically recycled when no longer usable, yielding steel fibers among the products. Emphasis lies in recovering steel fibers from used tires as part of resource recovery from waste. Experimental work explored flexural strength in SIFCON with waste steel fibers at volumes from 4% to 7%. The study extended to assess SIFCON's flexural strength with commercial steel fibers at similar volumes, aiming to correlate with those from waste steel fibers. M20 grade concrete and SIFCON slurry matrix specimens were cast as reference mixes for comparison. The flexural strength of SIFCON specimens with waste steel fibers recovered from used tires notably surpasses that of reference mixes and is comparable to SIFCON specimens with commercial steel fibers. Additionally, the two-layer technique proves effective in SIFCON using waste steel fibers from used tires, up to 6% volume. The test results show successful production of SIFCON from waste steel fibers recovered from used tires.

Keywords: Slurry Infiltrated Fibrous Concrete, Flexural strength, Waste steel fibers, Aspect ratio.

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1 Introduction

Globally, energy crises and their impact on the environment are significant challenges faced in the present scenario. These issues arise due to the increase in population, rapid urbanization, and the generation of substantial quantities of solid waste. The production of automobiles and trucks has significantly increased to meet the growing demand, leading to a proportional increase in the generation of waste tires. In today's modern world, the use of

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vehicles for the transportation of people and materials is steadily rising, resulting in a problem with the disposal of scrap tires at the end of their life [1, 2, 3]. Less than 40% of the embedded energy in tires that have been scrapped can be recovered as fuel energy, based upon studies [4]. The majority of discarded tires are utilized as a source of energy for cement kilns because of the high carbon content in tires [5]. It is better to embrace the concept of reusing and recycling to obtain resources from waste, which offers environmental benefits [6, 7]. Rubber recovered from scrap tires in recycling plants is used as a source of energy in industries, and the steel fibers with high strength that were extracted from scrap tires serve as raw materials for steel manufacturing plants. The focus has been made on extracting steel fibers with high strength from used tires as a concept of resource recovery from waste, reducing the need for using high-strength manufactured commercial steel fibers. Pyrolysis methods, cryogenic methods, or mechanical methods are generally employed for the recovery of rubber and steel fibers from scrap tires [8, 9]. Steel fibers extracted from used tires may not have a straight or definite aspect ratio, unlike manufactured commercial steel fibers.

It has been demonstrated that steel fibers with various aspect ratios that are extracted from used tires may be used as an alternative material while producing steel fiber-reinforced concrete. [10]. However, due to the balling effect, there is a limitation in using higher amounts of fibers in the preparation of fiber-reinforced concrete. A special form of steel fiber-reinforced concrete is Slurry Infiltrated Fibrous Concrete (SIFCON), a high-performance cementitious composite [11, 12]. The production of SIFCON is different from the conventional fiber-reinforced concrete, wherein molds are prepacked with the fibers and infiltrates the cement mortar slurry matrix. Due to the procedure of prepacking, higher amounts of fibers can be used in the manufacture of SIFCON using cement mortar slurry matrix with a low water-cement ratio, resulting in higher energy absorption or toughness compared to conventional steel fiber-reinforced concrete, as well as higher post-cracking strength. In the production of SIFCON, the fibers are placed by hand and infiltrated with a cement mortar slurry matrix, in which the balling of fibers will not be a limitation and facilitates the convenient use of the waste steel fibers extracted from scrap tires. Furthermore, waste steel fibers extracted from scrap tires are less expensive than industrial steel fibers, which is also an added advantage for SIFCON applications. Studies regarding the usage of waste steel fibers in the production of SIFCON are limited based on the available literature [13, 14, 15, 16, 17].

The maximum flexural strength of SIFCON is obtained at 9% of fiber volume with an aspect ratio of 80, and it is noted that SIFCON's flexural strength, split tensile strength, and compressive strength are optimum at 9% fiber content [18]. It is proved that the three-layer technique with hand tamping is effective in prepacking fibers in the casting of SIFCON specimens. It was observed that beyond 10% volume of hooked-end steel fibers with an aspect ratio of 70 and a length of 35 mm, the placement of fibers manually in the mold is very tedious [19]. It was shown that the compression, split tensile, and flexural strengths of SIFCON specimens will increase with an increase in the volume of the steel fiber fraction [20]. SIFCON slab specimens show superior performance in load-carrying capacity, stiffness, and energy absorption compared to fiber-reinforced concrete and plain cement concrete slab specimens in flexure [21]. Higher levels of waste fibers in SIFCON have improved its splitting and flexural strengths. However, the use of waste steel fibers had no effect on compressive strength. Waste steel fibers have the potential to be a desirable substitute in the manufacture of SIFCON, as shown by multi-objective optimization. [22]. It has been concluded adding SIFCON to regular concrete reduces the possibility of cracks spreading, improves strength, ductility, load carrying capacity, and energy absorption capability (toughness) [23].

Steel fibers are being utilized in the manufacturing of steel fiber-reinforced concrete in the construction industry. Slurry Infiltrated Fibrous Concrete (SIFCON) has been termed 'the

advanced version of Fiber-Reinforced Concrete (FRC)' due to the increased volume fraction of fibers, which contributes to improved hardened properties such as strength, toughness, and impact resistance. Generally, the fibers used in the preparation of SIFCON offer benefits similar to what reinforcing bars offer in Reinforced Cement Concrete (RCC). The improved properties of SIFCON elements depend on the type, geometry, shape, and orientation of the fibers utilized in experimental work. The main aim of this experimental work is to study the flexural strength of SIFCON, which is produced using waste steel fibers recovered from used tires.

2 Materials

2.1 Binding material

Grade 43 Ordinary Portland Cement (OPC) has been used as the binding material throughout the experimental work and conforms to Indian standards [24]. Tests were conducted on the cement used in the experimental study to determine its fineness, specific gravity, consistency, and initial-final setting times. The physical properties of the cement are shown in Table 1.

Table 1. Physical properties of Cement

Physical Properties	Test Result	Test method	Requirement
Specific gravity	3.13	IS 4031 (Part II):1988	-----
Fineness [m^2/Kg]	311.5	IS 4031 (Part II):1988	Min. 225
Normal consistency	33%	IS 4031 (Part IV):1988	-----
Initial setting time [minutes]	47	IS 4031 (Part V):1988	Min. 30
Final setting time [minutes]	252	IS 4031 (Part V):1988	Max. 600

2.2 Fine aggregate

Natural sand obtained from the riverbed has been used throughout the experimental work for the preparation of the reference mix and SIFCON specimens. However, a maximum aggregate size of 0.60 mm has been considered and used in the preparation of the SIFCON slurry matrix, and this size has been kept constant for the production of SIFCON throughout the experimental work. The fineness modulus, specific gravity, bulk density, and water absorption of the aggregates were determined according to IS codes. Table 2 shows the physical properties of the fine aggregate utilized in the experiment. However, natural sand obtained from the riverbed, conforms to Indian standards has been used fine aggregate in the preparation of M20-grade concrete.

Table 2. Fine Aggregate Test Results

Type of Test	Fine Aggregate
Fineness Modulus [%]	2.80
Specific Gravity	2.65
Water Absorption [%]	0.25
Bulk density [kg/m^3]	1750

2.3 Coarse aggregate

The maximum size of 20 mm obtained from the granite quarry, which conforms to Indian standards, has been used as coarse aggregate in the preparation of M20-grade concrete in the experimental work.

2.4 Mixing water

The laboratory's potable water has been utilized for mixing the SIFCON slurry matrix, reference mix, and curing of the specimens.

2.5 Chemical admixture

To achieve the necessary workability and flowability of the SIFCON slurry matrix, a high-range water-reducing admixture (superplasticizer) of polycarboxylic ether has been used. Manufacturer's data have been considered for the chemical admixture used in the study. Properties of the superplasticizer, i.e., AURAMIX 450 from M/s. FOSROC Chemicals, are shown in Table 3.

Table 3. Characteristics of Super plasticizer (AURAMIX 450)

Appearance	Light yellow colour liquid
pH value	Minimum 6.0
Volumetric mass @ 20°C	1.09 to 1.11
Chloride Content	Nil

2.6 Steel fibers

A survey was conducted to obtain waste steel fibers from used tires. Fibers recovered from scrap tires through a mechanical process at the recycling plant were used in this experimental study for preparing the SIFCON specimens. In the tire recycling plant, initially, collected scrap tires are shredded into small pieces using industrial shredders. After shredding, the tire pieces undergo a process called magnetic separation, in which powerful magnets are used to attract and separate the steel fibers from the shredded rubber. The shredded material is then passed through screens or filters to further separate any remaining steel fibers from the rubber particles. The steel fibers obtained from the recycling plants contained a small quantity of textiles and rubber fragments, which were manually removed to the extent possible before being used in the preparation of SIFCON. The waste steel fibers obtained from the recycling plant are irregular in shape. Waste steel fibers recovered from the used tires utilized in the study were tested to determine the diameter, length, aspect ratio, etc. Fig. 1 displays the waste steel fibers chosen for the experimental program. The length and diameter of the waste steel fibers, measured on randomly selected fibers, are shown in Table 4. Furthermore, round crimped steel fibers have been used as the commercial steel fibers in the experimental work. Manufacturer's data have been considered for the commercial steel fibers used in the study and are shown in Table 5. Fig. 2 displays the commercial steel fibers that were selected for the experiment.



Fig. 1. Waste steel fibers recovered from used tires.



Fig. 2. Commercial steel fibers.

Table 4. Properties of waste steel fibers

Diameter of Fiber [mm]	Length of Fiber [mm]	Average Aspect ratio	Contribution of Fibers (% by weight)
0.15 ± 0.01	26 ± 23	173	9.70 %
0.19 ± 0.01	13 ± 2	68	3.20 %
0.27 ± 0.02	37 ± 17	137	11.30 %
0.31 ± 0.01	45 ± 28	145	46.80 %
0.34 ± 0.01	30 ± 15	88	11.30 %
0.39 ± 0.03	46 ± 19	118	12.90 %
0.46 ± 0.01	68 ± 4	148	4.80 %

Table 5. Properties of commercial steel fibers

Type	Crimped
Diameter	0.45 mm
Length	35 mm
Aspect ratio (l/d)	78
Tensile Strength	1260 MPa

3 Methodology

M20 grade concrete was designed in accordance with the guidelines specified in Indian Standards. [25]. The proportions of ingredients for the M20 grade concrete are presented in Table 6.

Table 6. Mix proportions of M20 grade design mix concrete

	Water	Cement	Fine Aggregate	Coarse Aggregate	20 mm CA	10 mm CA
By Weight [kg]	160	320	667	1131	679	452
By Volume [m^3]	0.50	1	2.08	3.53	2.12	1.41

A flow test was conducted using a mini flow cone, as recommended by EFNARC [26]. The mini flow cone measures 60 mm in height, 70 mm in the top inner dimension, and 100 mm in base inner dimension. The equipment used in this study for the mini flow test is shown in Fig. 3. The SIFCON slurry was poured into the mold, lifted, and the spread diameter of the slurry matrix was measured. The slump flow ranged between 240 mm and 260 mm, in accordance with the guidelines stipulated in EFNARC [26]. Another test conducted on the fresh SIFCON slurry matrix is the mini v-funnel test. Fig. 3 illustrates the dimensions and form of the equipment utilized in this study. The SIFCON slurry was poured into the test equipment, and the time to empty the equipment was measured. The time to empty the test equipment ranged from 7 seconds to 11 seconds, in accordance with the guidelines stipulated in EFNARC [26].

Fresh tests, as described above, have been conducted using cement and fine aggregate in the proportion of 1:1, with a water-cement ratio varying from 0.30 to 0.40 in increments of 0.01 and superplasticizer from 0.50% to 2.00% by weight of cement, in increments of 0.1%. The procedures for the flow test and mini v-funnel tests are shown in Fig. 4 and Fig. 5, respectively. After detailed test trials, it was decided to use the SIFCON slurry matrix with a proportion of 1:1 (cement: fine aggregate) using a water-cement ratio of 0.33 and a superplasticizer content of 0.80% by weight of cement. The mix proportion of the SIFCON slurry matrix is provided in Table 7.

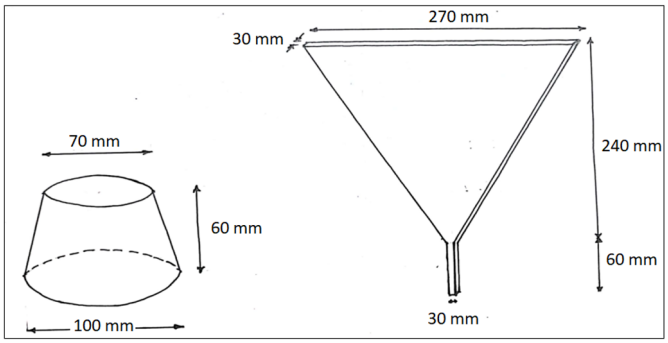


Fig. 3. Equipment for mini slump and v-funnel tests.



Fig. 4. Mini slump test.



Fig. 5. Mini v-funnel test.

Table 7. Mix proportion of SIFCON slurry matrix

Cement	Fine aggregate	W/C ratio	Super plasticizer
1	1	0.33	0.80 % by weight of cement

Upon finalizing the ratio of the SIFCON slurry matrix, the production process for SIFCON is as follows: The molds used for specimen production will be cleaned and coated with waste oil to facilitate easy demolding. Cement and fine aggregate, in a 1:1 proportion, are to be dry mixed. Subsequently, water and superplasticizer, as per the finalized ratios, are to be added to the dry mix. The total slurry must be mixed for a minimum of 2 minutes to ensure proper mixing of the slurry matrix.

A two-layer technique is employed for filling the fibers in the molds to ensure proper compaction and prevent honeycombing. Accordingly, 50% of the volume fraction of fibers is randomly hand-spread as the first layer in the mold. Once the first layer is in place, the prepared SIFCON slurry matrix is poured onto the fiber bed and compacted using hand tamping and a table vibrator.

Subsequently, a second layer of fibers is also randomly spread, followed by pouring of the SIFCON slurry matrix and compaction. The cast samples are left for 24 hours at room temperature. On completion of this time, the samples are demolded and placed in a curing chamber for the designated curing periods. Difficulties were encountered during the production of SIFCON specimens with a 6% volume fraction of steel fibers due to the irregular shape of waste steel fibers and their random placement. In consideration of this, a three-layer technique has been employed for the production of SIFCON specimens with 7% steel fibers. Fig. 6 depicts the production process of the SIFCON.

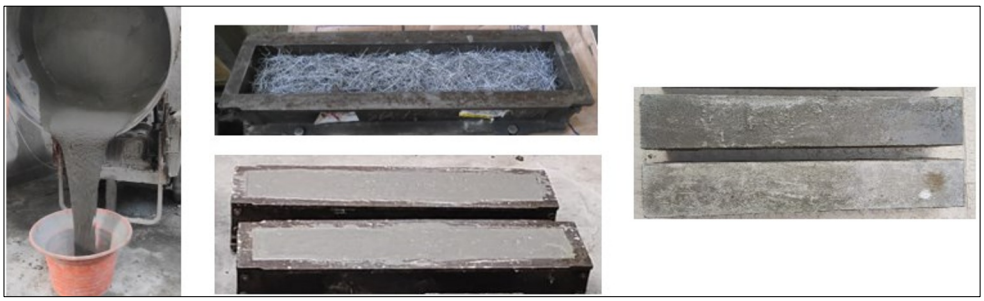


Fig. 6. Production process of SIFCON.

4 Experimental Programme

Flexural elements of 100x100x500 mm, with various volume percentages of waste steel fibers, commercial steel fibers, and reference elements, are casted. The quantity of fiber content used in the preparation of SIFCON specimens, corresponding to 4%, 5%, 6%, and 7% of the concrete volume, is 314 kg/m^3, 392.50 kg/m^3, 471 kg/m^3, and 549.50 kg/m^3, respectively. The designations for the specimens are provided in Table 8.

Table 8. Designation of specimens.

Type of Prism	Cross Section [mm]	Steel fibers		No. of speci-men	Designation
		Type	Vol.		
M 20 grade	100x100x500	----	----	9	RMPM20-1 to RMPM20-9
SIFCON slurry	100x100x500	----	0%	9	RMPF0-1 to RMPF0-9
SIFCON with fibers	100x100x500	Waste steel fibers	4%	9	S1PWF4-1 to S1PWF4-9
			5%	9	S1PWF5-1 to S1PWF5-9
			6%	9	S1PWF6-1 to S1PWF6-9
			7%	9	S1PWF7-1 to S1PWF7-9
SIFCON with fibers	100x100x500	Commer-cial steel fibers	4%	9	S1PMF4-1 to S1PMF4-9
			5%	9	S1PMF5-1 to S1PMF5-9
			6%	9	S1PMF6-1 to S1PMF6-9
			7%	9	S1PMF7-1 to S1PMF7-9

All specimens were tested for flexural strength using two-point loading. The universal testing machine has been used for testing the specimens, and the tests were carried out in accordance with the procedures outlined in IS: 516-1959. Fig. 7 depicts the test setup of the flexural strength. At the ages of 3, 7, and 28 days, tests were performed on the specimens. All necessary safety precautions have been followed during testing of the specimens.



Fig. 7. Test setup of flexural strength.

5 Results and Discussions

In Table 9, the flexural strength results of SIFCON specimens at 3, 7, and 28 days of age, produced with various percentages of waste and commercial steel fibers and the reference mixes, are displayed.

Table 9. Flexural strength of specimens

Sl. No.	Type of Specimen	Steel Fibers		Specimen designation	Average Flexural strength [N/mm^2]		
		Type	Per-centage		3 days	7 days	28 days
I	M20 grade prism	----	----	RMPM20	2.98	4.32	5.77
II	SIFCON slurry prism	----	0 %	R1MPF0	3.89	5.61	7.19
III	SIFCON prism	Waste steel fibers	4 %	S1PWF4	5.33	9.95	10.96
IV	SIFCON prism		5 %	S1PWF5	8.24	10.77	12.52
V	SIFCON prism		6 %	S1PWF6	11.66	12.97	13.42
VI	SIFCON prism		7 %	S1PWF7	16.33	16.21	15.04
VII	SIFCON prism	Commer-cial steel fibers	4 %	S1PMF4	17.17	21.64	21.98
VIII	SIFCON prism		5 %	S1PMF5	24.24	25.58	27.59
IX	SIFCON prism		6 %	S1PMF6	25.59	27.60	28.83
X	SIFCON prism		7 %	S1PMF7	27.53	29.91	32.49

From Table 9 and Fig. 8, it is observed that the average flexural strength of the M20 grade reference mix and the SIFCON slurry matrix at 3 days is 2.98 N/mm^2 and 3.89 N/mm^2 respectively. Additionally, at 7 days, the average flexural strength of the M20 grade reference mix and the SIFCON slurry matrix is 4.32 N/mm^2 and 5.61 N/mm^2 respectively. Furthermore, at 28 days, the average flexural strength of the M20 grade reference mix and the SIFCON slurry matrix is 5.77 N/mm^2 and 7.19 N/mm^2 respectively. The higher difference in flexural strength in the SIFCON slurry matrix is due to the increased amount of binding material and the absence of coarse aggregate.

From Table 9 and Fig. 8, it is observed that the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% waste steel fibers at 3 days is 5.33 N/mm², 8.24 N/mm², 11.66 N/mm², and 16.33 N/mm² respectively. Similarly, the average flexural strength of SIFCON with the same fiber percentages at 7 days is 9.95 N/mm², 10.77 N/mm², 12.97 N/mm², and 16.21 N/mm² respectively. Furthermore, at 28 days, the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% waste steel fibers is 10.96 N/mm², 12.52 N/mm², 13.42 N/mm², and 15.04 N/mm² respectively.

The results indicate that at 3 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers exhibits flexural strengths 79%, 177%, 291%, and 448% higher than M20 grade concrete, and 37%, 112%, 200%, and 320% higher than the SIFCON slurry matrix respectively. Similarly, at 7 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers shows flexural strengths 130%, 149%, 200%, and 275% higher than M20 grade concrete, and 77%, 92%, 131%, and 189% higher than the SIFCON slurry matrix

respectively. Furthermore, at 28 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers exhibits flexural strengths 90%, 117%, 133%, and 161% higher than M20 grade concrete, and 52%, 74%, 87%, and 109% higher than the SIFCON slurry matrix respectively. The increase in flexural strength of SIFCON produced with waste steel fibers, compared to reference mixes, is attributed to the SIFCON slurry matrix with various percentages of fiber volume fraction.

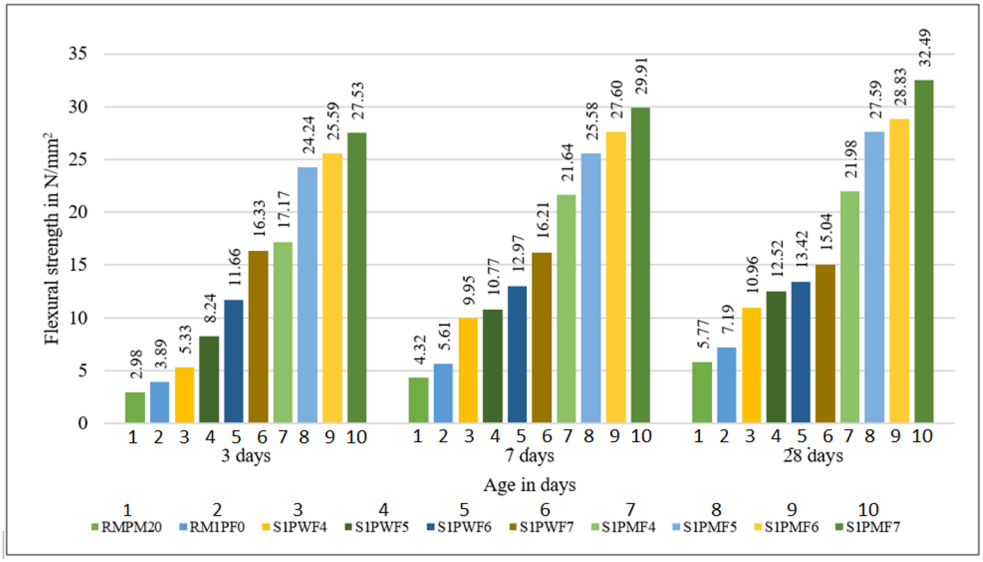


Fig. 8. Comparison of Flexural strength of SIFCON and reference mixes.

From Table 9 and Fig. 8, it is observed that the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% commercial steel fibers at 3 days is 17.17 N/mm², 24.24 N/mm², 25.59 N/mm², and 27.53 N/mm² respectively. Similarly, the average flexural strength of SIFCON with the same fiber percentages at 7 days is 21.64 N/mm², 25.58 N/mm², 27.60 N/mm², and 29.91 N/mm² respectively. Furthermore, at 28 days, the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% commercial steel fibers is 21.98 N/mm², 27.59 N/mm², 28.83 N/mm², and 32.49 N/mm² respectively.

The results indicate that at 3 days of age, SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers exhibits flexural strengths 476%, 714%, 759%, and 824% higher than M20 grade concrete, and 341%, 523%, 558%, and 608% higher than the SIFCON slurry matrix respectively. Similarly, at 7 days of age, SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers shows flexural strengths 401%, 492%, 539%, and 592% higher than M20 grade concrete, and 286%, 356%, 392%, and 433% higher than the SIFCON slurry matrix respectively. Furthermore, at 28 days of age, SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers demonstrates flexural strengths that are 281%, 378%, 400%, and 463% higher than M20 grade concrete, and 206%, 284%, 301%, and 352% higher than the SIFCON slurry matrix respectively. The increase in flexural strength of SIFCON produced with commercial steel fibers, compared to reference mixes, is attributed to the SIFCON slurry matrix with various percentages of fiber volume fraction.

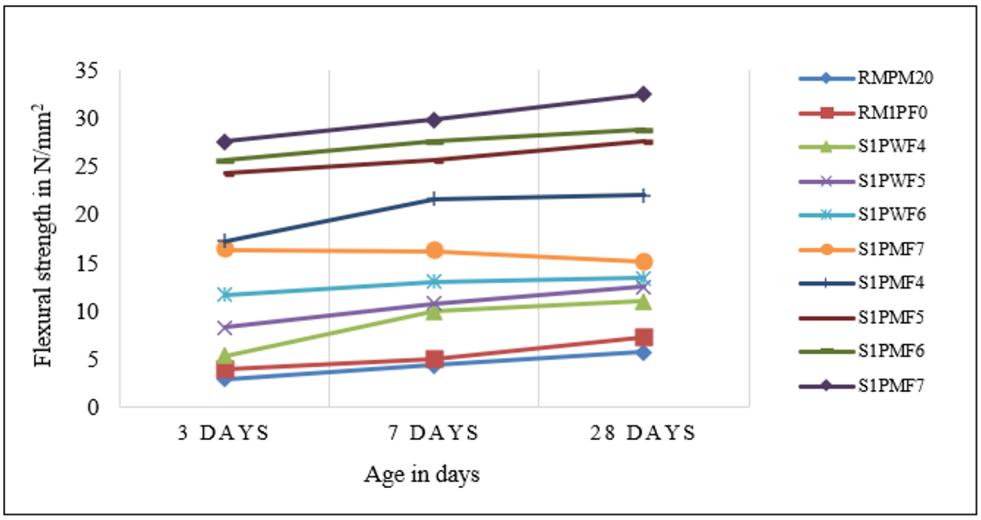


Fig. 9. Comparison of Flexural strength of SIFCON and reference mixes.

From the results, it is observed that at 3 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers exhibits flexural strengths 69%, 66%, 54%, and 41% less than SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers, respectively. Similarly, at 7 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers shows flexural strengths 54%, 58%, 53%, and 46% less than SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers, respectively. Furthermore, at 28 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers demonstrates flexural strengths that are 50%, 55%, 53%, and 54% higher than SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers, respectively. The increase in flexural strength of SIFCON produced with commercial steel fibers, compared to SIFCON produced with waste steel fibers, is attributed to the shape and aspect ratio of the waste steel fibers utilized in the experimental program.

6 Summary and Conclusions

The experimental work has been conducted in order to find out the flexural strengths of the SIFCON produced with waste steel fibers recovered from used tires and commercial steel fibers. Waste steel fibers recovered from used tires can be utilized in the production of Slurry Infiltrated Fibrous Concrete (SIFCON), despite their irregular shape and varying aspect ratios.

The slurry matrix used for the production of SIFCON exhibits flexural strengths that are 31%, 30%, and 25% higher than M20 grade concrete at 3, 7, and 28 days respectively. This increase in strength is attributed to the absence of coarse aggregate in the SIFCON slurry matrix and its richness in cementitious material.

It has been demonstrated that the flexural strength of SIFCON produced with 4% to 7% waste steel fibers increases by 90% to 161% compared to the M20 grade reference mix at the age of 28 days. Furthermore, it has been shown that the flexural strength of SIFCON produced with 4% to 7% waste steel fibers increases by 52% to 109% compared to the SIFCON slurry reference mix at the age of 28 days.

It has been demonstrated that the flexural strength of SIFCON produced with 4% to 7% commercial steel fibers increases by 281% to 463% compared to the M20 grade reference mix at the age of 28 days. Furthermore, it has been shown that the flexural strength of

SIFCON produced with 4% to 7% waste steel fibers increases by 206% to 352% compared to the SIFCON slurry reference mix at the age of 28 days.

It has been exhibited that the flexural strength of SIFCON produced with 4% to 7% waste steel fibers has a decrease of 50% to 54% with respect to SIFCON produced with 4% to 7% commercial steel fibers at the age of 28 days. The decrease in flexural strength of SIFCON produced with waste steel fibers, with respect to SIFCON produced with commercial steel fibers, is due to small fragments of rubber present on the surface of the waste steel fibers, their irregular shape, different aspect ratio, and fiber orientation.

From the experimental study, it can be mentioned that 6% of waste steel fibers with the two-layer technique is found optimal in producing SIFCON with waste steel fibers. The flexural strength of SIFCON produced with waste steel fibers recovered from used tires significantly increases compared to reference mixes and is comparable to SIFCON produced with commercial steel fibers. Waste steel fibers recovered from used tires can be effectively utilized up to a fiber volume fraction of 6% with a two-layer technique in the production of SIFCON.

It can be summarized that the waste steel fibers recovered from used tires exhibit significant variations in their geometrical properties, with lengths ranging from 3 to 73 mm and diameters from 0.14 to 0.47 mm. The dimensional diversity and bulk nature of the waste steel fibers have been shown not to be a concern in the production of SIFCON. There is a significant increase in the flexural strength of SIFCON produced with waste steel fibers, making it suitable for applications where there are flexural stresses that need to be handled. The cost-effectiveness of SIFCON elements with waste steel fibers is approximately 67% lower than that of SIFCON elements with commercial steel fibers. The multiple benefits confirm that the waste steel fibers recovered from used tires are an alternative reinforcement in the production of SIFCON.

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Experimental study on flexural strength of slurry infiltrated fibrous concrete (SIFCON) produced with various percentages of waste steel fibers recovered from used tires

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Abstract. Slurry Infiltrated Fibrous Concrete (SIFCON), a modified version of Fiber Reinforced Concrete (FRC), addresses the challenge of increased fiber volume fractions. Commercially produced steel fibers are typically used in FRC and SIFCON. Efforts to reduce energy use in making commercial steel fibers have led to seeking alternative sources. Vehicular tires are typically recycled when no longer usable, yielding steel fibers among the products. Emphasis lies in recovering steel fibers from used tires as part of resource recovery from waste. Experimental work explored flexural strength in SIFCON with waste steel fibers at volumes from 4% to 7%. The study extended to assess SIFCON's flexural strength with commercial steel fibers at similar volumes, aiming to correlate with those from waste steel fibers. M20 grade concrete and SIFCON slurry matrix specimens were cast as reference mixes for comparison. The flexural strength of SIFCON specimens with waste steel fibers recovered from used tires notably surpasses that of reference mixes and is comparable to SIFCON specimens with commercial steel fibers. Additionally, the two-layer technique proves effective in SIFCON using waste steel fibers from used tires, up to 6% volume. The test results show successful production of SIFCON from waste steel fibers recovered from used tires.

Keywords: Slurry Infiltrated Fibrous Concrete, Flexural strength, Waste steel fibers, Aspect ratio.

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1 Introduction

Globally, energy crises and their impact on the environment are significant challenges faced in the present scenario. These issues arise due to the increase in population, rapid urbanization, and the generation of substantial quantities of solid waste. The production of automobiles and trucks has significantly increased to meet the growing demand, leading to a proportional increase in the generation of waste tires. In today's modern world, the use of

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vehicles for the transportation of people and materials is steadily rising, resulting in a problem with the disposal of scrap tires at the end of their life [1, 2, 3]. Less than 40% of the embedded energy in tires that have been scrapped can be recovered as fuel energy, based upon studies [4]. The majority of discarded tires are utilized as a source of energy for cement kilns because of the high carbon content in tires [5]. It is better to embrace the concept of reusing and recycling to obtain resources from waste, which offers environmental benefits [6, 7]. Rubber recovered from scrap tires in recycling plants is used as a source of energy in industries, and the steel fibers with high strength that were extracted from scrap tires serve as raw materials for steel manufacturing plants. The focus has been made on extracting steel fibers with high strength from used tires as a concept of resource recovery from waste, reducing the need for using high-strength manufactured commercial steel fibers. Pyrolysis methods, cryogenic methods, or mechanical methods are generally employed for the recovery of rubber and steel fibers from scrap tires [8, 9]. Steel fibers extracted from used tires may not have a straight or definite aspect ratio, unlike manufactured commercial steel fibers.

It has been demonstrated that steel fibers with various aspect ratios that are extracted from used tires may be used as an alternative material while producing steel fiber-reinforced concrete. [10]. However, due to the balling effect, there is a limitation in using higher amounts of fibers in the preparation of fiber-reinforced concrete. A special form of steel fiber-reinforced concrete is Slurry Infiltrated Fibrous Concrete (SIFCON), a high-performance cementitious composite [11, 12]. The production of SIFCON is different from the conventional fiber-reinforced concrete, wherein molds are prepacked with the fibers and infiltrates the cement mortar slurry matrix. Due to the procedure of prepacking, higher amounts of fibers can be used in the manufacture of SIFCON using cement mortar slurry matrix with a low water-cement ratio, resulting in higher energy absorption or toughness compared to conventional steel fiber-reinforced concrete, as well as higher post-cracking strength. In the production of SIFCON, the fibers are placed by hand and infiltrated with a cement mortar slurry matrix, in which the balling of fibers will not be a limitation and facilitates the convenient use of the waste steel fibers extracted from scrap tires. Furthermore, waste steel fibers extracted from scrap tires are less expensive than industrial steel fibers, which is also an added advantage for SIFCON applications. Studies regarding the usage of waste steel fibers in the production of SIFCON are limited based on the available literature [13, 14, 15, 16, 17].

The maximum flexural strength of SIFCON is obtained at 9% of fiber volume with an aspect ratio of 80, and it is noted that SIFCON's flexural strength, split tensile strength, and compressive strength are optimum at 9% fiber content [18]. It is proved that the three-layer technique with hand tamping is effective in prepacking fibers in the casting of SIFCON specimens. It was observed that beyond 10% volume of hooked-end steel fibers with an aspect ratio of 70 and a length of 35 mm, the placement of fibers manually in the mold is very tedious [19]. It was shown that the compression, split tensile, and flexural strengths of SIFCON specimens will increase with an increase in the volume of the steel fiber fraction [20]. SIFCON slab specimens show superior performance in load-carrying capacity, stiffness, and energy absorption compared to fiber-reinforced concrete and plain cement concrete slab specimens in flexure [21]. Higher levels of waste fibers in SIFCON have improved its splitting and flexural strengths. However, the use of waste steel fibers had no effect on compressive strength. Waste steel fibers have the potential to be a desirable substitute in the manufacture of SIFCON, as shown by multi-objective optimization. [22]. It has been concluded adding SIFCON to regular concrete reduces the possibility of cracks spreading, improves strength, ductility, load carrying capacity, and energy absorption capability (toughness) [23].

Steel fibers are being utilized in the manufacturing of steel fiber-reinforced concrete in the construction industry. Slurry Infiltrated Fibrous Concrete (SIFCON) has been termed 'the

advanced version of Fiber-Reinforced Concrete (FRC)' due to the increased volume fraction of fibers, which contributes to improved hardened properties such as strength, toughness, and impact resistance. Generally, the fibers used in the preparation of SIFCON offer benefits similar to what reinforcing bars offer in Reinforced Cement Concrete (RCC). The improved properties of SIFCON elements depend on the type, geometry, shape, and orientation of the fibers utilized in experimental work. The main aim of this experimental work is to study the flexural strength of SIFCON, which is produced using waste steel fibers recovered from used tires.

2 Materials

2.1 Binding material

Grade 43 Ordinary Portland Cement (OPC) has been used as the binding material throughout the experimental work and conforms to Indian standards [24]. Tests were conducted on the cement used in the experimental study to determine its fineness, specific gravity, consistency, and initial-final setting times. The physical properties of the cement are shown in Table 1.

Table 1. Physical properties of Cement

Physical Properties	Test Result	Test method	Requirement
Specific gravity	3.13	IS 4031 (Part II):1988	-----
Fineness [m^2/Kg]	311.5	IS 4031 (Part II):1988	Min. 225
Normal consistency	33%	IS 4031 (Part IV):1988	-----
Initial setting time [minutes]	47	IS 4031 (Part V):1988	Min. 30
Final setting time [minutes]	252	IS 4031 (Part V):1988	Max. 600

2.2 Fine aggregate

Natural sand obtained from the riverbed has been used throughout the experimental work for the preparation of the reference mix and SIFCON specimens. However, a maximum aggregate size of 0.60 mm has been considered and used in the preparation of the SIFCON slurry matrix, and this size has been kept constant for the production of SIFCON throughout the experimental work. The fineness modulus, specific gravity, bulk density, and water absorption of the aggregates were determined according to IS codes. Table 2 shows the physical properties of the fine aggregate utilized in the experiment. However, natural sand obtained from the riverbed, conforms to Indian standards has been used fine aggregate in the preparation of M20-grade concrete.

Table 2. Fine Aggregate Test Results

Type of Test	Fine Aggregate
Fineness Modulus [%]	2.80
Specific Gravity	2.65
Water Absorption [%]	0.25
Bulk density [kg/m^3]	1750

2.3 Coarse aggregate

The maximum size of 20 mm obtained from the granite quarry, which conforms to Indian standards, has been used as coarse aggregate in the preparation of M20-grade concrete in the experimental work.

2.4 Mixing water

The laboratory's potable water has been utilized for mixing the SIFCON slurry matrix, reference mix, and curing of the specimens.

2.5 Chemical admixture

To achieve the necessary workability and flowability of the SIFCON slurry matrix, a high-range water-reducing admixture (superplasticizer) of polycarboxylic ether has been used. Manufacturer's data have been considered for the chemical admixture used in the study. Properties of the superplasticizer, i.e., AURAMIX 450 from M/s. FOSROC Chemicals, are shown in Table 3.

Table 3. Characteristics of Super plasticizer (AURAMIX 450)

Appearance	Light yellow colour liquid
pH value	Minimum 6.0
Volumetric mass @ 20°C	1.09 to 1.11
Chloride Content	Nil

2.6 Steel fibers

A survey was conducted to obtain waste steel fibers from used tires. Fibers recovered from scrap tires through a mechanical process at the recycling plant were used in this experimental study for preparing the SIFCON specimens. In the tire recycling plant, initially, collected scrap tires are shredded into small pieces using industrial shredders. After shredding, the tire pieces undergo a process called magnetic separation, in which powerful magnets are used to attract and separate the steel fibers from the shredded rubber. The shredded material is then passed through screens or filters to further separate any remaining steel fibers from the rubber particles. The steel fibers obtained from the recycling plants contained a small quantity of textiles and rubber fragments, which were manually removed to the extent possible before being used in the preparation of SIFCON. The waste steel fibers obtained from the recycling plant are irregular in shape. Waste steel fibers recovered from the used tires utilized in the study were tested to determine the diameter, length, aspect ratio, etc. Fig. 1 displays the waste steel fibers chosen for the experimental program. The length and diameter of the waste steel fibers, measured on randomly selected fibers, are shown in Table 4. Furthermore, round crimped steel fibers have been used as the commercial steel fibers in the experimental work. Manufacturer's data have been considered for the commercial steel fibers used in the study and are shown in Table 5. Fig. 2 displays the commercial steel fibers that were selected for the experiment.



Fig. 1. Waste steel fibers recovered from used tires.



Fig. 2. Commercial steel fibers.

Table 4. Properties of waste steel fibers

Diameter of Fiber [mm]	Length of Fiber [mm]	Average Aspect ratio	Contribution of Fibers (% by weight)
0.15 ± 0.01	26 ± 23	173	9.70 %
0.19 ± 0.01	13 ± 2	68	3.20 %
0.27 ± 0.02	37 ± 17	137	11.30 %
0.31 ± 0.01	45 ± 28	145	46.80 %
0.34 ± 0.01	30 ± 15	88	11.30 %
0.39 ± 0.03	46 ± 19	118	12.90 %
0.46 ± 0.01	68 ± 4	148	4.80 %

Table 5. Properties of commercial steel fibers

Type	Crimped
Diameter	0.45 mm
Length	35 mm
Aspect ratio (l/d)	78
Tensile Strength	1260 MPa

3 Methodology

M20 grade concrete was designed in accordance with the guidelines specified in Indian Standards. [25]. The proportions of ingredients for the M20 grade concrete are presented in Table 6.

Table 6. Mix proportions of M20 grade design mix concrete

	Water	Cement	Fine Aggregate	Coarse Aggregate	20 mm CA	10 mm CA
By Weight [kg]	160	320	667	1131	679	452
By Volume [m^3]	0.50	1	2.08	3.53	2.12	1.41

A flow test was conducted using a mini flow cone, as recommended by EFNARC [26]. The mini flow cone measures 60 mm in height, 70 mm in the top inner dimension, and 100 mm in base inner dimension. The equipment used in this study for the mini flow test is shown in Fig. 3. The SIFCON slurry was poured into the mold, lifted, and the spread diameter of the slurry matrix was measured. The slump flow ranged between 240 mm and 260 mm, in accordance with the guidelines stipulated in EFNARC [26]. Another test conducted on the fresh SIFCON slurry matrix is the mini v-funnel test. Fig. 3 illustrates the dimensions and form of the equipment utilized in this study. The SIFCON slurry was poured into the test equipment, and the time to empty the equipment was measured. The time to empty the test equipment ranged from 7 seconds to 11 seconds, in accordance with the guidelines stipulated in EFNARC [26].

Fresh tests, as described above, have been conducted using cement and fine aggregate in the proportion of 1:1, with a water-cement ratio varying from 0.30 to 0.40 in increments of 0.01 and superplasticizer from 0.50% to 2.00% by weight of cement, in increments of 0.1%. The procedures for the flow test and mini v-funnel tests are shown in Fig. 4 and Fig. 5, respectively. After detailed test trials, it was decided to use the SIFCON slurry matrix with a proportion of 1:1 (cement: fine aggregate) using a water-cement ratio of 0.33 and a superplasticizer content of 0.80% by weight of cement. The mix proportion of the SIFCON slurry matrix is provided in Table 7.

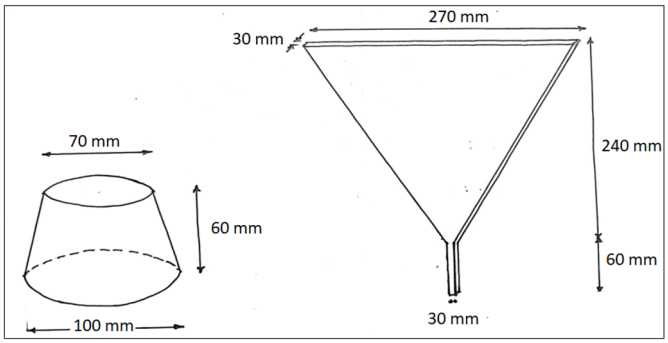


Fig. 3. Equipment for mini slump and v-funnel tests.



Fig. 4. Mini slump test.



Fig. 5. Mini v-funnel test.

Table 7. Mix proportion of SIFCON slurry matrix

Cement	Fine aggregate	W/C ratio	Super plasticizer
1	1	0.33	0.80 % by weight of cement

Upon finalizing the ratio of the SIFCON slurry matrix, the production process for SIFCON is as follows: The molds used for specimen production will be cleaned and coated with waste oil to facilitate easy demolding. Cement and fine aggregate, in a 1:1 proportion, are to be dry mixed. Subsequently, water and superplasticizer, as per the finalized ratios, are to be added to the dry mix. The total slurry must be mixed for a minimum of 2 minutes to ensure proper mixing of the slurry matrix.

A two-layer technique is employed for filling the fibers in the molds to ensure proper compaction and prevent honeycombing. Accordingly, 50% of the volume fraction of fibers is randomly hand-spread as the first layer in the mold. Once the first layer is in place, the prepared SIFCON slurry matrix is poured onto the fiber bed and compacted using hand tamping and a table vibrator.

Subsequently, a second layer of fibers is also randomly spread, followed by pouring of the SIFCON slurry matrix and compaction. The cast samples are left for 24 hours at room temperature. On completion of this time, the samples are demolded and placed in a curing chamber for the designated curing periods. Difficulties were encountered during the production of SIFCON specimens with a 6% volume fraction of steel fibers due to the irregular shape of waste steel fibers and their random placement. In consideration of this, a three-layer technique has been employed for the production of SIFCON specimens with 7% steel fibers. Fig. 6 depicts the production process of the SIFCON.

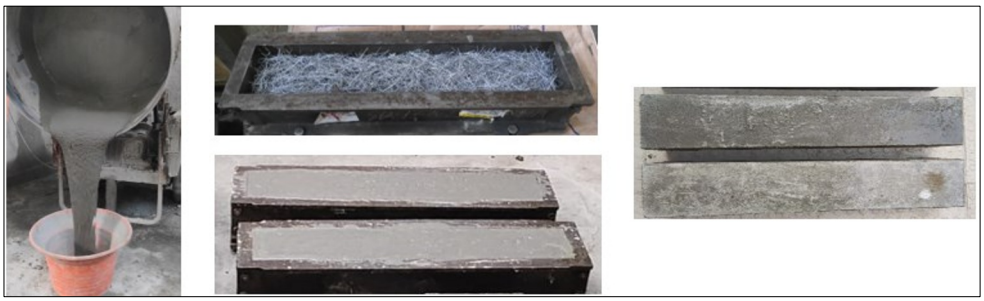


Fig. 6. Production process of SIFCON.

4 Experimental Programme

Flexural elements of 100x100x500 mm, with various volume percentages of waste steel fibers, commercial steel fibers, and reference elements, are casted. The quantity of fiber content used in the preparation of SIFCON specimens, corresponding to 4%, 5%, 6%, and 7% of the concrete volume, is 314 kg/m^3, 392.50 kg/m^3, 471 kg/m^3, and 549.50 kg/m^3, respectively. The designations for the specimens are provided in Table 8.

Table 8. Designation of specimens.

Type of Prism	Cross Section [mm]	Steel fibers		No. of speci-men	Designation
		Type	Vol.		
M 20 grade	100x100x500	----	----	9	RMPM20-1 to RMPM20-9
SIFCON slurry	100x100x500	----	0%	9	RMPF0-1 to RMPF0-9
SIFCON with fibers	100x100x500	Waste steel fibers	4%	9	S1PWF4-1 to S1PWF4-9
			5%	9	S1PWF5-1 to S1PWF5-9
			6%	9	S1PWF6-1 to S1PWF6-9
			7%	9	S1PWF7-1 to S1PWF7-9
SIFCON with fibers	100x100x500	Commer-cial steel fibers	4%	9	S1PMF4-1 to S1PMF4-9
			5%	9	S1PMF5-1 to S1PMF5-9
			6%	9	S1PMF6-1 to S1PMF6-9
			7%	9	S1PMF7-1 to S1PMF7-9

All specimens were tested for flexural strength using two-point loading. The universal testing machine has been used for testing the specimens, and the tests were carried out in accordance with the procedures outlined in IS: 516-1959. Fig. 7 depicts the test setup of the flexural strength. At the ages of 3, 7, and 28 days, tests were performed on the specimens. All necessary safety precautions have been followed during testing of the specimens.



Fig. 7. Test setup of flexural strength.

5 Results and Discussions

In Table 9, the flexural strength results of SIFCON specimens at 3, 7, and 28 days of age, produced with various percentages of waste and commercial steel fibers and the reference mixes, are displayed.

Table 9. Flexural strength of specimens

Sl. No.	Type of Specimen	Steel Fibers		Specimen designation	Average Flexural strength [N/mm^2]		
		Type	Per-centage		3 days	7 days	28 days
I	M20 grade prism	----	----	RMPM20	2.98	4.32	5.77
II	SIFCON slurry prism	----	0 %	R1MPF0	3.89	5.61	7.19
III	SIFCON prism	Waste steel fibers	4 %	S1PWF4	5.33	9.95	10.96
IV	SIFCON prism		5 %	S1PWF5	8.24	10.77	12.52
V	SIFCON prism		6 %	S1PWF6	11.66	12.97	13.42
VI	SIFCON prism		7 %	S1PWF7	16.33	16.21	15.04
VII	SIFCON prism	Commer-cial steel fibers	4 %	S1PMF4	17.17	21.64	21.98
VIII	SIFCON prism		5 %	S1PMF5	24.24	25.58	27.59
IX	SIFCON prism		6 %	S1PMF6	25.59	27.60	28.83
X	SIFCON prism		7 %	S1PMF7	27.53	29.91	32.49

From Table 9 and Fig. 8, it is observed that the average flexural strength of the M20 grade reference mix and the SIFCON slurry matrix at 3 days is 2.98 N/mm^2 and 3.89 N/mm^2 respectively. Additionally, at 7 days, the average flexural strength of the M20 grade reference mix and the SIFCON slurry matrix is 4.32 N/mm^2 and 5.61 N/mm^2 respectively. Furthermore, at 28 days, the average flexural strength of the M20 grade reference mix and the SIFCON slurry matrix is 5.77 N/mm^2 and 7.19 N/mm^2 respectively. The higher difference in flexural strength in the SIFCON slurry matrix is due to the increased amount of binding material and the absence of coarse aggregate.

From Table 9 and Fig. 8, it is observed that the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% waste steel fibers at 3 days is 5.33 N/mm², 8.24 N/mm², 11.66 N/mm², and 16.33 N/mm² respectively. Similarly, the average flexural strength of SIFCON with the same fiber percentages at 7 days is 9.95 N/mm², 10.77 N/mm², 12.97 N/mm², and 16.21 N/mm² respectively. Furthermore, at 28 days, the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% waste steel fibers is 10.96 N/mm², 12.52 N/mm², 13.42 N/mm², and 15.04 N/mm² respectively.

The results indicate that at 3 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers exhibits flexural strengths 79%, 177%, 291%, and 448% higher than M20 grade concrete, and 37%, 112%, 200%, and 320% higher than the SIFCON slurry matrix respectively. Similarly, at 7 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers shows flexural strengths 130%, 149%, 200%, and 275% higher than M20 grade concrete, and 77%, 92%, 131%, and 189% higher than the SIFCON slurry matrix

respectively. Furthermore, at 28 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers exhibits flexural strengths 90%, 117%, 133%, and 161% higher than M20 grade concrete, and 52%, 74%, 87%, and 109% higher than the SIFCON slurry matrix respectively. The increase in flexural strength of SIFCON produced with waste steel fibers, compared to reference mixes, is attributed to the SIFCON slurry matrix with various percentages of fiber volume fraction.

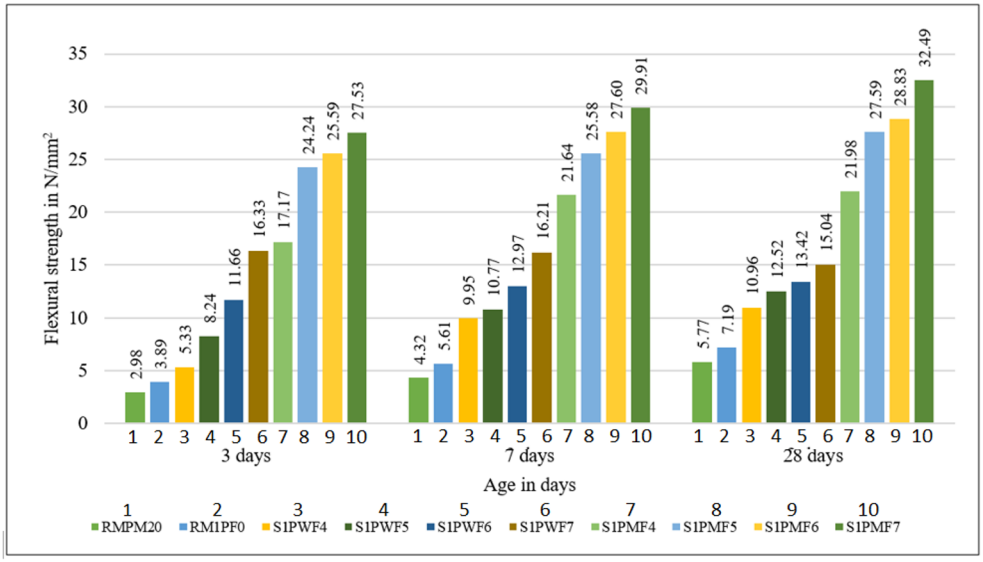


Fig. 8. Comparison of Flexural strength of SIFCON and reference mixes.

From Table 9 and Fig. 8, it is observed that the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% commercial steel fibers at 3 days is 17.17 N/mm², 24.24 N/mm², 25.59 N/mm², and 27.53 N/mm² respectively. Similarly, the average flexural strength of SIFCON with the same fiber percentages at 7 days is 21.64 N/mm², 25.58 N/mm², 27.60 N/mm², and 29.91 N/mm² respectively. Furthermore, at 28 days, the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% commercial steel fibers is 21.98 N/mm², 27.59 N/mm², 28.83 N/mm², and 32.49 N/mm² respectively.

The results indicate that at 3 days of age, SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers exhibits flexural strengths 476%, 714%, 759%, and 824% higher than M20 grade concrete, and 341%, 523%, 558%, and 608% higher than the SIFCON slurry matrix respectively. Similarly, at 7 days of age, SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers shows flexural strengths 401%, 492%, 539%, and 592% higher than M20 grade concrete, and 286%, 356%, 392%, and 433% higher than the SIFCON slurry matrix respectively. Furthermore, at 28 days of age, SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers demonstrates flexural strengths that are 281%, 378%, 400%, and 463% higher than M20 grade concrete, and 206%, 284%, 301%, and 352% higher than the SIFCON slurry matrix respectively. The increase in flexural strength of SIFCON produced with commercial steel fibers, compared to reference mixes, is attributed to the SIFCON slurry matrix with various percentages of fiber volume fraction.

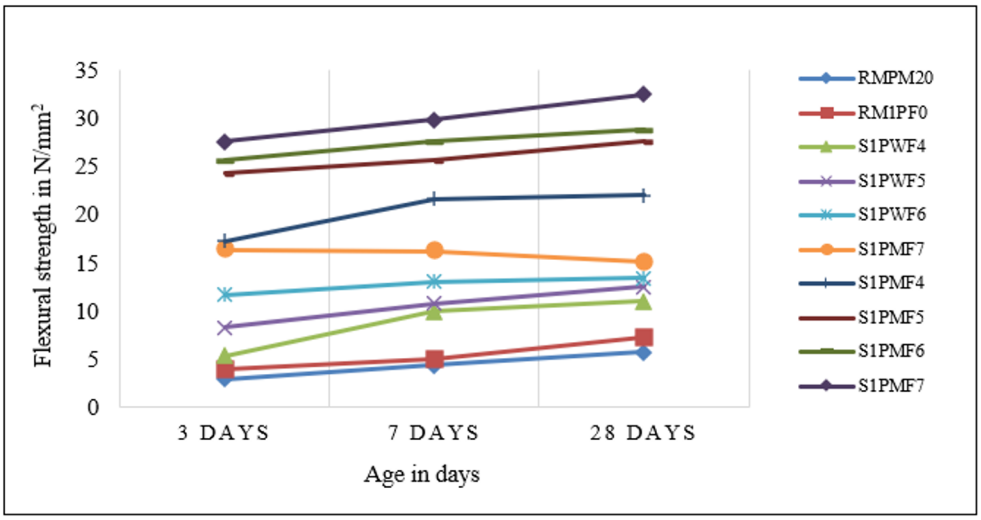


Fig. 9. Comparison of Flexural strength of SIFCON and reference mixes.

From the results, it is observed that at 3 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers exhibits flexural strengths 69%, 66%, 54%, and 41% less than SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers, respectively. Similarly, at 7 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers shows flexural strengths 54%, 58%, 53%, and 46% less than SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers, respectively. Furthermore, at 28 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers demonstrates flexural strengths that are 50%, 55%, 53%, and 54% higher than SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers, respectively. The increase in flexural strength of SIFCON produced with commercial steel fibers, compared to SIFCON produced with waste steel fibers, is attributed to the shape and aspect ratio of the waste steel fibers utilized in the experimental program.

6 Summary and Conclusions

The experimental work has been conducted in order to find out the flexural strengths of the SIFCON produced with waste steel fibers recovered from used tires and commercial steel fibers. Waste steel fibers recovered from used tires can be utilized in the production of Slurry Infiltrated Fibrous Concrete (SIFCON), despite their irregular shape and varying aspect ratios.

The slurry matrix used for the production of SIFCON exhibits flexural strengths that are 31%, 30%, and 25% higher than M20 grade concrete at 3, 7, and 28 days respectively. This increase in strength is attributed to the absence of coarse aggregate in the SIFCON slurry matrix and its richness in cementitious material.

It has been demonstrated that the flexural strength of SIFCON produced with 4% to 7% waste steel fibers increases by 90% to 161% compared to the M20 grade reference mix at the age of 28 days. Furthermore, it has been shown that the flexural strength of SIFCON produced with 4% to 7% waste steel fibers increases by 52% to 109% compared to the SIFCON slurry reference mix at the age of 28 days.

It has been demonstrated that the flexural strength of SIFCON produced with 4% to 7% commercial steel fibers increases by 281% to 463% compared to the M20 grade reference mix at the age of 28 days. Furthermore, it has been shown that the flexural strength of

SIFCON produced with 4% to 7% waste steel fibers increases by 206% to 352% compared to the SIFCON slurry reference mix at the age of 28 days.

It has been exhibited that the flexural strength of SIFCON produced with 4% to 7% waste steel fibers has a decrease of 50% to 54% with respect to SIFCON produced with 4% to 7% commercial steel fibers at the age of 28 days. The decrease in flexural strength of SIFCON produced with waste steel fibers, with respect to SIFCON produced with commercial steel fibers, is due to small fragments of rubber present on the surface of the waste steel fibers, their irregular shape, different aspect ratio, and fiber orientation.

From the experimental study, it can be mentioned that 6% of waste steel fibers with the two-layer technique is found optimal in producing SIFCON with waste steel fibers. The flexural strength of SIFCON produced with waste steel fibers recovered from used tires significantly increases compared to reference mixes and is comparable to SIFCON produced with commercial steel fibers. Waste steel fibers recovered from used tires can be effectively utilized up to a fiber volume fraction of 6% with a two-layer technique in the production of SIFCON.

It can be summarized that the waste steel fibers recovered from used tires exhibit significant variations in their geometrical properties, with lengths ranging from 3 to 73 mm and diameters from 0.14 to 0.47 mm. The dimensional diversity and bulk nature of the waste steel fibers have been shown not to be a concern in the production of SIFCON. There is a significant increase in the flexural strength of SIFCON produced with waste steel fibers, making it suitable for applications where there are flexural stresses that need to be handled. The cost-effectiveness of SIFCON elements with waste steel fibers is approximately 67% lower than that of SIFCON elements with commercial steel fibers. The multiple benefits confirm that the waste steel fibers recovered from used tires are an alternative reinforcement in the production of SIFCON.

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Solar P V system analysis in different configurations

The rapid emergence and evolution of renewable energy sources such as solar energy has become a vital component of the global effort to meet the energy needs of the future. The major concerns for continuous solar photovoltaic (PV) generation are partial shading conditions (PSC's), Hotspots, Degradation Rate, Bifacial PV Panels etc. These factors leads to increase in PV mismatch losses, decrease in fill factor and efficiency. One of the simplest solutions is the PV configurations. Hence in this book Series Parallel (SP), Bridge Link (BL), Triple Tied (TT) and Spider Web Tie (SWT) configurations are implemented on KC200GT 200 W PV system. Impact of Various factor such as Partial Shaded Conditions, Hotspots, Degradation Rate, Bifacial PV Panels are analysed. Optimal SMA and PSO MPPT Controller are evaluated for all SP, BL, TT and SWT configurations. The effectiveness of the Spider Web Tie (SWT) Configuration is evaluated in comparison with Series/Parallel (SP), Bridge-Link (BL), Triple-Tied (TT) configurations.

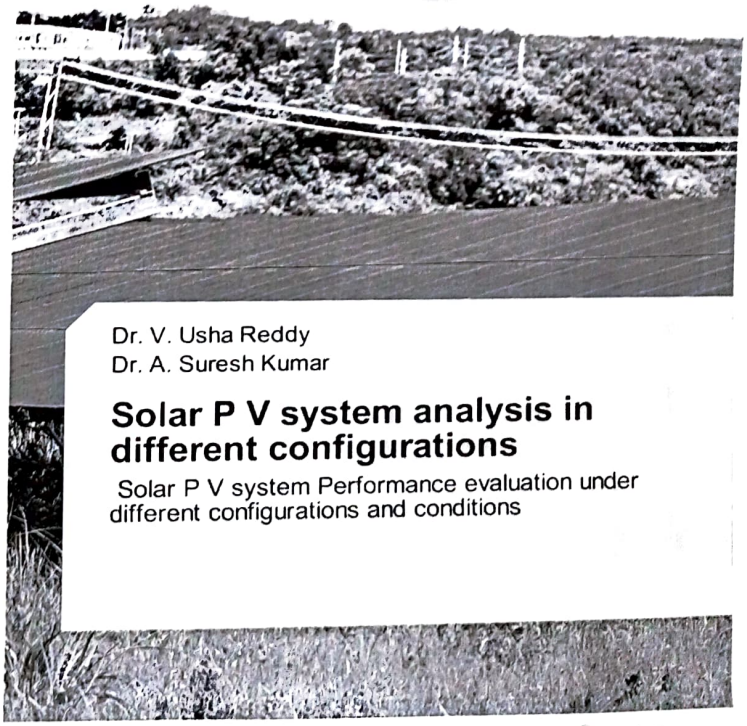
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Solar P V system analysis in different configurations

Solar P V system Performance evaluation under different configurations and conditions

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A study on the effect of NaOH molarity on flyash based self compacting geopolymer concrete

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ABSTRACT

The concrete industry has consistently pushed for sustainable development. This investigation aims to examine the characteristics of flyash-based self-compacting geopolymer concrete (SCGPC) made with varying NaOH molarities both while it is fresh and when it has hardened. The NaOH molarity is varied from 8 M to 16 M at an interval of 2 M. Sodium silicate (Na_2SiO_3) to sodium Hydroxide (NaOH) is kept at a constant ratio of 2. For the geopolymer process, the alkaline solution to Binder ratio (L/B) was kept at 0.45. Fresh properties like Slump flow, T_{50cm} slump flow, L-Box and V-funnel have been done to assess the fresh properties of flyash based SCGPC confirming to EFNARC guidelines. Mechanical Strength properties such as Compressive, split-tensile, and flexural strength of the flyash based SCGPC were also determined at various ages. Prior to testing, all specimens are cured under ambient curing. Results indicate that the hardened properties of flyash based SCGPC are enhanced by the increase in molarity from 8 M to 16 M. Furthermore, as the molarity tends to rise, it is shown that the fresh properties slightly decrease.
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1. Introduction

Concrete is one of the most widely utilised building materials in the globe. It is the next commonest used resource in communities worldwide after water [1]. It is normally produced using ordinary Portland cement (OPC), that consumes a lot of energy and releases an equal amount of carbon dioxide (CO_2) into the atmosphere [2]. As a result of this carbon dioxide emission, the greenhouse effect increases, causing global warming. Davidovits developed geopolymer concrete, which totally replaces cement with industrial by-products [3]. Industrial waste materials possessing a high alumina and silica content, such as flyash, metakaolin, GGBS, etc., are polymerized to manufacture geopolymer concrete. Through polycondensation, these aluminosilicate compounds become a dimensionally stable structure at low temperatures [4 5]. Fresh concrete must be compacted and placed in the formwork by skilled workers. To achieve a uniform mix with no voids (honey-comb), this compaction principally attempts to reduce the entrapped air within freshly laid concrete. Normal vibrating concrete might not be able to display the necessary fresh and hardened qualities once the concrete is being poured and compacted at the construction area. Skilled work is necessary to achieve proper compaction in freshly mixed concrete. Introducing self-compacting concrete (SCC) stands one way to solve this issue [6 7]. Modern concrete that could compact under its own weight in deep, narrow segments that are heavily reinforced to fill the formwork is known as self-compacting concrete (SCC)[8]. This study examines how the properties of flyash-based SCGPC are influenced by the molarity of sodium hydroxide in both the fresh and hardening states.

2. Materials

2.1. Flyash

In the present investigation, Class – F flyash is used which is collected from Rayalaseema Thermal Power Plant (RTTP), Kadapa, India. Flyash is confirming to IS: 3812:2003 [9]. The flyash has a specific gravity of 2.24. It has Blaine's fineness about 310 m^2/kg. Table 1 provides information on the chemical composition of fly ash.

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Table 1
Chemical Composition of Flyash.

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	SO_3	L.O. I	K_2O	Na_2O
Flyash (%)	65.60	20.86	4.98	1.0	0.55	0.5	0.2	0.16	0.82	0.20

2.2. Alkaline activation solution

In the current investigation, sodium hydroxide and sodium silicate solutions are employed to produce alkaline activators. While the ratios of sodium silicate to sodium hydroxide (Na_2SiO_3/NaOH) was kept at 2, the sodium hydroxide solution molarity (NaOH) is altered from 8 M to 16 M. To reduce the amount of heat created during the mixing procedure, the prepared alkaline solution is given 24 h to cool and mature.

2.3. Aggregates

In the current study, all of these flyash-based SCGPC mixtures contained fine aggregate made of natural river sand from the Tungabhadra River bed and a coarse aggregate of 12.5 mm downsize. Both the jelly and river sand are available locally. The used fine aggregate and coarse aggregate had specific gravities of 2.60 and 2.64, respectively. In accordance with the results of the sieve analysis, the fine and coarse aggregates utilised in this work both meet the requirements of IS: 383–1970 [10 11].

2.4. Superplasticizer

The Master Glenium series superplasticizer was utilised in the current investigation. It is a modified polycarboxilic ether-based admixture. It was created to improve the qualities of newly-poured and hardened high performance concrete. Given that it is free of chlorides and alkalis, it is suitable with all types of cement. Since it is devoid of chlorides and alkali, it can be used with any type of cement. Its relative density is approximately 1.09, in accordance with IS 9103:1999 [12].

3. Mix design of flyash based self compacting geopolymer concrete

Flyash based SCGPC mix design is solely distinct from cement concrete. The trial-and-error process was employed to produce flyash based SCGPC mix. Five flyash based SCGPC mixes were made by raising the molarity of Sodium Hydroxide (NaOH) solution from 8 M until16M. The total binder content was fixed at 496.55 kg/m^3, and the Liquid-to-binder (L/B) mass ratio was kept at 0.45. In line with the binder's molarities by mass, as stated in Table 2, a superplasticizer (S.P.) content of 1.5% and additional water content were used.

3.1. Mixing, casting and curing

In the pan mixer, the dry components of flyash based SCGPC i.e., fine aggregate, coarse aggregate and flyash were mixed about 2–3 mins. Then the liquid portion of the mixture i.e., The NaOH along with Na_2SiO_3 solution is mixed in the proportion of 1:2 (by weight) to produce alkali activator fluid. Super Plasticizer and Water are added at last for the perfect blending of flyash based SCGPC[5]. These all materials are allowed to mix for another 2–3 min. The newly mixed fresh concrete was examined for fresh flowability properties before being placed into the moulds. Prior to testing, all specimens are stored at room temperature (27 ± 2 °C).

3.2. Testing methods

3.2.1. Fresh properties

The fresh properties of flyash-based SCGPC mixes are assessed using slump flow, T_{50cm} slump flow, L-box, and V-funnel tests. The filling capacity of new concrete was determined by using slump flow test. The T_{50cm} slump flow test was used to determine a mixture's filling capacity by measuring how long it took for the mixture to expand to a diameter of 50 cm. The L-box test was used to determine whether concrete could withstand the reinforcement. The concrete heights at the horizontal component's (H_2) and the vertical section's (H_1) leading ends are measured for the L-box test. The viscosity and filling capacity of the concrete were evaluated using the V-funnel test. Each test was performed in compliance with the recommendations of the EFNARC [13].

3.2.2. Mechanical properties

Using the IS 516 (1959), IS 5816 (1999), and IS 516 (1959) standards, the compressive strength, split tensile strength, and flexure strength were assessed [14 15]. The cube compression, flexural strength and splitting tensile strengths of the flyash-based SCGPC were evaluated using three 150 mm × 150 mm cubes, three 500 mm × 150 mm prisms and three 150 mm × 300 mm cylinders.

4. Results and discussion

4.1. Slump flow and T_{50cm} slump flow test

Table 3, Fig. 1 and Fig. 2 clearly show the values for the rheological properties (slump flow values and T_{50cm} slump flow) of flyash based SCGPC mixes. The slump flow values and T_{50cm} slump flow for flyash based SCGPC mixes were in the ranging of 690 to 720 mm and 2.3 to 3.51 sec, respectively. At 8 M the maximum slump was measured, and the lowest slump was measured at 16 M. When the level of NaOH concentration was increased from

Table 2
Mix proportions for flyash based self compacting geopolymer concrete.

Mix designation	Molarity	Fly Ash (Kg/m^3)	F.A (Kg/m^3)	C.A (Kg/m^3)	NaOH Pellets (Kg)	Water (lit)	NaOH (Kg/m^3)	Na_2SiO_3 (Kg/m^3)	SP (%)	Extra Water Added (%)
M1	8 M	496.55	756	924	19.52	54.98	74.5	148.9	1.5	12
M2	10 M	496.55	756	924	22.12	52.06	74.5	148.9	1.5	12
M3	12 M	496.55	756	924	26.89	47.6	74.5	148.9	1.5	12
M4	14 M	496.55	756	924	29.87	44.62	74.5	148.9	1.5	12
M5	16 M	496.55	756	924	33.07	41.45	74.5	148.9	1.5	12

Table 3
Fresh Properties of flyash based SCGPC mixes.

S.No.	Mix Designation	Molarity	Slump Flow	T_{50} cm Slump flow	V-funnel	L-box
1	M1	8 M	720	2.3	7.5	0.95
2	M2	10 M	715	2.49	7.8	0.91
3	M3	12 M	710	3.06	7.9	0.89
4	M4	14 M	695	3.2	8.2	0.86
5	M5	16 M	690	3.51	8.4	0.84

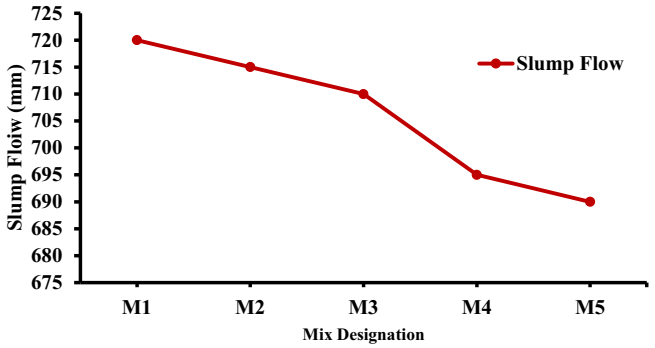


Fig. 1. Variation of Slump flow with different Sodium Hydroxide solution molarities.

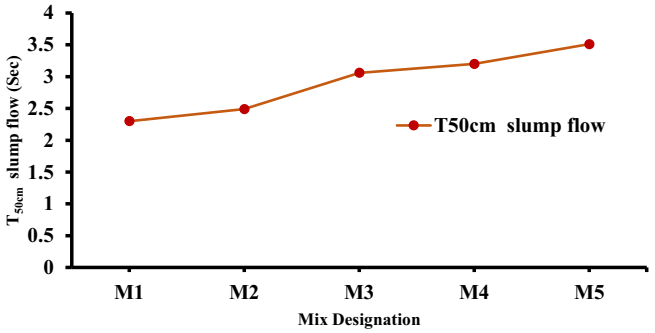


Fig. 2. Variation of T_{50cm} slump flow with different Sodium Hydroxide solution molarities.

8 M to 16 M, the slump flow was found to be reduced. All of the mixes constituted with higher molarity concentrations had lower slump flows. High T_{50cm} slump flow readings were also a result of a higher NaOH molar content. It has been observed that as the NaOH concentration rises, the slump value gradually decreases. This might be caused by the alkaline activator solution's high viscosity [16 17]. All mixes, however, conformed with the EFNARC, 2002[13].

4.2. V-funnel test

Table 3 tabulates the time taken for the V-funnel test and presented in Fig. 3, which shows that the time rose from 7.5 to 8.4 sec. As the concentration of NaOH rose from 8 M to 16 M, All V-funnel values were found to be less than 12 s and within the range of EFNARC, 2002.[13].As the amount of sodium hydroxide in the solution rises, so does its viscosity. Flyash-based self-compacting geopolymer concrete's flowability reduced as sodium concentration rose. As a result, the flow period of the V-funnel was extended.

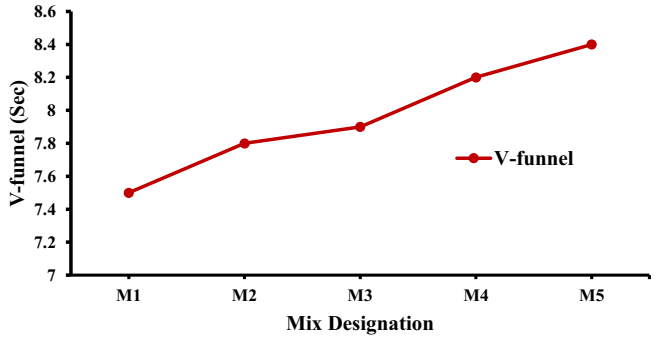


Fig. 3. Variation of V-funnel with different Sodium Hydroxide solution molarities.

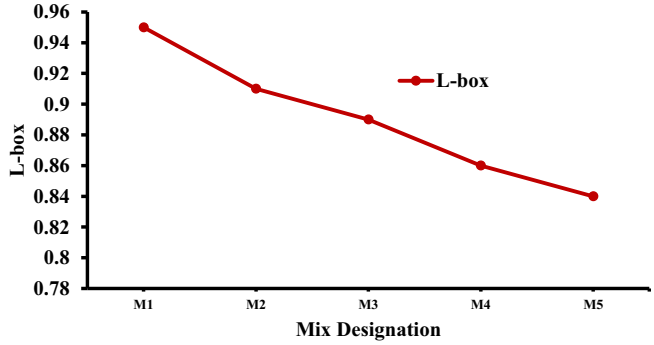


Fig. 4. Variation of L-Box with different Sodium Hydroxide solution molarities.

4.3. L-box test

The passing-ability (L-box) values are presented in Table 3 and Fig. 4. The results indicate that, regardless of the sodium hydroxide concentration, all flyash-based SCGPC mixes satisfied the L-Box ratio requirements of EFNARC [13]. The ratio of L-box dramatically declines with increased sodium hydroxide solution concentrations, as indicated in Table 3. For different concentrations of Sodium Hydroxide between 8 M and 16 M, the L-Box values varied from 0.95 to 0.84, respectively. The L-Box test results from the previous researchers' studies of three different sodium hydroxide solution concentrations (8 M, 10 M, and 12 M) in SCGPC combinations were very similar [16]. It was noticed that the L-Box values significantly decreased when sodium hydroxide concentration and molarity increased.

4.4. Compressive strength test

The results of the compressive strength test are listed in Table 4 and Fig. 5 shows how, after 7,28 days, the molarity of the NaOH solution influenced the compressive strength of the flyash-based SCGPC. The test findings demonstrated that the molarity of the sodium hydroxide solution has a significant impact on the flyash-based self-compacting geopolymer concrete. The flyash-based

Table 4
Hardened Properties of flyash based SCGPC mixes.

S.No.	Mix Designation	Molarity	Compressive Strength (MPa)		Split Tensile Strength (MPa)	Flexural Strength (MPa)
			7 days	28 days		
1	M1	8 M	17.15	25.74	2.56	3.22
2	M2	10 M	19.34	28.56	2.79	3.52
3	M3	12 M	22.34	31.94	3.12	4.05
4	M4	14 M	22.84	33.63	3.29	4.12
5	M5	16 M	23.33	34.9	3.42	4.22

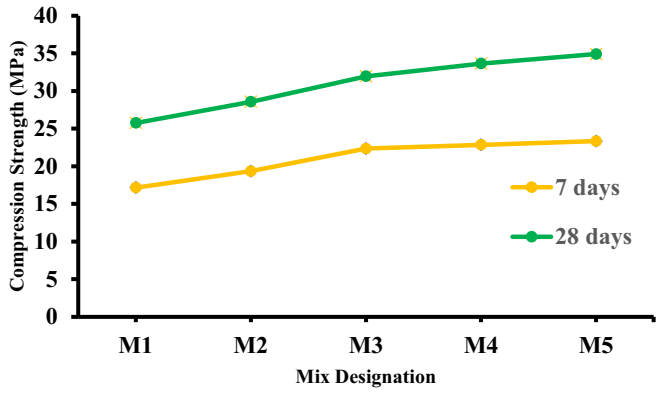


Fig. 5. Effect of NaOH solution molarity on Compressive Strength of SCGPC.

SCGPC gets harder when NaOH molar concentration rises from 8 Molarity to 16 Molarity. At 28 days, the combination with 16 M showed the highest compressive strength (34.9 MPa). When compared to flyash based SCGPC mix of 8 M, compressive strength increased by 10.95%, 24.08%, 30.65%, and 35.58%, respectively, for flyash based SCGPC mixes of 10 M, 12 M, 14 M, and 16 M. This might be the case because raising the molarity of NaOH enhances the pace at which aluminosilicate minerals dissolve, which enhances the geopolymerization process. This improvement in compressive strength characteristics is consistent with a number of previous research [18].

4.5. Split tensile strength test

Fig. 6 and Table 4 depicts the flyash-based SCGPC's split tensile strength test outcomes after 28 days. This graph clearly illustrates that as the molarity of the sodium hydroxide solution increases, the split tensile strength of the flyash-based SCGPC also increases. When compared to flyash-based SCGPC mix of 8 M, the improvement in split tensile strength is approximately 8.98%, 21.87%, 28.51%, and 33.59% for mixtures of 10 M, 12 M, 14 M, and 16 M, respectively. The split tensile test results validate the behaviour of the compressive strength test results.

4.6. Flexure strength test

At 28 days after casting, the results of the flexural strength test for the flyash-based SCGPC are displayed in Fig. 7 and Table 4. This graph unequivocally demonstrates that the flyash-based SCGPC's flexural strength increases as the molarity of the sodium hydroxide solution rises. Flyash-based SCGPC mixes of 10 M, 12 M, 14 M, and 16 M each had an increase in flexural strength of about 9.31%, 25.77%, 27.95%, and 31.05% when compared to flyash-based SCGPC mixes of 8 M. The behaviour of the compressive strength test findings is complemented by the flexural strength test results.

4.7. Effect of NaOH solution molarity

The workability of the mixture is found to be significantly reduced by a molarity rise. This is due to the alkaline activators (NaOH and Na_2SiO_3) greater viscosity in comparison to water. The viscosity of the NaOH solution increased as the molarity of NaOH increased. Additionally, the decrease in water levels caused by raising the molarity of NaOH lowers the workability of SCGPC. Increased sodium hydroxide solution concentrations hasten the polymeric reaction, which decreases workability by expediting the setting and hardening process [19]. This may also be because flyash based SCGPC that was sticky and cohesive was produced when the little fly ash particles were combined with viscous alkaline activators. Similar findings were reported by the previous researchers [20,21].

5. Conclusions

1. Flyash based SCGPC blends made by varying NaOH solution concentrations varying from 8 M to 16 M has achieved the desired fresh properties confirming to EFNARC guidelines[13].

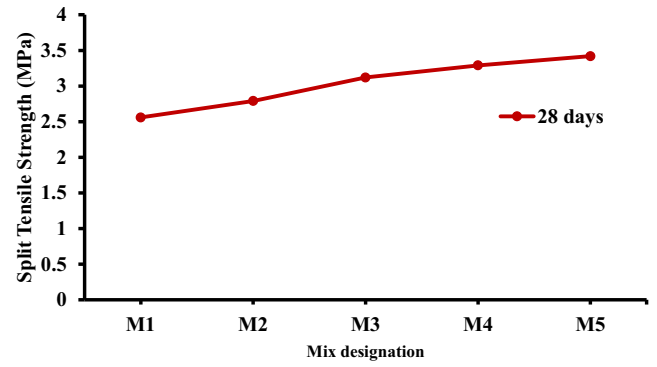


Fig. 6. Variation of Split Tensile Strength w.r.t different Molarities.

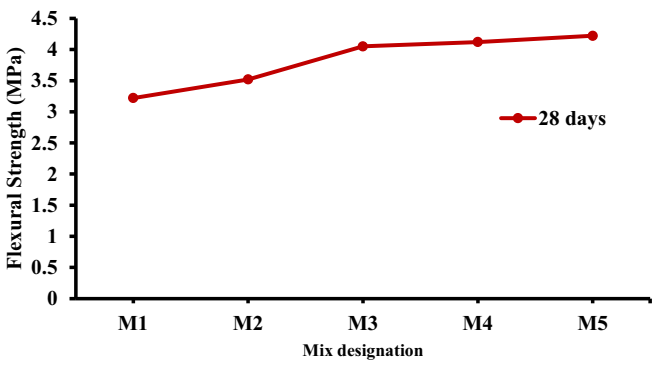


Fig. 7. Variation of Flexural Strength w.r.t different Molarities.

2. The molarity of the NaOH solution had a substantial impact on the strength of flyash-based SCGPC that was cured at room temperature.
3. The compressive strength of flyash based SCGPC increased by approximately 35.58% when the molar concentration of the NaOH was rose from 8 M to 16 M.
4. However, as the molar concentration of NaOH rose from 8 M to 16 M, the splitting tensile strength and flexural strength of flyash-based SCGPC improved by around 33.59% and 31.05%, respectively.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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3.4.8Bibliometrics of the publications during the year based on average Citation Index in Scopus/ Web of Science/PubMed									
S.No.	**Department**	**Title of the Paper**	**Name of Author**	**Title of journal**	**Year of publication**	**Citation Index**	**Institutional affiliation as mentioned in the publication**	**Volume & Issue No. & ISSN**	**DOI**
S.V.U. College of Sciences									
	Anthropology	An Informal Economy of Women in Asmara (Eritrea): A Case Study	Prof. K. Surendranadha Reddy, Dr. J. Lalu Naik and M. Surendra	International Journal of Social Sciences	2023			11(1) 117-128 2347-3797	https: //iahrw.org/our-services/journals /iahrw-international-journal-of-social-sciences-review
	Anthropology	Socio Economic conditions of the Ediga Community in karvetinaagar of chittoor disrtict	Prof. K. Surendranadha Reddy, and Madasi Mahendra Babu	UGC-Care List-Group-I	2023			12 (8) 15-26 2347-6648	
	Anthropology	Evolution of Physical Anthropology	Prof. K. Surendranadha Reddy, and Dr. K. Ramalinga Reddy	International Journal of Global Journal of Research Analysis	2024			13 (04) 20-21 2277-8160	10.36106/ijsr
	Anthropology	Evolution of Women Education in India	Prof. K. Surendranadha Reddy, and Dr. K. Ramalinga Reddy	International Journal of Scientific Research	2024			2277-8179	10.36106/ijsr
	Anthropology	NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population representative studies with 222 million children, adolescents, and adults.	Prof. K. Kodanda Reddy	International Journal of Lancet., Published Online	2024				https://doi.org/10.1016/S0140-6736(23)02750-2
	Anthropology	Influence of socio-demographic factors on criminal intent among adolescents : An Analysis	Dr. P. Thiripalu	Change Management : An International Journal	2024			24(1) 2327-9176	https://doi.org/10.5281/zenodo.11345926
	Anthropology	Poverty Management in India	Dr. P. Thiripalu and J. LaluNaik	International Journal of Scientific Research	2024			13 (4) 2277-8179	10.36106/ijsr
	Anthropology	Insurance Business Act in India	Dr. P. Thiripalu and J. LaluNaik	International Journal of Scientific Research	2024			13 (4) 2277-8179	10.36106/ijsr
	Anthropology	Microfinance standards and Principles in India	Dr. C. Venkateswarluand M. Siva Sankar	International Journal of Scientific Research	2023			12(11)2277-8179	10.36106/ijsr
	Anthropology	Women Selp Help groups in India	Dr. C. Venkateswarlu and M. Siva Sankar	International Journal of Scientific Research	2023			12(11)2277-8179	10.36106/ijsr
	Anthropology	An Informal Economy of Women in Asmara (Eritrea): A Case Study	Prof. K. Surendranadha Reddy, Dr. J. LaluNaik and M. Surendra	International Journal of Social Sciences	2023			11(1) 117-128 2347-3797	https: //iahrw.org/our-services/journals /iahrw-international-journal-of-social-sciences-review
	Anthropology	Poverty Management in India	Dr. P. Thiripalu and J. LaluNaik	International Journal of Scientific Research	2024			13(4) 2277-8179	10.36106/ijsr
	Anthropology	Insurance Business Act in India	Dr. P. Thiripaluand J. LaluNaik	International Journal of Scientific Research	2024			13(4) 2277-8179	10.36106/ijsr
	Anthropology	Evolution of Women Education in India	Prof. K. SurendranadhaReddy, and Dr. K. Ramalinga Reddy		2024			13(4) 2277-8179	10.36106/ijsr

	Environmental Science	Influence of industrial wastewater on Morphological and chlorophyll content of Groundnut (Arachis hypogaea l.)	V. Sudhakar, Jyothi Manohar Ch, K. Abraham and T. Damodharam	Pollution Research.	2024	https://scholar.google.com/citations?hl=en&user=Un_m9IwAAAAJ&view_op=list_works&sortby=pubdate	Department of Environmental Sciences, S.V. University, Tirupati 517 502, A.P, India	43 & 1 & 0257–8050	http://doi.org/10.53550/PR.2024.v43i01.006
	Environmental Science	Impact of Soil Pollutants on Groundnut (Arachis hypogaea L.) Seedlings	K. Abraham, Jyothi Manohar Ch., V. Sudhakar and T. Damodharam	Journal of Information and Computational Science	2023		Department of Environmental Sciences, S. V. University, Tirupati – 517502, A.P, India	1548-7741	DOI:10.12733.JICS.2023.V13I11.535569.10001
	Environmental Science	The Pot Culture Experiment Investigated The Influence of Lead on The Germination and Seedling Growth of Arachis Hypogaea.	K. Kiran, K. Abraham, M. Sreenivasulu and T. Damodharam	Technix International Journal for Engineering Research	2023		Dept. of Environmental Sciences, S.V.University, Tirupati-517502, A.P. India.	10 & 10 & ISSN 2349-9249	https://www.TIJER.org/papers/TIJER2310111
	Environmental Science	The Impact of Mercury on the Germination and Seedling Growth of Arachis Hypogaea; In a Pot Culture Experiment	K. Kiran, K. Abraham and T. Damodharam	Technix International Journal for Engineering Research			Department of Environmental Sciences, S. V. University, Tirupati – 517502	13 & 11 & ISSN: 1548-7741	https://joics.org/vol-13-issue-11-2023/
	Environmental Science	An in-depth analysis of the role of women in environmental protection within the Anupalle village, Ramachandrapuram Mandal, Sri Balaji District, Andhra Pradesh,	Dr.K.Kiran, Miss.Dasireddygari Jyothiand Dr. E.Mahadevareddy	Journal of Interdisciplinary Cycle Research	2024		Academic Consultant, Department of Environmental Science	10 & 10 & 0022-1945	https://drive.google.com/file/d/1wNHGVGmi2g0sTxFY-1BFm0RD7jzj4QB1/view
	Environmental Science	Women Role in Environmental Protection: A Case Study in Gangudupalli Village, Chandragiri Mandal, Sri Balaji District, Andhra Pradesh, India.	Dr.K.Kiran, Ms. Dasireddygari Jyothi, Dr. E.Mahadevareddy	Journal of Emerging Technologies and Innovative Research	2023		Academic Consultant, Department of Environmental Science	2349-5162	https://www.jetir.org/papers/JETIR2310578.pdf
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	Mathematics	Symmetric Generalized Reverse ⟦(α,1)⟧^*-Biderivations in *-rings	Sk. Haseena and Dr.C. Jaya Subba Reddy	Advances and Applications in Mathematical Sciences (AAMS)	2024		Sri Venkateswara University	Volume23 , Issue 4 & ISSN 0974-6803	https://doi.org/10.17654/0972555522033
	Mathematics	Some studies on Jordan ⟦(α,1)⟧^*-Biderivation in Rings	Sk. Haseena and Dr.C. Jaya Subba Reddy	Journal of Applied and Pure Mathematics (JAPM), Korean Society	2024		Sri Venkateswara University	Volume 6, & ISSN 2636-1612	https://doi.org/10.23091/japm.2024.013
	Mathematics	Orthogonal Symmetric Reverse Bi-(σ,τ)-Derivations in Semiprime Rings	Dr.C. Jaya Subba Reddy and V.S.V. Krishna Murty.	TuijinJishu/ Journal of Propulsion Technology (TJ/JPT)	2024		Sri Venkateswara University	Volume 45, Issue 1 & ISSN 1001-4055	TuijinJishu/Journal of Propulsion Technology
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	Mathematics	Orthogonal Generalized Symmetric Reverse Bi-(σ,τ)-Derivations of Semi prime Ring	V.S.V. Krishna Murty, K. Chennakesavulu and Dr.C. Jaya Subba Reddy	Communications on Applied Nonlinear Analysis (CANA)	2024		Sri Venkateswara University	Volume 31, Issue 3s & ISSN 1074-133X	https://internationalpubls.com
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	Mathematics	73 Is The Only Largest Prime Power Number And Composite Power Numbers	Dr.A.Sudhakaraiah,A. Madhan Kumar, Dr. P. Obulesu	IJSR	2023		Sri Venkateswara University	vol 12(Issue 11) & ISSN 2319-7064	https://www.ijsr.net/archive/v12i11/SR231118184617.pdf

	Mathematics	Roman doubly connected domination number using an algorithm of an interval graph	Dr.A.Sudhakaraiah, C.Gousiasulthanachoudri	Journal of Xidian University	2024		Sri Venkateswara University	vol 18(Issue 5) & ISSN 1001 - 2400	https://drive.google.com/file/d/179GDLHzSxN5Q3rU2jCOowoLlh8zIxLE3/view
	Mathematics	There is no other prime power number which is greater than 73 and composite power numbers	Dr.A.Sudhakaraiah,K.Ramakrishna, A. Madhan Kumar	Strad Research	2024		Sri Venkateswara University	vol 11(Issue 3) & ISSN 0039-2049	chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ijsr.net/archive/v12i11/SR231118184617.pdf
	Mathematics	Utilizing data mining techniques for predicting students' academic performance	Dr. P. Ramakrishna Reddy1 ,Dr.Hemanth Kumar Molapata2 , Dr. k. Ramakrishna3 , **Dr. T. Mahesh Kumar4**	JETIR	2024		Sri Venkateswara University	vol 11(Issue 3) & ISSN 2349-5162	file:///C:/Users/srikruthi/Downloads/JETIR2403A77.pdf
	Mathematics	Utilizing data mining techniques for predicting students' academic performance	Dr. P. Ramakrishna Reddy1 ,Dr.Hemanth Kumar Molapata2 , **Dr. k. Ramakrishna**3 , Dr.T. Mahesh Kumar4	JETIR	2024		Sri Venkateswara University	vol 11(Issue 3) & ISSN 2349-5163	file:///C:/Users/srikruthi/Downloads/JETIR2403A77.pdf
	Mathematics	Falkner-skan slip flow of non-newtonian fluid over a moving and nonlinearly radiated wedge with variable heat source/sink and viscous dissipation	Dr. R.L.V RENUKA DEVI	International Journal Of Modern Physics B	2024	6	Sri Venkateswara University	Volume 38, Issue 01 ISSN: 0217-9792	https://doi.org/10.1142/S0217979224500048
	Mathematics	APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS IN FLUID PHYSICS	Dr.Y .Swapna	COMMUNICATIONS ON APPLIED NON LINEAR ANALYSIS	2024	1	Sri Venkateswara University	Vol 31 (Issue 1) & ISSN 1074-133X	https://doi.org/10.52783/cana.v31.396
	Mathematics	Radiation and Chemical Reaction Effects on MHD Mixed Convection Flow Past an Inclined Porous Plate Embedded in A Porous Medium with Heat Source and Thermodiffusion	Dr. E. Hemalatha	International Journal of Innovative Research in Technology	2024		Sri Venkateswara University	Volume 10 Issue 11 & ISSN: 2349-6002	https://ijirt.org/Article?manuscript=162866
	Mathematics	Feasibility of integrated numerical and ANFIS models in predicting the thermophysical properties of unsteady coupled micropolar - Casson hybrid nanofluids"	Dr. E. Hemalatha	Journal of Process Mechanical Engineering, 2024	2024		Sri Venkateswara University	Volume1-15&2041-3009	https://doi.org/10.1177/09544089241253831
S.V.U. College of CM&CS									
	Computer Science	Advancements in Deep Learning Architectures for Natural Language Processing Tasks	Dr.E.kesavulu Reddy	SSRG International Journal of Computer Science and Engineering	2024	Scopus Indexed and Web of science	yes	11,6 2348–8387	https://doi.org/10.14445/23488387/IJCSE-V11I6P101
	Computer Science	Ultra-Low Power Design Techniques for IoT Edge Devices	Dr.E.kesavulu Reddy	SSRG International Journal of Computer Science and Engineering	2024	Scopus Indexed and Web of science	yes	11,6 2348–8387	https://doi.org/10.14445/23488387/IJCSE-V11I6P101
S.V.U. College of Engineering									
	Chemical Engineering	Reactive Extraction of Gluconic Acid Using Tri-n-Octylamine in 1-Hexanol	K. Laila, Dr.B.Sarath Babu and G. Jyothsna Deepika	International Journal for Research Trends and Innovation	Jul-23		SVUCE	8 &8 2456-3315	
	Chemical Engineering	Removal of Malachite Green Dye from Aqueous Solution using Lemon Leaf Powder as an Adsorbent	Dr. B. Sarath Babu and Seerla Venkata Priyanka	Journal of Solid Waste Technology and Management	August 2023		SVUCE	49 & 2	
	Chemical Engineering	Comparative Study of Bioplastics Using Corn Starch, RiceStarch & Coconut Fibre	Seerla Venkata Priyanka, Dr. B. Sarath Babu and Dr.P.Sreedhar	International Journal of Research and Analytical Reviews	Apr-24		SVUCE	11 &2 2349-5138	
	Chemical Engineering	Recovery of Propionic Acid from Aqueous Solution using Alamine 336 in 1 - Octanol by Reactive Extraction	Dr.B. Sarath Babu and Seerla Venkata Priyanka	Indian Journal of Petroleum Engineering	May-24		SVUCE	04 & 01 2582-9297	

	Chemical Engineering	Reactive Extraction of Gluconic Acid Using Tri n-Octylamine in 1-Octanol	K. Laila and Dr.B.Sarath Babu	International Journal of Innovative Research in Technology	Jun-24		SVUCE	11&1 2349-6002	
	Chemical Engineering	Data Driven Methodology for Battery RUL Prediction Using Machine Learning Algorithms	Dr. P. Akhila Swathantra , Dr.J.N. Chandra Sekhar, Ms.C.L. Sravanthi	Journal of Emerging Technologies and Innovative Research (JETIR)	Jun-23		SVUCE	10 &4 ISSN: 2349:5162	
	Chemical Engineering	Production of biodiesel from Palmolein oil, Ricebrane oil, Neem oil and their yield comparison	Dr. P. Akhila Swathanthra, P.G.R. Manyula	International Journal for Research Trends and Innovation (IJRTI)	Jul-23		SVUCE	8 & 7 2456-3315	
	Civil Engineering	AN EXPERIMENTAL PERFORMANCE OF STONE COLUMNS FILLED WITH REPURPOSING MATERIALS	K.MALLIKARJUNA RAO	JOURNAL OF TECHNOLOGY	2023	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:11ISSUE:,10 ISSN:10123	
	Civil Engineering	AN EXPERIMENTAL STUDY ON BULGING BEHAVIOUR OF RAMMED STONE COLUMNS	K.MALLIKARJUNA RAO	NEURO QUANTOLOGY	2023	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME 21 ISSUE 1 ISSN	
	Civil Engineering	EXPERIMENTAL STUDY ON FLEXURAL STRENGTH OF SLURRY INFILTRATED FIBROUS CONCRETE (SIFCON) PRODUCED WITH VARIOUS PERCENTAGES OF WASTE STEEL FIBERS RECOVERED FROM USED TIRES	I.V.RAMANA REDDY	CONFERENCES	2023	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME ISSUE ISSN	
	Civil Engineering	HYDROLOGICAL INFERENCE ON THE NANDIVARGAM SUB-WATER SHED FOR WATER RESOURCE ANALYSIS AND MANAGEMENT THROUGH REMOTE SENSING AND GIS YECHNIQUES	D.V.SATYANARAYANA MOORTHY	JOURNAL OF TECHNOLOGY	2023	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME :11 ISSUE :11 ISSN:1012-3407	
	Civil Engineering	ASSESSMENT OF SOIL EROSION RISK WITHIN A SMALL-WATER SHED NANDIVARGAM ,NANDYAL DISTRICT,INDIA. USING REVISED UNIVERSAL SOIL LOSS EQUATION(RUSLE):A REMOTE SENSING & GIS APPROACH	D.V.SATYANARAYANA MOORTHY	INDUSTRIAL ENGINEERING JOURNAL	2023	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME :52 ISSUE :7 ISSN:0970-2555	
	Civil Engineering	AN EXPERIMENTAL INVESTIGATION ON POLYPROPYLENE FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH ALCCOFINE	D.V.PRASADA RAO		2024	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:24 ISSUE :4 ISSN:	
	Civil Engineering	AN EXPERIMENTAL INVESTIGATION ON STEEL FIBER REINFORCED SELF-COMPACTING CONCRETE USING ALCCOFINE AND GRANITE POWDER	D.V.PRASADA RAO	JOURNAL FOR BASIC SCIENCES	2024	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:24 ISSUE :3 ISSN:	
	Civil Engineering	AN EXPERIMENTAL INVESTIGATION ON GLASS FIBER CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH ALCCOFINE	D.V.PRASADA RAO	JOURNAL FOR BASIC SCIENCES	2024	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:24 ISSUE :4 ISSN:	
	Civil Engineering	BUILDING INFORMATION MODELLING OF AN EARTH QUAKE RESISTANT STRUCTURE	D.V.PRASADA RAO	JOURNAL FOR BASIC SCIENCES	2024	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:24 ISSUE :4 ISSN:	

	Civil Engineering	AN APPLICATION OF GEOPOLYMER STABILIZED EXPANSIVE SOIL TO REDUCE THE RAINFALL-BASED EROSION IN SLOPES	CHIGURUPATI.SUDHA RANI	CONFERENCE SERIES	2023	0	S.V.U.COLLEGE OF ENGINEERING		
	Civil Engineering	EFFECT OF FLY ASH & MICROBES ON STRENGTH PROPERTIES OF SUBGRADE SOIL FOR PAVEMENTS	CHIGURUPATI.SUDHA RANI	CONFERENCE	2024	0	S.V.U.COLLEGE OF ENGINEERING		
	Civil Engineering	AN EXPERIMENTAL INVESTIGATION ON THE PROPERTIES OF GEOPOLYMER CONCRETE WITH PARTIAL REPLACEMENT OF MARBLE POWDER	B.MADHUSUDANA REDDY	INTERNATIONAL JOURNAL OF ENHANCED RESEARCH IN SCIENCE,TECHNOLOGY & ENGINEERING	2024	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:13 ISSUE :3 ISSN:2319-7463	
	Civil Engineering	STRENGTH AND DURABILITY CHARACTERISTICS OF GEOPOLYMER CONCRETE INCORPORATED WITH CLAY AS DELETERIOUS MATERIAL	B.MADHUSUDANA REDDY	INDIAN JOURNAL OF NATURAL SCIENCES	2023	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:14 ISSUE :80 ISSN:0976-0997	
	Civil Engineering	A STUDY ON THE PROPERTIES OF STEEL FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF ASBESTOS AND BANANA FIBERS	B.MADHUSUDANA REDDY	INTERNATIONAL RESEARCH JOURNAL OF MODERNIZATION IN ENGINEERING TECHNOLOGY AND SCIENCE	2024	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:06 ISSUE :03 ISSN:2582-5208	
	Civil Engineering	AN EXPERIMENTAL INVESTIGATION ON PROPERTIES OF GEOPOLYMER CONCRETE USING COMPOSITE FIBERS	B.MADHUSUDANA REDDY	JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH	2024	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:11 ISSUE :03 ISSN:2349-5162	
	Civil Engineering	A STUDY ON MECHANICAL AND DURABILITY PROPERTIES OF CONCRETE WITH RICE STRAW ASH	S.ARUNA JYOTHY	SEMI CONDUCTOR OPTOELECTRONICS	2023	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:42 ISSUE :01 ISSN:1001-5868	
	Civil Engineering	EXPERIMENTAL INVESTIGATION ON SELF –COMPACTING CONCRETE REINFORCED WITH FIBERS	S.ARUNA JYOTHY			0	S.V.U.COLLEGE OF ENGINEERING	VOLUME: ISSUE : ISSN:	
	Civil Engineering	A STUDY ON MECHANICAL PROPERTIES OF M40 GRADE CONCRETE WITH FOSROC ADMIXTURE	S.ARUNA JYOTHY	SEMI CONDUCTOR OPTOELECTRONICS	2023	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:42 ISSUE :01 ISSN:1001-5868	
	Civil Engineering	APPLICATION OF PREFORMED FLOC ADSORBENTS IN THE REMOVAL OF ACID DYE FROM AN AQUEOUS SOLUTION	N.MUNI LAKSHMI	RESEARCH ARTICLE	2023	0	S.V.U.COLLEGE OF ENGINEERING		
	Civil Engineering	ULTRA SOUND ASSISTED ADVANCE OXIDATION PROCESS FOR REMOVAL OF NICKLE	N.MUNI LAKSHMI	IOSR JOURNAL OF MECHANICAL AND CIVIL ENGINEERING	2023	0	S.V.U.COLLEGE OF ENGINEERING	VOLUME:20 ISSUE :05 ISSN:2320-334X	
	Mechanical Engg	Performance evaluation of machine learning based-classifiers in friction stir welding of Aa6061-T6 alloy2023, 17(1), pp. 469–472	Kumar,A.K., Surya, M.S.,Venkataramaiah, P.	International Journal on Interactive Design and Manufacturing	2023	14			10.1007/s12008-022-00904-2
	Mechanical Engg	Experimental Study on Mechanical Behaviour of Arhar-Reinforced Composites using GRA with PCA	Manubolu, V.N., Vanimireddy, D.R.	IJERR	2023	0			https://doi.org/10.52756/ijerr.2023.v36.023
	Mechanical Engg	Experimental Study on Mechanical Behavior of Corn-Based Reinforced Composites Using Taguchi Approach	Manubolu, V., Reddy, V.D., Kalapala, P.	Springer	2023	3			https://doi.org/10.1016/j.matpr.2023.04.291

	Mechanical Engg	Development of empirical models and machinability comparison on wire electrical discharge machining of aluminium based hybrid and metal matrix composites	Hemalatha, A., Reddy, V.D., Hemachandra, S.	Science Direct	2023	1			https://doi.org/10.1007/s12008-023-01200-3
	Mechanical Engg	Fluid structure interaction analysis of the hyperloopcapsule	Venkatapuram, R.S.R., Pothur, H., Kadapa, M.S., Penumadu, H.V., Gurram, S.N.	AIP Publications	2023	0			https://doi.org/10.1063/5.0156865
	Mechanical Engg	Experimental Investigations of CO2 Laser Beam Welded Joints of AISI 304 and AISI 4130 Steels	Narayana Reddy, B., Hema, P.	Springer	2023	0			https://doi.org/10.1007/978-981-19-7612-4_28
	Mechanical Engg	Review on Friction Stir Welding of Titanium Alloys—A Fracture Mechanics Perspective	Ganesan, R., Pothur, H.	Springer	2023	1			https://doi.org/10.1007/978-981-19-7612-4_36
	Mechanical Engg	Fabrication of Cooling Storage Device and Optimization Its Parameters for Thermal Energy Storage Application by Using Glycerine as a Phase Change Material (PCM)	K. Dharma Reddy; B. Prudhviraj; P. VenkataVineeth; G. Lokesh	Springer	2023			2195-4356 2195-4364	https://doi.org/10.1007/978-981-99-2349-6_57
	Mechanical Engg	Experimental investigations on nano-Fe2O3/ beeswax phase change materials for thermal energy storage applications	P VenkataVineeth; K. Dharma Reddy	Materials Today	2023			2214-7853	https://doi.org/10.1016/j.matpr.2023.07.337
	Mechanical Engg	Experimental investigations on oleic acid stabilized nano- Al2O3 / beeswax phase change materials for thermal energy storage applications	P. VenkataVineeth; K. Dharma Reddy	Materials Today	2023			2214-7853	10.1016/j.matpr.2023.04.567
	Mechanical Engg	Experimental investigation on machining of multiple micro-square holes	Aruna, K., Hiremath, S.S.	Taylor and Francis	2023	6		Pages 878-887 2377-9497	• https://doi.org/10.1080/10426914.2022.2149783
	CSE								

3.4.8Bibliometrics of the publications during the year based on Scopus/ Web of Science-– h-Index of the University

S.No.	Department	Title of the Paper	Name of Author	Title of journal	Year of publication	h-Index	Institutional affiliation as mentioned in the publication	Volume & Issue No. & ISSN	DOI
				S..V.U. College of Arts					
	CSEAP Studies	"Allure of the 'Indo-Pacific' and dynamics of regional cooperation after COVID-19,"	Prof. M. Prayaga	Mukt Shabd Journal	2023		Sri Venkateswara University	2 Vol. XII, Issue No. IV ISSN 347-3150	10.0014.MSJ.2023.V11I04.0086781.114300
	CSEAP Studies	"Shanghai Cooperation Organisation (SCO) and India's Role in its Regional Development and Stability,"	Prof. M. Prayaga	North Asian International Research Journal of Social Science & Humanities,	2023		Sri Venkateswara University	Vol. 9, Issue 3. 2454-9827	10.5575/nairjssh.2022.9.6.21
	CSEAP Studies	"India-ASEAN Centrality in the emerging Security Architecture in the Indo-Pacific,"	Prof. M. Prayaga	India-ASEAN Partnership : A Gamechanger in the Indo-Pacific	2023		Sri Venkateswara University	ISBN : 978-92-93402-14-1	
	CSEAP Studies	"Causes for the Conflict in Baluchistan"	Prof. G. Vijaykumar Reddy	*Mukt Shabd Journal*	2023		Sri Venkateswara University	Volume XII, Issue IVISSN : 2347-3150	10.0014.MSJ.2023.V11I04.0086781.114300
	CSEAP Studies	"Role of Women in Tourism Sector"	Prof. G. Vijaykumar Reddy	*Parishodh Journal*	2023		Sri Venkateswara University	Volume XII, Issue IV ISSN NO.2347-6648	
	CSEAP Studies	India, Indian Ocean Strategic and Energy Security"	Prof. G. Vijaykumar Reddy	Parishodh Journal	2023		Sri Venkateswara University	Volume XII, Issue IV	

	CSEAP Studies	A Historical Study of Feminist Movements in the Roots of Social Reform Movement in Andhra Pradesh"	Prof. G. Vijaykumar Reddy	International Journal of Research and Analytical Reviews	2024		Sri Venkateswara University	ISSN NO.2347-6648	
	CSEAP Studies	"Feminist Perspective Historians, Authors and Activities in Andhra Pradesh	Prof. G. Vijaykumar Reddy	Journal of Information and Computational Science	2024		Sri Venkateswara University	Vol.11, Issue 1	
	CSEAP Studies	"Economic – Co-operation between India and Japan"	Prof. V. Ramesh Babu	North Asian International Research Journal of Social Science &Humanities	2023		Sri Venkateswara University	Volume.9, Issue. 3, ISSN 2454-9827.	
	CSEAP Studies	"Exports and Imports between India and Japan: A Study",	Prof. V. Ramesh Babu	Parishodh Journal	2023		Sri Venkateswara University	Volume XII, Issue IV ISSN 2347-6648	
	CSEAP Studies	India –China Political and Economic Relations: An Overview"	Prof. V. Ramesh Babu	Mukt Shabd Journal	2023		Sri Venkateswara University	Volume XII, Issue IV ISSN 2347-3150	
	CSEAP Studies	"An Overview of Digital Banking System In India"	Prof. V. Ramesh Babu	Parishodh Journal	2023		Sri Venkateswara University	Volume XII, Issue IV ISSN 2347-6648	
	CSEAP Studies	A Study on Economic Development of Tourism Industry in India and Andhra Pradesh",	Prof. V. Ramesh Babu	North Asian International Research Journal of Business Economics & Management	2023		Sri Venkateswara University	Vol.7, Issue 10 ISSN 2277-1018	
	CSEAP Studies	"Role of Service Sector in the Growth of Indian Economy: A Study"	Prof. V. Ramesh Babu	GIS Science Journal	2024		Sri Venkateswara University	Vol. 11, Issue 6 ISSN 1869-9391	
	CSEAP Studies	"Study on Evolution of Women's Position in Higher Education in India"	Prof. V. Ramesh Babu	North Asian International Research Journal of Social Sciences & Humanities	2024		Sri Venkateswara University	Vol. 10, Issue 6, ISSN 2454-9827	
	CSEAP Studies	The Impact of Indian Diaspora in Indo-Pacific Region: India's Interest	Dr. M.Padmaja	INDIA-ASEAN Partnership A Game Changer in the Indo-Pacific:"	2023		Sri Venkateswara University	ISBN:978-92-93402-14-1, 2023, P.200-220	
	CSEAP Studies	"Cambodian Killing fields	Dr. M.Padmaja	Global Journal for Research Analysis	2024		Sri Venkateswara University	ISSN 2277-8160, VOL. 13, Issue-01	
	CSEAP Studies	Women Empowerment and Micro-Finance groups in Cambodia Kham phang floating village	Dr. M.Padmaja	Global Journal for Research Analysis	2024		Sri Venkateswara University	ISSN 2277-8160, vol.13, issue*03	
	CSEAP Studies	Cambodia Floating Village Kampong Seam Reap	Dr. M.Padmaja	Global Journal for Research Analysis	2023		Sri Venkateswara University	ISSN 2277 Vol.12, Issue 5	
	CSEAP Studies	Self help groups and microfinance: A study on Livelihood and Empowerment of the pulla Yerukula Trible in SPSR Nellore District of Andhrapradesh"	Dr. M.Padmaja	International Journal of Recent Research in Social Sciences and Humanities (IJRRSS)	2023		Sri Venkateswara University	Vol. 10, Isue-1	
	CSEAP Studies	"Pilgrims Amenities at Tirumala and Tirupati : A Comprehensive Study"	Dr. V. Thimmappa	International Journal of Research and Analytical Review (IJRAR)	2023		Sri Venkateswara University	Vol. 10, Issue No. 4. ISSN -2349-5138	https://www.ijrar.org/papers/IJRAR23D1833.pdf
	CSEAP Studies	Marine Tourism in India: Opportunities and Challenges	Dr. V. Thimmappa	North Asian International Research Journal of Social Sciences & Humanities,	2024		Sri Venkateswara University	Vol. 11, Issue 2 ISSN 2454-9827	DOI: 10.5575/nairjssh.2024.10.03.01

	CSEAP Studies	Community Empowerment Through Ecotourism: Study of Talakona in Tirupati District	Dr. V. Thimmappa	Proceedings of the Andhra Pradesh History Congress	2024		Sri Venkateswara University	Vol. 46 ISSN 2320-057X	https://aphistorycongress.com/wp-content/uploads/2025/01/APHC-Proceedings-of-the-46th-Session.pdf
S.V.U. College of Sciences									
	Anthropology	An Informal Economy of Women in Asmara (Eritrea): A Case Study	Prof. K. Surendranadha Reddy, Dr. J. Lalu Naik and M. Surendra	International Journal of Social Sciences	2023			11(1) 117-128 2347-3797	https: //iahrw.org/our-services/journals /iahrw-international-journal-of-social-sciences-review
	Anthropology	Socio Economic conditions of the Ediga Community in karvetinaagar of chittoor disrtict	Prof. K. Surendranadha Reddy, and Madasi Mahendra Babu	UGC-Care List-Group-I	2023			12 (8) 15-26 2347-6648	
	Anthropology	Evolution of Physical Anthropology	Prof. K. Surendranadha Reddy, and Dr. K. Ramalinga Reddy	International Journal of Global Journal of Research Analysis	2024			13 (04) 20-21 2277-8160	10.36106/ijsr
	Anthropology	Evolution of Women Education in India	Prof. K. Surendranadha Reddy, and Dr. K. Ramalinga Reddy	International Journal of Scientific Research	2024			2277-8179	10.36106/ijsr
	Anthropology	NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population representative studies with 222 million children, adolescents, and adults.	Prof. K. Kodanda Reddy	International Journal of Lancet., Published Online	2024				https://doi.org/10.1016/S0140-6736(23)02750-2
	Anthropology	Influence of socio-demographic factors on criminal intent among adolescents : An Analysis	Dr. P. Thiripalu	Change Management : An International Journal	2024			24(1) 2327-9176	https://doi.org/10.5281/zenodo.11345926
	Anthropology	Poverty Management in India	Dr. P. Thiripalu and J. LaluNaik	International Journal of Scientific Research	2024			13 (4) 2277-8179	10.36106/ijsr
	Anthropology	Insurance Business Act in India	Dr. P. Thiripalu and J. LaluNaik	International Journal of Scientific Research	2024			13 (4) 2277-8179	10.36106/ijsr
	Anthropology	Microfinance standards and Principles in India	Dr. C. Venkateswarluand M. Siva Sankar	International Journal of Scientific Research	2023			12(11)2277-8179	10.36106/ijsr
	Anthropology	Women Selp Help groups in India	Dr. C. Venkateswarlu and M. Siva Sankar	International Journal of Scientific Research	2023			12(11)2277-8179	10.36106/ijsr
	Anthropology	An Informal Economy of Women in Asmara (Eritrea): A Case Study	Prof. K. Surendranadha Reddy, Dr. J. LaluNaik and M. Surendra	International Journal of Social Sciences	2023			11(1) 117-128 2347-3797	https: //iahrw.org/our-services/journals /iahrw-international-journal-of-social-sciences-review
	Anthropology	Poverty Management in India	Dr. P. Thiripalu and J. LaluNaik	International Journal of Scientific Research	2024			13(4) 2277-8179	10.36106/ijsr
	Anthropology	Insurance Business Act in India	Dr. P. Thiripaluand J. LaluNaik	International Journal of Scientific Research	2024			13(4) 2277-8179	10.36106/ijsr
	Anthropology	Evolution of Women Education in India	Prof. K. SurendranadhaReddy, and Dr. K. Ramalinga Reddy		2024			13(4) 2277-8179	10.36106/ijsr

	Environmental Science	Influence of industrial wastewater on Morphological and chlorophyll content of Groundnut (Arachis hypogaea l.)	V. Sudhakar, Jyothi Manohar Ch, K. Abraham and T. Damodharam	Pollution Research.	2024	https://scholar.google.com/citations?hl=en&user=Un_m9IwAAAAJ&view_op=list_works&sortby=pubdate.	Department of Environmental Sciences, S.V. University, Tirupati 517 502, A.P, India	43 & 1 & 0257–8050	http://doi.org/10.53550/PR.2024.v43i01.006
	Environmental Science	Impact of Soil Pollutants on Groundnut (Arachis hypogaea L.) Seedlings	K. Abraham, Jyothi Manohar Ch., V. Sudhakar and T. Damodharam	Journal of Information and Computational Science	2023		Department of Environmental Sciences, S. V. University, Tirupati – 517502, A.P, India	1548-7741	DOI:10.12733.JICS.2023.V13I11.535569.10001
	Environmental Science	The Pot Culture Experiment Investigated The Influence of Lead on The Germination and Seedling Growth of Arachis Hypogaea.	K. Kiran, K. Abraham, M. Sreenivasulu and T. Damodharam	Technix International Journal for Engineering Research	2023		Dept. of Environmental Sciences, S.V.University, Tirupati-517502, A.P. India.	10 & 10 & ISSN 2349-9249	https://www.TIJER.org/papers/TIJER2310111
	Environmental Science	The Impact of Mercury on the Germination and Seedling Growth of Arachis Hypogaea; In a Pot Culture Experiment	K. Kiran, K. Abraham and T. Damodharam	Technix International Journal for Engineering Research			Department of Environmental Sciences, S. V. University, Tirupati – 517502	13 & 11 & ISSN: 1548-7741	https://joics.org/vol-13-issue-11-2023/
	Environmental Science	An in-depth analysis of the role of women in environmental protection within the Anupalle village, Ramachandrapuram Mandal, Sri Balaji District, Andhra Pradesh,	Dr.K.Kiran, Miss.Dasireddygari Jyothiand Dr. E.Mahadevareddy	Journal of Interdisciplinary Cycle Research	2024		Academic Consultant, Department of Environmental Science	10 & 10 & 0022-1945	https://drive.google.com/file/d/1wNHGVGmi2g0sTxFY-1BFm0RD7jzj4QB1/view
	Environmental Science	Women Role in Environmental Protection: A Case Study in Gangudupalli Village, Chandragiri Mandal, Sri Balaji District, Andhra Pradesh, India.	Dr.K.Kiran, Ms. Dasireddygari Jyothi, Dr. E.Mahadevareddy	Journal of Emerging Technologies and Innovative Research	2023		Academic Consultant, Department of Environmental Science	2349-5162	https://www.jetir.org/papers/JETIR2310578.pdf
	Fishery Science& Aquaculture	Impact of The Probiotics Rhodococcusand Rhodobacteron The Biochemical and Growth Parameters of Pangasius HypophthalmusFish and Maintenance of Pond"	KIRAN KUMAR BAZARand Prof. P. NAGA JYOTHI	"JETIR	(March 2024)			Volume 11, Issue 3 Page no e395-e408, Impact Factor: 7.95	www.jetir.org(ISSN-2349-5162)UGC,ISSN APPROVED JOURNAL 63975
	Mathematics	Mangoldt Graph and its perfect codes	Dr.D. Bharathi	International Journal of Research and Analytical Reviews-IJRAR	2024		Sri Venkateswara University	2349-5138	
	Mathematics	Perfect Codes in Quadratic residue Cayley Graphs G(Zn, Q)	Dr.D. Bharathi	International Organizing Scientific Research Journal of Mathematics- IOSR	2024		Sri Venkateswara University	Volume 20, Issue 1 & ISSN 2278-8727	https://DOI:10.9790/0661-2001031012
	Mathematics	Binary Cyclic codes in circular cliques	Dr.D. Bharathi	International Journal for Research in Applied Sciences and Engineering Technology-IJRASET	2024		Sri Venkateswara University	Volume 12, Issue VI & ISSN 2321-9653	https://doi.org/10.22214/ijraset.2024.63487
	Mathematics	PAIRS (54963, 52974), (6543, 2187) & (3285, 5274) WITH ALS' ROUTINE	Dr.D. Bharathi	IJCRT	2024		Sri Venkateswara University	Volume 12, Issue 6 & ISSN 2320-2882	https://ijcrt.org/papers/IJCRT2406966.pdf
	Mathematics	Some Centralizing Theorems on Generalized (α,1)-Reverse Derivations in Semiprime Rings	Sk. Haseena, Dr.C. Jaya Subba Reddy and C. Venkata Sai Raghavendra Reddy	International Journal of Engineering, Science and Mathematics (IJESM)	2023	5	Sri Venkateswara University	Volume 12, Issue 10 & ISSN 2320-0294	http://www.ijesm.co.in
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	Mathematics	Some Results in Prime Rings with Generalized Reverse Derivations Involving Jordan Involution	V.S.V. Krishna Murty, Dr.C. Jaya Subba Reddy, A. Vidhyullatha and D. Dheeraj	International Research Journal of Pure Algebra (IRJPA)	2023	5	Sri Venkateswara University	Volume 13, Issue 12 & ISSN 2248-9037	www.rjpa.info
	Mathematics	Some Results of Generalized Reverse Biderivations on Prime Rings	V.S.V. Krishna Murty and Dr.C. Jaya Subba Reddy	International Journal of Mathematics And its Applications (IJMAA)	2023	5	Sri Venkateswara University	Volume 11, Issue 4 & ISSN 2347-1557	http://ijmaa.in
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Virology

PHYTOCHEMICAL ANALYSIS AND ANTIMICROBIAL ACTIVITY OF PLUMBAGO ZEYLANICA LEAF EXTRACT

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ABSTRACT In India, *Plumbago zeylanica* is a beneficial medicinal herb. The current study examines the antibacterial, and antifungal properties and phytochemical analysis of *Plumbago zeylanica* leaf extract. Using the well diffusion technique, the antibacterial activity was evaluated against gram-positive and gram-negative microorganisms. the antifungal activity was carried on *Aspergillus niger*. The study's findings imply that the plant leaf extract possesses an inhibitory effect on both gram-positive and gram-negative bacteria and fungi and it could be used as phytomedicine for bacterial and fungal diseases

KEYWORDS :

INTRODUCTION:

Plumbago zeylanica is an herbaceous plant with ascending, prostrate, or erect glabrous stems. Additionally, the ovate petiolate or sessile leaves have leaves. It belongs to the *Plumbago* genus and the family *Plumbaginaceae*. Tropical and subtropical areas across the world support the growth of the native *Plumbago zeylanica* plant. Deciduous woodland in (Australia, and India). The herb has a variety of therapeutic benefits [1-4]. Chitrak, chitramoolam, plumbago, Ceylon leadwort, doctor bush, or wild leadwort are some of the native names for the plant. Chitra is the name in Hindi, while Chitramoolam is the name in Tamil [5,6]. Molubda scandens (L.) Raf., Plumbagidium scandens (L.) Spach, Plumbago scandens L., and Plumbago zeylanica var. glaucescens Boiss are some synonyms for the plant [7,8].

The *P. zeylanica* plant grows to a height of 0.5–2 meters. The leaves are simple, alternating, elliptic, or oblong, 0.5–12 cm long, with a tapering base, and sometimes have a hairy edge. They can also be ovate or ovate-lanceolate. Young leaves lack stipules and have a thin petiole with tiny auricles. The inflorescence has numerous flowers and is of the terminal raceme type, measuring 6 to 30 cm in length [4-7]. White flowers are produced in terminal and axillary elongated spikes. They are pentamerous, pedicellate, bisexual, regular, and sweet-scented. Free and included are the stamens. The ovary is superior and single-celled, and the style is filiform with five elongated stigma lobes. The flowers also have a tubular calyx with glandular trichomes (hairs) that secrete gooey mucilage, which is another distinguishing feature [3]. The plant blooms all year round, and insects are the main pollinators. The mucilaginous glands facilitate animal fruit distribution and insect capture. The plant's fruit is a single-seeded, oblong capsule with five ridges. Each seed has an oblong shape, is 5–6 mm long, and ranges in color from reddish-brown to dark brown. Roots are at least 30 cm long, smooth, branching, or unbranched, with or without secondary roots, and 6 cm in diameter. When they are young, they are light yellow, and as they dry, they turn reddish-brown. The roots taste caustic and bitter and have a potent, distinctive smell [7].

Description:

The generic name comes from the Latin words plumbum, which means lead since this plant was thought to be able to treat lead poisoning and eye illness. The particular plant comes from Sri Lanka and is known as Ceylon. In India, the plant *Plumbago zeylanica* is also known as Chitrak, and it has several conventional and effective medical applications. The plant's blossoms may be eaten and are used to adorn salads, desserts, and cold beverages. The plant thrives in West Bengal, Madhya Pradesh, and Chhattisgarh. It also grows in a variety of soil types, including deep soil, deep black soil, and red literate soil. It may be quickly propagated via stem cuttings [8].

including cardiotoxicity, atherogenicity prevention, and cardiotonic neuroprotection. It may also be used to lower blood cholesterol levels and improve the poor density of lipoproteins. Diabetes, cancer, skin infections, rheumatoid arthritis, constipation, asthma, and muscle discomfort are all treated with this herb [9].

Growth and Development:

The plant *Plumbago zeylanica* is a wild species that grows in many locations and has a variety of medicinal uses. The plants are cultivated in tropical and subtropical areas where it rains throughout the rainy season [10]. To identify the numerous bioactive substances that are significant from a pharmacological standpoint, including alkaloids, steroids, flavonoids, phenolic compounds, and many more, a phytochemical examination was carried out. The plant's bioactive components are a source for making medicines [11]. The bioactive substances are known to behave as microbial inhibitors [12]. The hunt for novel structural medications to replace synthetic antioxidants that are reportedly harmful has led researchers to explore plants in the present [13].

MATERIALS AND METHODS:

Collection of plant material:

The plant *Plumbago zeylanica* was harvested from the Nallamala forest in the Kurnool district, Andhra Pradesh, India. The gathered plant leaves are divided into bits, let to air dry for 10 days, and then ground into a fine powder for use in further research.

Preparation of plant leaf extract:

Up to 10 gms of the dried leaf powder were used, and 100 ml of distilled water was used to dissolve it. The leaf extract that had been dissolved was utilized to analyze phytochemicals and test the antibacterial and antifungal activities.

Phytochemical analysis of leaf extract of *Plumbago zeylanica*:

The phytochemical examination of the *Plumbago zeylanica* leaf extract was used to identify the bioactive components, such as alkaloids, flavonoids, tannins, phenolic compounds, and saponins [14].

Test for carbohydrates:

Molisch's test:

Plant leaf extract (2ml) was mixed with 1ml of Molisch's reagent and a few drops of concentrated H_2SO_4: the production of a violet color at the intersection of the two layers shows the presence of carbohydrates.

Test for reducing sugars:

Benedict's test:

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Ecofriendly Dyes: Extraction, Characterization and Potential Applications

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DOI: https://doi.org/10.53555/jaz.v45i1.3590

Keywords: Natural Dyes, Extraction, Characterization, Dyeing, Synthetic chemical dyes

Abstract

Indians were thought to be forerunners in the technique of natural dyeing. Although indigenous knowledge systems have been practiced for many years, the usage of natural dyes has declined over generations owing to a lack of documentation and accurate understanding of the extraction and dyeing processes. As a result, natural dyes aren't commercially viable. Currently, all ecologically hazardous synthetic chemical dyes are utilized to colour textile fabrics. They are nonbiodegradable, carcinogenic, and cause water contamination and waste disposal issues. Natural colours provide a viable answer to these issues. Natural dyes are used to colour textiles, meals, medicines, and cosmetics. Dyes are also used in small amounts to colour paper, leather, shoe polish, wood, cane, candles, and other materials. Historically, dyes were obtained only from natural sources. Natural dyes, on the other hand, suffer from the inherent limitations of uniform application and dye standardization, since dyes obtained from comparable plants or natural sources are impacted and exposed to the vagaries of climate, soil, cultivation practices, and so on. As a result, standardization procedures play a critical and essential role for natural dyes to be ir[illegible]ialized and compete with synthetic dyes. This study is all about natural dyes, their [illegible]haracterization, applications, and their uses.

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ADMET DMPK. 2023 Jul 1;11(4):573-585. doi: 10.5599/admet.1793. eCollection 2023.

Green synthesis, characterization and biological activities of silver nanoparticles synthesized from *Neolamarkia cadamba*

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PMID: 37937248 PMCID: PMC10626518 DOI: 10.5599/admet.1793

Abstract

Background and purpose: Metal nanoparticles are essential due to their unique catalytic, electrical, magnetic, and optical characteristics, as well as their prospective use in sensing, catalysis, and biological research. In recent years, researchers have focused on developing cost-effective and eco-friendly biogenic practices using the green synthesis of metal nanoparticles (AgNP).

Experimental approach: In the present study, the aqueous extracts prepared from the leaf, stem, bark, and flower of *Neolamarkia cadamba* were used for the synthesis of silver nanoparticles. Synthesized silver nanoparticles were characterized using UV-Visible spectroscopy, zeta potential, dynamic light scattering, scanning electron microscope (SEM), and EDAX.

Key results: The current study showed absorption of synthesized AgNPs at 425, 423, 410, and 400 nm. Dynamic light scattering of AgNPs Showed size distribution of AgNPs synthesized from leaf, stem, and flower aqueous extracts ranges from 80-200 nm and AgNPs prepared from bark extract ranges from 100-700 nm. Zeta-potential of the biosynthesized AgNPs was found as a sharp peak at -23.1 mV for the leaf, -27.0 mV for the stem, -34.1 mV for the bark, and -20.2 mV for the flower. Silver nanoparticles and crude extracts of *Neolamarkia cadamba* showed effective antibacterial, antifungal, and antioxidant activities.

Conclusion: Silver nanoparticles have substantial antibacterial activity against Gram-positive bacteria and also exhibit the utmost antifungal activity against *Aspergillus niger*. The study concludes that the green synthesis of silver nanoparticles from *N. cadamba* leaf, stem, bark, and flower extract is a reliable and eco-friendly technique.

Keywords: Antibacterial activity; antifungal activity; antioxidant activity; electron microscopy.

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Figures

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Leaf-mediated green synthesis of silver nanoparticles from Azadirachta indica and Ficus religiosa: characterization and bioactive properties

Article 6, Volume 102, Issue 3, September 2024, Page 392-406 XML PDF (935.02 K)

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Abstract

Silver nanoparticles are nano-sized metallic particles widely used in various fields, including medicine, pharmaceutical, food, and agriculture. This study carried out the green synthesis of AgNPs using leaf extracts from *Azadirachta indica* (Neem) and *Ficus religiosa* (Peepal) plants. The silver nanoparticles were characterized using sophisticated instruments. UV-visible spectroscopy confirmed the formation of AgNPs, while FTIR identified biomolecules (amino and carboxyl groups) acting as stabilizing agents. SEM determined the size and morphology of AgNPs. Particle size analysis was conducted using DLS, and zeta potential measurements provided information on the size and charge of the silver nanoparticles. The AgNPs were tested for antibacterial efficacy against Gram-positive (*S. aureus*) and Gram-negative (*E. coli*) bacteria. Similarly, the AgNPs exhibited high fungicidal activity against the fungal strain *A. niger*. The free radical scavenging activities of nanoparticles were studied using DPPH and Hydrogen Peroxide in vitro assays. The antiviral activity of AgNPs was investigated against the *Sesbania mosaic virus* (SeMV), which infects *Sesbania* plants. The AgNPs exhibited excellent antiviral properties, decreasing the viral infection in Sesbania plants, indicating the antiviral efficacy of silver nanoparticles in the agricultural sector.

Keywords

Silver nanoparticles; Characterization; Antimicrobial activity; Antioxidant activity; Antiviral activity; Sesbania mosaic virus (SeMV)

Statistics

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RESEARCH ARTICLE

Strength and Durability Characteristics of Geopolymer Concrete Incorporated with Clay as Deleterious Material

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ABSTRACT

Sustainability is increasingly a prerequisite for all civil engineering projects due to depletion of natural resources and escalating pollution levels. Several researchers have suggested a wide range of sustainable solutions for various applications in the civil engineering. Among them, geopolymer cement concrete is one of the sustainable approaches which can reduce the high amounts of CO_2 by replacing Portland cement concrete. Further, the presence of deleterious materials in conventional concrete revealed a reduction in performance of concrete structures, But, the studies related to the influence of deleterious materials on properties of geopolymer concrete are limited. So, the present study is aimed to evaluate the influence of black cotton soil as a deleterious material on mechanical behavior of geopolymer concrete. The strength of concrete is evaluated in terms of compressive strength, split tensile strength, flexural strength, shear strength and bearing strength while durability is measured by using chloride intrusion test. The results showed a contrast behavior as compared to the conventional concrete. The presence of clay in geopolymer concrete has showed an increase in strength up to 5% of clay. The same was conformed through the chloride intrusion test conducted on geopolymer concrete

Keywords: Deleterious material, clay, geopolymer concrete, strength, elevated temperature, durability.

INTRODUCTION

Concrete is typically made of cement, water, coarse particles, and fine aggregates. The strength and durability of concrete constructions can be negatively impacted by the presence of any components, including lignite, coal, pyrites, mica, shale or similar minerals, clay, alkali, soft pieces, marine shells, and organic impurities. Often, these substances are referred to as deleterious materials. The strength and durability of concrete can be dramatically decreased if these components are present in excess of permitted levels. The permitted limits for each type of deleterious material are provided in standard codes for conventional concrete, but the corresponding limits for geopolymer concrete must be obtained through a systematical and focused research in order to prevent the performance of concrete structures from being reduced. Hence, the present article is aimed to evaluate the influence of clay as a deleterious material on strength and durability of geopolymer concrete. French scientist "Joseph Davidovits" first used the phrase "geopolymer concrete" in 1972. Since no Portland cement is utilised in the geopolymer concrete, it is often referred to as zero-cement concrete. Alkali activating solution and silica-alumina rich source materials, including flyash, ground granulated blast furnace slag (GGBS), metakaolin, etc., are used to create geopolymer concrete. In order toprepare geopolymer cement or binder, alkali activating solutions were used to activate the silica-alumina source materials [1]. The composition of geopolymer concrete is shown in figure 1.

Geopolymer mix components including the alkali solution concentration [3, 5, 9, 10, 11, 12], the ratio of silicate solution to hydroxide solution [2, 6, 7, 8], and the ratio of solids to activating solution [4] all have a significant impact on the strength of the mixture. Due to its lower price, sodium hydroxide solution was suggested over potassium hydroxide solution for the preparation of alkali activating solutions. Few research examined the relationship between sodium hydroxide solution concentration and the strength of geopolymer concrete, and they found that increasing sodium hydroxide solution concentration increased the strength of geopolymer concrete.

MATERIALS AND METHODOLOGY

In the present study, the geopolymer binder was prepared by using alkali activating solution (NaOH solution and sodium silicate solution) and flyash. In this study, a powder to liquid ratio of 2.5 and sodium silicate to NaOH ratio of 2 was considered. 15% of geopolymer binder (by weight of mix) is used for preparation of geopolymer concrete. Two series of mixes were prepared using geopolymer binder and ordinary portland cement. Both the concrete mixes were incorporated with black cotton soil (clay) at a dosage of 0, 2.5, 5, 7.5 and 10% by weight of coarse aggregates. A set of cubic specimens, cylindrical specimens and prismatic specimens were prepared with these concrete mixes and subjected to compressive, split tensile and flexural strengths were evaluated. In addition, shear strength, bearing strength of geopolymer concrete and traditional concrete were evaluated. The influence of elevated temperature (200^{o}C) on compressive strength of both geopolymer and traditional concrete was studied. Finally, the effect of clay on durability of concrete (in terms of compressive and flexural strength) was investigated through chloride intrusion of concrete specimen.

RESULTS AND DISCUSSIONS

Compressive strength

A set of 30 cubic specimens (150mm size) were prepared with different dosages of clay for each series of concrete mix and subjected to uniaxial compression as per IS:516-1959. The specimens were cured for a period of 28 and 180 days. The corresponding compressive strengths of geopolymer and traditional concrete specimens are compared as shown in figure 2(a) and 2(b). The results showed a maximum 28-days compressive strength of 49.1MPa and 45.6MPa for geopolymer concrete and traditional concrete respectively. The addition of clay content showed an adverse effect on compressive strength of traditional concrete while the addition of clay content up to 5% showed a positive effect on compressive strength of geopolymer concrete. But, the addition of clay beyond 5% caused a

considerable reduction in compressive strength. The addition of 2.5% clay reduced the compressive strength (28-days) of traditional concrete by 8% while a reduction of 33% was observed with an addition of 10% clay. The addition of 2.5% and 5% clay increased 28-day compressive strength by 3.4% and 11.1% respectively. The alumino-silicate compounds in clay up to 5% played a key role and reacted with alkali activated solution and beyond this dosage the clay acted as a foreign material and become detrimental to the geopolymer concrete. Due to this reason, the strength was increased up to 5% of clay and then started declining. But, this has to be confirmed by the microstructural studies using scanning electron microscopy, X-ray diffraction. Similarly, the same trend was observed in case of 180-days compressive strength.

Split tensile strength

A set of 30 cylindrical specimens (150mm diameter and 300mm height) were prepared with different dosages of clay for each series of concrete mix and subjected to split tensile load as per IS:5816-1999. The specimens were cured for a period of 28 and 180 days. The corresponding split tensile strengths of geopolymer and traditional concrete specimens are compared as shown in figure 3(a) and 3(b). The results showed a maximum 28-days split tensile strength of 4.72MPa and 4.02MPa for geopolymer concrete and traditional concrete respectively. The addition of clay content showed an adverse effect on tensile strength of traditional concrete as similar to compressive strength of traditional concrete. In case of geopolymer concrete, the addition of clay content up to 5% showed a positive effect on tensile strength of geopolymer concrete.

Flexural strength

A set of 30 prismatic specimens (150mm x 150mm x 700mm) were prepared with different dosages of clay for each series of concrete mix and subjected to 4 point bending as per IS:516-1959. The specimens were cured for a period of 28 and 180 days. The corresponding flexural strengths of geopolymer and traditional concrete specimens are compared as shown in figure 4(a) and4(b). The results showed a maximum 28-days flexural strength of 5.41MPa and 4.67MPa for geopolymer concrete and traditional concrete respectively. The addition of clay content showed an adverse effect on flexural strength of traditional concrete as similar to compressive strength of traditional concrete. In case of geopolymer concrete, the addition of clay content up to 5% showed a positive effect on tensile strength of geopolymer concrete by increasing 10.6%. The addition of 10% clay caused a reduction of 20.4% and 17.1% for geopolymer and traditional concrete respectively.

Shear strength and bearing strength

A set of 15 concrete specimens were prepared for each series of concrete mix at different dosage of clay as specified. The specimens were cured for a period of 28 days and then subjected to shear loading. Similarly, a set of 15 concrete specimens for each series of mix were subjected to bearing strength test. The corresponding results are presented figure 5 and 6 for shear and bearing strengths respectively. The results showed a maximum 28-days shear strength of 3.67MPa and 3.38MPa for geopolymer concrete and traditional concrete respectively. The addition of clay content showed a considerable decrease in shear strength of traditional. In case of geopolymer concrete, the addition of clay content up to 5% showed a positive effect on tensile strength of geopolymer concrete by increasing 6.4%. The addition of 10% clay caused a reduction of 16.2% and 14.8% for geopolymer and traditional concrete respectively. Similarly, the addition of clay (10%) reduced the bearing strength by 22.1% and 5.8% for traditional concrete and geopolymer concrete respectively.

Effect of elevated temperature

A set of 30 cubic specimens (150mm) were prepared for each series of concrete mix at different dosage of clay as specified. The specimens were cured for a period of 28 days and then subjected to uniaxial compression at an elevated temperature of 200^{o}C. The results showed the same trend for both traditional and geopolymer concrete as described in the compressive strength of these two mixes (figure 7). The elevated temperature reduced the compressive strengths in the range of 17.7-21.4% and 18.2-23.5% for geopolymer concrete and traditional concrete respectively.

Durability characterization

In this study, the durability of traditional and geopolymer concrete was evaluated in terms of reduction in strength (compressive and flexural) of concrete subjected to chloride intrusion. The results showed same trend of strength with addition of clay for geopolymer concrete and traditional concrete as described in the cases without chloride intrusion. The results are presented in figure 8 and 9 for compressive and flexural strengths respectively. The results showed a reduction of compressive strength in the range of 11.1-15.5% and 12.9-16.0%for geopolymer concrete and traditional concrete respectively. In case of flexural strength, a range of 14.7-18.3% and 14.1-21.2% for geopolymer concrete and traditional concrete respectively.

CONCLUSIONS

- The addition of clay content showed an adverse effect on the strength of traditional concrete while the addition of clay content up to 5% showed a positive effect on the strength of geopolymer concrete. But, the addition of clay beyond 5% caused a considerable reduction in the strength.
- The elevated temperature reduced the compressive strengths in the range of 17.7-21.4% and 18.2-23.5% for geopolymer concrete and traditional concrete respectively.
- The durability studies revealed a reduction of compressive strength in the range of 11.1-15.5% and 12.9-16.0%for geopolymer concrete and traditional concrete respectively. In case of flexural strength, a range of 14.7-18.3% and 14.1-21.2% for geopolymer concrete and traditional concrete respectively.
- Finally, a maximum of 5% of clay can be recommended for geopolymer concrete without compromising the strength and durability of concrete.

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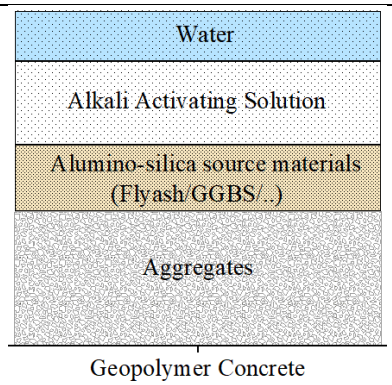
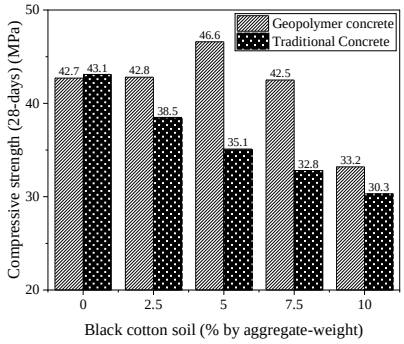
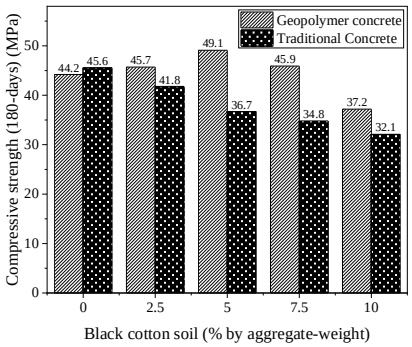


Figure 1. The composition of geopolymer concrete

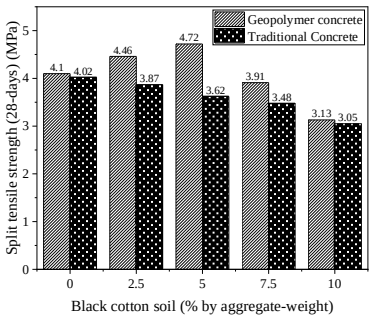


(a) 28 days

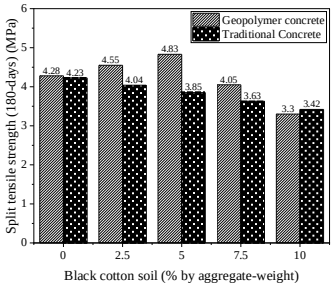


(a) 180 days

Figure 2. The effect of clay-content on compressive strength

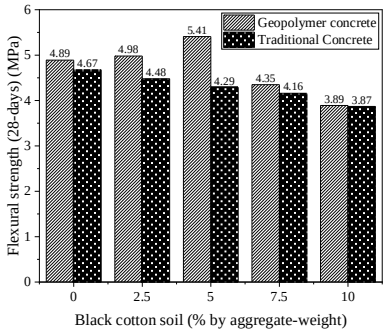


(a) 28 days

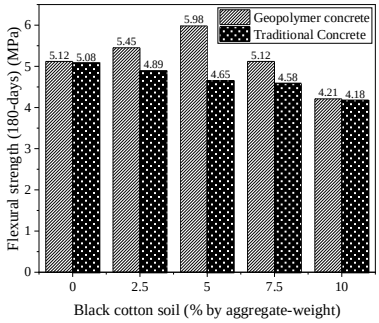


(b) 180 days

Figure 3. The effect of clay-content on split tensile strength



(a) 28-days



(a) 180-days

Figure 4. The effect of clay-content on flexural strength

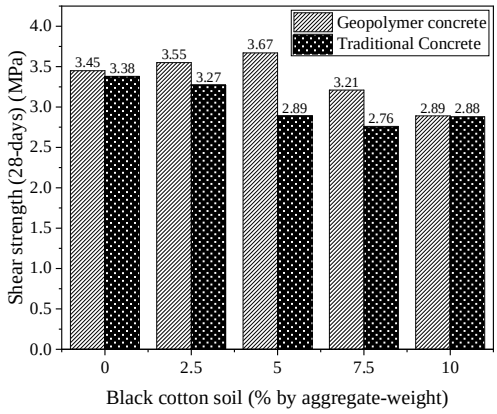


Figure 5. The effect of clay-content on shear strength

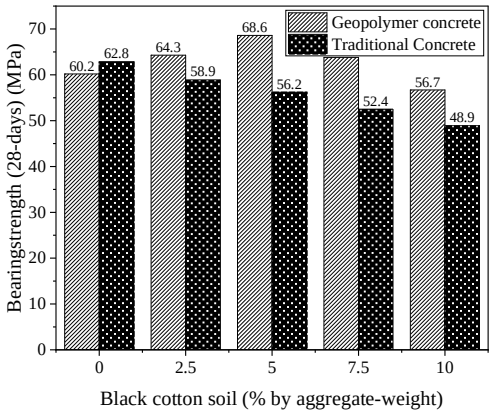


Figure 6. The effect of clay-content on bearing strength

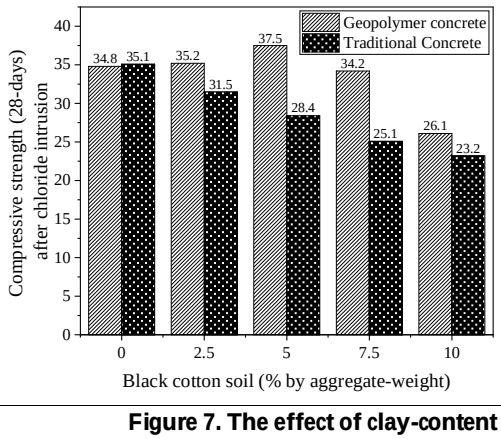


Figure 7. The effect of clay-content on compressive strength at 200°C

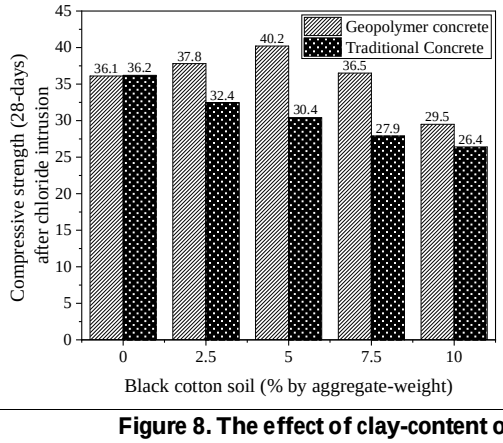


Figure 8. The effect of clay-content on compressive strength after chloride intrusion

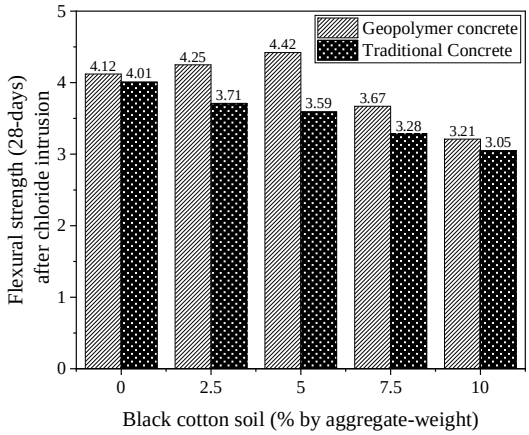


Figure 9. The effect of clay-content on flexural strength after chloride intrusion

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RESEARCH ARTICLE

Parametric studies on the fresh, mechanical and microstructural properties of GGBS blended self compacting geopolymer concrete cured under ambient condition

N. L. N. Kiran Kumar[1] · I. V. Ramana Reddy[1]

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Abstract
The primary goal of the present research is to look into the rheological, mechanical as well as microstructural characteristics of flyash based self-compacting geopolymer concrete (SCGPC) comprised of the combination of fly ash and ground-granulated slag from blast furnaces (GGBS), that is cured at room temperature. GGBS is incorporated together with flyash from 0 to 50% with intervals of 10% binder concentration to make GGBS blended SCGPC. The rheological properties of GGBS blended SCGPC mixes which include slump flow, T_{50cm} slump flow, L-Box, and V-funnel are evaluated for various mixes in accordance with the EFNARC guidelines. For various GGBS blended SCGPC mixtures, mechanical characteristics such compressive strength test, split tensile strength test, and flexural strength test are also evaluated. The replacement of GGBS is optimised in accordance with the findings of mechanical and rheological characteristics. In compliance with the EFNARC guidelines, the outcomes revealed that each of the GGBS blended SCGPC mixes satisfied the fresh properties requirements, and that when GGBS was replaced with 40% of the binder, the resulting strength properties was superior to that of other GGBS blended SCGPC mixes. This article also discusses how X-ray diffraction (XRD), scanning electron microscopy (SEM) with EDAX, and Fourier Transform Infrared Spectroscopy (FTIR) techniques were carried out in order to assess the structural, morphological also mechanical characteristics of the SCGPCs. Findings show that replacement of GGBS enabled a greater degree of geopolymerization, which in turn caused the geopolymer matrix to become denser and enhance the attributes of GGBS blended SCGPC when compared to Flyash based control SCGPC.

Keywords Flyash · GGBS · Self Compacting Geopolymer Concrete (SCGPC) · Fresh properties · Mechanical properties · Microstructural properties

1 Introduction

Concrete, which has become essential in the construction sector, is mostly made of cement [1]. Making cement emits greenhouse gases onto the earth's atmosphere [2]. Cement production harms the environment because it is a major source of greenhouse gases entering the atmosphere [3]. The production of one tonne of cement (OPC) results in the release of an equal amount of carbon dioxide into the atmosphere, which accounts for roughly between five and seven percent of the global emissions of carbon dioxide (CO_2) [4]. Because of the alarming situation, There was a critical need for the cement manufacturing industry to decrease emissions of carbon dioxide (CO_2) [5]. To combat global warming, many researchers have concentrated their research to replace cement with cementitious materials. Davidovits created Geopolymers, in which cement was entirely replaced by industrial by-products [6, 7]. Geopolymers are produced by polymerizing an alkaline solution with a silicon- and aluminum-based primary material, which has the same chemical makeup as zeolites but a different kind of internal structure [8]. For the production of alumina and silica-based binders, Green Geopolymers uses binders made from inexpensive ingredients or byproducts of certain industries which include fly ash, GGBS and

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metakaolin [9]. These raw materials react with alkali-activating solvents to form a tri-alumino-silicate chain. Compounds like sodium aluminosilicate and calcium silicate hydrate are also formed during this geopolymerization which enhances mechanical characteristics, while sodium silicate hydrate creates a tetrahedral network with SiO_4 and AlO_4 [10, 11]. A shift from amorphous to semi-crystalline structures occurs as a result of a complicated chemical reaction involving binders and activators [12]. According to reports, the entire process is accelerated by curing at an elevated temperature [13, 14]. Fly ash is a type of industrial waste produced when thermal coal is burned in electricity-generating facilities [15]. Fly ash can lower carbon dioxide emissions in geopolymer concrete by a proportion of 25–45% as a result of the utilization of the combustion of coal waste [16, 17]. The majority of the byproduct material for GGBS comes from iron manufacturing facilities. CaO, MgO, SiO_2, and Al_2O_3 are all present in GGBS, a granular substance. During the activation of GGBS, the main reaction result is gel composed of calcium silicate hydrate (C-S–H gel) [18], This results in the development of adequate strength regardless of ambient curing conditions [19]. GGBS and fly ash have been extensively utilized as SCMs for research purposes due to their benefits to the mechanical characteristics of GPC, the environment, and the economy as a whole [20, 21]. The formwork must be compacted and filled with fresh concrete by trained personnel. To obtain a homogenous mixture without voids (honeycomb), The main goal of this compaction is to release the trapped air in freshly laid concrete. Normally, when being poured and consolidated at the construction location, normal vibrating concrete couldn't be capable demonstrate the appropriate fresh and toughened characteristics. In freshly mixed concrete, proper compaction requires skilled labour. One approach to resolving this problem is to use self-compacting concrete (SCC) [22, 23]. Self-compacted concrete (SCC) is an improved form of concrete owing to its own weight and can be entirely consolidated into frameworks corners. The main objective of SCC development is to achieve the best compaction and to make it easier to place concrete in crowded areas and small apertures [24–26]. The primary features of SCC is its mobility, fill and passage without any indication of separation and bleeding. Flyash based SCGPC is a pioneering concept in the building sector. As can be seen in Fig. 1, it is an upgraded form of concrete which combines all the advantages from both geopolymer concrete as well as SCC [27–29].

For instance, Flyash prolongs the time needed for the mix to set while GGBS slows down FA's development of strength. As a result, an investigation has been carried out on the control samples consisting of 100% flyash and blended mixes with FA replaced with GGBS at various percentages to a maximum of 50%. In this study, FA and GGBS will be combined in different amounts in order to produce GGBS blended SCGPC and analyse the synergistic effects of this combination. Initially, rheological and mechanical properties were assessed. Later, Microstructural experiments involving



Fig. 1 GGBS blended SCGPC production process

Table 1 Chemical and physical characteristics

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	SO_3	L.O. I	K_2O	Na_2O	Specific gravity	Blaine's fineness
Flyash (%)	65.60	20.86	4.98	1.0	0.55	0.5	0.2	0.16	0.82	0.20	2.29	319
GGBS (%)	34.40	16.39	0.69	37.12	8.30	0.74	0.49	1.64	3.63	0.35	2.84	390

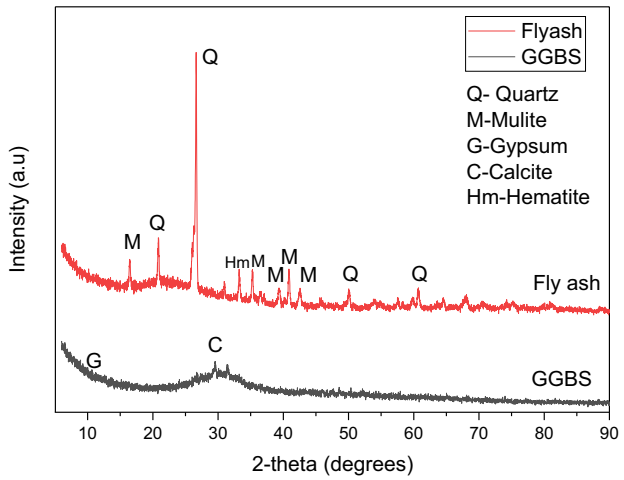


Fig. 2 XRD of flyash and GGBS

XRD, SEM, and FTIR were conducted to investigate the structural and morphologies of the flyash based control SCGPC and GGBS blended SCGPC.

2 Materials

2.1 Flyash

In this study, flyash produced by the Rayalaseema Thermal Power Generating Station (RTTP) in Kadapa, India, and compliant with Indian Standard IS: 3812:2003 [30] was used. Its widespread availability causes disposal issues in many nations, necessitating the utilization of flyash in concrete with the objective to lower the amount of CO_2 in the atmosphere. In the creation of GGBS blended SCGPC, the present study replaces cement with Class F flyash. The physical and chemical attributes of the flyash employed in the current investigation can be found Table 1. The results demonstrate that the fly ash contains silicate glass with a significant silica concentration and considerable levels of the crystalline phases quartz, mullite, and magnetite. It may be used to create SCGPC due to its SiO_2 and Al_2O_3 composition. The XRD analysis was employed to identify the crystalline phase and composition of flyash, as illustrated in Fig. 2. In the Fig. 3a SEM micrograph was used to determine the morphological characteristics of Flyash.

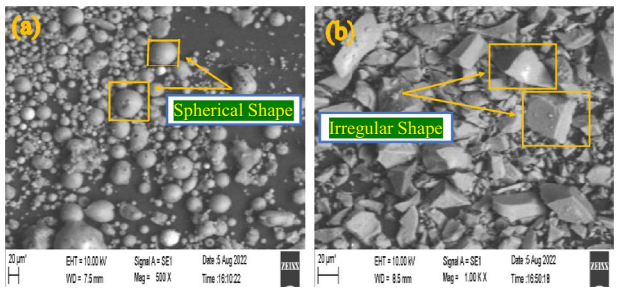


Fig. 3 SEM micrographs of **a** Flyash, **b** GGBS

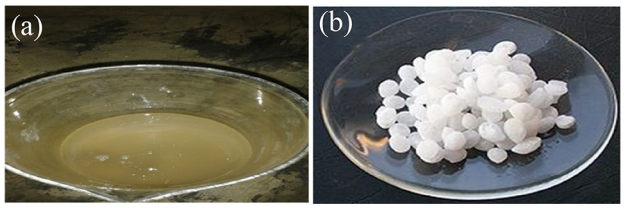


Fig. 4 **a** Sodium silicate, **b** Sodium hydroxide

2.2 GGBS

The by-product of the steel and iron processing sectors is known as GGBS. GGBS would be off-white and have better cementitious properties than other fillers. The supplier of GGBS was JSW Steel Ltd. in Bellary, Karnataka, India. It is referred to as ASTM C 989 and has high silicate and alumina content to improve the material's properties. The physical and chemical characteristics of the GGBFS provided by JSW Steel Ltd. are displayed in Table 1. As seen in Fig. 2 The crystalline structure and phase of the GGBS were determined using the XRD approach. The morphological characteristics of GGBS were determined by capturing micrographs using SEM, as illustrated in Fig. 3b.

2.3 Alkaline activator

In the current experiment, Sodium-based activators were used to produce alkaline activators, including sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) solutions from a dealer of the chemical manufacturer Astrra Chemicals in Chennai as shown in Fig. 4. while maintaining a 2:1 ratio of Na_2SiO_3 to NaOH. To lessen the amount

of heat that is generated throughout the blending process, the prepared alkaline fluid is left for twenty-four hours to settle as well as cool.

2.4 Aggregates

All of these GGBS blended SCGPC mixtures in the present study included a fine aggregate consisting of naturally existing river sand collected from the Tungabhadra Riverbank as well as coarse aggregate with an average size of approximately 12.5 mm as shown in Fig. 5. Using the findings of a sieve examination, it was discovered that the coarse and fine aggregates looked to have specific gravities of 2.64 and 2.60, respectively, and that they complied with IS: 383–1970 [31, 32]. Local suppliers provided the fine and coarse aggregates.

2.5 Super plasticizer

In the current investigation, a superplasticizer from the Master Glenium series was used. It's an admixture made of polycarboxylic ether. This was intended to develop the characteristics of recently laid, extremely efficient concrete. It works effectively with any kind of cement since it doesn't include chlorides or alkalis. A superplasticizer is used to enhance the workability and fluidity of GGBS mixed SCGPC blends without reducing the final product's strength and durability. According to IS 9103:1999 [33], its relative density is roughly 1.09.

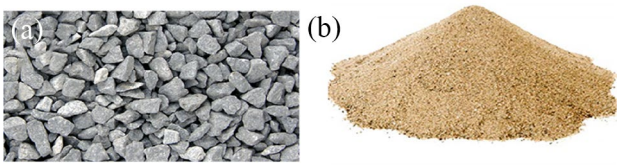


Fig. 5 **a** Coarse aggregate, **b** Fine aggregate

3 Mix proportioning

Six SCGPC blends with GGBS were created by raising the GGBS from 0 to 50%. Liquid to binder ratio was maintained at 0.45, and the total quantity of binder was maintained at 496.55 kg/m^3. In line with the mass of the binder, a superplasticizer (S.P.) with a dosage of 2% and additional water content was used can be seen in Table 2.

3.1 Blending, casting process and curing

Flyash, GGBS and aggregates were all the dry components of the flyash based SCGPC that were mixed together for two to three minutes in a pan mixer. Then, to create alkali activator fluid, the mixture's liquid component, consisting of NaOH and Na_2SiO_3 solution, is combined in a ratio of 1:2 (by weight). In order to complete the perfect blending of GGBS blended SCGPC, Super Plasticizer and Water were provided. For an additional two to three minutes, let these materials mix together. Before being placed onto the moulds, the freshly poured concrete was tested for its rheological characteristics. Before testing, each sample is kept at 27 °C, or room temperature.

3.2 Experimental program

3.2.1 Rheological properties

The rheological characteristics of the GGBS blended SCGPC blends were evaluated utilising slump flow, T_{50cm} slump flow, L-box, and V-funnel experiments. To ascertain the freshly poured concrete's capability for filling, a slump flow experiment was performed. The filling capacity of the mix was determined by timing how long it took the mix to reach a 50 cm diameter employing the T_{50cm} slump flow test. To ascertain if concrete could survive the reinforcing, the L-box test was performed. The vertical section (H_1) and horizontal component's (H_2) leading ends' concrete heights are taken into account for the L-box examination. The V-funnel

Table 2 Mix Proportions of GGBS blended SCGPC

Mix designation	Fly ash (Kg/m^3)	GGBS (Kg/m^3)	C.A (Kg/m^3)	F.A (Kg/m3)	NaOH (Kg/m^3)	Na_2SiO_3 (Kg/m^3)	SP (%)	Extra water added (%)
100FAG0	496.5	0	924	756	74.5	148.9	2	12
90FAG10	446.85	49.65	924	756	74.5	148.9	2	12
80FAG20	397.2	99.3	924	756	74.5	148.9	2	12
70FAG30	347.55	148.95	924	756	74.5	148.9	2	12
60FAG40	297.9	198.6	924	756	74.5	148.9	2	12
50FAG50	248.2	248.2	924	756	74.5	148.9	2	12

experiment was used to gauge the concrete's consistency and filling capacity. Each experiment was conducted in conformity with the guidelines provided by the EFNARC [34].

3.2.2 Mechanical properties

For mechanical characteristics of the GGBS blended SCGPC blends, compressive strength was assessed at 3, 7, and 28 days. Splitting tensile strength and strength in flexural were evaluated after 28 days. Three 150 mm × 150 mm × 150 mm cubes are utilised for the compression strength test in line with IS 516 (1959), and three 500 mm × 150 mm prisms and three 150 mm × 300 mm cylinders were employed for the splitting tensile and flexural strength examinations in compliance with IS 5816 (1999) and IS 516 (1959) standards, respectively [35, 36].

3.2.3 Micro Structural Studies

3.2.3.1 XRD analysis The method that is most frequently employed is X-ray diffraction analysis (XRD), which utilises diffraction patterns to identify the phases and structures of compounds present in a material. By using XRD analysis, the various mineral phases and compounds existing in both the source materials and hardened SCGPC samples were detected. Only the optimal hardened concrete samples (100FAG0and 60FAG40) were pulverised using an agate mortar and sieved using an IS 75-micron sieve prior to examination because the raw materials were already in powder form. Using the fifth-generation Rigaku Miniflex 600 and the programme X'Pert High Score Plus, the test and phase identification were carried out.

3.2.3.2 SEM Analysis For improved visibility and image clarity, several polishing cloths and papers were used to polish the broken GGBS blended SCGPC samples. The samples were then given a final polish with diamond polish before being coated with platinum. For this analysis, an EVO MA18 with Oxford EDS(X-act) was used. This piece of equipment is capable of operating from 100 V and 30 kV especially offers a resolution range of 1–4 nm.

3.2.3.3 FTIR Analysis Employing a Perkin Elmer Spectrometer 2000 in transmission mode having an operating frequency range about 4000 cm-1 to 400 cm-1 and a resolution of 4 cm-1, Fourier infrared spectroscopy analysis (FTIR) was utilised to detect the various functional groups of the developed GGBS blended SCGPC samples. The samples were assessed using pellets of potassium bromide (KBr).

4 Results and Discussion

4.1 Fresh SCGPC properties

Due to qualities including ability to pass, ability to fill, and ability to resist segregation, fresh SCGPC is a very workable concrete. Four tests—Slump flow, T_{50cm} Slump flow, V funnel test, U-box and L-box were performed in order to determine the qualities of fresh SCGPC [34]. Table 3 displays the test outcomes for the newly poured GGBS blended SCGPC characteristics.

4.2 Compressive strength

When evaluating the performance as well as the quality of almost any type of concrete, compressive strength is a key characteristic. Figure 6 illustrates the compressive strengths of the GGBS blended SCGPC samples after 7, 14, and 28 days. In the Fig. 6, The graph illustrates how the compressive strength rises as the percentage of GGBS rises. In comparison to the mixes without GGBS, the GGBS blended SCGPC composites with 10, 20, 30, 40, and 50% GGBS of the total binder, respectively, had compressive strengths that were 21, 33, 53, 65, and 49% higher at 28 days. This increase is in line with the prior research investigation [37]. This rise in strength is attributable to the synthesis of Calcium Alumino Silicate Hydrate gel (C-A-S–H gel) along with Sodium Alumino Silicate Hydrate gel (N-A-S–H gel), that increased the microstructure's compactness [38, 39]. The compressive strength graph demonstrates that mix with 40% GGBS, it increases from 35. 79 MPa at three days and then increases up to52.6 MPa at28 days of curing. This outcome

Table 3 Rheological Properties of GGBS blended SCGPC mixes

S.No	Mix designation	Slump flow (mm)	T_{50cm} slump flow (sec)	V-funnel (sec)	U-box (mm)	L-box (H_2/H_1)
Efnarc guidelines		650–800	2–5	6–12	0–30	0.80–1.0
1	100FAG0	720	3.06	7.9	10	0.89
2	90FAG10	700	3.20	8.1	14	0.91
3	80FAG20	695	3.50	8.4	18	0.93
4	70FAG30	690	3.80	9.4	20	0.94
5	60FAG40	685	3.98	9.8	22	0.95
6	50FAG50	680	4.23	10.3	25	0.97

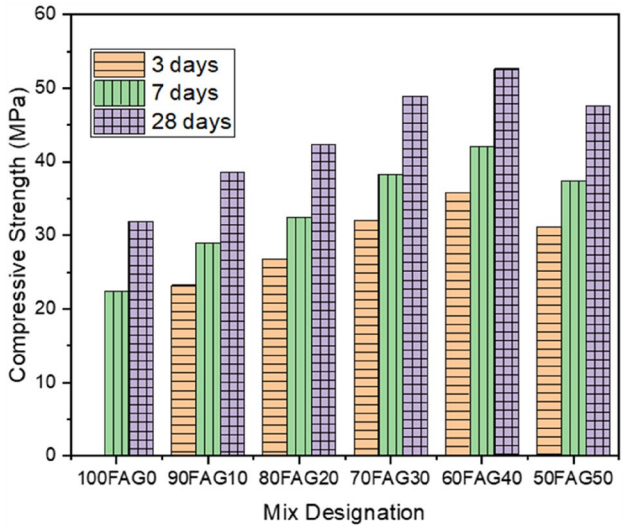


Fig. 6 Compressive strength of SCGPC mixes

is in line with the previous research investigation already in existence [40].

4.3 Split tensile strength

At 28 days, Fig. 7 depicts the outcomes of the splitting tensile strength tests conducted on the GGBS blended SCGPC. The splitting tensile strength of the GGBS blended SCGPC is shown in this graph to be directly proportional to the percentage of GGBS replacement up to 40%. The improvement in splitting tensile strength of GGBS-blend SCGPC mix over flyash-based control SCGPC is roughly 20, 27, 40, 58 and 50% for mixtures of replacement of 10, 20, 30, 40, and 50%, respectively. The outcomes of the splitting tensile assessment support the performance of the compressive strength assessment outcomes.

4.4 Flexure strength test

The outcomes of the flexural strength evaluation for the GGBS blended SCGPC after 28 days after casting are depicted in Fig. 8. The flexural strength of the GGBS blended SCGPC rises as the percentage of GGBS does, as this graph clearly shows. In comparison with the flyash-based control SCGPC mix (100FAG0), the flexural strength of GGBS blended SCGPC mixes of 10, 20, 30, 40, and 50% increased by roughly 16.36, 34.52, 40.47, and 48.21%, respectively. The behaviour of the compressive strength outcomes is enhanced by using the results of the flexural strength evaluation.

4.5 XRD analysis

By using XRD analysis, the mineralogical properties of fly-ash based control SCGPC (100FAG0) and GGBS blended SCGPC incorporated with 40% of GGBS (60FAG40) were inspected after 28 days of healing. Figure 9 displays the XRD pattern. Aluminosilicate substances with an amorphous structure are the primary polymerization products produced in geopolymer (N-A-S–H and C-A-S–H). Thus, a wide amorphous hump of aluminosilicate ($2\Theta = 25°–32°$) and a low crystalline C-S–H gel make up the majority of the 60FAG40 XRD pattern. In fly ash, It is also observed that only the glassy components will react and hence the primary crystalline peak found is quartz (SiO_2) and mullite ($3Al_2O_3$-SiO_2) [41]. Fly ash's reactive glassy fraction and

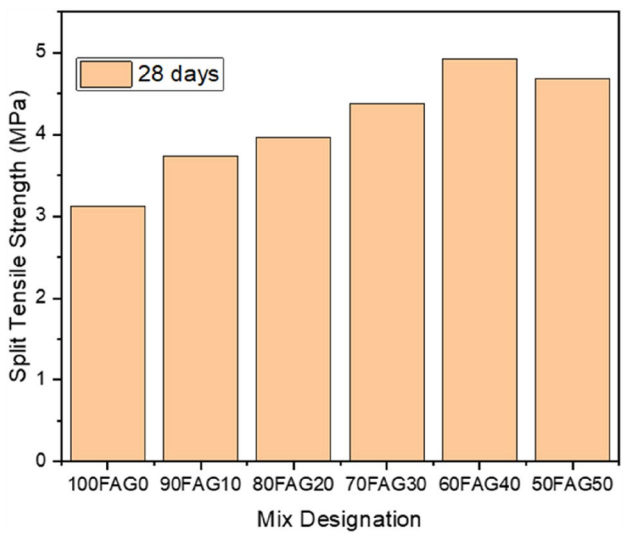


Fig. 7 Splitting tensile strength of SCGPC mixes

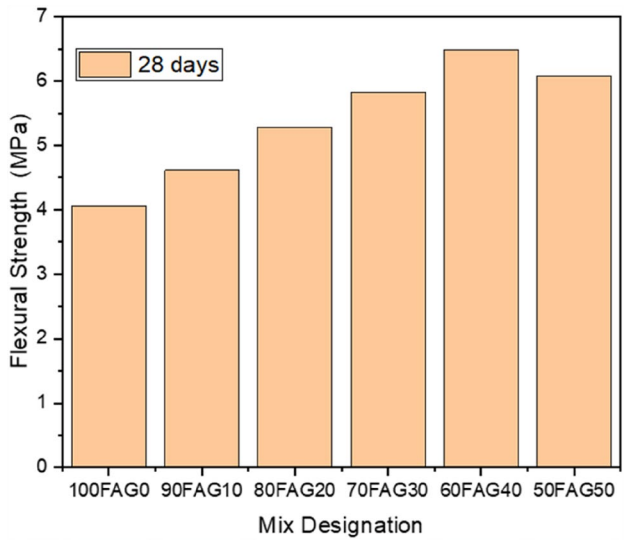


Fig. 8 Flexure strength of SCGPC mixes

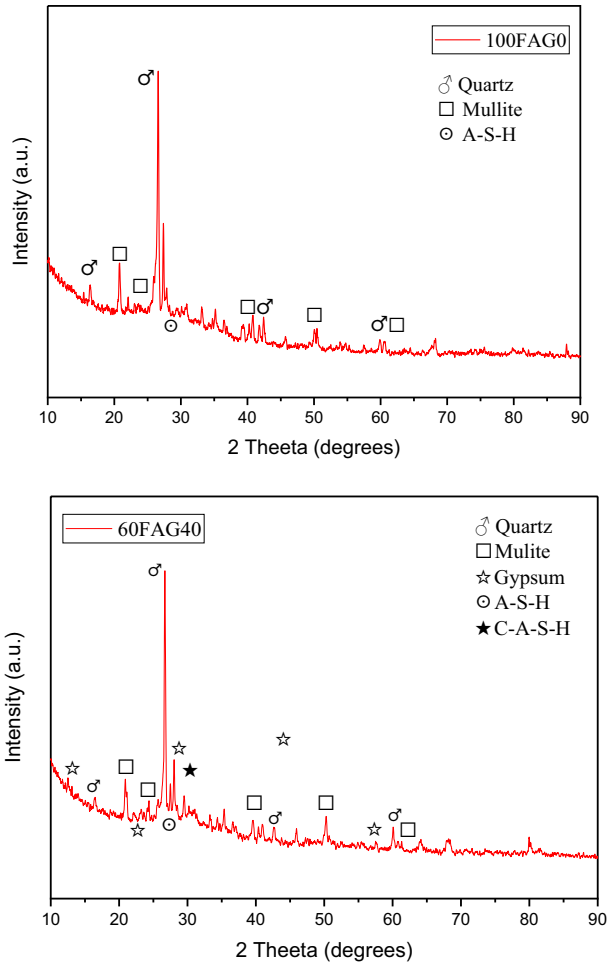


Fig. 9 XRD analysis of SCGPC samples

GGBS reacted to form reaction products that ranged from amorphous to imperfectly crystalline phases. It is crucial to note that only reactive glass participates in geopolymerization, while the fly ash's glass content also includes refractory glass. A wide and dispersed background peak with maximum of around 10° is produced by the hydrotalcite (Mg_6A_{l2}-$CO_3OH_{16}4H_2O$) short-range order which increases C-(N)-A-S–H gel polymerization and a reduction in the available Al element [42, 43].Each sample that included GGBS had detectable peaks at 30° and 50° that belonged to the A-S–H and C-S–H gels. It needs to be noticed that the Peak crystalline phase's intensity reduces as the GGBS increases [44].

4.6 SEM with EDS

Figure 10 displays the SEM images of the control flyash based SCGPC (100FAG0) and the GGBS blended SCGPC with 40% GGBS replacements (60FAG40). The images shown here clearly demonstrate that the mixture of 60% FA and 40% GGBS has a denser microstructure, a matrix that has almost completely reacted, and some cenosphere and plerosphere FA particles that have not yet completely reacted. According to a report, the unreacted particles in the combination did not function as filler but instead gradually increased the matrix's strength alternatively.This is in line with the compression outcomes and the prior literature-reported outcomes [45]. An aluminosilicate gel (N-A-S–H) gets formed when alkali-activation was applied to flyash based control SCGPC (100FAG0). On the other hand, the Calcium ions from GGBS take the place of sodium ions in GGBS mixed SCGPC (60FAG40) with a high pH (> 12), causing C-A-S–H or C-S–H to precipitate till the calcium ions have been used up. Thus, N-A-S–H, C-S–H, and C-A-S–H were identified within the GGBS blended SCGPC (60FAG40) sample [46].The reason why the fly ash particles in Fig. 10 have needle-like shapes is most likely due to the mixture's high activator solution content. This unreacted alkali solution precipitated during the geopolymerization process as minute needle particles in the mixture [47][47].

Based on EDS tests carried out on a selected area in both samples, the primary components of the SCGPC samples, which belong to the N–C-S–H, N-A-S–H, C-S–H, and Mg $(OH)_2$binders type, are Aluminium, silica magnesium, calcium, oxygen, and Sodium. As shoen in Table 5, Higher Si/Al ratios, especially Si/Al > 2.5, are necessary for the creation of 3D networked polysialate- siloxo and polysialatedisiloxo polymers. In addition to calcium and sodium, 3D networks (Ca,K) polysialate-sililoxane also need small quantities of silicon, oxygen, and aluminum. [49].

4.7 FTIR analysis

The FTIR spectra of the 100FAG0 and 60FAG40 mix sample are depicted in Fig. 11. The strong signals seen at 3369and 3432 cm^{-1} in the 100FAG0 and 60FAG40, respectively, are caused by symmetrical bending vibrations of water molecule-associated H–O-H bonds [50]. The C-H groups are responsible for the small bands at 2816 and 2882 cm^{-1} on the spectra of the 100FAG0 and 60FAG40, indicating an existence of organic molecules from super plasticizers [50]. The bands at a distance of 1637–1793 cm^{-1} are also attributable to the stretching and bending vibrations of O–H bonds, which show the water molecules attached to the geopolymer network [51].The efflorescence phenomenon [52], which results from the geopolymerization process between unreacted Na^+ and ambient CO_2, is linked to the splitting of absorption bands in the ranges of 1446–1476 cm^{-1} and 1422–1482 $cm^{-1}$is observed on the 100FAG0 and 60FAG40,respectively. This finding suggests that degenerescency caused by distortion has been eliminated [53]. It is possible that this area may be linked to the silica and

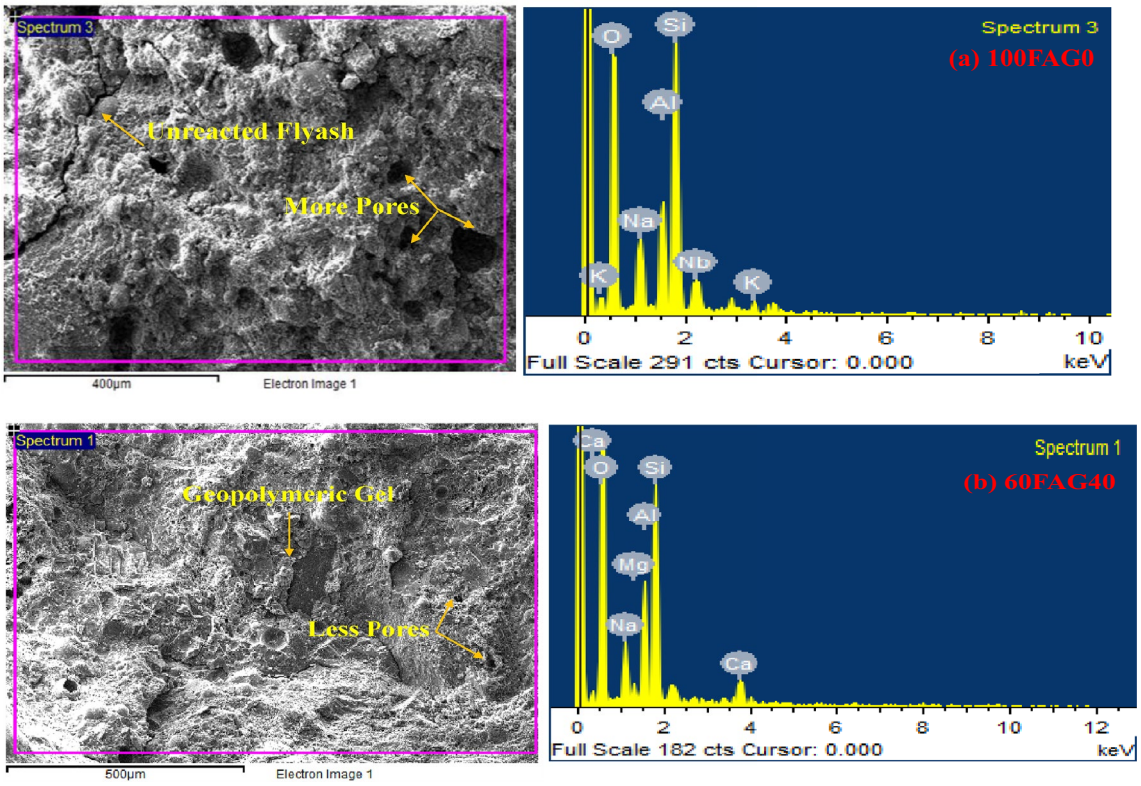


Fig.10 SEM analysis of SCGPC samples

Table 5 Chemical elements (atomic %) and their ratio at 28 days

Mix	O K	Si K	Na K	Ca K	Al K	Si/Al ratio
100FAG0	60.29	24.16	2.09	0.67	7.26	3.32
60FAG40	37.83	33.75	3.09	15.9	8.92	3.78

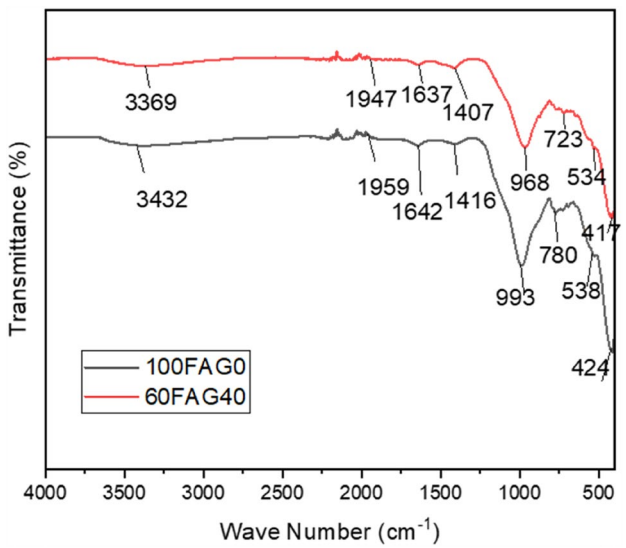


Fig. 11 FTIR analysis of SCGPC samples

alumina connections (C-A-S–H and N-A-S–H) that drive polymerization during the geopolymerization process [54].

5 Conclusions

In this current research, the impact of GGBS on the flyash based SCGPC's performance in both the fresh, hardened phases and Microstructural properties were examined. The following Results were attained;

- The results showed that up to 40% FA was successfully substituted for GGBS as a precursor binder in SCGPC's producing outstanding fresh and mechanical qualities that satisfied the EFNARC standards for SCC.
- With an increase in GGBS quantity in the binder, the workability of the fresh GGBS blended SCGPC's reduced. The reason for this is mainly due to the calcium reacting more

quickly and to the angular shape of the slag in contrast to the spherical shape of the fly ash particles.

- As compared to control SCGPC (100FAG0), the mix with 40% GGBS blended SCGPC (60FAG40) which does not require heat curing, exhibits the highest compressive strength increased by 40.26 and 33.97%after 7 days and 28 days.
- However, when the GGBS grew from 0 to 50%, both the splitting tensile strength and flexural strength of the GGBS blended SCGPC enhanced by about 33.59 and 31.05%, respectively.
- The results of the XRD-based microstructural analysis of SCGPCs revealed a decrease in the number of crystalline phases when the GGBS content was raised as a partial substitute for Flyash. Consequently, the porosity decreased while the density and C, N-(A)-S–H gel were enhanced.
- As shown by SEM and EDAX analysis, the GGBS increased the degree of polymerization and polycondensation, which subsequently improved the densification of the entire system and increased its strength. Cristobalite and stishovite, which are unreacted FA/GGBS, function as fillers by saturating pore spaces, which raises the packing density of the binder phase.
- When the proportion of GGBS is raised, FTIR data revealed shifts in geopolymer process and the development of C-S–H gel, which enhance the strength qualities.

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Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval Not Applicable.

Consent to participate Not Applicable.

Consent for publication Not Applicable.

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AN EXPERIMENTAL INVESTIGATION ON PROPERTIES OF GEOPOLYMER CONCRETE USING COMPOSITE FIBERS

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ABSTRACT: Geopolymer technology represents a significant advancement in concrete production, especially in mitigating the environmental concerns that arise from the use of conventional cement materials that emit significant amounts of CO_2. By substituting cement with alternative ingredients such as Fly ash and Ground Granulated Blast Furnace slag (GGBFS), a more environmentally friendly approach is possible. Geopolymer concrete, utilizing a synthetic resin binder that reacts with alkaline solutions like sodium hydroxide and sodium silicate, emerges as a viable alternative. This project aims to enhance the properties of fly ash and slag-based Geopolymer concrete by incorporating composite fibers. It seeks to investigate the effects of Crimped steel, Polypropylene, and Glass fibers on the compressive, split tensile, and flexural strength of Geopolymer concrete. By introducing varying proportions of fibers, ranging from 0.5% to 1.5% of the concrete volume, the study intends to determine their impact on the mechanical properties of concrete. These investigative efforts hold significant potential for broadening the application of Geopolymer concrete, providing an efficient alternative to traditional cement concrete for a wide range of construction applications.

***Key words*: Crimped steel fibers, Fly ash, Geopolymer concrete, Ground Granulated Blast Furnace Slag (GGBFS), Glass fibers, Polypropylene fibers, Sodium silicate, Sodium hydroxide.**

I. INTRODUCTION

Concrete, a fundamental material in global construction, relies heavily on cement. However, cement production contributes significantly to greenhouse gas emissions. To address this, researchers have explored alternative binding materials, including non-crystalline alkali-aluminosilicate geopolymers. Geopolymer concrete, made from byproduct waste, reduces direct carbon dioxide emissions during production. Geopolymer concrete is an innovative alternative to traditional cement-based concrete, where pozzolanic materials rich in silica and alumina, such as fly ash or blast furnace slag, are activated by alkaline liquids to act as binders. This substitution reduces the carbon footprint of concrete production. Geopolymerization, the chemical process behind geopolymer concrete, involves exposing alumina-silicate materials to high-alkaline environments, typically sodium or potassium hydroxide solutions. This results in the formation of a strong binder characterized by a Si-O-Al structure. The reaction involves breaking valency bonds between silicon, aluminium, and oxygen atoms, leading to the formation of three-dimensional polymeric chains and ring structures. Alkaline cations like sodium and potassium compensate for charge imbalances caused by aluminium in the gel product. The rate of dissolution and the resulting properties of geopolymers are influenced by factors such as the quantity and content of materials used and the pH of the activating solution. Geopolymer concrete utilizes thermally activated natural resources or industrial by-products as sources of silicon and aluminium. Despite its advantages, geopolymer concrete exhibits brittleness. To overcome this limitation, we turn to fibers. By reinforcing geopolymer concrete with fibers, we aim to enhance its toughness, durability, and applicability across a wide range of construction scenarios. This review sheds light on the promising future of fibre-reinforced geopolymer concrete and emphasizes the need for standardized manufacturing processes.

The objective of this journal paper is to present the results of an experimental investigation on Geopolymer concrete, formulated using fly ash and Ground Granulated Blast Furnace Slag (GGBFS), along with sodium silicate, sodium hydroxide, crimped steel fibers, polypropylene fibers, glass fibers, and a chemical admixture. Specifically, the study utilizes the PCE-based super plasticizer AURAMIX 450 to achieve the desired properties of Geopolymer concrete. The chemical admixture is dosed at 1.4% by weight of binder content based on a trial method, while maintaining a constant water-to-binder ratio of 0.45. The mix design and proportioning of ingredients for the Geopolymer concrete involve maintaining a fixed ratio of 2 for sodium silicate and sodium hydroxide, along with the use of a 12M alkaline solution. The mechanical properties under investigation include compressive strength, split tensile strength, and flexural strength of the concrete specimens. To further enhance the mechanical properties and observe changes, crimped steel fibers, polypropylene fibers, and glass fibers are added in varying percentages (0%, 0.5%, 0.75%, and 1%) collectively. This addition aims to investigate the effects of fiber reinforcement on the Geopolymer concrete's performance. By systematically varying the fiber content and assessing the resulting mechanical properties, the study aims to provide insights into the optimization of Geopolymer concrete formulations for enhanced performance and durability in various engineering applications.

II. OBJECTIVES

The following are the objectives of this experimental investigation:

1. To find the optimum percentage of Steel fibers in developing the strength of the Geopolymer concrete and to mitigate the brittleness of GPC
2. To develop the strength of Geopolymer concrete using Steel fibers and Polypropylene fibers in various percentages from the optimum percentage of Steel fibers and to observe the changes in properties of GPC.
3. To develop the strength of Geopolymer concrete using Steel fibers and Glass fibers in various percentages from the optimum percentage of Steel fibers and to observe the changes in properties of GPC.
4. To determine the mechanical properties of Geopolymer concrete such as compressive strength, split tensile strength and flexural strength by the addition of various percentages of fibers in Geopolymer concrete.
5. To compare the properties of Geopolymer concrete with fibers and without fibers.

III. MATERIALS

In this experimental investigation the following materials are used

3.1 Fly Ash

Fly ash, derived from the combustion of pulverized coal in coal-fired thermal power plants, is a by-product extensively utilized in hydraulic-cement concrete. Class F fly ash, specifically chosen for this experimental investigation, possesses a specific gravity of 2.12.

3.2 Ground Granulated Blast Furnace Slag (GGBFS)

Ground Granulated Blast Furnace Slag (GGBS) is a by-product of the iron-making process in blast furnaces. With a specific gravity ranging between 2.80 and 3.00, slag holds the distinction of having the highest specific gravity among all mineral admixtures. As a processed material, its fineness can be finely adjusted to meet specific requirements. In numerous applications, the fineness of slag closely resembles that of cement. GGBS primarily consists of calcium silicates and alumino-silicates. Its specific gravity is measured at 2.9.

3.3 Fine Aggregate

River sand sourced locally, adhering to the IS: 383-1970 specifications, was utilized as the fine aggregate in the concrete mix. The sand particles pass through a 4.75mm sieve and are retained on a 75µm sieve. Table 3.1 provides details regarding the physical properties of the fine aggregate.

Table 3.1: Physical properties of Fine aggregate

Particulars	Values
Specific gravity	2.58
Fineness modulus	3.15
Grading	Zone II

3.4 Coarse aggregate

For this investigation, well-graded coarse aggregate consistent with the specifications outlined in IS: 383-2016 will be utilized. The coarse aggregate, sourced from local quarry units and conforming to IS: 383-1970 standards, has been selected for this study. The maximum size of the coarse aggregate employed is 12.5mm. The physical properties of the coarse aggregate are detailed in Table 3.2.

Table 3.2: Physical properties of Coarse aggregate

Particulars	Values
Specific gravity	2.60
Fineness modulus	6.30
Water absorption (%)	0.72

3.5 Sodium Hydroxide Flakes

Sodium hydroxide (NaOH) is commonly available in solid forms such as pellets or flakes. Its price varies based on purity. Solutions of NaOH are prepared by dissolving pellets in water to achieve different molarities. It is advised to prepare the NaOH solution at least 24 hours before use and to use it within 36 hours to prevent it from solidifying.

3.6 Sodium Silicate

Sodium metasilicate, also referred to as sodium silicate, is an industrial-grade compound containing 31.12% SiO_2 and 14.2% Na_2O by mass. Manufacturers commonly utilize it as a bonding agent in detergent and textile industries. Sodium silicate is typically found in liquid form.

3.7 Chemical Admixture

Polycarboxylate ether (PCE) based superplasticiser AURAMIX 450 was used.

3.8 Crimped steel fibers

In this study, crimped steel fibers with a length of 35mm and a diameter of 0.5mm are utilized, resulting in an aspect ratio of 70.

3.9 Polypropylene fiber

In this study, FIBERCRETE MF, a synthetic monofilament fiber is used. Polypropylene fibers with a length of 12mm and a diameter of 0.02 mm are utilized, resulting in an aspect ratio of 600.

3.10 Glass fibers

In this study, glass fibers with a length of 12mm and a diameter of 0.014mm are utilized, resulting in an aspect ratio of 857.

IV. EXPERIMENTAL INVESTIGATION

4.1 Mix proportions

In this experimental investigation, the binder content, obtained from a mix design referenced in prior literature, is 496 kg/m^3. This composition consists of 80% fly ash and 20% GGBFS. For the 12M solution, the NaOH content is measured at 74.5 kg/m^3, while the Na_2SiO_3 content is taken as 149 kg/m^3. To achieve the desired fresh properties of Geopolymer concrete, a water-to-binder ratio of 0.45 is selected, alongside a chemical admixture dosage of 1.4% by weight of the binder content, determined through trials. The study assesses the impact of crimped steel fibers on Geopolymer concrete, identifying the optimal percentage, and then explores substitutions with glass and polypropylene fibers at varying proportions of 0.5%, 0.75%, and 1% by weight of the binder content. Table 6 summarizes the concrete mixture proportions for Geopolymer concrete.

Table 6: Mix proportions of Geopolymer concrete addition with percentage of Crimped Steel fibers, Polypropylene fibers &Glass fibers

Materials kg/m^3 / Mix No.	Fly Ash & GGBS	Sodium Hydroxide	Sodium Silicate	Fine Aggregate	Coarse Aggregate	Super plasticizer	Crimped steel fibers (%)	Polypropylene fibers (%)	Glass fibers (%)
M_1	496	74.5	149	756	924	6.9	0	0	0
M_2	496	74.5	149	756	924	6.9	1.5	0	0
M_3	496	74.5	149	756	924	6.9	1	0.5	0
M_4	496	74.5	149	756	924	6.9	0.75	0.75	0
M_5	496	74.5	149	756	924	6.9	0.5	1	0
M_6	496	74.5	149	756	924	6.9	1	0	0.5
M_7	496	74.5	149	756	924	6.9	0.75	0	0.75
M_8	496	74.5	149	756	924	6.9	0.5	0	1
M_9	496	74.5	149	756	924	6.9	0.5	0.5	0.5

4.2 Mix procedure

For the experimental investigation, materials such as fly ash, GGBS, aggregates, sodium silicate, and sodium hydroxide are procured and tested to determine the properties such as specific gravity and water absorption. Mix design for Geopolymer concrete (GPC) is done, considering the desired proportions of the materials. Additionally, different volumes of fibers are incorporated into the mix to assess their impact on the concrete's performance. Following the mix design, concrete samples in the form of cubes, cylinders, and prisms are casted and cured for 24 hours before demolding. Subsequently, the specimens undergo an air-curing process at ambient temperature for durations of 7, 28, and 56 days to facilitate concrete strength development. Mechanical properties including compressive strength, split tensile strength, and flexural strength are then determined at the designated curing ages of 7, 28, and 56 days to analyze the performance of the Geopolymer concrete specimens.

4.3 Test procedure on Hardened concrete

The following tests are conducted to find the mechanical properties on hardened concrete:

Compressive Strength: The compressive strength of Geopolymer concrete is determined by casting the specimens of size 100*100*100mm. These samples undergo testing at ages of 7, 28, and 56 days using a compressive testing machine (CTM) with a capacity of 3000kN, as per IS 516:1959, as shown in Fig 1a.

Split Tensile Strength: The split tensile strength of Geopolymer concrete is determined by casting the cylinders of size 100*200mm. These samples undergo testing at 28 days using a compressive testing machine (CTM) with a capacity of 3000kN, as per IS 516:1959, as shown in Fig 1b.

Flexural Strength: The flexural strength of Geopolymer concrete is determined by casting the beam specimens of size 100*100*500mm. These samples undergo testing at 28 days, as per IS 516:1959, as shown in Fig 1c.



Fig. 1a Compression test



Fig. 1b Split tensile



Fig. 1c Flexure test

V. RESULTS AND DISCUSSION

5.1 Mechanical properties of Geopolymer concrete:

The following are the test results of compressive, split tensile and flexural strength tests to determine the mechanical properties of Geopolymer concrete.

5.1.1 Compressive strength test

Figure 2 illustrates the compressive strength variations of Geopolymer concrete mixes denoted as M1 to M9, each incorporating different types of fibers including crimped steel, polypropylene, and glass fibers. For the control mix (M1), the compressive strength at 7, 28, and 56 days was determined as 34.88, 39.15, and 40.8 N/mm^2, respectively. Upon introducing crimped steel fibers in mix M2, a notable increase in strength was observed compared to the control mix. Of note, mixes M2 and M8 exhibit nearly equal compressive strengths. This suggests that the combination of steel and glass fibers in mix M8 yields a compressive strength similar to that achieved with crimped steel fibers alone.

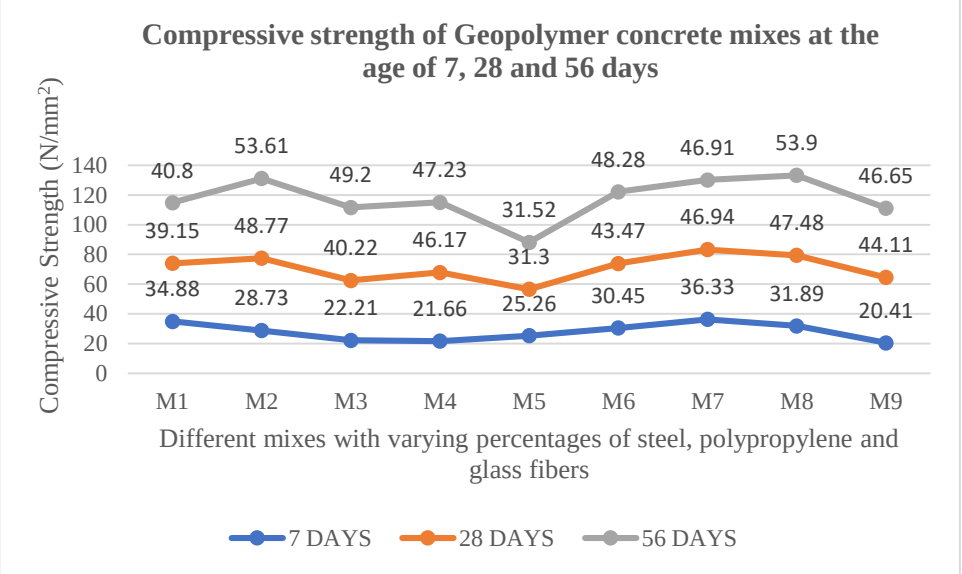


Fig. 2 Variation compressive strength of different mixes

5.1.2 Split tensile strength test

Figure 3 displays the split tensile strength variations of Geopolymer concrete mixes denoted as M1 to M9, incorporating different types of fibers such as crimped steel, polypropylene, and glass fibers. For the control mix, denoted as M1, the 28-day split tensile strength was recorded as 1.705N/mm^2. With the addition of 1.5% crimped steel fibers (the optimum percentage), this strength increased to 4.605 N/mm^2 in mix M2. Remarkably, mix M8 exhibits a split tensile strength similar to that of mix M2. This suggests that the combination of steel and glass fibers in mix M8 yields a split tensile strength comparable to that achieved with crimped steel fibers alone.

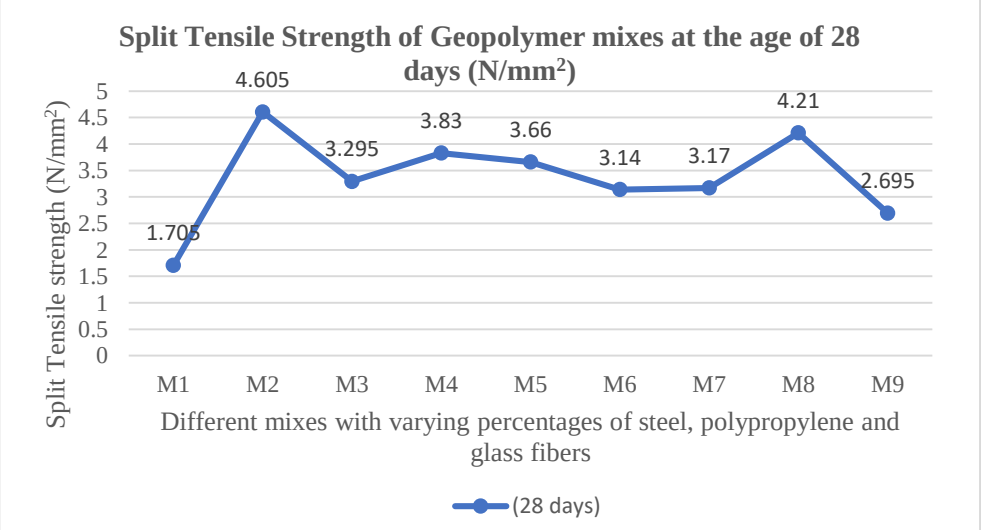


Fig. 3 Variation Split tensile strength of different mixes

5.1.3 Flexural strength test

Figure 4 displays the flexural strength variations of Geopolymer concrete mixes denoted as M1 to M9, incorporating different types of fibers such as crimped steel, polypropylene, and glass fibers. For the control mix, denoted as M1, the 28-day flexural strength was recorded as 4.27 N/mm^2. With the addition of 1.5% crimped steel fibers (the optimum percentage), this strength increased to 6.69 N/mm^2 in mix M2. Remarkably, mix M8 exhibits a flexural strength similar to that of mix M2. This suggests that the combination of steel and glass fibers in mix M8 yields a flexural strength comparable to that achieved with crimped steel fibers alone.

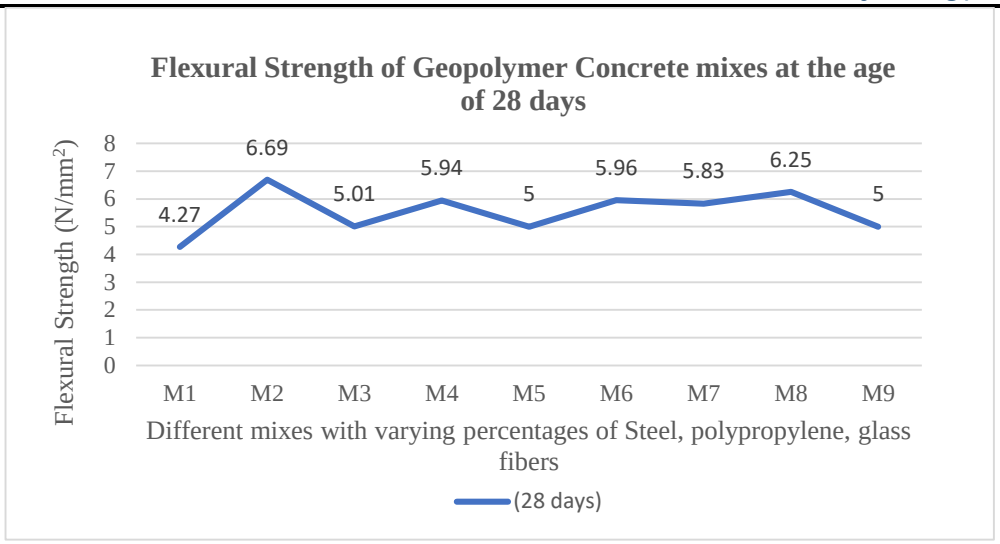


Fig. 4 Variation Flexural strength of different mixes

VI. CONCLUSIONS

In this research work, nine different mixes of Geopolymer concrete were considered to investigate their strength characteristics, including compressive strength, flexural strength, and split tensile strength, with the incorporation of various fiber types such as crimped steel, polypropylene, and glass fibers.

1. The partial replacement of 20% GGBFS in the Geopolymer concrete mixture effectively mitigates setting delays, particularly during air curing at ambient temperatures.
2. Through experimental analysis, a Geopolymer concrete mix design with a liquid binder ratio of 0.45 and an alkaline solution ratio of 2 was identified, exhibiting desirable strength properties and advantageous environmental and economic benefits.
3. Cube compressive strength assessments revealed that mixes M1 and M2, augmented with crimped steel fibers, demonstrated increased strength at 28 and 56 days, with values escalating from 39.15 MPa to 48.77 N/mm^2 and from 40.8 N/mm^2 to 53.69 N/mm^2, respectively. Optimal performance was achieved with a 1.5% addition of crimped steel fibers. Similar strength outcomes were observed in mix M8, which featured a combination of 0.5% crimped steel and 1% glass fibers.
4. Split tensile strength evaluations exhibited a similar trend, with mixes M1 and M2 registering enhancements from 1.705 N/mm^2 to 4.605 N/mm^2 at 28 days upon the incorporation of crimped steel fibers. The optimal mix again featured a 1.5% addition of these fibers, with mix M8 showing comparable results due to the combination of 0.5% crimped steel and 1% glass fibers.
5. Flexural strength assessments followed suit, with mixes M1 and M2 displaying increases from 4.27 N/mm^2 to 6.69 N/mm^2 at 28 days with the inclusion of crimped steel fibers. The optimal mix was identified at a 1.5% addition of crimped steel fibers, mirroring the results of mix M8, which combined 0.5% crimped steel and 1% glass fibers.
6. The overall analysis suggests that Geopolymer concrete incorporating 1.5% crimped steel fibers achieves optimal strength performance. Additionally, composite fiber mixes, particularly those combining steel and glass fibers, exhibit superior performance compared to combinations of steel and polypropylene fibers.
7. Despite the enhanced strength provided by steel fibers, their weight and cost implications prompt consideration of alternatives. Replacement of 1% steel fibers with glass fibers yields lighter, more cost-effective Geopolymer concrete with strength levels approaching those of Geopolymer concrete with optimal steel fiber content.

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Chemical Engineering & Technology Research Article

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Application of Preformed Floc Adsorbents in the Removal of Acid Dye from an Aqueous Solution

Preformed flocs prepared by using coagulants, i.e. $Fe_2(SO_4)_3$, $MnSO_4.4H_2O$, and $MnCl_2.4H_2O$, were applied as adsorbents for the decolorization of an aqueous C.I. Acid Red 1 dye solution. In order to determine the decolorizing efficiency of different adsorbents, kinetic and equilibrium studies were carried out at the optimum pH. Excellent color removal of 87 % was obtained with $Fe_2(SO_4)_3$ at pH 4, good color removal of 65 % was achieved with manganese sulfate at pH 10, and moderate color removal of 58 % was obtained with manganese chloride at pH 10, at an optimum sorbent dose of 500 mg L^{-1} and an equilibrium contact time of 15 min. The sorption data of the equilibrium studies fitted well to the Langmuir isotherm, stating the occurrence of monolayer formation in the adsorption process of dye color removal. The maximum adsorption capacities of ferric sulfate and manganese sulfate are 47.619 and 23.474 mg g^{-1}, respectively. The data of the kinetic studies fitted well to the pseudo-second-order equation, stating that chemisorption is the rate-limiting step.

Keywords: Adsorption, Flocs, Ferric sulfate, Manganese sulfate, Manganese chloride

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1 Introduction

Dyes are used in many industries, such as in textile, paper pulp, tannery, cosmetics, leather, plastics, printing, rubber, food, and pharmaceuticals production [1–5]. Dyes are aromatic amines with different types of organic functional groups and with heavy metals embodied in the basic structure, like chromium, copper, and cobalt [6]. The presence of such metals retards biological treatment. Their discharge into water bodies causes pollution due to their recalcitrant nature. The toxicity of dyes causes serious problems for the environment, aquatic life, and human and animal health [7].

The presence of coloring matter in significant quantities in receiving water would not only reduce light penetration and photosynthetic activity, but would also render their appearance unaesthetic [8, 9]. Furthermore dyes may impart toxicity to aquatic and plant biota and may be mutagenic and carcinogenic, causing severe damage to human life, such as misfunctioning of the kidneys, brain, liver, reproductive system, and central nervous system [10]. A majority of the used dyes are azo dyes, which are bright in color due to the presence of one or several azo (–N=N–) groups associated with substituted aromatic structures [11–13], and consist of more stable organic compounds that are carcinogenic, also causing allergic responses after exposure to them [7]. Therefore, it becomes mandatory that color should be removed from dye effluents before disposal of the effluent. Treatment processes such as physical, physicochemical, chemical, and biological methods have been investigated and proved to be effective, but to varying degrees of success [14]. Michaels and White [15] observed that treatment through biological methods cannot reduce the chemical oxygen demand (COD) and color, even though it reduces the biochemical oxygen demand (BOD). Chemical coagulation seems to be a very efficient method in the removal of color from dye wastewater [14, 16–19]. Coagulation and flocculation of the inorganic coagulants such as ferric sulfate, manganese sulfate, alum, and iron salts have been used in the decolorization of dye color over many years. But the main disadvantages of coagulation treatment are the process control and the sludge production, for which settling, dewatering, and converting to a cake for land filling is needed [20]. Among different methods, the adsorption process has good potential in removing dyes from effluents, due to its simplicity of design, ease of operation, wide adaptability, high efficiency, and economic viability [21]. The adsorption process produces good-quality effluent and it is

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Ultrasound Assisted Advance Oxidation Process For Removal Of Nickle

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Abstract:
Nickel polluted wastewater is directly or indirectly discharged into the environment increasingly, especially in developing countries. It is difficult to remove nickel from wastewater using conventional methods. Efficient method like advanced oxidation process is an important breakthrough in the removal of nickel. This method is referred to as ultrasound assisted advanced oxidation process in the removal of nickel. This study investigated the use of Hydrogen peroxide, Fenton Reagent, ultrasound homogenously and heterogeneously. The removal efficiency of homogenous process and heterogenous process along with the process parameters like concentration of oxidant, effect of pH, Optimum dosage of Oxidants and time taken were investigated. Results indicated that removal efficiency is strongly dependent on the optimal pH and the dose of the oxidant. All the oxidants can removal nickel effectively from the wastewater but the maximum removal which provides desirable nickel quantity after treatment was obtained by heterogenous processes. At optimal pH:11Fenton reagent and Ultrasound process in combination with Hydrogen peroxide and Fenton reagent has shown 98%, 100% and 100% removal respectively.

Keywords: *Nickel; Advanced Oxidation Process; Hydrogen Peroxide, Fenton, Ultrasound; Optimum dose*

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I. Introduction

Growing industrial development is leading to the production of contaminants that are seriously threatening the ecosystem and the contamination of water resources has been a worldwide environment problem. Heavy metals are the elements having atomic weights between 63.5 and 200.6 and specific gravity greater than 5 which are non bio-degradable. Toxic heavy metals of particular concern in treatment of industrial wastewater include copper, zinc, nickel, mercury, cadmium, lead and chromium. Among these different heavy metals, nickel is extensively utilized in the modern industry.

The tolerance limit of nickel in drinking water is 0.01 mg/L, and for industrial wastewater it is 2.0 mg/L. However, effluents of different industries contain higher concentrations of nickel than its acceptable limit. Nickel is well known heavy metal pollutant, which is present in effluents of electroplating industries to the tune of 20 – 200 ppm (Piyush kant pandey et al., 2007).

The intake of nickel in considerable concentrations may cause formation of free radicals in body tissue which leads to various DNA complications, serious lung and kidney problems, gastrointestinal distress, pulmonary fibrosis, headache, dizziness, dry cough, vomiting, extreme weakness, and direct exposition to nickel cause skin dermatites. So it is very essential to remove Nickel from soil, industrial wastewater and effluents.

Generally, the nickel wastewater is amenable to physical, chemical and biological treatment but is inefficient and involves high cost in removal of nickel. In this sense, procedure known as Advanced Oxidation Process (AOP) are being studied and applied to mineralize non-biodegradable organic compounds or oxidize bio degradable compounds, that converts them completely into CO_2 and H_2O (Hoffman et al., 1995). Advanced Oxidation Process (AOP) is defined as aqueous phase oxidation processes which are based primarily on the intermediacy of the hydroxyl radicals in the mechanism resulting in the destruction of target pollutant (Poulopoulos et al., 2006).

In the present work, synthetic nickel wastewater was prepared by Nickel Ammonium Sulphate for the concentration of 200 mg/L and was treated by Advanced Oxidation Process (AOP). The processes were carried out with Hydrogen Peroxide (H_2O_2), Fenton Reagent, and Ultrasound and with a combination of US + H_2O_2 and US + Fenton Reagent Further removal of nickel has been studied. Various process parameters like concentration of oxidant, effect of pH, Optimum dosage of Oxidants and time taken were investigated.

OP-006

Effect of Fly ash & Microbes on Strength properties of Subgrade soil for Pavements

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Abstract: This work investigates the utilization of microbial-induced calcite precipitation (MICP) treatment to improve the stability of soil by introducing Class F fly ash and Bacillus subtilis microbes. Various experiments were carried out using soil that was readily available in the vicinity area. The primary tasks consisted of mixing fly ash and subsequently utilizing varying quantities of fly-ash. The experiment involved the incorporation of fly ash at varying ratios, specifically 5%, 10%, 15%, 20%, 25%, and 30%.The soil's characteristics are influenced by the presence of fly ash, as evidenced by the following tests: reduction in liquid limit, increase in UCC and CBR values, analysis of soil compaction under high pressure, measurement of unconfined compressive strength (UCC) at various time intervals (0, 3, 7, 14, and 21 days), and assessment of California bearing ratio (CBR) for soil samples with varying amounts of fly ash. The most favorable results are obtained by integrating 25% fly ash into the soil, surpassing all other quantities. Following the introduction of Bacillus subtilis C4nc8 bacteria, the OMC is blended with a mixture consisting of 25% fly ash and soil. In addition, it is shown that the optimal values for CBR (2.2 times higher than that of soil) and UCC (6.5 times higher than that of pure soil) are attained by blending soil with 25% fly ash and microorganisms. Ultimately, the addition of soil, 25% fly ash, and microorganisms has been discovered to significantly improve the CBR strength of the subgrade.

Keywords: Fly ash, clayey sand, microbes, ucc, cbr.

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An Application of Geopolymer stabilized expansive soil to reduce the rainfall-based erosion in slopes

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Abstract. Soil stabilization is critical in civil infrastructure, acting as a cornerstone for sustainable and resilient building practices. It enables the construction of strong foundations capable of withstanding enormous loads and adverse conditions, assuring the safety and lifespan of structures such as buildings and roads. The utilization of industrial by products for enhancing the qualities of locally expanding soils has become increasingly popular, mostly due to its low carbon emissions and cost-effectiveness. The present investigation focused on the effect of the addition of Ground Granulated Blast furnace Slag (GGBS) and Geopolymer solution to expansive soil in order to reduce the erosion of slopes. Unconfined compressive strength tests were performed and found that 10% GGBS is the optimum amount for stabilization. SEM studies were conducted to know the microstructure before and after stabilization. The study determined that the rate of rainfall erosion on the stabilized slope was lower compared to the untreated soil, and the load-carrying capacity of the stabilized slope was much greater.

Keywords: Geopolymer Stabilization; GGBS; SEM; Physical Model; Slopes.

1.0 Introduction

Soils that show volumetric variations due to fluctuations in their moisture content are commonly known as expansive soils. The observed behaviour of swelling when exposed to moisture and shrinking when subjected to drying is commonly attributed to seasonal variations in moisture levels. Various parameters, including mineralogy, fabric structure, moisture content, density, and loading circumstances, impact expansive soils volume instability. Nevertheless, the main contributing factor can be attributed to minerals such as montmorillonite [1]. In the montmorillonite structure, the oxygen and hydroxyl groups at the tips of the tetrahedra are shared with the octahedral sheet, forming a monolayer. The rapid infiltration of water and exchangeable cations into the structure, leading to the separation of primary layers, is attributed to the charge shortfall inside the structure and weaker Vander Waals bonds between succeeding silica sheets [2]. Hence, the propensity of soil rich in montmorillonite to retain moisture renders it more susceptible to swelling. Correspondingly, as the water undergoes evaporation, it is susceptible to significant contraction, resulting in observable settlement and shrinkage.

Expansive soils demonstrate significant volumetric expansion and contraction in response to variations in seasonal moisture levels. The challenges associated with the variation in volume of global entities have garnered significant attention [3-5]. Moreover, expansive soils pose significant structural and geotechnical difficulties in various tough scenarios across the globe. Soil deformations, namely

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In Press, Corrected Proof ? What's this?

Experimental investigation on geopolymer-stabilized expansive soil

Janaki Ramudu Dudekula, Sugali Anil Kumar, Sudharani Chigurupati

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Abstract

Expansive soils pose serious issues because to their insufficient bearing capacity and trivial deformation characteristics. These soils must be made suitable for engineering projects by soil improvement in the present scenario due to non availability of appropriate sites. The addition of industrial by products to locally expansive soils has gained popularity due to low carbon emissions and low incurring cost for improving soil properties. At present excellent bonding properties of geopolymers have been recognised as superior sustainable Alkali activated binders for soil stabilization. The paper discusses the effect of addition of Ground Granulated Blast furnace Slag(GGBS) with Geopolymer in combination to a selected high expansive nature soil properties varying GGBS proportions from 5% to 20% and Geopolymer solution from 0.6 Molarity to 1.0 Molarity (0.6M to 1.0M). Series of tests were conducted for Plasticity characteristics, Compaction characteristics, Unconfined Compressive strength test and Consolidation characteristics. From the test results optimum amount of GGBS is 10% and Geopolymer is 1.0M, at this

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Laboratory and modelling investigation on chemically stabilized native expansive soil as a CNS material

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ABSTRACT

Expansive soils challenge the stability of several civil engineering structures. Because of the presence of Montmorillonite clay mineral, they have the inherent property of swelling and shrinking upon wetting and drying. Researchers proposed several ground improvement and foundation techniques to enchase the properties of these soils. Cushion materials, particularly Cohesive Non– Swelling (CNS) cushions, attracted the attention of civil engineers due to their simplicity and long-term stability. To avoid the problem of the non-availability of required soil, a technique is presented in this study to convert local expansive soils into suitable CNS materials via chemical stabilisation. The study uses clayey sand from the Tirupati region of Andhra Pradesh. Admixtures such as fly ash and lime chemically modify native soils into CNS materials. The effectiveness of these prepared CNS materials in reducing expansive soil heave is investigated using model test tanks. SEM and XRD analyses are also used to determine changes in soil microstructure. According to the findings, 5% lime and 20% fly ash are optimal for preparing CNS material. The microstructure of the stabilised soil revealed the formation of cementation compounds, which improved the strength of the native soil stabilization using fly ash.
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1. Introduction

The Due to a lack of fulfilling the required geotechnical qualities, utilizing locally accessible soil as a construction material is not always appropriate. Several additions have been considered for modifying the geotechnical qualities of inappropriate soils to match specific needs, a process known as soil stabilization . Preloading, vertical drainage, reinforcing materials, and mechanical stabilization are among the techniques. However, increasing soil qualities with industrial byproducts such as fly ash, steel slag, and rice husk is gaining favor because it is both cost- effective and reduces waste disposal regions . On the other hand, the majority of India is covered with expansive soil, which undergoes significant volumetric variations according to the water content of the soil . These soils create a worldwide problem that civil engineers must address. Pavements, roads, building foundations, embankments, and canals constructed with these soils are susceptible to cracking or rusting. Large soil deposits are found in the world's arid and semiarid regions. If annual evaporation surpasses annual precipitation at a particular place, expansive soils expand and contract as water evaporates from the surface. The anomalous behaviour is due to the existence of Montmorillonite.

In addition, growing urban sprawl has reduced the availability of appropriate land. Therefore, it will be required to frequently assess inappropriate land sites, for construction projects. Diverse researchers conducted analyses to determine a safe and cost-effective construction method for these sites. These techniques include surcharge application, soil replacement, physical and chemical change of the soil minerals use of cohesive, non-swelling soil cushion materials (CNS). Among the numerous remedial strategies, CNS was the most effective in accommodating the expansive soils' uplift. Prof. R. K. Katti designed and implemented the CNS layer approach as a nicotine alternative to the conventional sand cushion technique . According to him, the Saturation of expansive soils causes the formation of cohesive forces up to a depth of approximately 1 to 1.2 m, which counteract heave. This approach is utilized extensively in India, particularly for river valley projects. S. Oruh and O. N. Ergun looked into the safe and effective way to get rid of zinc waste leachate using fly ash, phosphogypsum, and red mud as lining materials . According to the

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RESEARCH

Application and evaluation of ANN and other classification algorithms for identification of clays based on mineralogical composition: a comparative study

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Abstract
Mineralogical identification of clay minerals is essential as clays exhibit different degrees of expansivity based on the minerals present. Montmorillonite clays have high swelling and shrinkage characteristics, followed by Illite and Kaolinite. The presence of such clays affects the stability of the foundation and thus the structure as a whole. Therefore, the geotechnical engineer has to ascertained the presence of expansive clays before design foundation system. XRD and differential thermal analysis are intricate and expensive techniques for identifying clay minerals. Identifying the clay minerals with the help of their index properties is an indirect and inexpensive approach. In machine learning, classification is a predictive modelling problem. The current study examines the suitability of liquid limit and plastic limit/plasticity index as input features for eight classification models viz. Logistic Regression, K Nearest Neighbourhood, Support Vector Machine, Naive Byes, Decision Tree, Random Forest, XG Boost and Artificial Neural Networks. Scikit learning libraries are used for classification models in Python. K-fold cross-validation is used for each classification model to evaluate the training set and accuracy score, and ROC curves evaluate test data performance. The current study found that Montmorillonite clays can be classified with the highest degree of accuracy, followed by Kaolinite and Illite.

Keywords Kaolinite · Illite · Montmorillonite · Classification

Introduction

Majority of clays have Kaolinite, Illite and Montmorillonite as minerals in them. Swelling and shrinkage characteristic of clays are very much dependent on dominant clay minerals present. Expansive soil is typically defined as any soil whose volume variations are moisture sensitive. Due to their adverse effects on the stability of the buildings they support, expansive soils are viewed as problematic (Asuri & Keshavamurthy, 2016). The study of the physico-chemical behaviour of the soils has indicated that clays having Montmorillonite are more expansive followed by Illite and Kaolinite. X-ray diffraction, differential thermal analysis, scanning electron microscopy etc. are promising technics to establish clay minerology. However, for the purpose of soil investigation from geotechnical engineering applications these methods are unfeasible as not many geotechnical labs equipped with these facilities, also such investigations demand skilled workforce.

Many researchers and codes have come up with degree of expansivity of clays by experimental results of index properties such as liquid limit, plastic limit, shrinkage limit, free swelling index and free swelling ratio. Chen and Snethan et al. have suggested liquid limit ranges and the corresponding swelling potential. Holtz and Gibs and Chen have labelled four swelling potentials viz. Low, Medium, High and Very high based on plasticity index. Based on the shrinkage limit, Holtz and Gibbs and Altmeyer have recommended volume changes for expansive soils. Considering percent clay size fraction, Chen and Holtz and Gibbs have proposed four degrees of expansivity for clayey soils. Sridharan and Prakash have suggested clay type, swell potential and dominant clay mineral type based on free swell ratio. Cation exchange capacity, total surface area are also quite instrumental in identifying the clay minerals. Therefore, every clay mineral is a function of Atterberg limits,

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percentage clay fraction, cation exchange capacity and total surface area. Identification of clay minerals can also be carried out with these test results with a reasonably good accuracy rather than more sophisticated tests such as X-Ray diffraction, scanning electron microscope etc. The most challenging part of identifying the clay minerals with the help of index properties is, there is no standard procedure established for this purpose.

Machine learning is a subset of artificial intelligence that focuses on the development of adaptive computing systems that can enhance their performance through the use of experience-based data. (Jasmina Dj et al., 2017). The three types of machine learning algorithms are supervised, unsupervised, and reinforcement learning. The task of developing a capacity from the prepared knowledge is referred to as supervised learning. The preparation information comprises of a lot of perceptions together with its result. Supervised learning can be further separated into classification and regression. Classification methods are utilized to foresee categorical values and Regression methods are utilized to anticipate numerical qualities (Johnson et al., 2019).

Medical research, medication design, astronomy, atmospheric science, agronomy, manufacturing, telecommunications, marketing, business decision making, image processing, traffic design, and road safety are all examples of where classification algorithms are applied.

In the present study, all the eight classification algorithms viz. (1) Logistic Regression (LR), (2) K Nearest Neighbourhood (KNN), (3) Support Vector Machine (SVM), (4) Naive Bayes (NB), (5) Decision Tree (DT), (6) Random Forest (RF), (7) XG Boost (XGB), (8) Artificial Neural Networks (ANN) are applied on the three types of clay sample data collected from various reputed journals viz. Kaolinite, Montmorillonite and Illite with input features liquid limit, plastic limit/plasticity index for the prediction of clay mineral present.

The two main objectives of present work are as follows:

1. To check suitability of liquid limit & plastic limit (also plasticity index) data for classifying clays based on mineralogical composition.
2. To identify appropriate classification model useful in identification clays minerals.

Collection of data

The soil property data of three types of clays considered in the current study viz. Kaolinite, Illite and Montmorillonite is obtained from 152 research articles published in more than 15 reputed journals and a couple of conferences. All the journals have substantiated their claims on mineralogical composition of clays with XRD and other investigation reports.

In the present study the 175 sample data of Kaolinite, 117 sample data of Illite and 192 sample data of Montmorillonite clays accounting to 484 are considered. Liquid limit and plastic limit values for the three types of clays considered are shown in the three independent plasticity charts as shown in the Figs. 1, 2, and 3.

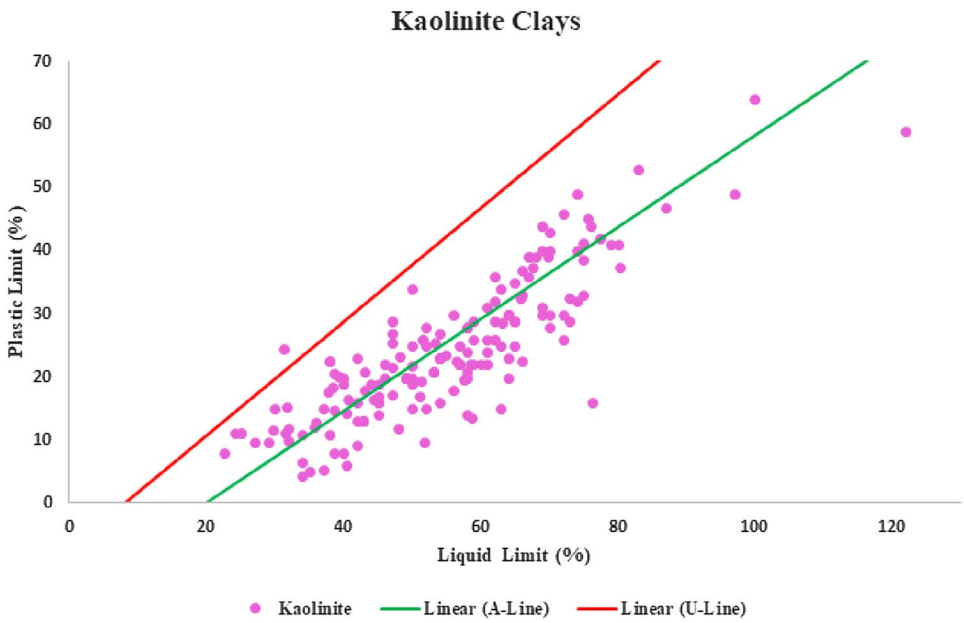


Fig. 1 Kaolinite clay data on plasticity chart

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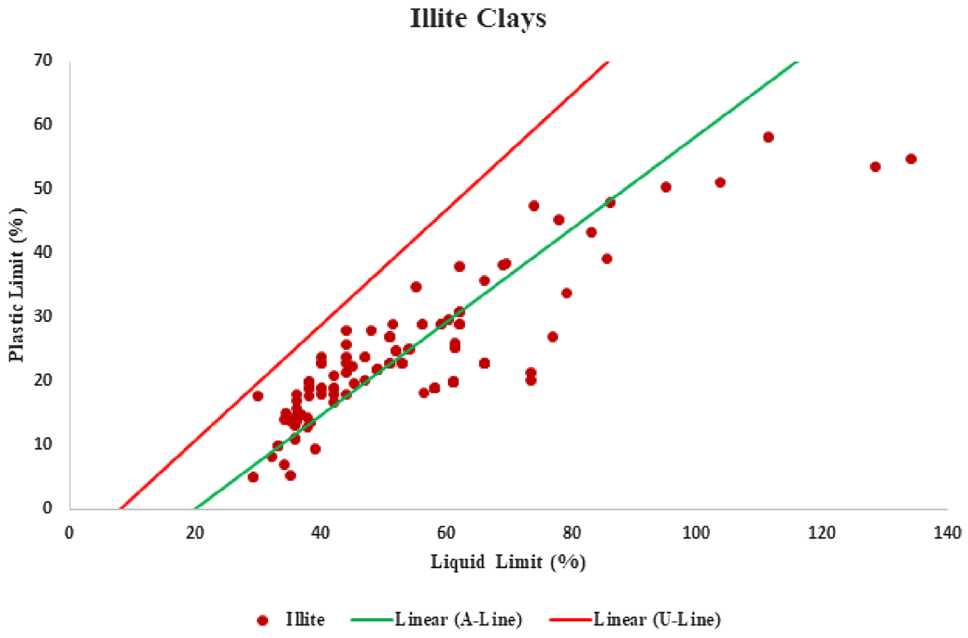


Fig. 2 Illite clay data on plasticity chart

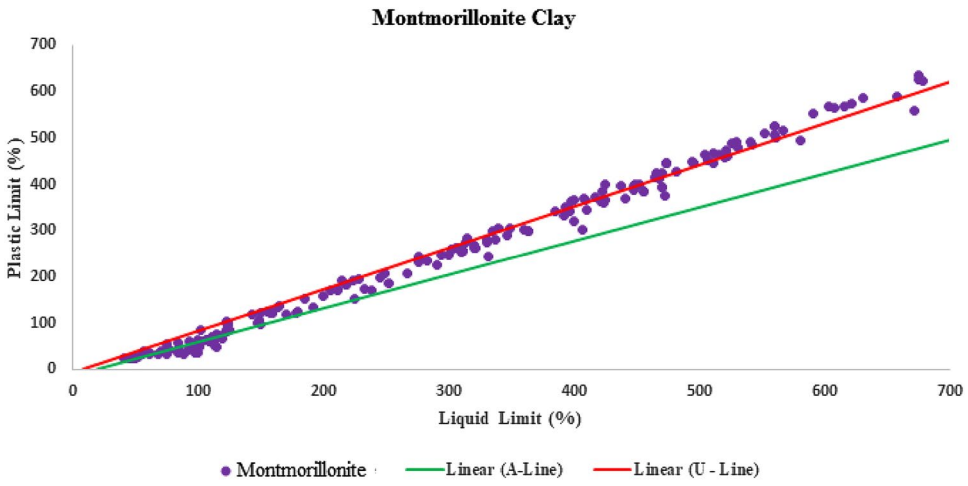


Fig. 3 Montmorillonite clay data on plasticity chart

Methodology

The data is organized into six binary and two multiclass (three class) datasets. Six binary datasets, out of which three have input features as liquid limit and plastic limit, and the remaining three have input features liquid limit and plasticity index. The three having liquid limit and plastic limit as input features are designated as 'A' group, and the remaining three having liquid limit and plasticity index as input features are designated as 'B' group. For '1A' and '1B' datasets, output variables are Kaolinite and Illite. For '2A' and '2B' datasets, the output variables are Illite and Montmorillonite. Similarly, the output variables are Kaolinite and Montmorillonite for '3A' and '3B' datasets. Two multiclass datasets have input features as liquid limit and plastic limit, and the other one has liquid limit and plasticity index and is designed as '4A' and '4B', respectively. For both '4A' and '4B', the output variables are Kaolinite, Illite and Montmorillonite. The details of datasets, input features, output variables and applied classification techniques are shown in Table 1.

In all the eight classification techniques applied on eight datasets, 80% of the data is used to train the model, and 20% is for testing. On each of the datasets, eight classification models are applied viz. (1) Logistic Regression, (2) K Nearest Neighbourhood, (3) Support Vector Machine, (4) Naive Bayes, (5) Decision Tree, (6) Random Forest, (7) XG Boost and (8) Artificial Neural Networks. K-Fold Cross-Validation is used to assess the model performance and is applied to training set data. Each classification model is

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Table 1 Details of dataset for classification model study

Dataset	Input features	Out variables (Class)	Applied classification models
01A	1. Liquid limit 2. Plastic limit	Kaolinite (0) Illite (1)	1. Logistic Regression 2. K Nearest Neighbourhood 3. Support Vector Machine 4. Naive Bayes 5. Decision Tree 6. Random Forest 7. XG Boost 8. Artificial Neural Networks
01B	1. Liquid limit 2. Plasticity index		
02A	1. Liquid limit 2. Plastic limit	Illite (0) Montmorillonite (1)	
02B	1. Liquid limit 2. Plasticity index		
03A	1. Liquid limit 2. Plastic limit	Kaolinite (0) Montmorillonite (1)	
03B	1. Liquid limit 2. Plasticity index		
04A	1. Liquid limit 2. Plastic limit	Kaolinite (0) Illite (1) Montmorillonite (2)	
04B	1. Liquid limit 2. Plasticity index		

evaluated on test data with the help of matrices derived from the confusion matrix and by drawing Receiver Operating Characteristic (ROC) curve to measure the Area Under the Curve (AUC). The better model on each dataset is selected by comprehending K-Fold Cross-Validation, matrices from confusion matrix and AUC of ROC curve.

Implementation and results

Classification models

The eight classification techniques used the present study are briefed below:

Logistic regression

The process of modelling the likelihood of a discrete result given an input variable is called logistic regression. Binary outcomes, such as true/false, yes/no, and other outcomes with only two possible values, are most frequently modelled by logistic regression. Multiple discrete outcomes in a given scenario can be modelled using multinominal logistic regression. (Thomas & David, 2017).

K Nearest Neighbourhood

K Nearest Neighborhood is a classification method that classifies a given example based on the votes of its neighbours. The observation is put in the same category as its nearest K neighbours. The model's input data determines the value of K. In general, the bigger the value of K, the less impact noise or classification errors have. (Johnson et al., 2019).

Support vector machine

The goal of the support vector machine algorithm is to locate an N-dimensional hyperplane (where N is the number of features) that categorizes the data points. Numerous potential hyperplanes might be selected to divide the two classes of data points. The objective of an SVM is to locate a plane with the most significant margin or the most excellent separation between data points from both classes. (Rohith, 2018).

Naive Bayes

A probabilistic classifier called the Naive Bayes classifier, which is based on the Bayes theorem, assumes that each feature contributes equally and independently to the target class. The naive Bayes classifier assumes that each feature is separate from the others and does not interact; therefore, each feature independently and equally influences the likelihood that a sample belongs to a particular class.

For a binary classification problem having two features say, X1 and X2, the probability of a class yi is expressed as (Misra & Li, 2020)

$$P(yi|X1, X2) = \frac{P(X1|yi)P(X2|yi)}{P(X1)P(X2)}$$

Decision tree

A tree-like decision structure with a root node and numerous leaves is produced by the decision tree classifier after processing the training dataset. Internal nodes are all located between the root node and the leaves. Each node is divided into internal nodes and/or leaves so that the dataset becomes purer due to the division; specifically, each split should result in the dataset being divided into groups with samples predominately from one class (Misra & Li, 2020).

Random Forest

An ensemble technique called Random Forest classifier trains several decision trees concurrently with bootstrapping, aggregation, and bagging (Misra & Li, 2020).

XG Boost

XGBoost is a robust machine learning algorithm, specifically where speed and accuracy are concerned.

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XGBoost implements a gradient-based decision tree designed for speed and performance that dominates competitive machine learning.

Artificial neural networks

ANN stands for artificial neural network which is a computing system that works in parallel and is designed to emulate the human brain processes and analyzes the information. By utilizing data from past experiences, it can model, classify, recognize, and predict a wide range of problems (Kaveh & Iranmanesh, 1998). Typically, an ANN is made up of an input layer, one or more hidden layers, and an output layer. There are multiple layers of neurons, each connected to the other via a weighted connection to form a network of processing units (Kaveh et al., 2008). The input neurons receive information from the external environment and transmit it to the hidden neurons, which then process the information and reconstruct the input–output mapping based on the key features they extract (Kaveh & Servati, 2001; Kaveh et al., 2001). Lastly, the neurons of the output layer will provide the network predictions to the outside world (Kaveh et al., 2014).

In Fig. 4, inputs, weights, summation functions, activation functions, and outputs are shown. It is possible for neurons to receive input from external data or to receive output from neurons in previous layers. By calculating the weighted sum of all inputs, adding a bias, and passing this value through a nonlinear activation function, the neuron produces its output. A neuron's output feeds an input for the next neuron of the layer below to it (Nakkeeran & Krishnaraj, 2023).

The mathematical expression is

$$o_j = f\left(\sum_{i=1}^{n} w_{ij}x_i + b\right)$$

where o_j is the output of the jth neuron, w_{ij} the weight, x_i the input, b the bias, and f an activation function. Over-fitting may be avoided by normalizing the variables, which can be done using the equation below (Nakkeeran et al., 2023):

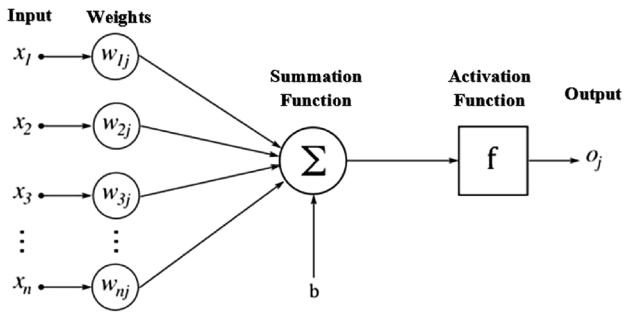


Fig. 4 ANN General Architecture

$$X_{norm} = \frac{(X_{max} - X_{min})(Y_i - Y_{min})}{(Y_{max} - Y_{min})} + Y_{min}$$

X_{norm} is the normalized parameter, X_{max} is the maximum and X_{min} is the minimum value of the scaling range, Y_i is the actual data to be scaled, Y_{max} and Y_{min} are the minimum and maximum values of the actual data, respectively.

Cross-validation

K fold cross-validation is applied to the training set to access the model performance. K fold cross-validation algorithm divides the training set into equal K parts. Out of the K parts, K-1 parts are used to train the model and left out 1 part is used for validating the model in one iteration. Similar iterations are performed by considering another 1 parts of data as test data and the remaining parts as training data. In all iterations, the accuracies are evaluated. The test reports the average of all the accuracies alongside standard deviation. In the current study, the K value is set as 10. The K fold cross-validation data for all the eight datasets are shown in the tables, and the corresponding statistical analysis of the data is shown in the

Table 2 K fold cross-validation data on training set of 01A

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	61.81	0.60
KNN	63.14	7.18
SVM	61.81	0.60
NB	58.34	3.43
DT	69.55	5.12
RF	69.11	7.80
XGB	72.15	6.22
ANN	58.79	4.93

Table 3 K fold cross-validation data on training set of 01B

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	58.36	2.03
KNN	63.08	6.62
SVM	58.37	0.96
NB	56.64	3.33
DT	63.56	8.68
RF	63.14	5.65
XGB	66.57	5.94
ANN	65.23	5.92

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Table 4 K fold cross-validation data on training set of 02A

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	89.46	3.92
KNN	88.65	3.67
SVM	91.10	4.14
NB	89.46	3.92
DT	89.06	4.18
RF	91.10	2.69
XGB	88.66	2.33
ANN	91.10	4.80

Table 5 K fold cross-validation data on training set of 02B

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	88.31	7.21
KNN	89.08	3.00
SVM	88.71	7.24
NB	88.71	7.37
DT	89.90	3.77
RF	87.85	4.23
XGB	88.27	3.79
ANN	89.07	2.71

Table 6 K fold cross-validation data on training set of 03A

Classification Model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	92.16	1.81
KNN	93.18	1.92
SVM	92.84	1.55
NB	93.52	2.18
DT	87.03	3.28
RF	91.80	2.66
XGB	91.45	2.80
ANN	93.86	2.64

Table 7 K fold cross-validation data on training set of 03B

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	91.14	3.24
KNN	93.86	2.34
SVM	92.85	3.85
NB	93.19	3.25
DT	94.54	1.53
RF	92.50	3.03
XGB	94.20	3.21
ANN	94.55	1.91

Table 8 K fold cross-validation data on training set of 04A

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	70.02	1.17
KNN	71.57	5.27
SVM	69.25	0.71
NB	68.21	2.20
DT	71.06	4.86
RF	74.70	4.46
XGB	73.93	5.62
ANN	73.42	4.75

Table 9 K fold cross-validation data on training set of 04B

Classification model	Accuracy mean (%)	Accuracy standard deviation (%)
LR	70.03	1.08
KNN	68.47	3.56
SVM	69.51	0.59
NB	68.73	1.15
DT	72.08	3.66
RF	72.61	4.24
XGB	73.90	3.30
ANN	72.08	7.39

form of a box plot. Tables 2, 3, 4, 5, 6, 7, 8 and 9 presents mean accuracy and standard deviation for the classification models on datasets 01A through 04B when K fold cross-validation is applied on their training sets. Figures 5, 6, 7, 8, 9, 10, 11, and 12 are the boxplots drawn for the means obtained on the training sets of datasets 01A through 04B when K fold cross-validation is applied on each classification model.

Evaluating classification models

In order to evaluate the classification model, two approaches are adopted in the current study. The first approach is evaluating the accuracy, precision, recall, and f1 score deduced from the confusion matrix for binary and multiclass classifications. The second approach is to draw the Receiver Operating Characteristic (ROC) curve and measure the Area

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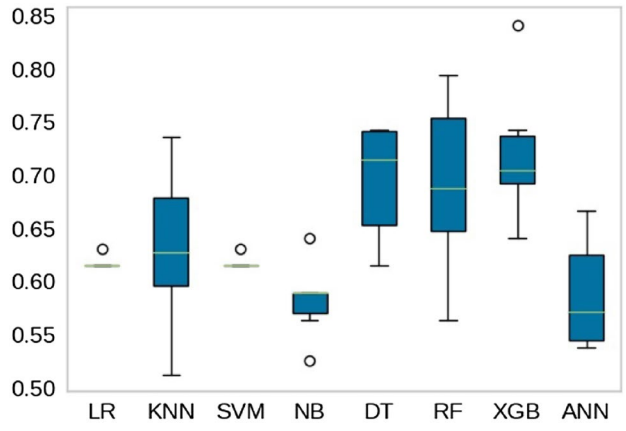


Fig. 5 Boxplot of K fold cross-validation accuracies obtained on training set of 01A

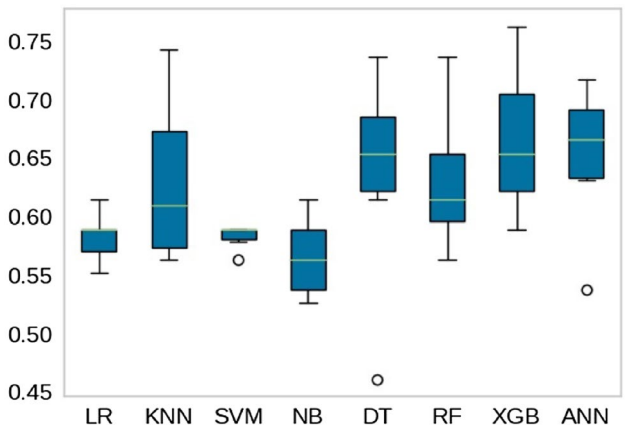


Fig. 6 Boxplot of K fold cross-validation accuracies obtained on training set of 01B

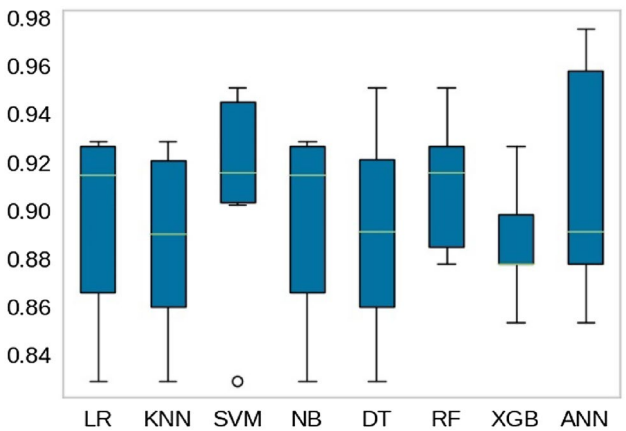


Fig. 7 Boxplot of K fold cross-validation accuracies obtained on training set of 02A

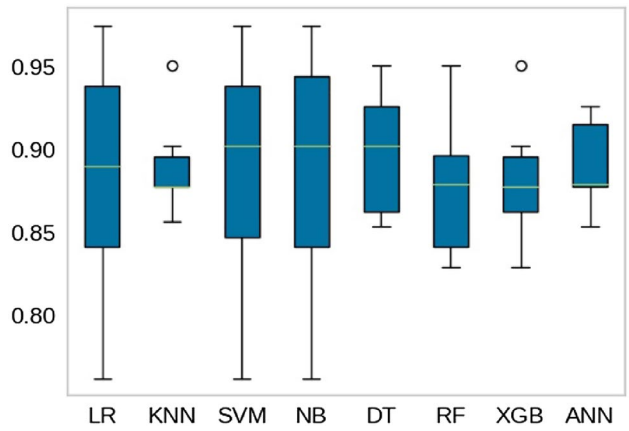


Fig. 8 Boxplot of K fold cross-validation accuracies obtained on training set of 02B

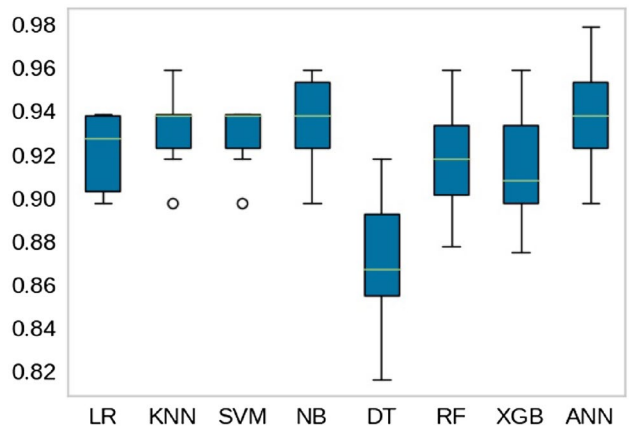


Fig. 9 Boxplot of K fold cross-validation accuracies obtained on training set of 03A

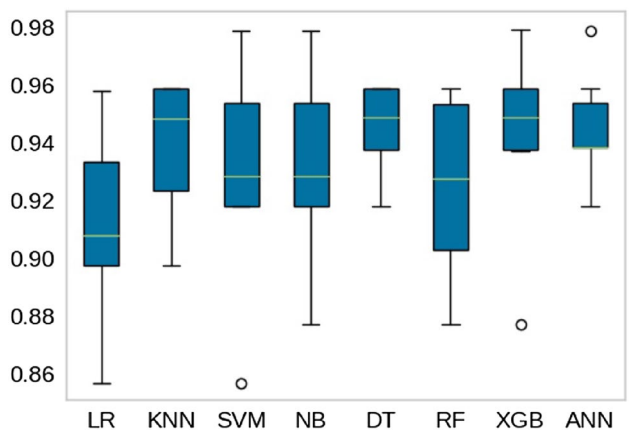


Fig. 10 Boxplot of K fold cross-validation accuracies obtained on training set of 03B

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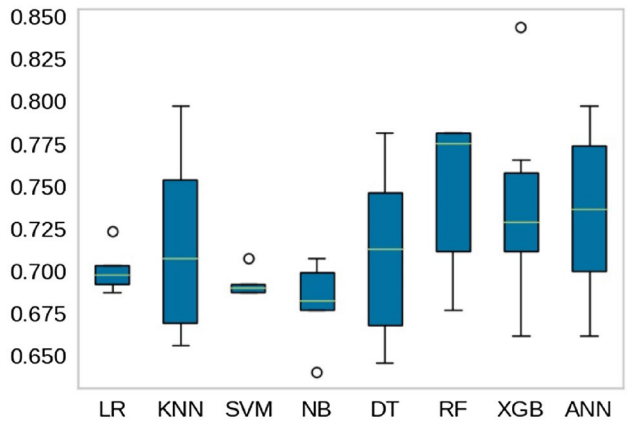


Fig. 11 Boxplot of K fold cross-validation accuracies obtained on training set of 04A

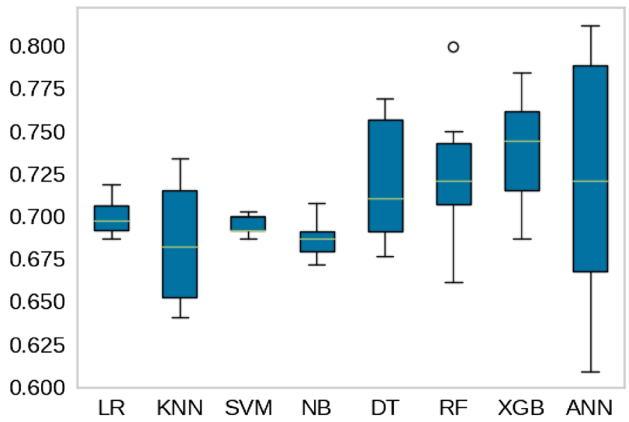


Fig. 12 Boxplot of K fold cross-validation accuracies obtained on training set of 04B

Under the Curve (AUC). Both the approaches and corresponding measured metrics are detailed in the following sections.

Confusion matrix

A confusion matrix is a square matrix formed between predicted values and actual values of the classes of a classification model. The structure and the various metrics calculated from the confusion matrix is explained with the help of a binary classification whose classes are 'Yes' & 'No' as shown in Fig. 13.

Here TP = Count of both predicted and actual positive; FP = Count of actual negative but predicted positive; TN = Count of both predicted and actual negative; FN = Count of actual positive but predicted negative.

The metrices calculated from confusion matrix for a binary classifier are as follows:

		Predicted	
		Yes	No
Actual	Yes	TP	FP
	No	FN	TN

Fig. 13 Confusion matrix for binary classification

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN}$$

$$Precision = \frac{TP}{TP+FP}$$

$$Recall\ or\ True\ Positive\ Rate\ (TPR) = \frac{TP}{TP+FN}$$

$$FalsevPositive\ Rate\ (FPR) = \frac{FP}{TN+FP}$$

$$f1\ Score = \frac{2xRecallxPrecision}{Recall+Precision}$$

Metrices calculated from confusion matrix Precision, Recall, Accuracy and f1 Score are calculated for the six binary datasets and two multiclass datasets on which eight classification algorithms viz (1) Logistic Regression, (2) K Nearest Neighbourhood, (3) Support Vector Machine, (4) Naive Bayes, (5) Decision Tree, (6) Random Forest (7) XG Boost and (8) Artificial Neural Networks is applied. The weighted averages of each metric obtained from the eight classification models are shown in column charts in Figs. 14, 15, 16, 17, 18, 19, 20, and 21 for better visualization.

ROC curve and AUC calculation

Receiver Operating Characteristic curve is a plot drawn between *True Positive Rate* on the vertical axis in function with *False Positive Rate* on the horizontal axis for different cut-off points. Each point on the ROC curve represents FPR, TPR pair corresponding to a particular decision threshold.

The area under the ROC curve is a valuable metric to evaluate the model's performance in the case of a binary classifier. For a truly accurate model, the AUC value is 1. When the AUC value is 0.5, the model cannot distinguish the positive and negative classes. Therefore, the higher the AUC value, the better the ability of the model to distinguish between positive and negative. The Sckit-Learn roc plot can be drawn for the binary classifier alone. With the help of roc_auc_score, AUC values can be calculated for multiclass classifiers. However, the plotting of multiclass ROC curves is not supported by all classification models directly in Sckit-Learn.

Yellowbrick's *ROCAUC* visualizer helps to plot multiclass classification curves containing ROC curves for each class with one-vs-rest (micro score) and one-vs-all (macro score) strategies on the same plot.

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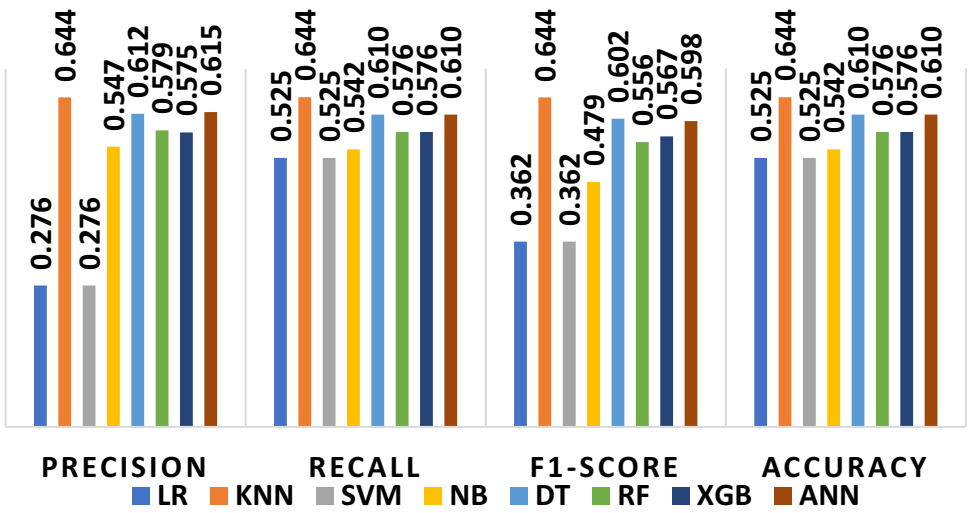


Fig. 14 Weighted average of evaluation metrics of 1A test set

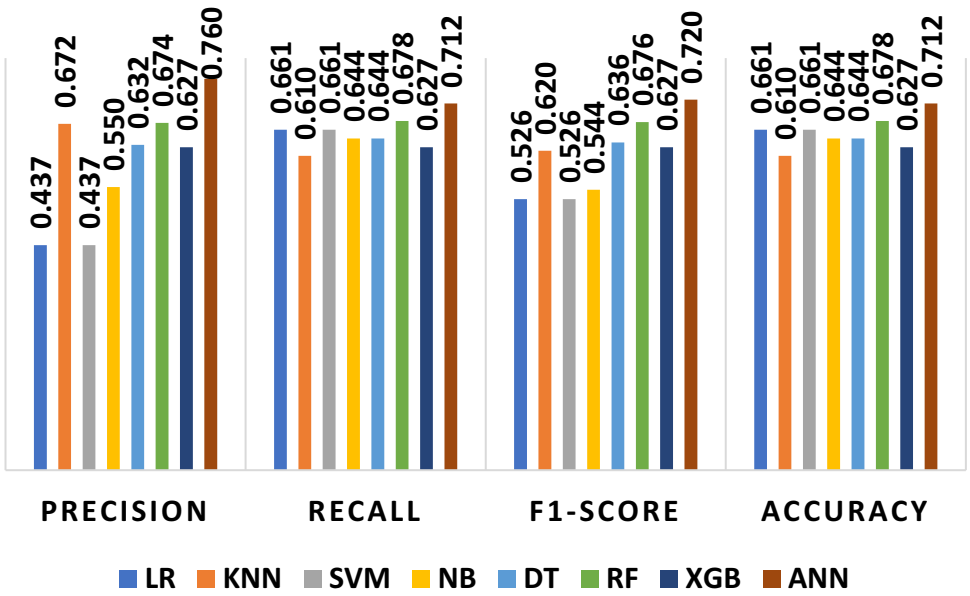


Fig. 15 Weighted average of evaluation metrics of 1B test set

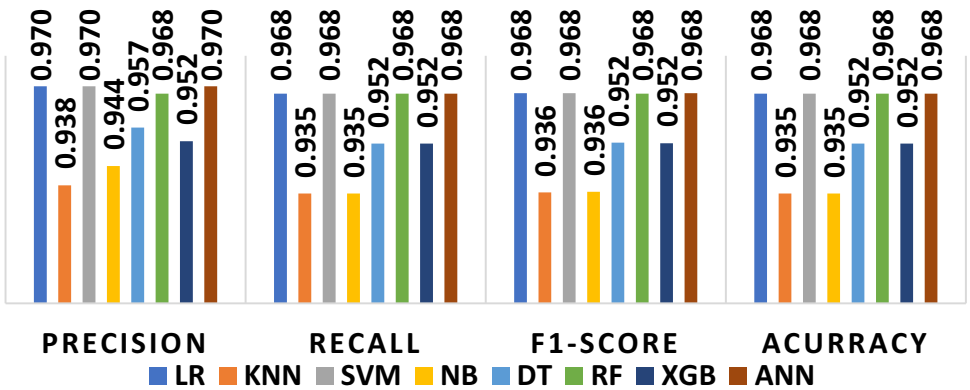


Fig. 16 Weighted average of evaluation metrics of 2A test set

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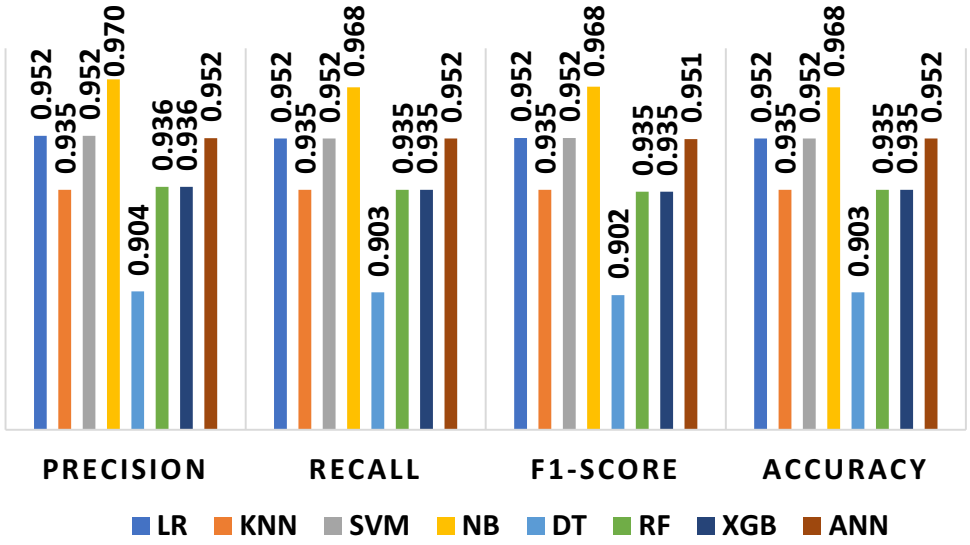


Fig. 17 Weighted average of evaluation metrics of 2B test set

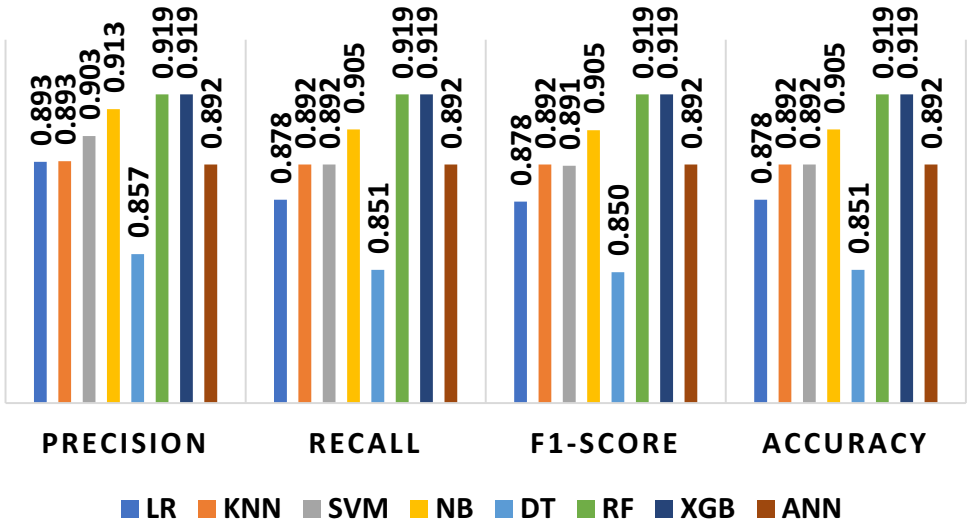


Fig. 18 Weighted average of evaluation metrics of 3A test set

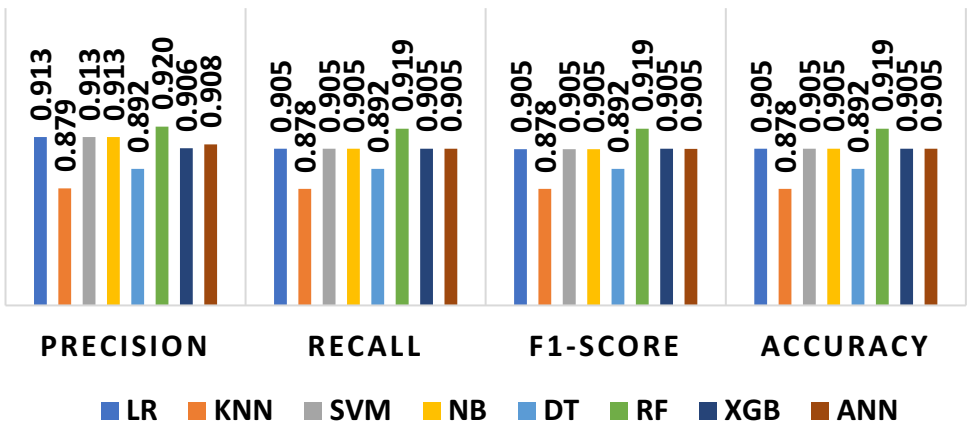


Fig. 19 Weighted average of evaluation metrics of 3B test set

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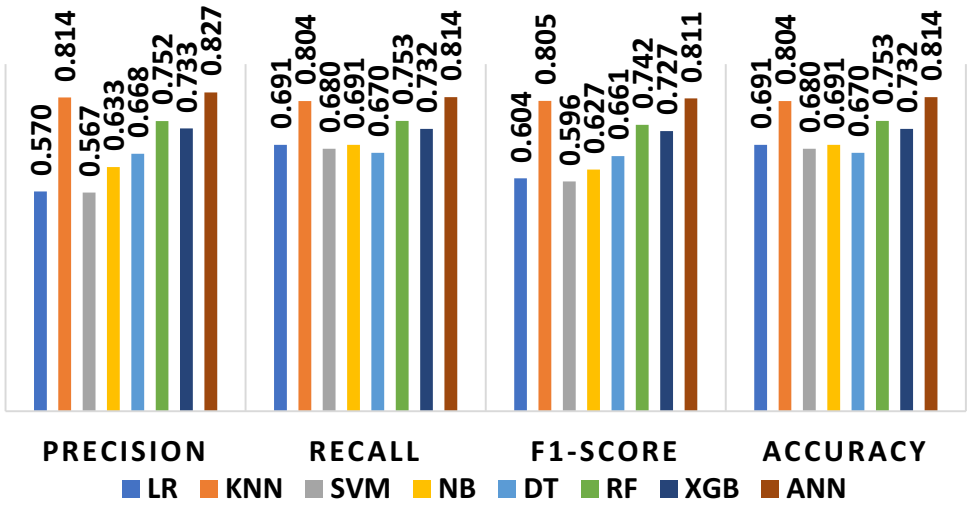


Fig. 20 Weighted average of evaluation metrics of 4A test set

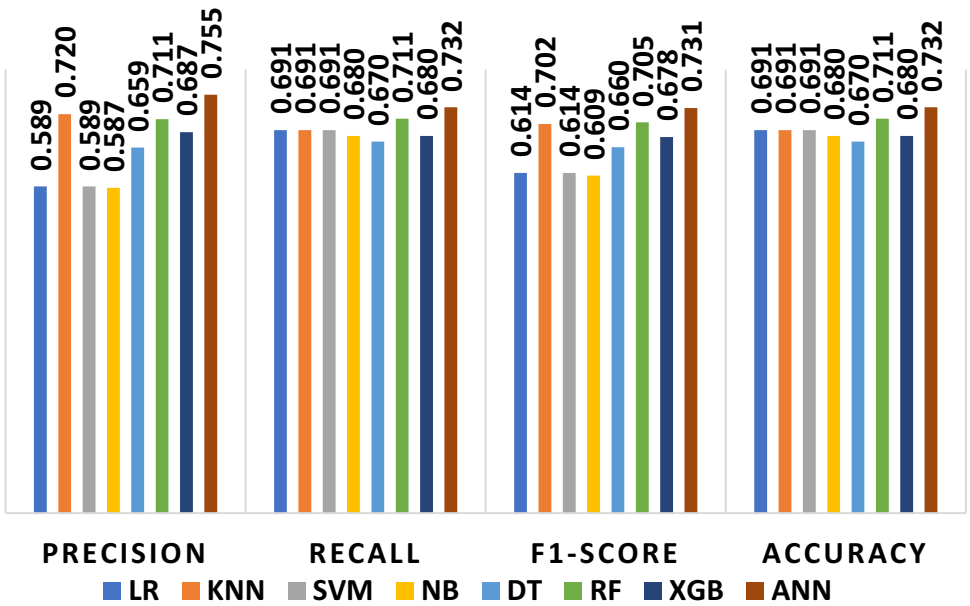


Fig. 21 Weighted average of evaluation metrics of 4B test set

In the current study, Sckit-Learn *RocCurveDisplay* is used to draw ROC curves of different models of a binary classifier on the same plot. For drawing multiclass ROC curves, Yellowbrick's *ROCAUC* visualizer is used.

ROC curves for binary classification datasets On the binary datasets, the eight classification models are applied, and the corresponding ROC curves are plotted on a single graph along with their AUC values for better comparison, as shown in Fig. 22.

ROC curves for multiclass datasets With the help of Yellowbrick's library, ROC curves are drawn for the multiclass datasets. Yellowbrick's ROCAUC visualizer allows drawing ROC curves for one classification model, consisting of ROC curves for each class and their micro-average and macro-average ROC along with their AUC values. Figure 23 shows ROC plots for multiclass datasets namely 04A and 04B for different classification models in the sequence (a) 04A – LR (b) 04A – KNN (c) 04A – SVM (d) 04A – NB (e) 04A – DT (f) 04A – RF (g) 04A – XGB (h) 04B – LR (i) 04B – KNN (j) 04B – SVM (k) 04B – NB (l) 04B – DT (m) 04B – RF (n) 04B – XGB.

Conclusions and future scope

Following conclusions can be drawn from the extensive study on classification models:

- Artificial Neural Networks have better performed and evaluated out of 6 binary classification datasets and two

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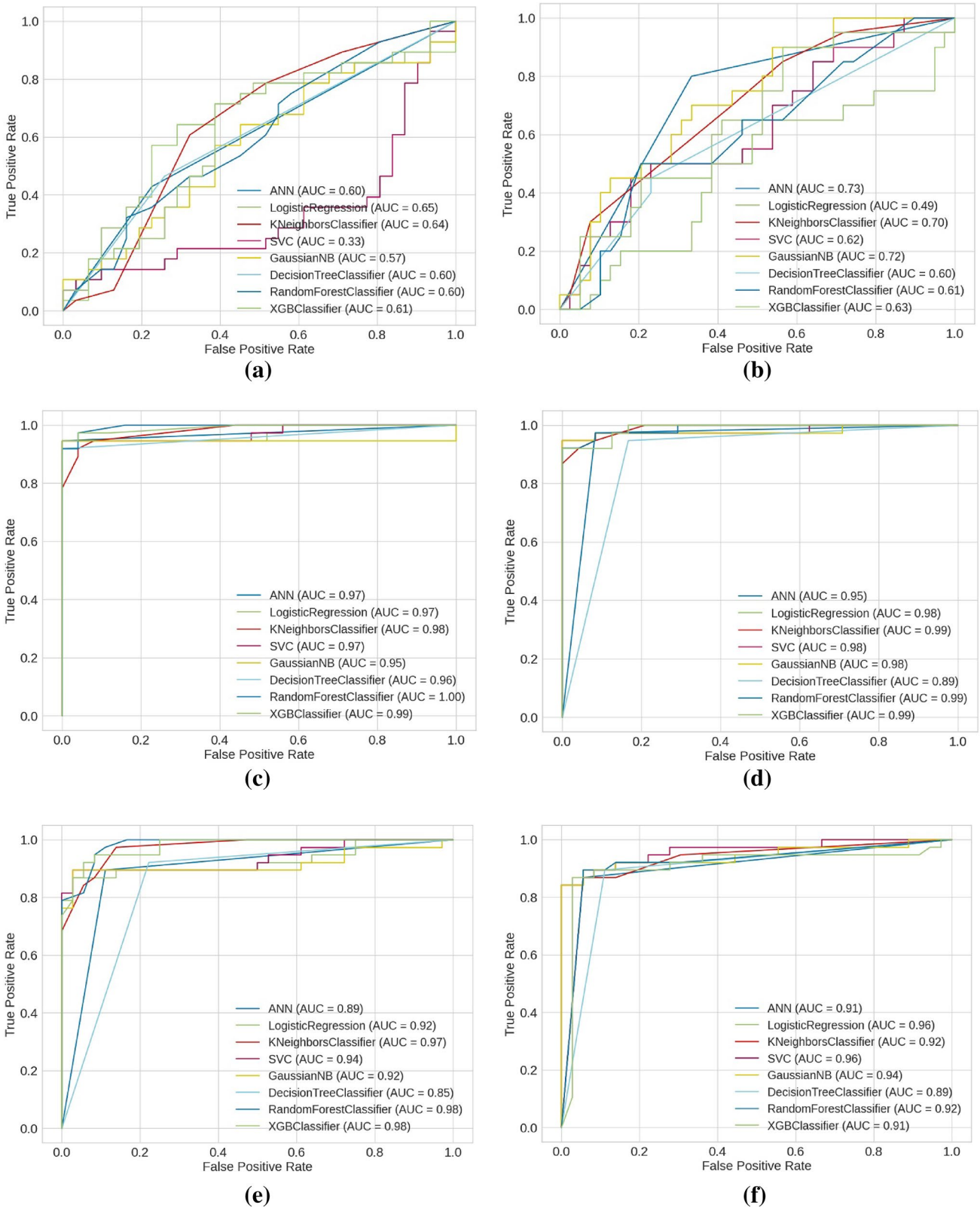


Fig. 22 ROC curves for drawn for classification models on datasets 01A to 03A

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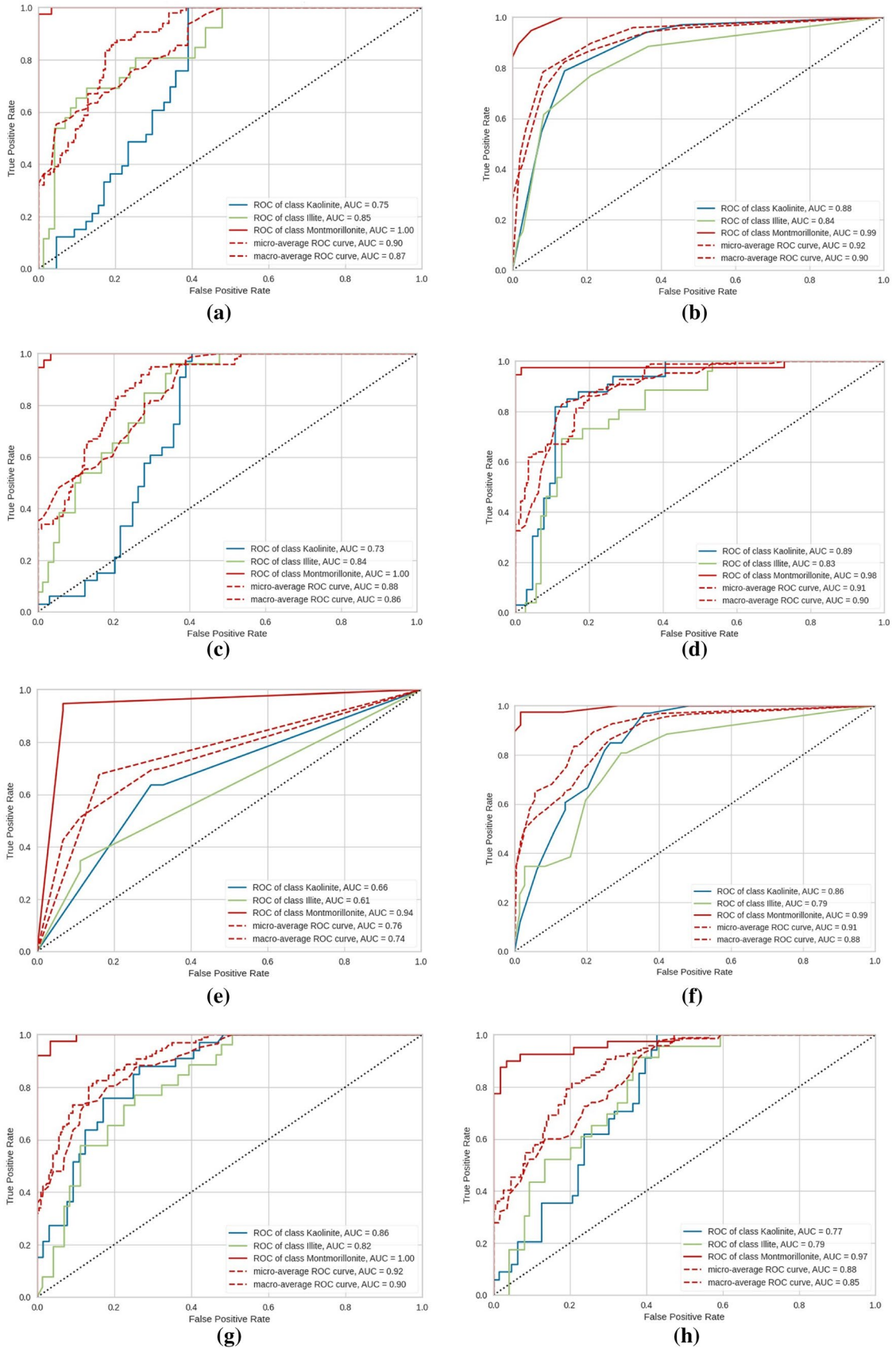


Fig. 23 ROC curves of multiclass datasets for different classification models

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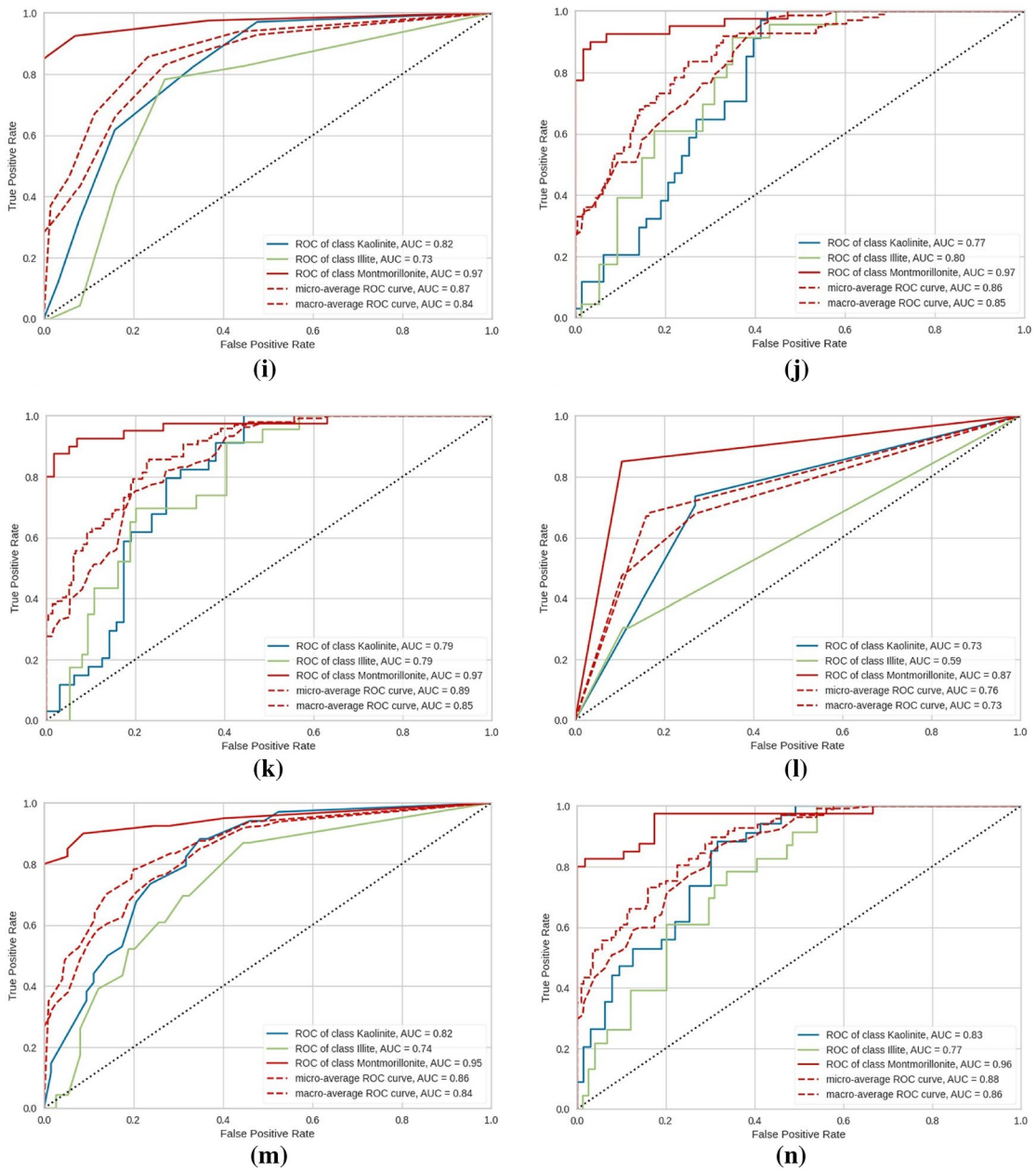


Fig. 23 (continued)

multiclass data sets. ANN proves to be a very effective classification model for multiclass datasets.

- In the 01A binary dataset, both ANN and Decision Tree have better accuracy; however, Decision Tree has consistent accuracy while cross-validating with the least standard deviation.
- For 01B, ANN was proved to be the only model which gave high and consistent accuracies, while K cross-validation was applied with a lower standard deviation.
- For the datasets 03A & 03B, though the Random Forest model gave slightly high accuracy, ANN produced better cross-validation accuracy with significantly less standard deviation proving to be better suitable for these datasets.
- The binary datasets having montmorillonite gave very high accuracy predictions, followed by Kaolinite.
- The plasticity index in place of plastic limit has not significantly contributed to the performance of predictions as an independent variable.

The current study establishes that Atterberg limits, namely liquid limit and plastic limit/plasticity index, are reliable input features for classifying clays based on the mineralogical

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composition. Montmorillonite can be predicted with the highest accuracy with these input features out of the three clay minerals. Next to Montmorillonite, Kaolinite can be predicted with reasonable accuracy; however, classifying Illites is quite challenging with these input features. Other features, namely shrinkage limit, percentage clay fraction, cation exchange capacity, and total surface area, can be examined to improve clays' predictions, especially Illite clays.

Author contributions CSKP: conceptualization, methodology, data curation, original draft Writing.KMR: conceptualization, methodology, data curation, original draft Writing.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

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Trends in Renewable Energy

EVALUATION OF PV-BASED BUCK-BOOST AND SEPIC CONVERTERS FOR EV CHARGING APPLICATIONS

JAGADEESH K, Ch. Chengaiah

ABSTRACT

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Study of AI-Driven MPPT in AC/DC Microgrid with Type-III Fuzzy Controller Enhanced by Bacterial Foraging Algorithm

Journal of Electrical Systems

Abstract: - The ongoing shift towards sustainable energy solutions has driven the development of microgrids, which offer a promising approach to ensure reliable and environmentally friendly energy production. This research presents a novel microgrid design that incorporates a variety of solar energy harvesting methods, including rooftop solar panels, photovoltaic cells, floating photovoltaic arrays and grid-connected PV systems with Batteries. DC-DC converters are used as power converters between load and source in order to amplify or increase the PV power depending on the output voltage. This study helps to provide a robust energy solution that not only meets fluctuating load requirements, but also strengthens the energy system against the disturbances associated with solar energy. This design incorporates an intelligent control system controlled by an Interval Type-3 fuzzy logic controller. The controller is meticulously designed to deal with the uncertainties and non-linear characteristics of renewable energy systems and to ensure optimal performance under varying weather and load profiles. The analysis in this microgrid uses an artificial intelligence-driven Maximum Power Point Tracking system that dynamically adjusts the operating parameters to utilize the maximum energy yield from the solar systems. A further improvement in the control strategy is achieved through the use of a bacterial foraging optimization algorithm. This advanced algorithm fine-tunes the fuzzy controller parameters, significantly increasing the efficiency and stability of the microgrid's power generation. The synergy between the Interval Type-3 fuzzy logic controller and the BFOA results in a resilient and adaptive control system that can efficiently deliver high quality energy. Extensive simulations were conducted using MATLAB Simulink 2023b to validate the performance of the proposed microgrid design and control architecture. The empirical results show that the integrated system effectively optimizes the energy flow of different solar systems, maintains power stability and achieves superior efficiency. The study pushes the boundaries of microgrid design and provides a scalable and smart energy solution that paves the way for the widespread adoption of renewable microgrids in different geographical areas.

Keywords: Artificial Intelligence(AI), Bacterial Foraging Optimization Algorithm (BFOA) Interlinking Converter, Interval Type-3 Fuzzy Controller, Microgrid, Maximum Power Point Tracking system(MPPT), Boost Converter and STATCOM.

1. Introduction

In the face of global warming, it is imperative to prioritize the reduction of carbon emissions and the transition to renewable energy sources in the energy sector. This is crucial for the sustainability of our planet and the well-being of future generations. a group of interconnected loads and decentralized energy resources that acts as a single controllable entity in relation to the grid. i.e. microgrids (MG). It plays a critical role in integrating distributed renewable energy generation such as photovoltaic (PV), wind power with energy storage systems, combined heat and power (CHP) systems, fuel cells and electric vehicles (EVs) into the grid. By operating as self-sufficient systems, MGs can continue to provide power to critical loads during grid outages or emergencies, reducing the impact of power outages on communities, businesses and essential services. The challenges posed by the unpredictable nature of renewable energy sources, which are dependent on fluctuating weather conditions and whose energy production is not entirely predictable, are usually overcome by using multiple energy sources. To overcome the above challenges and improve energy efficiency, controllers are equipped as an integral part of any microgrid operation and serve as the brain for managing various energy sources, storage systems and loads. These devices continuously monitor grid conditions and adjust parameters such as current flow, voltage and frequency to ensure grid stability and reliability [1,2,3,4].

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At the beginning of this section, a detailed introduction to the MPPT algorithms for solar systems with artificial intelligence is required. The active power (P) of a solar power system with PV panels is affected by solar irradiance (E) and operating temperature (T), especially under rapidly changing partial shading conditions due to the nonlinear nature of photovoltaic cells. The complicated correlation between power output and PV input parameters leads to suboptimal power extraction, prompting researchers to focus on AI-based MPPT methods as an alternative to traditional perturbation and observation techniques to maximize the performance of wind turbines and PV systems. Several applications have been used in grids as a result of the introduction of new technologies in the development of controllers and converters [5]. These include solar arrays, fuel cells, wind turbines, small diesel generators, small hydroelectric plants, backup energy systems, and DC/AC load systems for energy demand. It is difficult to develop a hybrid system with all renewable and non-renewable energy sources, storage devices, converters and loads. In most hybrid systems, the DC components are the wind turbine, the solar panels and the battery bank, while the AC components are the diesel generator and the load. The conversion from AC to DC and vice versa is performed by an IGBT-based high-power converter [6]. Constant power loads (CPLs) in DC-MGs reduce the effective damping of the DC-DC converter and can have destabilizing effects since CPLs have nonlinear dynamics and negative incremental impedance [7-8]. An MG can be either a DC network or a mixture of DC and AC. Therefore, a DC microgrid is the best option for operating renewables, power converters and modern loads, all of which require DC power. Several non-linear control methods are used for a regulated DC bus voltage and stable operation.

In the past, linear PI/PID control, SMC and AI-based control have been used in some cases to control MG. However, in the last decade, much attention has been paid to the intelligent control of nonlinear systems [9]. As a result, common controls such as neural networks, fuzzy and neuro-fuzzy controls have been explored. in 1965, Zadeh introduced fuzzy logic for use in cellular robotics. Since then, numerous studies have applied this fuzzy logic to various modelling in control systems. It provides a framework for understanding the uncertainties and opacity of the entire model through human reasoning based on membership functions and linguistic variables. The application of fuzzy logic controllers (FLC) to the operation and control of power grids has become increasingly important in recent years [10]. Fuzzy controllers are excellent at dealing with non- linearities and uncertainties associated with renewable energy sources and loads, and provide superior performance in scenarios where conventional controllers struggle to maintain stability. The Integral Fuzzy Type-3 controller used in this research offers several advantages for microgrid control. By integrating fuzzy logic with proportional-integral-derivative control, this controller combines the adaptability and robustness of fuzzy logic with the ability of integral behavior to eliminate steady-state errors.

Bacterial foraging optimization, also known as BFOA, is a bio-inspired metaheuristic algorithm based on the foraging behaviour of Escherichia coli bacteria. It is used to solve optimization problems by gradually refining a population of potential solutions towards an optimal solution. The main goal of this process is to improve the controller's performance in terms of precision, resilience and effectiveness by iteratively adjusting the fuzzy logic membership functions and other parameters using the BFOA. This allows the controller to adapt and improve its performance even in difficult and unpredictable environments [11,12,13].

Another crucial component in most MG’s are power converters, which help to connect the AC and DC grids in addition to maintain the stability of the entire microgrid. A bi-directional droop control approach has been utilised along with Bi-directional DC/AC converters to measure the power demand of the AC and DC miFcrogrids depending on the frequency of the AC terminal bus and the voltage of the DC terminal bus, respectively. Moreover, the amplitude and direction of the power transfer through the power converters are deter- mined [14]. To maintain a constant DC link voltage, primary or local control with PV cells and batteries is used. To provide a stable voltage, ensure smooth grid synchronization and ensure proper sharing of active power between the DC and AC buses, the secondary or system level is achieved by controlling the intercom nested converter located between the AC and DC buses.

In a hybrid microgrid, the interconnected converter (ILC) plays a crucial role in connecting the AC and DC grids. Its control strategy has an impact on energy flow management, power quality, system efficiency and stability. The ILC is normally controlled as a current source, resulting in poor dynamic stability when a remote, weak AC sub-grid with a high connection impedance is connected. In times of surplus energy generation, e.g. during strong weather, the storage devices are used in microgrids to temporarily store this surplus energy for later use. Likewise the energy generation is not sufficient to cover the increasing load demand then the stored energy is utilized [15,16].

To link the sections presented above and ensure proper energy transaction, Artificial Intelligence (AI) is revolutionizing the operation and control of microgrids by providing advanced algorithms to optimize energy generation, storage and consumption. Through machine learning and predictive analytics, AI can forecast renewable energy generation, predict fluctuations in demand and dynamically adjust microgrid parameters in real time. This enables microgrids to achieve higher efficiency, reliability and resilience while seamlessly integrating different energy sources. The study on AI-driven Maximum Power Point Tracking (MPPT) in AC/DC microgrids with an interval type III fuzzy controller enhanced by the Bacterial Foraging Algorithm (BFA) presents a sophisticated approach to optimize the performance of renewable energy systems. In the following sections, Work Motivation, detailed view of MG Components, mathematical modelling of the relevant components in MG and the simulated experimental results of this research work and other requirements are described in detail.

2. Literature review

Prepare Hybrid power supply systems based on renewable energies are increasingly being used worldwide to reduce carbon emissions. However, renewables are sporadic and incredibly unpredictable, which can lead to significant frequency fluctuations. By using optimally designed control systems, these fluctuations can be kept within the appropriate limits. Maximum Power Point Tracking (MPPT) becomes the focus of study to increase the efficiency of the solar system and ensure that the operating point is always at the Maximum Power Point (MPP) to overcome the aforementioned limitations [5]. It is possible to achieve uniform peaks without abrupt irradiation or under PSC by using traditional hill-climbing (HC) MPPT approaches such as Incremental Conductance (IC) and Perturb and Observe (P&O) [6]. Despite some advantages of existing MPPT methods, AI-based MPPT methods for DC-DC converters are implemented in solar energy systems to increase the efficiency of solar energy. Electronically implemented MPPTs also include adjusting the tilt angle of solar panels to track the direction of the sun and integrating soft computing weather forecasts [7].In this research work, this AI driven MPPT trend has been successfully implemented.

Kinetic Gas Molecule Optimization (KGMO) is a state-of-the-art algorithm that uses the principles of kinetic gas molecules to optimize photovoltaic systems and increase their performance. The KGMO algorithm uses the principles of kinetic gas molecules to optimize the performance and maximize the power output of photo- voltaic systems together with ANN, which provides better results than the results of conventional MPPT schemes[29,30]. An LFC structure based on a Tilt-Fraction-Order-Integral (TI) controller and an FO-PID controller with a filter was proposed by Ahmed et al [16]. The Artificial Gorilla Troops Optimizer is used to optimally design this proposed controller. The effects of high renewable energy share on the considered power system is also investigated with the proposed controller. In [17], the performance of the system is improved with the recently developed ISSA (Improved Squirrel Search Algorithm) algorithm, which is used to adjust the parameters of several controllers, including PID, two- and three-degree PIDs, and cascaded 2DOF fractional-order PIDs (FOI). The performance of the optimal controller was modified using the integrated Particle Swarm Optimization (PSO) and Squirrel Search Algorithm (SSA). Numerous case studies have been con- ducted to evaluate the reliability, adaptability and flexibility of the system.

In [18], a hybrid energy system including a thermal system, wind and solar energy, diesel generators, electric vehicles, and energy storage systems such as batteries and superconducting magnetic energy storage is used. The frequency was controlled by a reliable FOPI frequency controller. In addition, the Water Cycle Optimization Algorithm (WOA) optimizes the FOPI parameters. The selected objective function is the Integral Time Absolute Error (ITAE). The results of the proposed algorithm are compared with those of PSO, another well-known optimization technique, to demonstrate its effectiveness. By maintaining a faster settling time, the pro- posed optimization method performs better than PSO. To address the frequency anomaly caused by the presence of renewable generation units in [19]. Microgrids are becoming increasingly popular to manage energy demand in localized areas [26]. The integration of the bacterial foraging algorithm with a fuzzy controller in microgrids offers a promising solution to optimize energy management and improve grid stability [27]. By using the bacterial foraging algorithm in conjunction with a fuzzy controller, microgrids can effectively balance energy supply and demand, thus improving the overall efficiency and stability of the grid [28].

An FLC-based EMS with AC/DC microgrid is implemented. The power quality of the MG is increased in addition to the EMS design. It proposes to analyse and manage storage devices. The FLC extends battery life and creates an ideal SoC. To reduce power quality issues caused by non-linear, unbalanced load conditions, a grid-integrated MG based on FLC is implemented. For automatic load frequency management (ALFC) of a hybrid power system, a hybrid sperm swarm optimized-gravitational search algorithm based on chaotic search is presented in [21]. The integral-time absolute error of the hybrid system is minimized to determine the control parameters of the PID controller for the ALFC, which controls the frequency of the system. The effectiveness of the proposed technique is tested with different combinations of power sources connected to the system. In addition, a sensitivity analysis is performed to investigate the flexibility of the proposed technique considering the real-time weather-related interruptions and load changes of the renewable energy sources. In [22], the innovative fuzzy PID+PID hybrid controller used for frequency regulation in a hybrid power system is optimized using the whale optimization algorithm (WOA). The proposed application of WOA approach for frequency regulation in HPS can be considered unique at this stage. Compared to other controllers, the proposed WOA-optimized fuzzy PID + PID hybrid controller performs the best, which proves the effectiveness of WOA in load frequency control experiments. Due to the spatial and temporal variability associated with renewable energy sources and the large operational uncertainties caused by the changing natural environment, the long- term optimal operation of RES is a difficult challenge. Stochastic model predictive control (MPC) based on probabilistic forecasting and rolling stochastic optimization is designed and implemented for the long-term operation of renewable energy [24].

PV energy generation systems are ranked as a top energy system by utilities around the world because they generate electricity from renewable sources. These energy options have the disadvantage of being unpredictable and dependent on climate and weather conditions. To achieve noise-free voltage reduction for DFIG and PV systems, an effective strategy using a Landsman converter has been developed [25]. The tracking point of maximum power is controlled with a PWM-based PI controller using the firefly method. A grid-synchronized 3-phase VSI with an LC filter converts the DC voltage into AC voltage, ensuring smooth operation and elimination of harmonics. The outputs have a minimum THD value.

3. Research Motivation

In today's world, there is a growing emphasis on generating electricity from sustainable sources to mitigate the impact on the environment. Researchers and energy stakeholders are exploring advanced technologies like AI, machine learning, deep learning, and fuzzy logic for developing microgrids. However, renewable energy sources such as solar radiation and wind speed are constrained by fluctuations that affect efficiency. In order to accommodate that Artificial intelligence techniques and fuzzy logic concepts are being explored to improve Power Quality in a cost-effective manner without significantly increasing costs through additional components such as converters and filters.

In this work, a study on the design of a proposed two-level control framework for stable and voltage-tracking operation of the HMG under variable generation and load changes is presented. In this paper the following considerations are necessary for design and reliable HMG operation. Firstly: Maintaining a stable DC link voltage in the variation of temperature and irradiation fluctuations through AI based MPPT. at next, this model ensure that the inverter can be precisely controlled in conjunction with the load grid and to minimize the voltage deviation from the reference voltage specified by the load. In addition, a robust control method must be implemented in the inverter in conjunction with the load grid to achieve high performance due to changes in load dynamics. Finally, it is mandate that will ensure synchronized operation between the AC and DC sides of the HMGs to enable appropriate power sharing between the primary grid and the DC side. In particular, the controller's design process has been split into two stages: one addressing stability issues through partial feed- back linearization method while another deals with robust control methods alongside operational synchronization between AC and DC sides of HMGs accomplished using VSC controlled by PI controller. This section provides an overview of the motivations behind the study, which will be further explained in succeeding sections.

4. Proposed Research Methodology

The block diagram represents an advanced hybrid AC/DC microgrid system integrating solar PV energy sources. A key feature of this system is the AI-driven Maximum Power Point Tracking (MPPT) scheme used for the

solar PV systems. In order to explore advanced control strategies, an interval type 3 fuzzy-based controller enhanced by the Bacterial Foraging Optimization Algorithm (BFOA) and interlinking drop control, ensure power quality. Here's a detailed breakdown of the elements and processes involved.

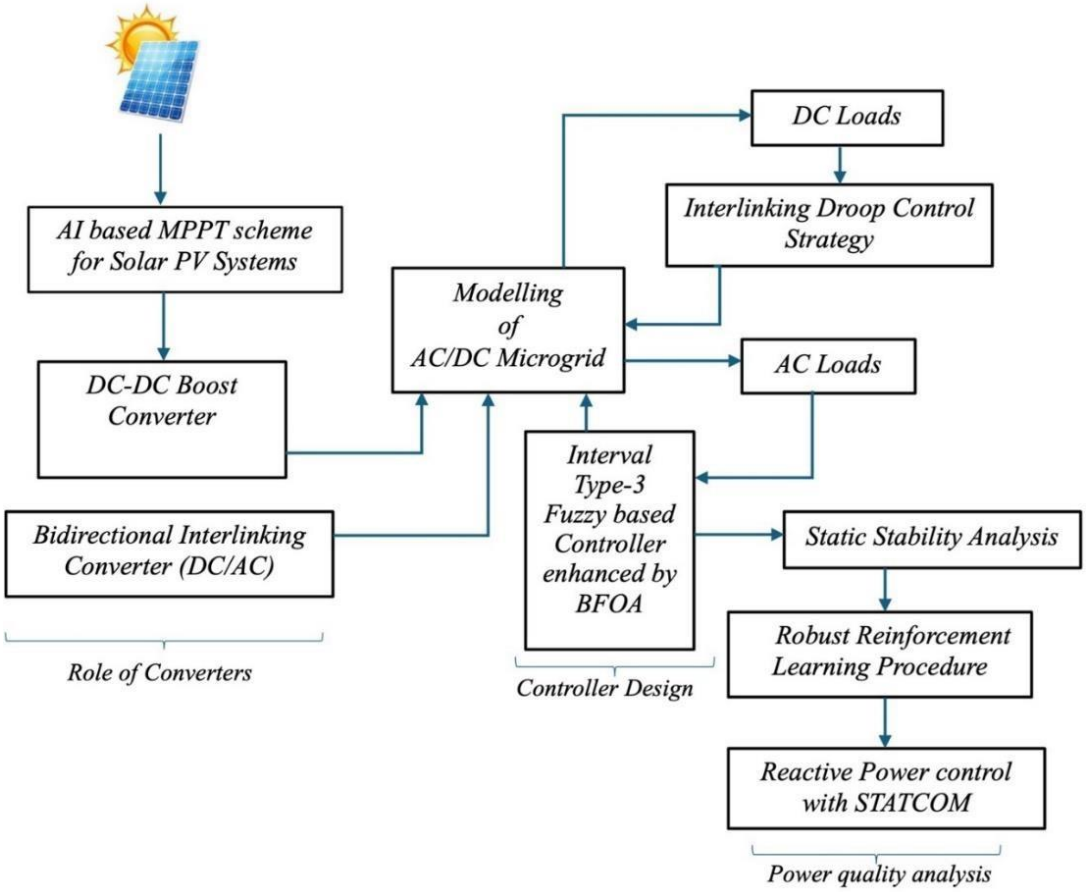


Fig.1. Block diagram for AI driven Hybrid AC/DC Microgrid

4.1 Modeling of AC/DC Microgrid

Comprehensive and accurate modelling enable researchers and industry professionals to gain valuable insights into the behaviour, performance, and control of AC/DC microgrids. The microgrid integrates both AC and DC loads, requiring thorough modelling for efficient operation and control. The dynamics of the power grid are significantly influenced by the growing adoption of renewable energy sources such as rooftop solar cells, photovoltaic, floating PV, solar PV, battery storage along with the grid (refer to Fig. 1). This system features AI-based Maximum Power Point Tracking which optimizes the power output of solar modules. A boost DC-DC converter with multiple inputs manages this optimized DC current in addition to a bi-directional link converter that facilitates current flow between AC and DC loads. Advanced control strategies including an Interval Type 3 fuzzy-based controller also improved by Bacterial Foraging Optimization Algorithm together with interlinking drop control ensure stability and quality in powering on demand needs. This proposed system delivers electricity to consumers via power converters, ensuring stable high-quality power supply even under extreme conditions. The paper discusses the use of reinforcement learning algorithms and static synchronous compensators for improving the performance and control of hybrid microgrids (Cheng et al., 2021). The paper highlights the importance of comprehensive modelling techniques and proposes an enhanced fuzzy-based en- ergy management strategy for a hybrid power system. This strategy aims to optimize power output, ensure stable high-quality power supply, and effectively manage the dynamics of the power grid.

4.2 AI-Driven MPPT Scheme for Solar PV Systems

In general, AI-based MPPT algorithms often use machine learning models such as neural networks, support vector machines, or fuzzy logic systems. These models are trained using historical data on solar irradiance and temperature, allowing them to accurately predict the maximum power point in real-time for photovoltaic systems. The use of ANN for MPPT allows for the identification and utilization of nonlinear correlations between variables in PV systems, resulting in a reliable, quick, and efficient maximum power point tracking process (Chen & Wang, 2019). Additionally, the ANN-based MPPT method eliminates the need for additional hardware and reduces dependence on system parameter variations.

This approach proves to be robust and versatile, making it a preferred choice for achieving optimal power generation in PV systems, particularly under partially shaded conditions. Furthermore, the combination of an artificial neural network controller with a scanning algorithm in this novel method enhances the tracking of the global maximum power point under partially shaded conditions, leading to improved performance and efficiency in PV systems. The proposed method, known as the ANN-KGMO MPPT controller, utilizes the Kinetic Gas Molecular Optimization Algorithm to train the developed Artificial Neural Network. This process enables the evolution of connection weights and biases to achieve optimal values for adjusting the duty cycle of the converter in accordance with PV array's Maximum Power Point, as depicted in a block diagram (refer to Fig. 2).

Real-world optimization problems are increasingly being solved by swarm-based algorithms. The optimization algorithm Kinetic Gas Molecule Optimization (KGMO), which is based on the kinetic energy of gas molecules, is presented in this study. The kinetic theory of gases, which establishes the guidelines for gas molecule inter- actions in the model, applies to the agents, which are gas molecules that are moving in the search space.

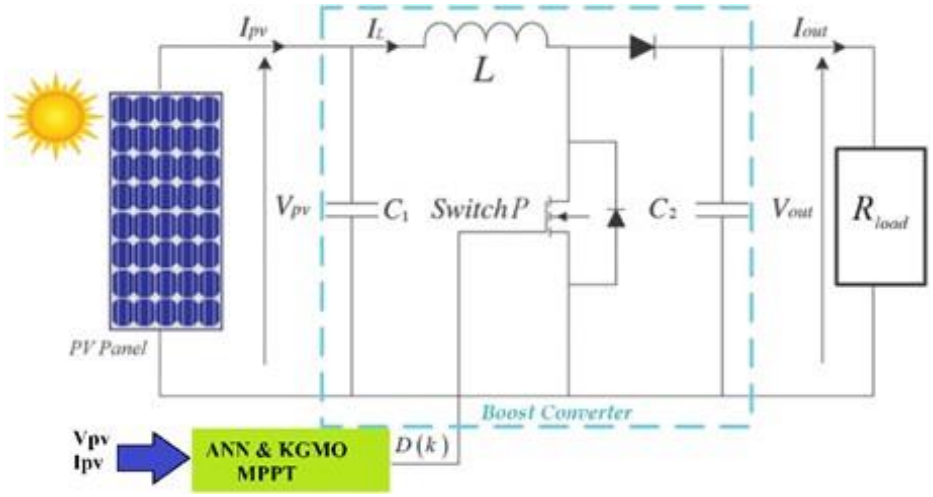


Fig. 2. Block diagram of the proposed ANN-KGMO MPPT model

The proposed MPPT algorithm involves three steps at most important i.e. data preparation and ANN training, Kinetic Gas Molecular Optimization, and applying KGMO optimized parameters to the ANN model. This approach combines data preparation and training of an Artificial Neural Network with the use of Kinetic Gas Molecular Optimization to optimize the model's parameters.

By utilizing this three-step approach, the proposed MPPT algorithm aims to effectively and accurately track the maximum power point of the photovoltaic system as depicted in Fig. 3. In this manuscript, we propose a metaheuristic optimized multilayer feed-forward artificial neural net- work controller to extract the maximum power from available solar energy. To improve the maximum power point delivered by PV arrays and overcome drawbacks in conventional MPPT methods under irradiation variation, a hybrid MPPT controller is designed. It takes PV array voltage and current as input parameters, and outputs the duty cycle of the DC/DC boost converter con- trolling power transfer between the PV array and the load. Discussion in this section will provide a summary of the Artificial Neural

Network based KGMO MPPT technique, highlighting its features and updates in managing DC power conversion for grid integration that will explained in subsequent sections.

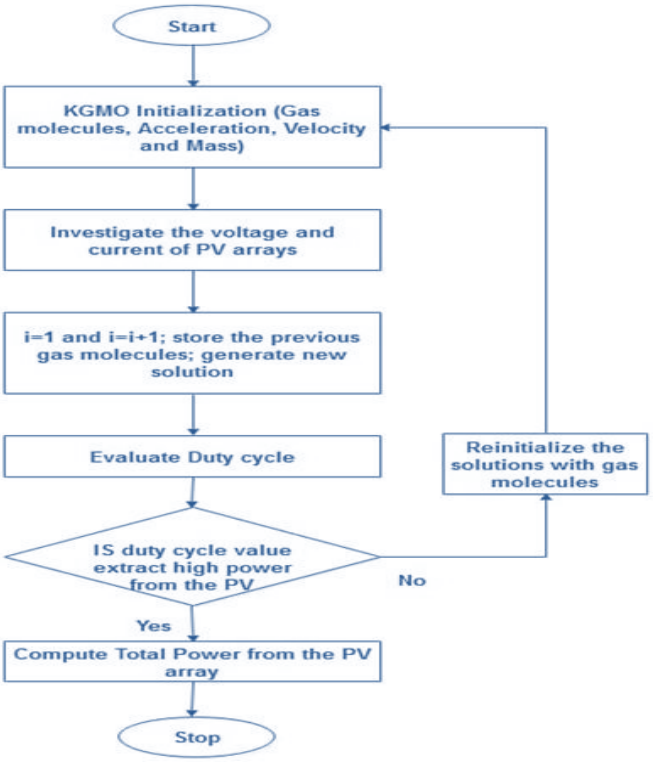


Fig. 3. Flow chart of the proposed ANN-KGMO MPPT model

4.3 Implementation of Converters in Hybrid Microgrid

In a hybrid microgrid, comprises a DC grid and an AC grid interlinked by a multi-objective control scheme of a bidirectional DC/AC converter. Bidirectional converters are crucial in hybrid microgrids because they enable two-way energy flow between various energy sources, storage systems, and the grid. They allow for efficient charging and discharging of batteries, facilitate seamless integration of renewable energy sources, and support grid stability by regulating voltage and frequency. By managing energy storage and distribution flexibly, bidirectional converters enhance the reliability, efficiency, and resilience of hybrid microgrids. Interlinking Converter (ILC) is a key component to connect the AC sub grid and DC sub grid. Its control strategy significantly affects power flow management, power quality, system efficiency and stability.

In microgrids, the primary or local level control is implemented for solar and battery for maintaining stable DC bus voltage. DC-DC Boost converters are being used as power converters in between load and source to enforce and increase the PV depending on the voltage output signal. The secondary or system level control is implemented by controlling the interlinking converter placed between ac and dc buses to supply stable voltage along with the smooth grid synchronization and ensuring the proper real power sharing between DC/AC buses. Furthermore, the ILC control prevents any negative sequence currents from flowing into the AC source.

4.3.1 Role of DC-DC Boost converter with MPPT in HMG

A boost converter is a DC/DC power converter which steps up voltage from its input (source) to its output (load). In continuous conduction mode (current through the inductor never falls to zero), it play a crucial role in increasing the voltage output from the maximum power point tracking system (Chen & Wang, 2019). These boost converters are responsible for efficiently converting the harvested solar energy into a higher voltage output, which is necessary for charging batteries or powering devices that require a higher voltage (Nguyen et al., 2020). Furthermore, the boost converters also help in maintaining a stable and regulated output voltage, thereby improving the overall efficiency and performance of the system as illustrated in Fig. 4.

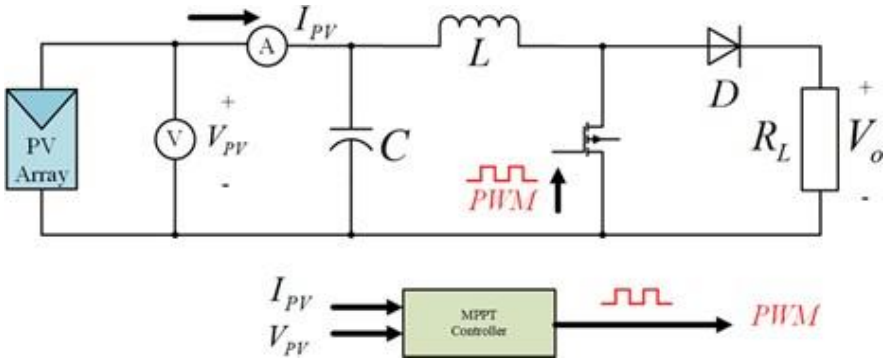


Fig.4. Circuit diagram of DC-DC Boost Converter

The boost converter output-input voltage relationship is proportional to the duty cycle in the sense that higher D will yield higher output voltages for a given input voltage. If the input voltage is Vin and the output voltage is Vout, Vout/Vin= 1/(1-D), where 0≤ D≤ 100% and D is the Duty cycle. In this case study, the power output of PV panel is 2000W, so the maximum operating power of the converter is 2000 W. Output voltage of the panel is 200 V at its MPP. The design parameters are the inductance, capacitance (supply) and capacitance (Load) are chosen as L=0.15H, C=100 and 470 uF and Vin=200V, Vout=400V, the voltage conversion ratio is set at K=400/200=2, frequency is 2.5 kHz, Load resistance is 80Ω. The algorithm proposed for MPPT in this manuscript, and detailed in the previous section, mainly focuses on the operating voltage and its corresponding power deviation. If the difference in power is positive, the future perturbation should follow suit to obtain MPP. Conversely, if the deviation in power is negative, the perturbation should be reversed and move in a reverse direction to obtain MPP. This procedure continues until it achieves maximum power.

4.4 Role of Bi-Directional DC/AC Converters in Hybrid Microgrid

Bidirectional converters are versatile power electronic devices that facilitate the flow of electrical energy in both directions between different parts of a power system. Unlike traditional unidirectional converters, which allow energy to flow in a single direction, bidirectional converters can switch between converting AC to DC and DC to AC, or between different DC voltage levels. This dual functionality is crucial in modern electrical systems, particularly in applications involving renewable energy sources and energy storage systems.

In renewable energy systems, bidirectional converters enable the integration of sources like solar panels and wind turbines with battery storage, allowing energy to be stored when production exceeds demand and later retrieved when needed. They also support grid stability by managing energy exchanges between microgrids and the main grid, helping balance supply and demand.

To validate the fuzzy logic-based control technique implemented in this proposed HMG, we had to design a bidirectional DC–AC converter that was capable of functioning as both an inverter and a PFC rectifier. The transition between these two modes of operation needed to be fully automated and without human intervention for our HMG to autonomously store, produce and supply energy for domestic use. Before validating its operation by appropriate experimental measurements, it is essential to detail the operating modes of the converter, as well as its control strategies. The energy transfer between a DC voltage source and an AC voltage source, and vice versa, was the basis of this structure. The association in series of a DC–DC stage and a DC–AC stage ensured this principle of operation with these two stages being necessarily bidirectional. The DC–DC stage needed to generate a rectified sine wave from the PWM command of the power switches. Since the power devices in this stage switched at a frequency of a few hundred kilohertz to optimize the compactness of the whole converter, the inductance, noted L1 was sized so that the ripple of the current was negligible com- pared to the sinusoidal component at low frequency (in this case, 50 Hz). Therefore, the DC–DC converter acted as a controllable output voltage source. By changing the voltage of a modulation stage, the output current could be regulated. This is very interesting, especially when the output current is strongly reduced or in the of variable DC voltage. This strategy allowed the output voltage of the DC–DC stage to be modulated. Specifically, when this modulated voltage was higher than the mains voltage, the

output current had a positive value. In the opposite case, the output current was negative. The design approach that was chosen allowed the converter to be used in both grid-connected and off-grid modes. Since the microcontroller was synchronized with the AC grid to sensibly drive the DC–DC and DC–AC stages, only the grid-connected mode will be discussed in the remainder of this paper. In this section of the paper, we will describe the control strategies of the pro- posed bidirectional DC–AC converter. We will only give the principles and thus, we will not detail the control circuit or the AC network connection strategy because several patents are pending. The DC–AC stage was controlled by the very same signal as the inverter mode, so it was synchronized with the AC grid at a frequency of 50 Hz.

Overall, bidirectional converters are essential for enhancing the flexibility, efficiency, and reliability of modern power systems, playing a key role in the transition to more sustainable and resilient energy infrastructures.

4.4.1 ILC Droop Control Coefficient

This paper proposes a novel, generalized droop scheme of ILC for autonomous power-sharing and control of a hybrid microgrid. A standalone hybrid microgrid is considered where the control of active power is more complex as compared to the grid-connected mode. The AC microgrid operates on frequency droop while voltage droop is used in the DC microgrid. A 3-dimensional plane is proposed for ILC control where the axis corresponds to DC voltage, AC frequency and converter power. The converter utilizes frequency droop at the AC terminal and voltage droop at the DC terminal so any change in DC voltage or AC frequency results in active power flow from an underloaded to the overloaded grid. The three quantities, namely active power, AC frequency and DC voltage, are introduced in the outer control loop of the converter along with three scaling factors which define the converter frequency and voltage droop.

To enable autonomous power-sharing between AC and DC grids, DC voltage droop and AC frequency droop are implemented in the outer control loop of the converter. Any load change in the ac grid will result in frequency variation and the power flow through the converter will change according to the frequency droop. Similarly, any dc load change will result in voltage variation which will change the converter power according to the dc voltage droop. Taking into account the fact that the converter does not generate any power and neglects converter losses, the following relation can be established.

$$k_1\Delta V_{dc} + k_2\Delta P_c - k_3\Delta f = 0 \tag{01}$$

Further expansion of this expression yields:

$$k_1\Delta V_{dc} + k_2 P_c - k_3 f - \left(k_1 V_{dc,ref} + k_2 P_{c,ref} - k_3 f_{ref}\right) \tag{02}$$

This is the generalized droop control which combines dc voltage and ac frequency. The maximum power flow through the tie line between ac and dc grids is represented as $P_{c,ref}$. The droop coefficients define the power flow through the converter. Equation (02) is a plane $ax + by + cz + d = 0$ drawn on the axis. If k_1 is set to zero, the converter operates in frequency droop and the droop coefficient is set by the ratio of k_2 and k_3 as shown in (03). This droop line is drawn on the plane on $f - P_c$ axis. In this case, no change in active power is observed due to load change in the dc grid and converter power is only dependent on ac grid frequency.

$$\frac{\Delta f}{\Delta P_c} = \frac{k_2}{k_3} \tag{03}$$

A voltage-frequency droop can be established by setting k_2 zero. In this case, the droop coefficient is given by

$$\frac{\Delta V_{dc}}{\Delta f} = \frac{k_3}{k_1} \tag{04}$$

This droop coefficient is the slope of the line drawn on $V_{dc} - f$ axis on the plane. Any change in DC voltage is translated into a change in frequency of ac grid but there is no control on the active power flowing through the converter. Any change in AC grid load will vary the power generated by the AC grid and the power flow through the converter according to the following relation:

$$\Delta P_L = \Delta P_{g,ac} - \Delta P_c \tag{05}$$

The load change in the ac sub-grid will cause frequency change. According to frequency droop, the change in ac power generation due to a change in frequency is given by:

$$\Delta P_{g,ac} = \frac{2\pi}{m}\Delta f \tag{06}$$

From the control scheme of the converter, the total change in active power ΔP_c from AC grid to DC grid is given by:

$$\Delta P_c = \frac{k_3\Delta f - k_1\Delta V_{dc}}{k_2} \tag{07}$$

Substituting Eqns.(06) and (07) in Eqn (05) gives us:

$$\Delta P_L = \frac{2\pi}{m}\Delta f - \frac{k_3\Delta f - k_1\Delta V_{dc}}{k_2} \quad (08)$$

This equation describes the impact of the ac load change on AC frequency and DC voltage in a hybrid microgrid. The change in power consumed by DC load can then be expressed as:

$$\Delta P_L = \frac{\Delta V_{dc}}{n} + \frac{k_3\Delta f - k_1\Delta V_{dc}}{k_2} \quad (09)$$

This relation can be used to determine its effect on frequency and DC voltage. Different voltage and frequency control strategies have been successfully implemented within AC and DC grids, but the control of hybrid microgrids requires further attention with a focus on ILC. In summary, interlinking converters are essential in microgrids as they allow for the integration of different energy sources, optimize power flow, enable power transfer between voltage systems, and ensure grid stability.

4.5 Controller Design

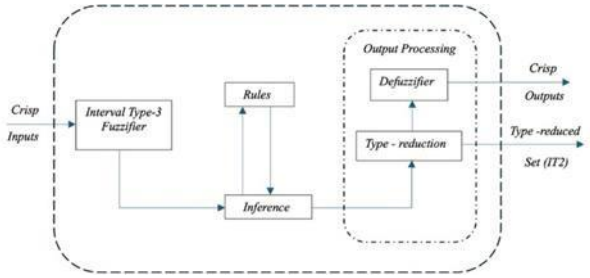


Fig. 5. Block Diagram of Interval Type-3 Fuzzy Controller

The voltage and frequency of MGs are strongly impressionable from the active and reactive load fluctuations. A change in load leads to an imbalance between generation and consumption. The output voltage and frequency of the DGs are primarily controlled by the droop characteristics. But, in case of severe changes in load, the DGs may be failed and the Microgrid is collapsed. Subsequently, the research proposed the interval type 3 fuzzy controller is used for controlling the load frequency of the multi-area system. A 1% step load perturbation is applied to the load demand of the power plant and analysis of the system responses in terms of settling time, peak overshoot and peak undershoot. Henceforth, it is necessary to maintain the system frequency to be constant. The structure of an interval type-3 system is almost the same as for type-2 and type-1, and it is composed of a fuzzifier, rules, inference, type reduction and defuzzifier [36]. In Fig. 5 we show the structure of an interval IT3 system [33,34,35].

Implementing an Interval Type-3 Fuzzy Controller in MATLAB involves defining fuzzy sets, membership functions, a rule base, and processes for fuzzification, inference, and defuzzification. Below is a basic outline ,

Step 1: Define Membership Functions

First, define the primary and secondary membership functions.

```
" function mu = primary_membership_function(x, a, b, c)
% Triangular membership function
mu = max(min((x - a) / (b - a), (c - x) / (c - b)), 0);
end

function mu = secondary_membership_function(primary_mu, l, u)
% Secondary membership function as a simple linear combination
mu = (primary_mu * (u - l)) + l;
end "
```

Step 2: Fuzzification

Convert crisp inputs into fuzzy values using the membership functions.

```
" function fuzzy_values = fuzzify(input_value, membership_functions)
  fuzzy_values = zeros(1, length(membership_functions));
```

```
    for i = 1:length(membership_functions)
        fuzzy_values(i) = membership_functions{i}(input_value);
    end
end"
```

Step 3: Rule Base

Define a set of fuzzy rules and apply them.

```
" function output_fuzzy_values = rule_base(input_fuzzy_values)
    % Example: simple rule base with two rules
    rule1 = min(input_fuzzy_values(1), input_fuzzy_values(2));
    rule2 = min(input_fuzzy_values(3), input_fuzzy_values(4));
    output_fuzzy_values = [rule1, rule2];
end"
```

Step 4: Inference

Apply the fuzzy rules to determine the output fuzzy sets.

```
" function inference_result = inference(fuzzy_values, rule_base)
inference_result = zeros(1, length(rule_base));
for i = 1:length(rule_base)
inference_result(i) = rule_base(i);
end
end"
```

Step 5: Defuzzification

Convert the fuzzy output sets back into crisp values.

```
"function crisp_output = defuzzify(fuzzy_output_values)
% Example: centroid method
numerator = sum(fuzzy_output_values);
denominator = length(fuzzy_output_values);
crisp_output = numerator / denominator;
end"
```

This is a simplified implementation to demonstrate the basic structure of an Interval Type-3 Fuzzy Controllerin MATLAB. A real-world implementation would require more detailed handling of the secondary member- ship functions, more complex rule definitions, and more sophisticated methods for fuzzification, inference, and defuzzification.

4.5.1 Interval Type 3 Fuzzy Controller

The interval type-3 FLSs (IT3-FLSs) are developed to handle more levels of uncertainty. In this study, IT3-FLSs are used for online dynamic identification. as Illustrated in Fig. 5,The structure of IT3-FLS is explained step-by-step below:

The inputs of IT3-FLSs are $y_1 = I_p(t)$, $y_2 = V_c(t-\tau)$, $y_3 = I_b(t)$, where, I_p and I_b are the currents of PV and battery, respectively and V_c is the load voltage. τ represents the sample time.

For each input, two Gaussian membership functions (MFs) are considered. The centres of MFs are set to the upper and lower bounds of each input. For input I_p, $\tilde{A}^2_{I_p}$, respectively. Similarly, for input I_b, one has: the upper and lower memberships are obtained as:

$$\bar{\mu}_{\tilde{A}^1_{I_p}|\alpha}(I_p) = exp\left(-\frac{\left(I_p - \underline{c}_{\tilde{A}^1_{I_p}}\right)^2}{\bar{\sigma}^2_{\tilde{A}^1_{I_p}|\alpha}}\right) \tag{10}$$

$$\bar{\mu}_{\tilde{A}_{I_p}^2|\alpha}(I_p) = exp\left(-\frac{\left(I_p-\bar{c}_{\tilde{A}_{I_p}^2}\right)^2}{\bar{\sigma}^2_{\tilde{A}_{I_p}^2|\alpha}}\right) \tag{11}$$

$$\underline{\mu}_{\tilde{A}_{I_p}^1|\alpha}(I_p) = exp\left(-\frac{\left(I_p-\underline{c}_{\tilde{A}_{I_p}^1}\right)^2}{\underline{\sigma}^2_{\tilde{A}_{I_p}^1|\alpha}}\right) \tag{12}$$

$$\underline{\mu}_{\tilde{A}_{I_p}^2|\alpha}(I_p) = exp\left(-\frac{\left(I_p-\bar{c}_{\tilde{A}_{I_p}^2}\right)^2}{\underline{\sigma}^2_{\tilde{A}_{I_p}^2|\alpha}}\right) \tag{13}$$

Where, α is the level of the horizontal slice. $\tilde{A}_{I_p}^1$ and $\tilde{A}_{I_p}^2$ are the first and second MFs for input I_p. $\underline{c}_{\tilde{A}_{I_p}^1}$ and $\bar{c}_{\tilde{A}_{I_p}^2}$ are the centres of $\tilde{A}_{I_p}^1$ and $\tilde{A}_{I_p}^2$, respectively. $\bar{\sigma}_{\tilde{A}_{I_p}^1|\alpha}/\underline{\sigma}_{\tilde{A}_{I_p}^1|\alpha}$ and $\bar{\sigma}_{\tilde{A}_{I_p}^2|\alpha}/\underline{\sigma}_{\tilde{A}_{I_p}^2|\alpha}$ are the standard division for the upper/lower bounds of $\tilde{A}_{I_p}^1$ and $\tilde{A}_{I_p}^2$, respectively. Similarly, for input I_b, one has:

$$\bar{\mu}_{\tilde{A}_{I_b}^1|\alpha}(I_b) = exp\left(-\frac{\left(I_b-\underline{c}_{\tilde{A}_{I_b}^1}\right)^2}{\bar{\sigma}^2_{\tilde{A}_{I_b}^1|\alpha}}\right) \tag{14}$$

$$\bar{\mu}_{\tilde{A}_{I_b}^2|\alpha}(I_b) = exp\left(-\frac{\left(I_b-\bar{c}_{\tilde{A}_{I_b}^2}\right)^2}{\bar{\sigma}^2_{\tilde{A}_{I_b}^2|\alpha}}\right) \tag{15}$$

$$\underline{\mu}_{\tilde{A}_{I_b}^1|\alpha}(I_b) = exp\left(-\frac{\left(I_b-\underline{c}_{\tilde{A}_{I_b}^1}\right)^2}{\underline{\sigma}^2_{\tilde{A}_{I_b}^1|\alpha}}\right) \tag{16}$$

$$\underline{\mu}_{\tilde{A}_{I_b}^2|\alpha}(I_b) = exp\left(-\frac{\left(I_b-\bar{c}_{\tilde{A}_{I_b}^2}\right)^2}{\underline{\sigma}^2_{\tilde{A}_{I_b}^2|\alpha}}\right) \tag{17}$$

Where, $\tilde{A}_{I_b}^1$ and $\tilde{A}_{I_b}^2$ are the first and second MFs for input Ib. $\underline{c}_{\tilde{A}_{I_b}^1}$ and $\bar{c}_{\tilde{A}_{I_b}^2}$ are the centres of $\tilde{A}_{I_b}^1$ and $\tilde{A}_{I_b}^2$, respectively. $\bar{\sigma}_{\tilde{A}_{I_b}^1|\alpha}/\underline{\sigma}_{\tilde{A}_{I_p}^1|\alpha}$ and $\bar{\sigma}_{\tilde{A}_{I_b}^2|\alpha}/\underline{\sigma}_{\tilde{A}_{I_b}^2|\alpha}$ are the standard division for the upper/lower bounds of $\tilde{A}_{I_b}^1$ and $\tilde{A}_{I_b}^2$, respectively. Finally, for input V_c, one has:

$$\bar{\mu}_{\tilde{A}_{V_c}^1|\alpha}(V_c) = exp\left(-\frac{\left(V_c-\underline{c}_{\tilde{A}_{V_c}^1}\right)^2}{\bar{\sigma}^2_{\tilde{A}_{V_c}^1|\alpha}}\right) \tag{18}$$

$$\bar{\mu}_{\tilde{A}_{V_c}^2|\alpha}(V_c) = exp\left(-\frac{\left(V_c-\bar{c}_{\tilde{A}_{V_c}^2}\right)^2}{\bar{\sigma}^2_{\tilde{A}_{V_c}^2|\alpha}}\right) \tag{19}$$

$$\underline{\mu}_{\tilde{A}_{V_c}^1|\alpha}(V_c) = exp\left(-\frac{\left(V_C-\underline{c}_{\tilde{A}_{V_c}^1}\right)^2}{\underline{\sigma}^2_{\tilde{A}_{V_c}^1|\alpha}}\right) \tag{20}$$

$$\underline{\mu}_{\tilde{A}_{V_c}^2|\alpha}(V_c) = exp\left(-\frac{\left(V_c-\bar{c}_{\tilde{A}_{V_c}^2}\right)^2}{\underline{\sigma}^2_{\tilde{A}_{V_c}^2|\alpha}}\right) \tag{21}$$

Where, $\tilde{A}_{V_c}^1$ and $\tilde{A}_{V_c}^2$ are the first and second MFs for input V_c. $\underline{c}_{\tilde{A}_{V_c}^1}$ and $\bar{c}_{\tilde{A}_{V_c}^2}$ are the centres of $\tilde{A}_{V_c}^1$ and $\tilde{A}_{V_c}^2$, respectively. $\bar{\sigma}_{\tilde{A}_{V_c}^1|\alpha}/\underline{\sigma}_{\tilde{A}_{V_c}^1|\alpha}$ and $\bar{\sigma}_{\tilde{A}_{V_c}^2|\alpha}/\underline{\sigma}_{\tilde{A}_{V_c}^2|\alpha}$ are the standard division for the upper/lower bounds of $\tilde{A}_{V_c}^1$ and $\tilde{A}_{V_c}^2$, respectively. 3) The output of $\hat{f}_1$ and $\hat{f}_2$ are:

$$\hat{f}_1 = \theta_1^T\zeta_1 \tag{22}$$

$$\hat{f}_2 = \theta_2^T\zeta_2 \tag{23}$$

Where, θ_i and ζ_i are:

$$\theta_i = \left[\underline{w}_{i1}, \dots, \underline{w}_{iR}, \overline{w}_{i1}, \dots, \overline{w}_{iR}\right]^T \tag{24}$$

$$\zeta_i = \left[\underline{\zeta}_{i1}, \dots, \underline{\zeta}_{iR}, \bar{\zeta}_{i1}, \dots, \bar{\zeta}_{iR}\right]^T \tag{25}$$

Where, $\overline{w}_{i1}$ and $\underline{w}_{i1}$ are the parameters of $l-$th rule for $i-$th IT3-FLS and R represents the number of rules. $\underline{\zeta}_{i1}$ and $\bar{\zeta}_{i1}$ are:

$$\bar{\zeta}_l = \frac{\sum_{j=1}^{n_\alpha} \bar{\alpha}_j \frac{\bar{z}^l_{\mu s=\bar{\alpha}_j}}{\sum_{l=1}^{R}\left(\bar{z}^l_{\mu s=\bar{\alpha}_j} + \underline{z}^l_{\mu s=\bar{\alpha}_j}\right)}}{\sum_{j=1}^{n_\alpha}(\bar{\alpha}_j + \underline{\alpha}_j)} + \frac{\sum_{j=1}^{n_\alpha} \underline{\alpha}_j \frac{\bar{z}^l_{\mu s=\underline{\alpha}_j}}{\sum_{l=1}^{R}\left(\bar{z}^l_{\mu s=\underline{\alpha}_j} + \underline{z}^l_{\mu s=\underline{\alpha}_j}\right)}}{\sum_{j=1}^{n_\alpha}(\bar{\alpha}_j + \underline{\alpha}_j)}, \; l = 1, \dots 8 \tag{26}$$

$$\underline{\zeta}_l = \frac{\sum_{j=1}^{n_\alpha} \bar{\alpha}_j \frac{\underline{z}^l_{\mu s=\bar{\alpha}_j}}{\sum_{l=1}^{R}\left(\bar{z}^l_{\mu s=\bar{\alpha}_j} + \underline{z}^l_{\mu s=\bar{\alpha}_j}\right)}}{\sum_{j=1}^{n_\alpha}(\bar{\alpha}_j + \underline{\alpha}_j)} + \frac{\sum_{j=1}^{n_\alpha} \underline{\alpha}_j \frac{\underline{z}^l_{\mu s=\underline{\alpha}_j}}{\sum_{l=1}^{R}\left(\bar{z}^l_{\mu s=\underline{\alpha}_j} + \underline{z}^l_{\mu s=\underline{\alpha}_j}\right)}}{\sum_{j=1}^{n_\alpha}(\bar{\alpha}_j + \underline{\alpha}_j)}, \; l = 1, \dots 8 \tag{27}$$

Where, n_α is the number of horizontal slices and:

$$\underline{\zeta}_l = \frac{\sum_{j=1}^{n_\alpha} \bar{\alpha}_j \frac{\underline{z}^l_{\mu s=\bar{\alpha}_j}}{\sum_{l=1}^{R}\left(\bar{z}^l_{\mu s=\bar{\alpha}_j} + \underline{z}^l_{\mu s=\bar{\alpha}_j}\right)}}{\sum_{j=1}^{n_\alpha}(\bar{\alpha}_j + \underline{\alpha}_j)} + \frac{\sum_{j=1}^{n_\alpha} \underline{\alpha}_j \frac{\underline{z}^l_{\mu s=\underline{\alpha}_j}}{\sum_{l=1}^{R}\left(\bar{z}^l_{\mu s=\underline{\alpha}_j} + \underline{z}^l_{\mu s=\underline{\alpha}_j}\right)}}{\sum_{j=1}^{n_\alpha}(\bar{\alpha}_j + \underline{\alpha}_j)}, \; l = 1, \dots R \tag{28}$$

The rules are written as:

Rule #1: If I_p is $\tilde{A}^1_{I_p}|\alpha$ and I_b is $\tilde{A}^1_{I_b}|\alpha$ and V_c is $\tilde{A}^1_{V_c}|\alpha$
Then $\hat{f}_i \in [\underline{w}_{i1}, \overline{w}_{i1}]$
Rule #2: If I_p is $\tilde{A}^1_{I_p}|\alpha$ and I_b is $\tilde{A}^1_{I_b}|\alpha$ and V_c is $\tilde{A}^2_{V_c}|\alpha$
Then $\hat{f}_i \in [\underline{w}_{i2}, \overline{w}_{i2}]$
Rule #3: If I_p is $\tilde{A}^1_{I_p}|\alpha$ and I_b is $\tilde{A}^2_{I_b}|\alpha$ and V_c is $\tilde{A}^1_{V_c}|\alpha$
Then $\hat{f}_i \in [\underline{w}_{i3}, \overline{w}_{i3}]$
Rule #4: If I_p is $\tilde{A}^1_{I_p}|\alpha$ and I_b is $\tilde{A}^2_{I_b}|\alpha$ and V_c is $\tilde{A}^2_{V_c}|\alpha$
Then $\hat{f}_i \in [\underline{w}_{i4}, \overline{w}_{i4}]$
Rule #5: If I_p is $\tilde{A}^2_{I_p}|\alpha$ and I_b is $\tilde{A}^1_{I_b}|\alpha$ and V_c is $\tilde{A}^1_{V_c}|\alpha$
Then $\hat{f}_i \in [\underline{w}_{i5}, \overline{w}_{i5}]$
Rule #6: If I_p is $\tilde{A}^2_{I_p}|\alpha$ and I_b is $\tilde{A}^1_{I_b}|\alpha$ and V_c is $\tilde{A}^2_{V_c}|\alpha$
Then $\hat{f}_i \in [\underline{w}_{i6}, \overline{w}_{i6}]$
Rule #7: If I_p is $\tilde{A}^2_{I_p}|\alpha$ and I_b is $\tilde{A}^2_{I_b}|\alpha$ and V_c is $\tilde{A}^1_{V_c}|\alpha$
Then $\hat{f}_i \in [\underline{w}_{i7}, \overline{w}_{i7}]$
Rule #8: If I_p is $\tilde{A}^2_{I_p}|\alpha$ and I_b is $\tilde{A}^2_{I_b}|\alpha$ and V_c is $\tilde{A}^2_{V_c}|\alpha$
Then $\hat{f}_i \in [\underline{w}_{i8}, \overline{w}_{i8}]$

In the type-3 MFs, the secondary membership is not a crisp value but it is a fuzzy set. Also a horizontal slice of a level $\mu_s = \alpha_k$ is equal with two slices at levels $\mu_s = \underline{\alpha}_k$ and $\mu_s = \overline{\alpha}_k$ in type-2 counterpart. Consequently, the research proposed a swarm-based hybrid metaheuristic optimizer of the Bacterial Foraging Optimization Algorithm (BFOA) which optimally tunes and controls the fuzzy controller parameters.

4.3.2 Enhanced Controller efficiency by BFOA

Initiating the deployment of the Bacterial Foraging Optimization Algorithm to refine the operations of a fuzzy type-3 controller within a microgrid framework involves a sequence of strategic steps. Commence with the construction of a detailed microgrid model encapsulating its integral components—distributed generation units,

storage mechanisms, consumer loads, and command modules. Forge a sophisticated fuzzy type-3 controller, crafted to govern the intricacies of power distribution, voltage modulation, and frequency stabilization, pinpointing the specific variables that warrant enhancement. Subsequently, establish a robust objective function adept at evaluating the microgrid's operational efficacy, engaging metrics that aim to curtail energy dissipation, equilibrate supply-demand dynamics, fortify voltage constancy, and augment frequency adherence. Proceed to meticulously calibrate the BFOA configurations, setting parameters such as bacterial population foundation, chemotaxis stages, navigational duration, procreation sequencing, and the probability metrics for elimination and dispersal phases. Culminate by methodically applying the BFOA, refining the controller parameters through iterative optimization, assiduously informed by the designated objective function's feedback, to realize an apex in microgrid performance (Das et al., 2009) (Hu et al., 2020)

4.3.2.1 Pseudo-code for BFOA-based Optimization

Initialize microgrid model and fuzzy type-3 controller parameters
Define objective function F(x) to evaluate microgrid performance

Initialize BFOA parameters:
S (number of bacteria)
Nc (number of chemotactic steps)
Ns (swim length)
Nre (number of reproduction steps)
Ned (number of elimination-dispersal events)
Ped (elimination-dispersal probability)

Initialize bacteria positions randomly in the search space

FOR each elimination-dispersal event
FOR each reproduction step
FOR each chemotactic step
FOR each bacterium i

Compute the objective function F(x) for current position

Tumble: generate a random direction Δ(i)
Move: compute new position using Δ(i)

Compute F(x) at new position

WHILE (not better or swim length not exceeded)
Move in the same direction and compute F(x)
END WHILE
END FOR

Implement swarming behavior

END FOR
Sort bacteria based on objective function value
Reproduce: eliminate least healthy half and split the healthier half
END FOR
Eliminate and disperse bacteria with probability Ped
END FOR
Output the optimized fuzzy type-3 controller parameters
Apply optimized controller to the microgrid and validate performance

By integrating the optimized parameters into the fuzzy type-3 controller and simulating the microgrid operation, you can validate the performance by comparing it against predefined benchmarks or previous configurations. If necessary, iterate the optimization process, adjusting the BFOA parameters for improved results and leading to enhanced system performance and stability.

However, most fuzzy controllers are static in that they respond only to current input, so they may not offer any improvement over the dynamic nature of designs. By replacing nonlinear and time-varying aspects of a neural network with uncertainties, a robust reinforcement learning procedure results that are guaranteed to remain stable even as the neural network is being trained.

4.6 Power Quality Analysis

In this study, a new reactive power control strategy is employed for optimization of the reactive power along with the stability improvement of the system under different small perturbed conditions. Therefore, this study focuses on controlling the reactive power of the hybrid power system model with the aid of a Static Synchronous Compensator (STATCOM). Further, evaluate the renewable energy resources' penetration limit of the AC-DC hybrid grid, which considers both economy and safety. The static stability indicators are considered for an evaluation of the penetration limit of RES.

4.6.1 Implementation of STATCOM as a Reactive Compensator

STATCOM is developed on the solid-state-based synchronous source of voltage which replicates a synchronous machine of ideal nature. It generates a set of 3-phase balanced sinusoidal voltages at the fundamental frequency by continuous controlling of phase angle and amplitude. The schematic of the STATCOM and its equivalent structure has been given in Fig. 6. A illustrated in Fig. 6, the voltage source converter, DC capacitor, and coupling transformer. The real part of the STATCOM controller current is insignificant and considered zero. The reactive current can be controlled by the variation of α and δ.

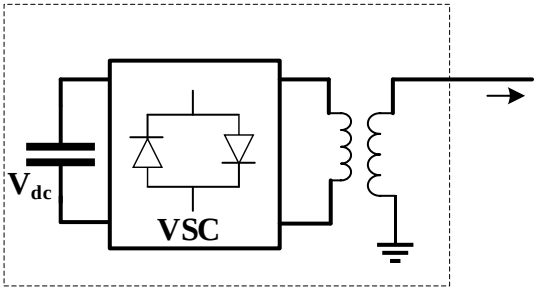


Fig. 6: Schematic Diagram for STATCOM Configuration

In this paper, α is the STATCOM's fundamental output voltage (kV_{dc}) phase angle and δ is the phase angle of the system bus voltage, U where the STATCOM is connected. The amplitude of the converter's fundamental output voltage is $kU_{dc}$where U_{dc}represents DC voltage developed in between the DC capacitor. The STATCOM controller injecting the reactive power to the connected bus has been given as in equation (30).

$$Q_{STATCOM} = kU_{dc}^2 B - kU_{dc} UB\ cos\ (\alpha - \delta) + kU_{dc} UG\ sin(\alpha - \delta) \quad (29)$$

In the considered HPS, bus voltage is taken as a reference voltage; so, the bus angle (δ) is zero. In the above equation, the G term is also insignificant, because $(G + jB)$ characterizes the admittance of the step-down transformer. Thus, equation (30) now becomes equation (31), considering G and δ as zero.

$$Q_{STATCOM} = kU_{dc}^2 B - kU_{dc} UB\ cos\alpha \quad (30)$$

Here, in equation (31), U and α, are the variable terms on which the reactive power depends; under the small perturbations, the change in reactive power of STATCOM can be written as equation (32).

$$\Delta Q_{STATCOM}(s) = G_1 \Delta\alpha(s) + G_2 \Delta U(s) \quad (31)$$

Where, $G_1 = kU_{dc}UB\ sin\alpha$ and $G_2 = kU_{dc}UB\ cos\alpha$.

It evaluates the renewable energy resources' penetration limit of the AC-DC hybrid grid, which considers both economy and safety. The static stability indicators are considered for an evaluation of the penetration limit of RES.

4.7 Loads, Energy storage Devices and utility Grid

DC Load: Devices that consume direct currents, such as DC machines, electric vehicles, and many electronic devices, are defined as DC loads. Similarly to the DC source, the DC load is represented as a controlled direct current source, but functions by absorbing power from the microgrid.

AC Load: The AC loads are represented by sets of impedance, composed of balanced three-phase resistors and inductances in series. Thus, these AC loads consume the active and reactive power of the AC microgrids (ACMG). The input and output of such loads occur according to the desired power profiles.

Nonlinear Load: The nonlinear load represents devices that distort the electrical current waveform, contaminating the grid with harmonic content. Such loads are modelled as a diode rectifier bridge with a resistive load and inductive filter at the input. The distortion in the waveform occurs due to the harmonic components added to the fundamental sinusoidal current. These harmonic distortions cause issues in the utility grid, thereby affecting the power quality of the energy supplied by the system.

Energy Storage Device: Among different existing energy storage technologies, Li-ion batteries are chosen as ESD in this work. The dynamic behaviour of such ESD is based on the Shepherd model, which represents the battery as a controlled DC source in series with internal resistance.

It is possible to describe, in a simplified way, the output voltage of the battery bank, according to equation (1).

$$V_{bat} = E_{bat} - R_{bat} I_{bat} \quad (32)$$

Where, V_{bat} and E_{bat} are the output and internal battery voltage, respectively; R_{bat} is the internal resistance, and I_{bat} is the battery's electrical current.

Utility Grid: Despite the main aspect of a microgrid being the possibility of operating in the standalone or grid-connected mode, this paper focuses exclusively on studying the grid-connected operation. In this study, the utility grid is implemented by a balanced, 60 Hz, three-phase, 220 V RMS, phase-to-phase AC source. Each voltage source represents a phase, with 120o of phase-shift between each phase, in the positive sequence. RL impedances are employed to characterize the conductors' dynamic effect, emulating the transmission line impedances. The value of these impedances is determined according to conventional short-circuit power for electrical distribution systems.

5. Simulation results

The simulation of the proposed hybrid microgrid involves modelling various components, integrating them into a unified system, and analysing performance under different operating conditions using MATLAB 2023a environment. The simulation is conducted on a Personal Computer System running Windows 11 Operating System with 6GB DDR3 of RAM and Intel Core i7 processor @ 3.5GHz. The total simulation time amounts to 10.190 seconds including power flow analysis and power quality evaluation at the DC-link of the DC Microgrid and the utility grid. The system includes loads and sources rated up to 4.5 kW, along with interlinkingconverters designed for a nominal power of 3 kW to ensure efficient hybrid power system operation based on selected inductors and capacitors which meet voltage ripple requirements as well as nominal power needs of the power converters. This accurate simulation models effectively analysing its performance under variousconditions using high-performance computer configurations advantageous in demonstrating successful integration of various components within this complex energy network while providing valuable insights into its feasibility showcasing effective component integration enabling smooth operations across diverse scenarios.

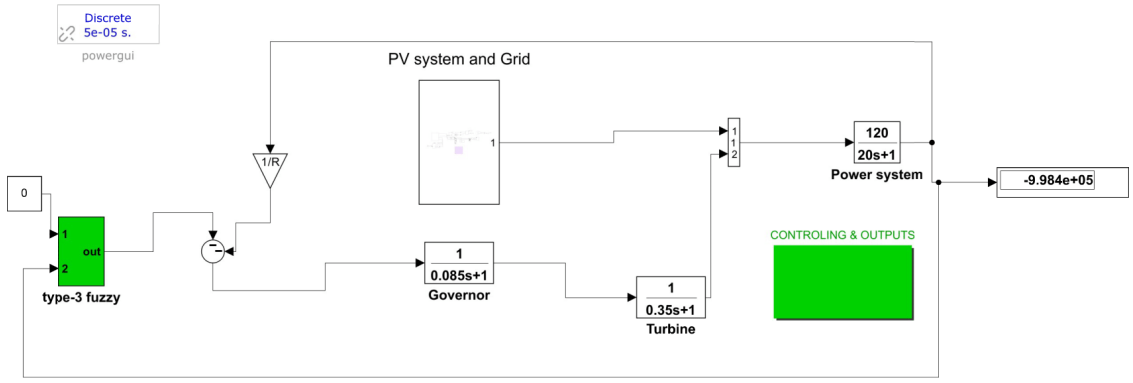


Fig.7. Simulation Model for Hybrid Renewable Energy Resources

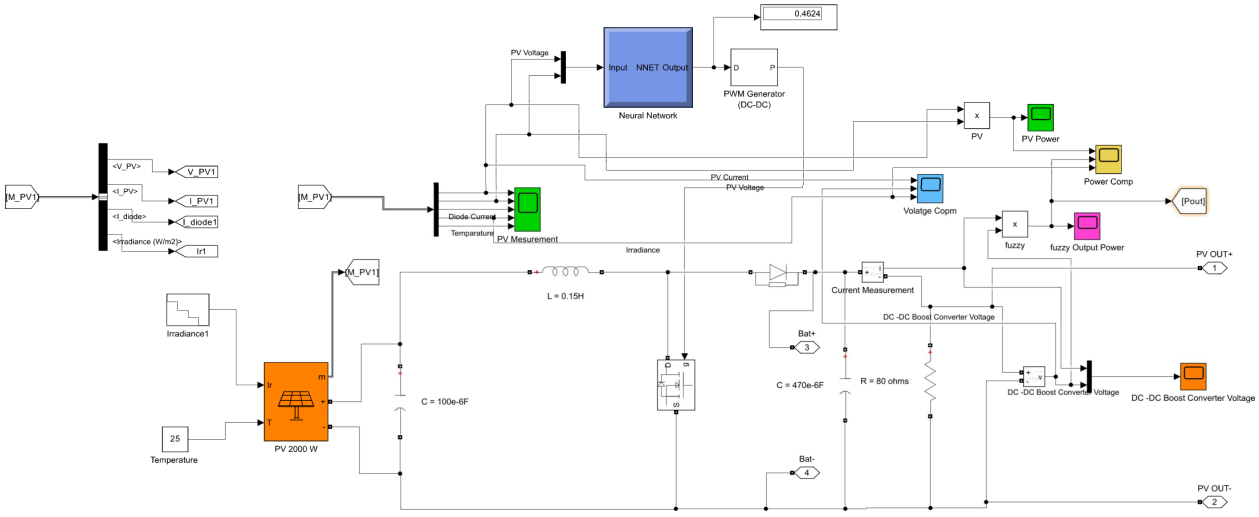


Fig. 8. Simulation Model of AI Based MPPT Scheme

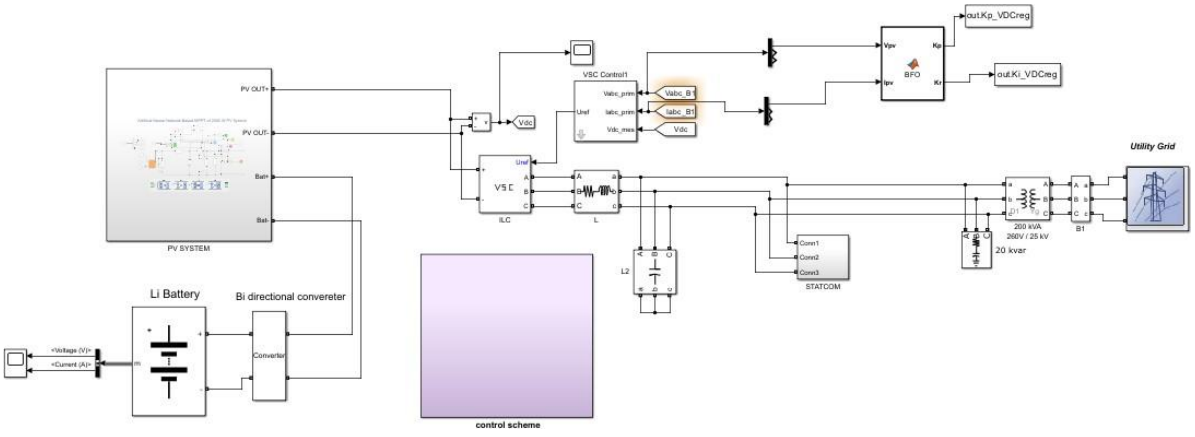


Fig.9. Proposed Simulation Model of PV system and Grid

The simulation model for hybrid renewable energy resources, illustrated in Fig. 7,8,9 was developed using MATLAB/Simulink. In this hybrid PV system, the PV array serves as the primary power source. Renewable energy sources are connected in parallel, with a battery connected across this parallel combination. The battery discharges when the voltage exceeds 30V and charges when the voltage drops below 30V. In this Battery circuit, if the semi-oxide concentration decreases linearly then the battery voltage drops rapidly.

The Key components in this model include the PV Panel with AI based MPPT, Type 3 fuzzy Controller, Bidi-rectional converter ,DC/DC converter, battery model, and power system. The optimum power control and pitch angle control mechanisms drive the induction generator. The turbine's external inputs are wind speed and rotor speed. The main

objective of the grid-side converter is to regulate the DC link capacitor voltage and control power flow between the DC bus and the AC side.

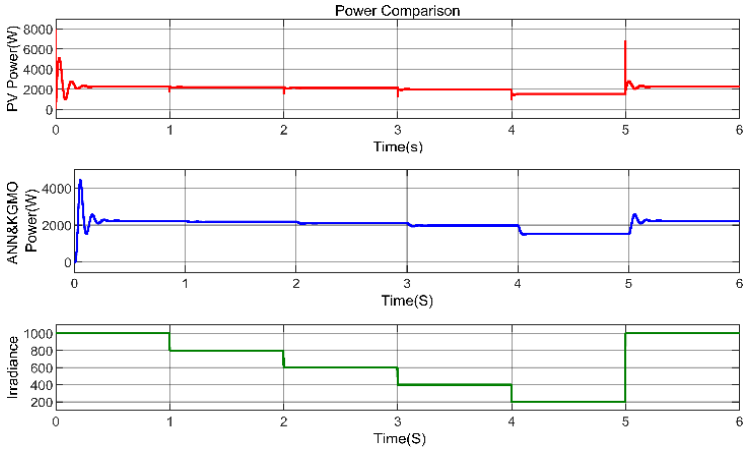


Fig. 10(a). Power Comparison from ANN-KGMO *method*

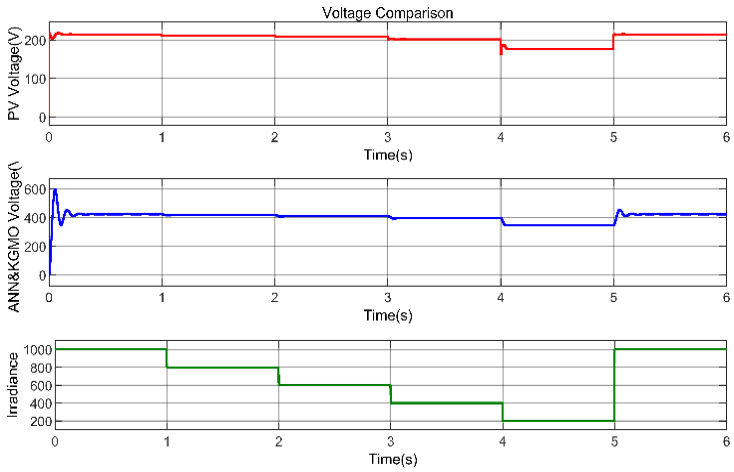


Fig. 10(b). Voltage Comparison from ANN-KGMO *method*

Fig. 10 shows the simulation outcome with ANN-KGMO based MPPT tracking algorithm is more reliable than the conventional control methods. It has less settling time with no steady state oscillations and more power output.

It is observed that ANN-KGMO based MPPT algorithm regulates the output voltage at 400V and hence the power at 2000 W with rapid step changes in the solar irradiance.

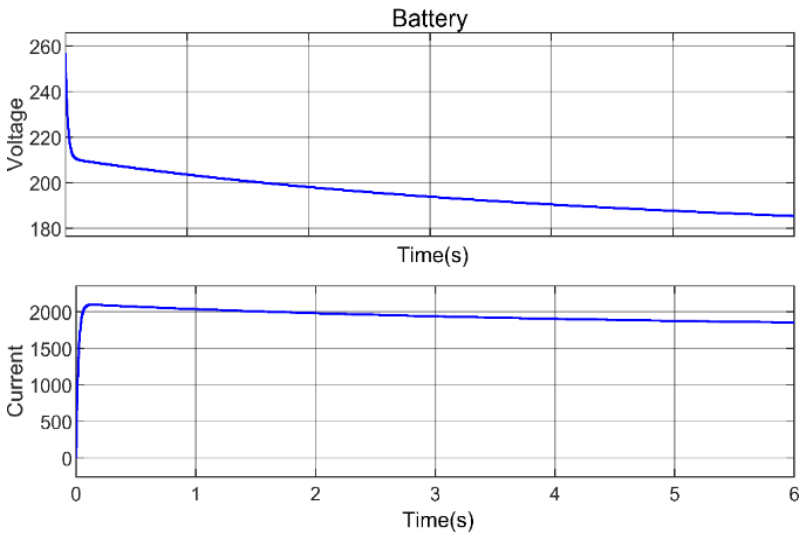


Fig.11. Current and Voltage Graph for Battery

The current and voltage graph for the battery is presented in Fig. 11. It produces a battery current of approximately 1900 A for 6 second. However, the voltage produced due to the battery is approximately 190 V for time 6 second. The input charging current to the battery stack in a photovoltaic hybrid solution will not be constant due to the atmospheric conditions and the time of day.

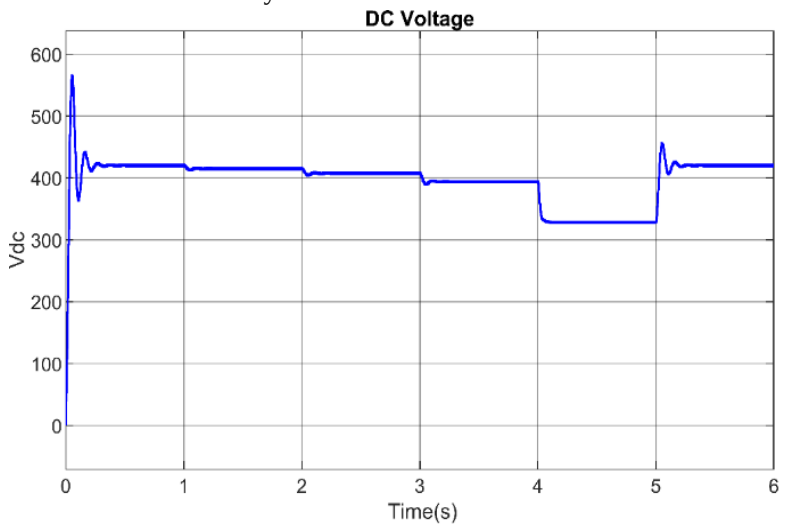


Fig.12. Response of Hybrid V_{dc} value

Fig. 12 the simulation results of ANN-KGMO methods and Battery DC Voltage at 25°C temperature and light intensity is varied from 1000 to 200 W/m^2 in steps at rate of 200 W/m^2 per second. After reaching 200 W/m^2 the intensity is varied to 1000W/m^2 in single step. Upto 4 sec (400 W/m^2) seconds the output voltage is maintained approximately 410V but after reaching 200 W/m^2 at 4 second the DC Voltage value reduced to 340V and gain the intensity is varied to 1000W/m^2 in single step the DC Voltage is reached to approximately 410V.

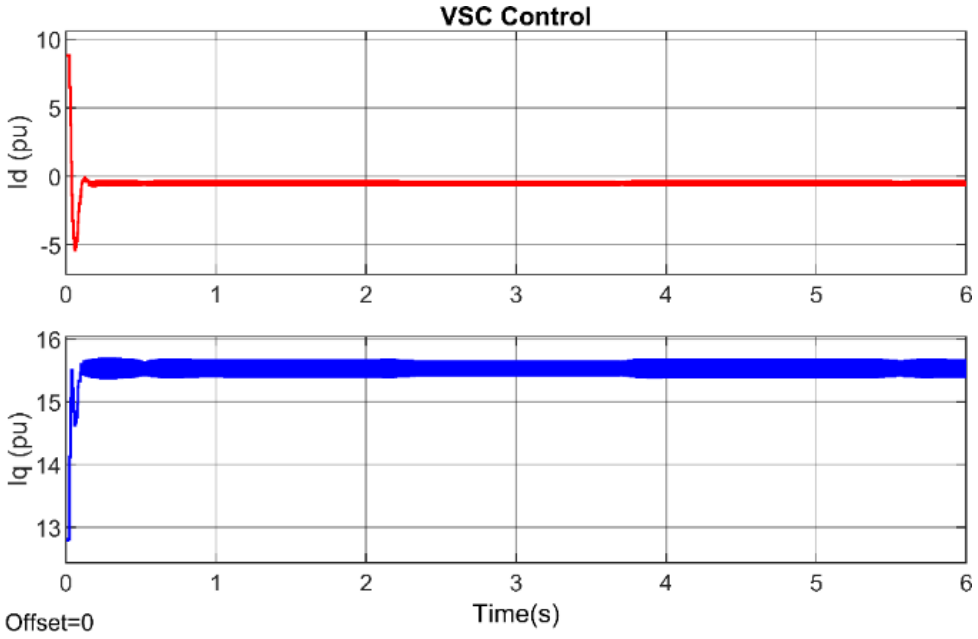


Fig.13. Response of I_d, I_q in VSC Conrol

Fig. 13. shows the high quality of the current injected into the grid with the proposed current control scheme. This result meets the requirements of the grid-connection standard. The grid voltage produces 1.9 X 10^4 V. The grid voltage harmonic disturbances are rejected by the robust ADRC controller, leading to much better performance.

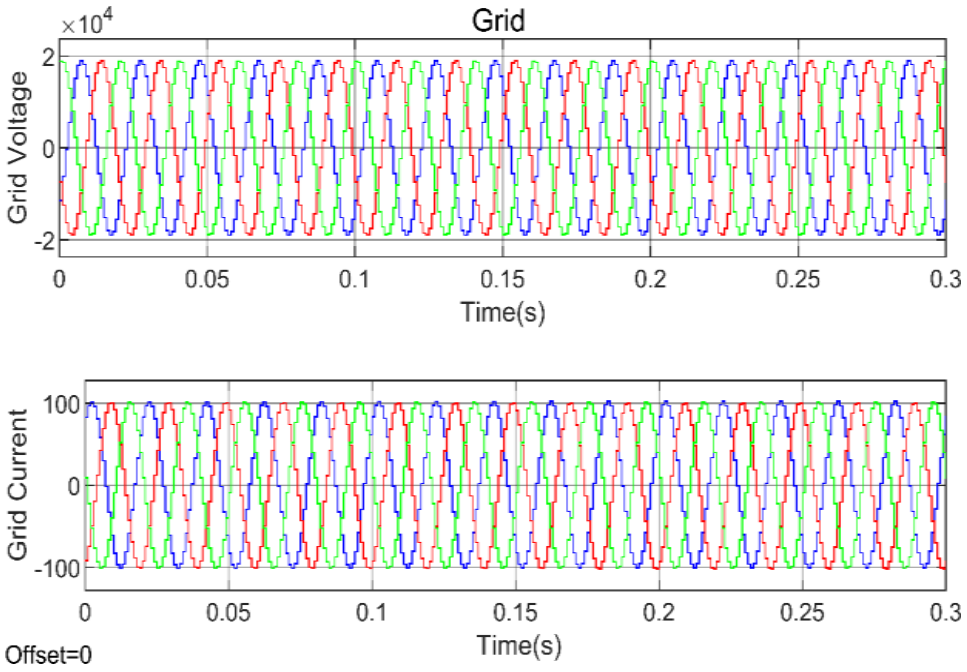


Fig.14. Grid Current and Grid Voltage

Fig. 14 reveals the grid current and grid voltage. The grid current is regulated to its nominal value and is in phase with the grid voltage as can be seen in Fig. 9. The grid voltage produces 1.9 X 10^4 V.

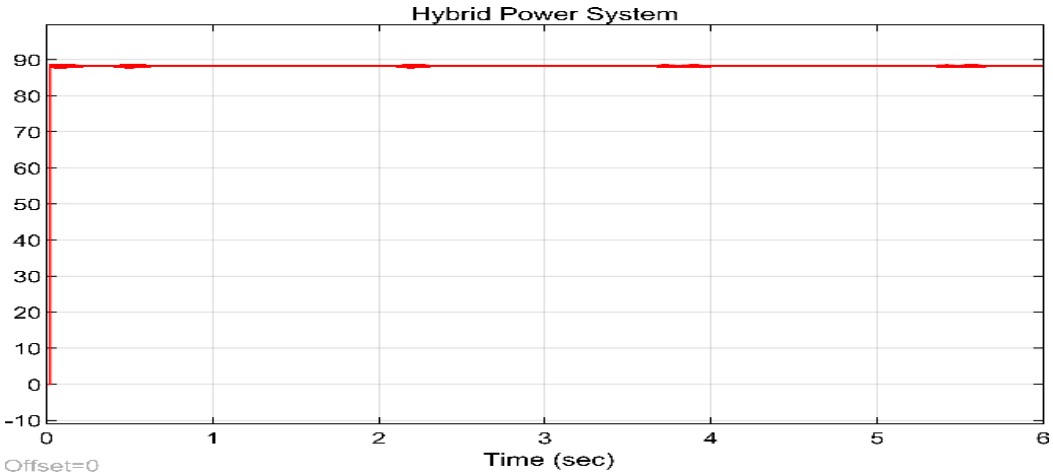


Fig.15. Response of Power for proposed hybrid power system

The power graph for the proposed hybrid power system is presented in Fig. 15. It produces approximately 90 kW of power generated from hybrid power systems. This power value is measured based on the time seconds. This reading of power was measured when the time was 0 to 6 second, respectively. The temperature is set at 25 degrees Celsius, and the light intensity is gradually reduced from 1000 to 200 W/m^2 at a rate of 200 W/m^2/s. After attaining 200 W/m2, the intensity is increased in one step to 1000 W/m2. The light intensity varied with respect to time but power generated by proposed hybrid power system was maintained constant that is approximately 90 kW.

Fig. 16 appearances PLL frequency and ω under different conditions. The frequency was maintained constant and Output 1: Measured frequency (Hz)=w/(2pi), Output 2: Ramp w.t varying between 0 and 2*pi, synchronized on zero crossings of the fundamental (positive-sequence) of phase A. parameters are Minimum frequency (Hz):45, Initial inputs [Phase (degrees), Frequency (Hz)]:[0,60] and For optimal performance, set regulator gains [K_p K_i K_d] = [180 3200 1] and check the Enable Automatic Gain Control parameter. Com- pared to API, it has been found that the proposed controller results in more improvement of the DC-side volt-age within the operating frequency range of the ac-side of the ILC.

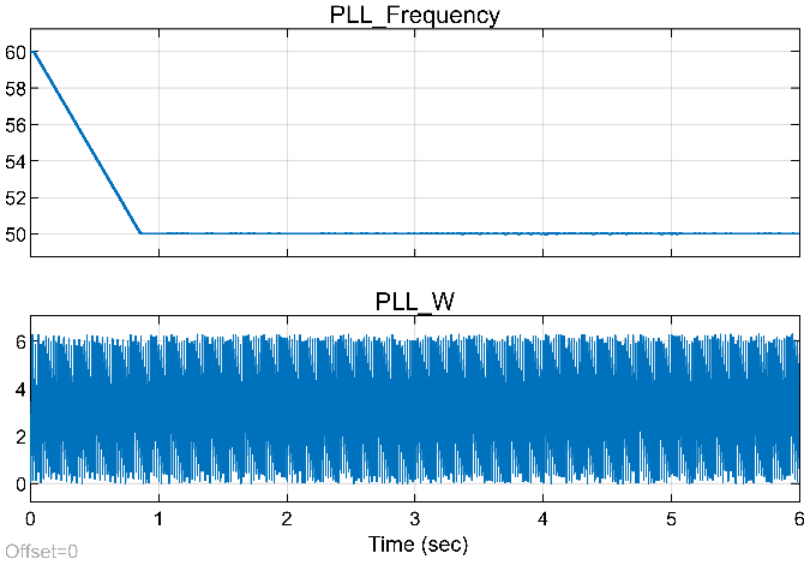


Fig.16. Response of PLL frequency and ω

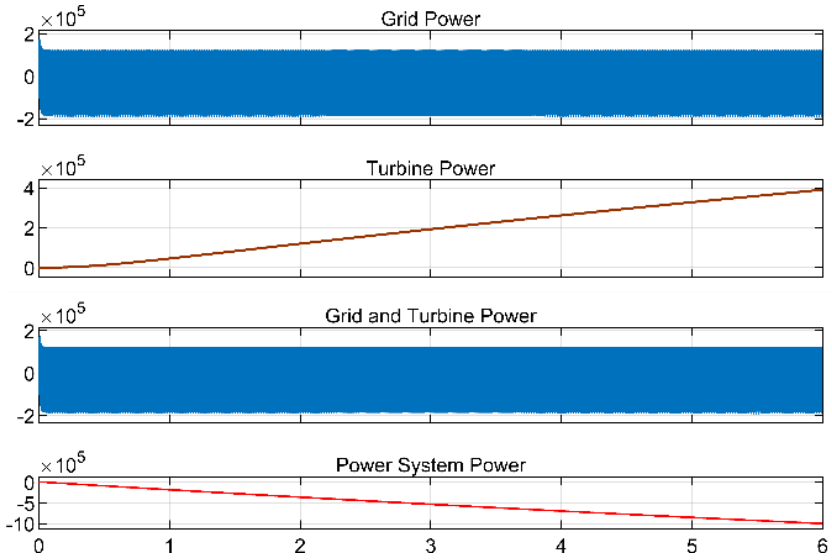


Fig.17.Response of Power for proposed powersystem powers

Fig. 17 appearances of grid, turbine, grid_turbine and finally power system outputs as present. Which has running 6 sec with different conditions however grid maintained constant output levels so turbine gives the residual power to the hybrid renewable energy sources. These results demonstrated the ability of the proposed redesigned interlinking converters to regulate power flow under all hybrid microgrid operating situations whilealso delivering the needed ancillary services. In the future, investigations on deep uncertainty analysis and stability analysis will be given, as well as the crea-tion of an intelligent control algorithm for the HMG.

Fig. 18 depicts the comparison graph for the overshoot voltage of converters. It shows the output voltage response with an overshoot of different converters' performance like P&O, FLC, and proposed converter. Based on the discussion the existing P&O method is unstable, and the FLC is stable but the proposed methodis more stable than these existing techniques. These perturbations are limited by the joint action of the output capacitor and the feedback control: the former limits the initial overshoot caused by a sudden change in load current, whereas the controller behaviour depends on the control circuit being used. From this Fig.18,

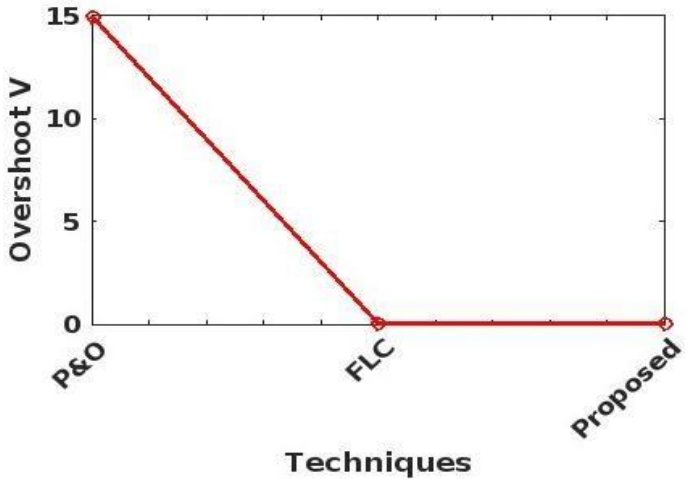


Fig.18. Comparison Graph for Overshoot Voltage

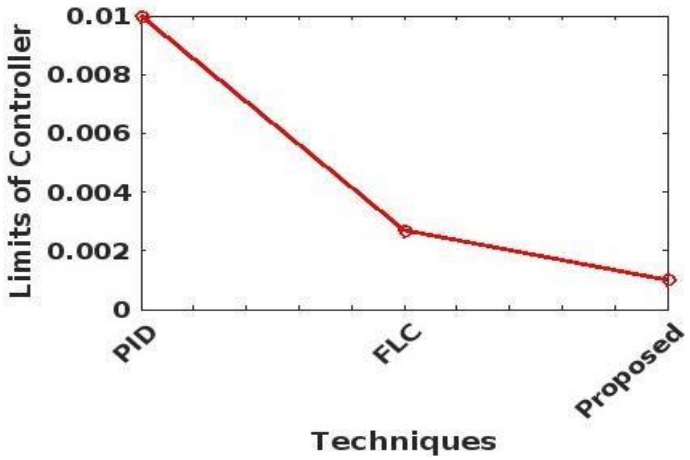


Fig.19. Comparison Graph for Limits of Controller

Fig. 19 depicts the comparison graph for Limits of Controller. In that The limits of the controller compared to the existing PID and FLC controllers are presented in this Fig. 19. The Fig. depicts that the limits of the PID controller are 0.01, and the limits of FLC controllers are 0.0027, however, the proposed method produces lower controller limits of 0.0013, respectively.

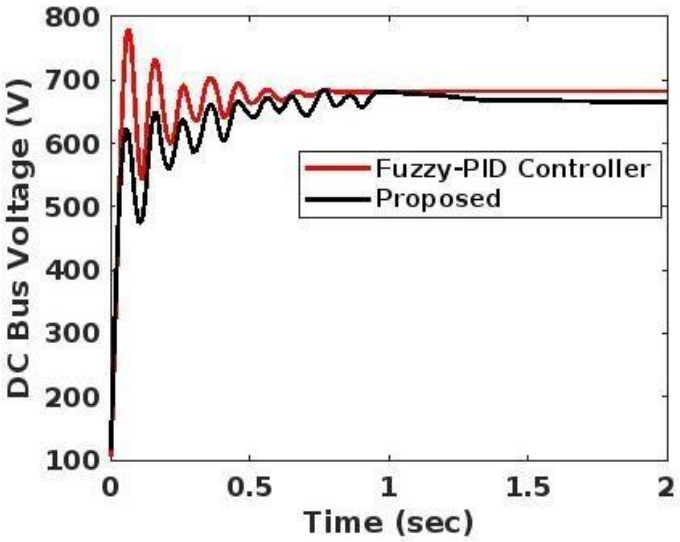


Fig.20 Comparison of DC Bus Voltage

Fig. 20 reveals the comparison graph for DC bus voltages, the proposed IT3-FLS controller is compared with the existing Fuzzy-PID controller. It can be observed that the error signal contains only the DC component due to the cancellation of the ripple component in the measured DC bus voltage. Consequently, the line currentwaveform is nearly sinusoidal.

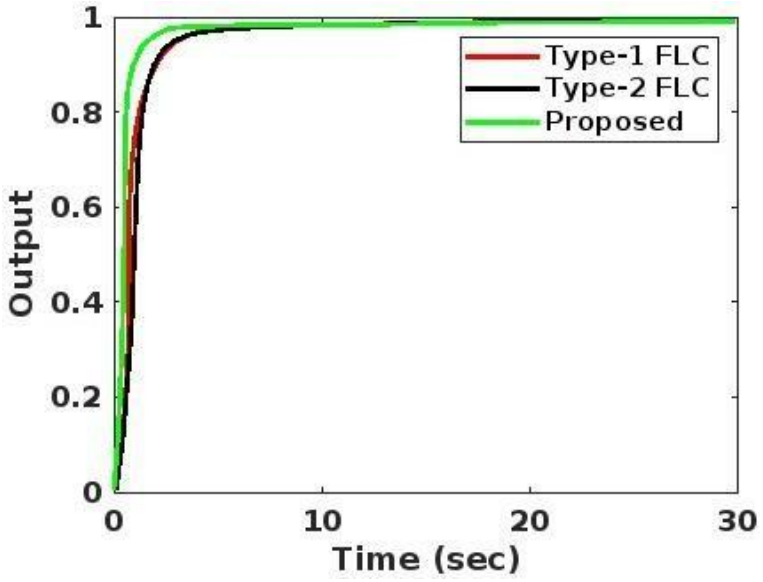


Fig.21. Comparison Graph for Dynamic Response of Controllers

Fig. 21 reveals the comparison graph of the dynamic response of different controllers. The proposed Interval Type-3 FLC is compared with the existing methods like Type-1 FLC, and Type-2 FLC. It evaluates the pro- posed method and knows the dynamic performance of the control system. From this Fig., the proposed method produces higher output dynamic response.

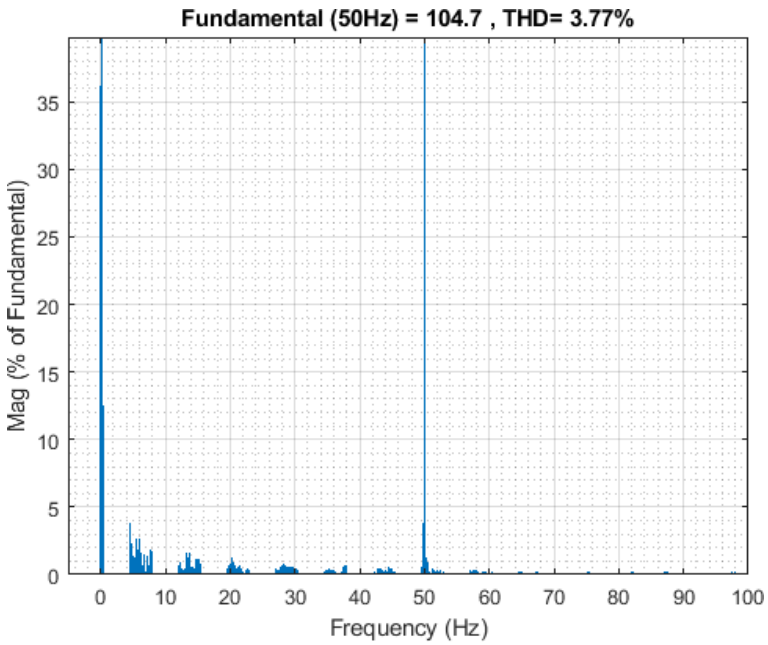


Fig.21. Grid Current % THD

From the IEEE – 519 Standard for Harmonic Control in Electric Power Systems suggests that total harmonicdistortion (THD) of the grid current has been maintained under 5% under all conditions. It is to be noted the grid current THD has been maintained under 3.77% as exposed in Fig. 21 and grid voltage THD has been maintained under 0.32% as presented in Fig. 22.

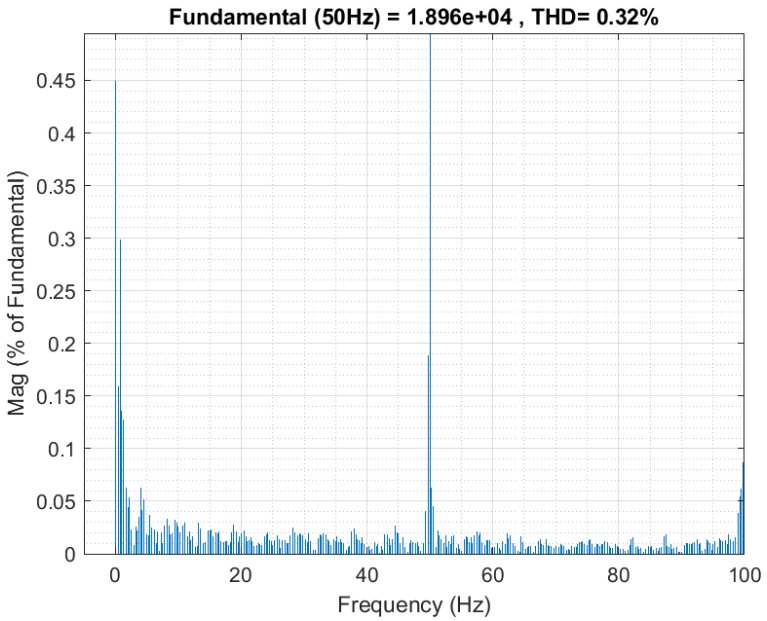


Fig.22. Grid Volatge % THD

Advanced hybrid AC/DC microgrid system integrating solar PV energy sources. A key feature of this systemis the AI-driven Maximum Power Point Tracking (MPPT) scheme used for the solar PV systems. In order to explore advanced control strategies, an interval type 3 fuzzy-based controller enhanced by the Bacterial For- aging Optimization Algorithm (BFOA) and interlinking drop control, ensure smooth operation and eliminationof harmonics. The grid voltage and current THD has been maintained under 5% with all conditions as per theIEEE-519 Standard.

5. Conclusion

A microgrid is a small-scale electrical system made up of distributed generation (DG) and energy storage devices (ESD) technologies designed to suit the needs of local loads. This paper proposes a Boost converter and a type-3 fuzzy controller, as well as a Swarm-based hybrid metaheuristic optimizer based on the Bacterial Foraging Optimization Algorithm (BFOA) for optimally tuning and managing the PI controller settings. Con- trolling the reactive power of the hybrid power system model using a Static Synchronous Compensator (STATCOM). In the MATLAB Simulink environment, a hybrid microgrid consisting of solar, battery, utilitygrid, and AC and DC loads is created using the AC and DC bus. The findings show that the suggested approach based on the algorithm outperforms the adaptive PI (API) controller in terms of rapid reaction time and tight regulation of power flow, voltage, and frequency under various situations. In comparison to API, the suggested controller improves the dc-side voltage within the working frequency range of the ac-side of the ILC. As a result, the penetration level characteristics are compared with the converter, and the suggested control approach is used to determine the efficiency of the hybrid power system. The grid voltage is 1.9 X 10^4 V, the battery current is around 1900 A for 6 seconds, and the voltage produced by the battery is around 190 V for 6 seconds. However, the acquired power-sharing diminishes the energy supplied by the power grid, avoiding focusing the required effort in the battery system. The power quality study demonstrated the efficiency of theinterlinking converters in reducing harmonic distortions and reactive power under all operating situations. Furthermore, the excellent performance of the voltage regulation, accomplished by a hierarchical control, was recorded and employed to rectify the voltage deviation induced by the droop technique. These results demonstrated the ability of the proposed redesigned interlinking converters to regulate power flow under all hybrid microgrid operating situations while also delivering the needed ancillary services. In the future, investigationson deep uncertainty analysis and stability analysis will be given, as well as the creation of an intelligent controlalgorithm for the HMG.

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An Experimental Investigation on Steel Fiber Reinforced Self-Compacting Concrete Using Alccofine and Granite Powder

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ABSTARCT: *"The requirement for self-compacting concrete(SCC) in the construction area is increasing due to its benefits, such as easy finishing, excellent flow even in dense reinforcement, and enhanced structural integrity. In this experimental study, the binding materials are Ordinary Portland Cement (OPC), Alccofine-1203, and Granite Powder (GP). The mineral admixture of Alccofine-1203 helps to avoid segregation and bleeding while increasing workability. Granite powder (GP) is chosen as a suitable cement replacement due to its high silica content. To study the fresh and hardened properties of M30 Grade self-compacting concrete, the binder content is fixed at 500 kg/m³, with 70% OPC, 12% Alccofine-1203, and 18% GP. Furthermore, crimped steel fibers (CSF) are added at 1%, 2%, 3%, 4%, and 5% by the weight of binder content to improve the flexural strength of hardened concrete. The water-to-binder ratio is 0.4 for all the SCC mixes. The workability tests on SCC are performed according to the EFNARC 2005 Guidelines by Slump flow test (Diameter and T50), V-funnel, and L-Box. The mechanical properties of SCC studied include compressive, split tensile, flexural strength, and modulus of elasticity. Based on the test results, it can be observed the improved strength properties."*

Key words: Self-compacting concrete (SCC), Alccofine-1203, Granite powder, Crimped steel fibers, Mechanical properties

1. Introduction

Self-compacting concrete (SCC) is a special type of concrete that can settle into heavily reinforced, deep, and narrow sections by its own weight. It can consolidate itself without necessitating internal or external vibration while maintaining stability without leading to segregation and bleeding. SCC demands a large amount of powder content compared to conventional vibrated concrete to produce a homogeneous and cohesive mix. One of the disadvantages of SCC is its cost, which is associated with the use of chemical admixtures. One alternative to reduce the cost of SCC is the use of mineral additives such as limestone powder, Alccofine-1203, natural pozzolans, fly ash, slag, and granite powder, which are finely divided materials. Granite stone is one of the most commonly used building materials, leading to a high amount of waste, amounting to almost 50% of the volume of the final granite products, throughout its processing and extraction. Granite waste has accumulated over the years, with only negligible amounts being used, while the rest is dumped, resulting in environmental problems. As these mineral additives replace part of the Portland cement, the cost of SCC will be reduced, especially if the mineral additive is an industrial by-product or waste. Therefore, the use of these types of mineral additives in SCC will not only decrease the cost but also increase its long-term performance.

In this present experimental investigation, the self-compacting concrete achieved using Ordinary Portland cement, Alccofine-1203, Granite Powder, and a dosage of Chemical Admixture. In this study, the PCE-based superplasticizer BUILDPLAST-SP200(M) is used to achieve self-compacting concrete, with the dosage of chemical admixture set at 1.3% by weight of binder content, using a trial method in which the water-to-binder ratio is maintained constant at 0.4. Alccofine-1203 enhances the workability of concrete by acting as a micro-filler, reducing the water demand without

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AN EXPERIMENTAL INVESTIGATION ON POLYPROPYLENE FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH ALCCOFINE

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ABSTRACT: *In this experimental investigation an attempt was made to study the feasibility and effectiveness of integrating Alccofine as a supplementary material in Polypropylene Fiber Reinforced Concrete of grade M25. Various concrete mixes with Alccofine substitution (5%, 10%, and 15%) were examined to determine the optimal percentage. The addition of Polypropylene fibers to concrete at 0.1%, 0.2%, 0.3%, and 0.4% by weight of concrete were prepared to determine the optimum dosage of Polypropylene fibres in concrete which is replaced with optimum Alccofine percentage. These fibers help control cracking from plastic and drying shrinkage, reduce concrete permeability, and enhance impact strength. Addition of Polypropylene fibres transforms the material from brittle to ductile. The study includes determination of compressive strength, split tensile strength, flexural strength and impact characteristics. The findings reveal that a combination of 10% Alccofine substitution along with 0.3% Polypropylene fibers leads to notable enhancement 45.3%, 35.6%, 16.67%, and 191% in compressive, split tensile, flexural, and impact strength, respectively, compared to control concrete. Based on the results it can be concluded that the combination of 10% Alccofine and 0.3% Polypropylene fibers in concrete significantly improves both the strength properties and impact strength of the concrete in comparison to control concrete.*

Keywords: *Polypropylene Fiber Reinforced concrete, Alccofine, impact characteristics, impact strength*

1. Introduction

The modern construction constantly evolves to meet the demands of sustainable development and enhanced performance. Conventional concrete compositions often rely heavily on Portland cement, a material associated with significant carbon emissions during its production. To address environmental concerns and improve concrete properties, innovative solutions such as Alccofine as partial replacement for cement offers multifaceted benefits. By reducing the cement content, these materials help lower carbon emission associated with concrete production, aligning with sustainability objectives. Moreover, to enhance the mechanical properties and Impact characteristics of concrete, resulting in structures that exhibit superior performance and longevity. Polypropylene fibers, derived from a thermoplastic polymer, is increasingly recognized for its ability to enhance the impact strength of concrete. When dispersed within the concrete matrix, these fibers act as reinforcement, improving tensile strength, crack resistance, and Impact characteristics. Additionally, Polypropylene fibers mitigate plastic shrinkage cracking and improve Impact strength, making them invaluable in various construction applications. Alccofine, a supplementary cementitious material, offers a sustainable alternative to conventional cement. Produced from finely ground aluminosilicate materials, Alccofine possesses pozzolanic properties that react with calcium hydroxide forming additional calcium silicate hydrate (C-S-H) gel. This reaction not only contributes to the densification of the concrete matrix but also enhances long-term strength of the concrete. Furthermore, Alccofine reduces the heat of hydration and mitigates alkali-silica reaction, thus improving the overall sustainability and performance of concrete structures. In this investigation the effects of incorporating Polypropylene fibers and Alccofine

BUILDING INFORMATION MODELLING OF AN EARTHQUAKE RESISTANT STRUCTURE

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ABSTRACT

Constructing a structure that minimizes earthquake damage can be challenging due to the unpredictable nature of seismic events, making it seem impractical. However, this study focuses on developing earthquake-resistant structure by incorporating Building Information Modelling (BIM) in the design and detailing process. The primary focus is on a G+5 apartment building designed to withstand seismic forces and prioritize occupant safety during earthquakes. BIM technology, using software such as Revit, ETABS, SAFE, SketchUp, AutoCAD, etc., is employed to enhance the structural design. Starting with creating a detailed architectural plan for the G+5 structure and rendered different architectural 3d views by creating models in Blender software. Then the detailed seismic analysis and design is done in ETABS & SAFE as per seismic design code (IS:1893-2016). BIM tools generate a dynamic 3D model, facilitating the visualization and simulation of seismic responses. The project encompasses comprehensive Structural, Architectural, and MEP (Mechanical-Electrical-Plumbing) BIM. The BIM model serves as a central information repository, allowing for precise quantity take-offs and cost assessments. The study's outcomes contribute significantly to the advancement of earthquake-resistant building design, highlighting the efficiency of BIM in optimizing structural performance and cost-effectiveness. These findings hold relevance for professionals in structural engineering, architecture, and construction management, underscoring the pivotal role of integrating BIM in earthquake-resistant designs. Furthermore, the detailed cost estimation for the entire G+5 building is also included.

Keywords: Building Information Modelling (BIM), seismic resilience, G+5 apartment building, earthquake-resistant structure, cost estimation, architectural, MEP BIM.

I. INTRODUCTION

1.1 General

Designing earthquake-resistant structures is crucial in civil engineering, particularly in earthquake-prone areas. Building design must consider hindrances to earthquake forces and ensure adequate support to prevent collapse. In this G+5 project, advanced BIM tools like AutoCAD, ETABS, Revit, and SAFE are employed. These tools help as digital assistants, enhance the design process, provide detailed information, and optimize the building's resilience to both routine and seismic challenges.

In India the earthquake prone area is divided into 4 zones based upon their vulnerability to earthquakes. So, for designing any type of structure in these zones, there are some design codes (see in 1.2). Following these codes will ensure that our constructions are not only safe but also capable of withstanding earthquakes.

Design Guidelines: Structural designers must adhere to key standards for earthquake-resistant design:

- IS 1893: 2016: Criteria for Earthquake Resistant Design.
- IS 13920: 1993: Ductile Detailing of Reinforced Concrete Structures subjected to seismic forces.
- IS: 456–2000: Indian Standard Plain Reinforced Concrete Code of Practice (Fourth Revision).
- IS 875 (Part 1-5): 1987: Code of Practice for Design Loads (excluding earthquake) for Buildings and Structures (Second Revision), encompassing dead loads, live loads, wind loads, snow loads, and special loads.

These streamlined guidelines ensure structures are resilient to seismic challenges in their respective zones, promoting safety and structural integrity.

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An Experimental Investigation on Glass Fiber Concrete by Partial Replacement of Cement with Alccofine

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Abstract: Concrete is the most widely used construction material due to its strength, durability, and versatility. However, the production of cement, which is a key component of concrete, is a major contributor to greenhouse gas emission. The use of supplementary Cementitious materials (SCMs) can improve the properties of concrete, reduce use on natural resources and CO_2 emissions. The present study is directed to investigate the effect of Alccofine-1203 (AL) as partial replacement of cement on Glass Fibers (GF) reinforced M30 grade concrete. Different types of concrete mixes were prepared by replacing cement with Alccofine-1203 of 5%, 10% and 15%, respectively, then it is found to be the optimum percentage of replacement of cement with Alccofine-1203 is 10%. Further, the effect of Alccofine and Glass Fiber with different combinations, such as, 10%AL+0.1%GF, 10%AL+0.2%GF, and 10%AL+0.3%GF was also carried out. Based on the test results of Mechanical properties of concrete the optimum dosage is found to be 10% AL and 0.2% GF.

Keywords: Alccofine-1203, Glass fibre, Compressive strength, Split tensile strength, Flexural strength, Modulus of Elasticity.

1. INTRODUCTION

Cement is the most prevalent kind of concrete binder. At present sustainable development of the cement and concrete industry requires the utilization of industrial and agricultural by-products. At present, for a variety of reasons, the concrete construction industry is not sustainable. It consumes huge quantities of virgin materials and the principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. So, finding a solution to substitute for part of the cement seems to be desirable for sustainable development. In the present investigation applications ofAlccofine-1203 as partial replacement of Cement for the Glass fibers reinforced concrete is adopted.

OBJECTIVES

The main objective of the present experimental investigation is to obtain the influence of Alccofine-1203 and Glass fibre on various Mechanical properties of M30 grade concrete.

It consists of following:

- To find out optimum replacement percentage of Alccofine-1203 .
- To determine the mechanical properties such as Compressive Strength, Split Tensile Strength, Flexural Strength and Modulus of elasticity of concrete prepared using alccofine-1203 and Glass fibers and to compare with conventional concrete.

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A STUDY ON THE PROPERTIES OF STEEL FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF ASBESTOS AND BANANA FIBERS

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ABSTRACT

This summary discusses a study focused on making regular concrete stronger by adding fibers like steel, asbestos, and banana fibers. The goal was to see how these fibers affect M35 grade concrete. Tests were done to check things like how much weight it can hold and its resistance to breaking, compressive strength, flexural strength, split-tensile strength, ultrasonic pulse velocity. The study found that using 1.5% steel fibers makes the concrete much stronger, improving its ability to withstand pressure and bending. Additionally, combining steel, asbestos, and banana fibers in specific amounts created an even stronger mix. Comparisons showed that this new mix performed significantly better than regular concrete and the one with only steel fibers. Notably, it was lighter and more cost effective. This research provides practical ideas for making stronger concrete without increasing weight and costs too much. It's a useful guide for building stronger structures economically.

Keywords: Steel Fibers, Asbestos Fibers, Banana Fibers, Compressive Strength, Flexural Strength, Split Tensile Strength.

I. INTRODUCTION

Concrete is a vital material, in a worldwide consumption. It is the second most utilized substance on Earth after water. Comprising a mixture of sand, gravel, bound together by a water-based binder called cement, concrete often incorporates modifiers and additives like fine mineral powders to enhance its characteristics during the mixing process or in its final hardened state. Having been a favoured construction material for an extensive period, concrete remains popular for its cost-effectiveness and ease of fabrication in the building industry. Despite its commendable strength and durability, concrete does possess weaknesses, with low tensile strength being one of them. To address this, reinforcement with alternative materials becomes essential. While traditional steel reinforcement bars serve this purpose, this research takes a different approach by utilizing fibers. Fiber Reinforced Concrete involves reinforcing concrete with fibers, whether they be continuous filaments or threads. Various fiber types, including steel, glass, natural, and synthetic, have been integrated into concrete. Initially, fibers were employed to counteract plastic and drying shrinkage in concrete. Over time, research and advancements have revealed that adding fibers to concrete can enhance properties such as flexural strength, compressive strength, tensile strength and post-crack strength. Some studies have even explored the incorporation of multiple fiber types, leading to the development of Hybrid Fiber Reinforced Concrete. The problem addressed in this study revolves around the need to increase the compressive strength, flexural strength, and split-tensile strength of concrete by reinforcing it with materials possessing these mechanical properties. While steel fibers are suitable for this purpose, their high cost, attributed to manufacturing and transportation expenses, necessitates a reduction in percentage and substitution with other materials. In this investigation, asbestos, and banana fibers are chosen to replace a portion of the steel fibers. Mineral fiber, like asbestos are very good fibers give well mechanical properties and Natural organic fibers, such as banana fibers obtained from the banana tree, are abundant in our surroundings. In India, where tons of banana trees go unused and are discarded, especially in rural areas, this study explores the potential of repurposing this local waste as concrete composites. These fibers are not only cost effective but also have low manufacturing costs and are easy to process.

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II. OBJECTIVES

1. To cast the M35 grade concrete mix as control mix and to cast the mixes with different ratios of fibres.
2. To study the strength of fibre reinforced concrete using Steel fibers, asbestos fibers, and banana fibres in various percentages from the optimum percentage of Steel fibers and to observe the changes in properties of fiber reinforced concrete (FRC).
3. To test the strength of fibre reinforced concrete using steel fibres, asbestos fibres in various percentages from the optimum percentage of steel fibres and to observe the changes in properties of fibre reinforced concrete.
4. To study the strength of fibre reinforced concrete using steel fibres, banana fibres in various percentages from the optimum percentage of steel fibres and to observe the changes in properties of FRC.
5. To perform the different tests like compressive strength test, flexural, split tensile, and non-destructive tests (ultrasonic pulse velocity test) on fibre reinforced concrete.
6. To compare the properties of steel fibre reinforced concrete with conventional concrete.
7. To compare the properties of fibre reinforced concrete with steel fibres and with composite fibres.

III. METHODOLOGY

MATERIALS

In this experimental investigation the following materials are used.

3.1 Cement

Ordinary Portland cement (OPC) of 53 grade confirming to IS 12269:2013 was used. The specific gravity is 3.15.

3.2 Coarse Aggregate

Well graded coarse aggregate conforming to the provision of IS: 383-2016 is going to use throughout the investigation. Aggregate of nominal size 20mm, were blended to a desired proportion and mixed intimately to obtain well graded aggregate. The specific gravity, water absorption and fineness modulus for 20mm is shown below.

Property	Value
Specific gravity	2.67
Water absorption	0.45%
Fineness modulus	7.2



3.3 Fine Aggregate

Locally available river sand conforming to IS 383:2016 specifications passing through 4.75 mm sieve and retained on 75µm was used as the fine aggregate in the concrete mix. The fineness modulus, specific gravity were determined and Sieve analysis of the fine aggregate is shown below.

Property	Value
specific gravity	2.55
fineness modulus	3.15
grading	Zone-II

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3.4 Steel fibers

Irregular steel fibers, distributed randomly, are employed in this investigation. The chosen fibers are crimped and made of low carbon, cold-drawn steel, intended to offer concrete temperature and shrinkage crack control while enhancing its resistance to cracking. They are formulated for effortless mixing, placement, and finishing in concrete applications.

Property	Crimped steel fibre
Length	30 mm
Diameter	0.5 mm
Aspect ratio	60
Density	7800 kg/m^3
Young's modulus	200 Gpa
Tensile strength	750-1100 N/mm^2



3.5 Asbestos fibers

Mineral fiber stands out as the most effective due to its compatibility with Portland cement. The tensile strength of asbestos ranges from 560 to 980 N/mm^2. Asbestos cement paste exhibits significantly greater flexural strength compared to Portland cement paste.

Property	Asbestos fibre
Colour	White
Physical state	Solid
Melting point	800-850 ℃
Specific gravity	2.55
solubility	Insoluble in water and organic solvents
Density	2426 (kg/m^3)



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3.6 Banana fibers

In an era where global awareness of environmental issues is increasing, there is a rising demand for sustainable materials. One such material that has garnered attention in recent times is banana fiber, known for its diverse and noteworthy characteristics. From its capacity to absorb moisture to its impressive tensile strength, banana fiber presents itself as a material worthy of exploration due to its multitude of advantages.

Property	Banana Fibre
Colour	Gold brown
Tensile Strength	650-780 (N/mm^2)
Young's Modulus	27-32 (Gpa)
Density	1300 (kg/m^3)
Length	40 mm
Diameter	2 mm
Aspect ratio	20



3.7 Super plasticizer:

AURAMIX 450 is utilised as superplasticizer in this project. It is a polycarboxylate Ether (PCE) based high performance super plasticizer. It is used for concrete requiring long workability retention.

Type	Property
Appearance	Light yellow coloured liquid
pH	Minimum 6.0
Chloride content	Nil to IS 456



Here we used three fibres namely steel, asbestos and banana fibers at a time and M35 grade concrete is prepared using them. As steel is extensively used fiber we have given higher proportion for it.

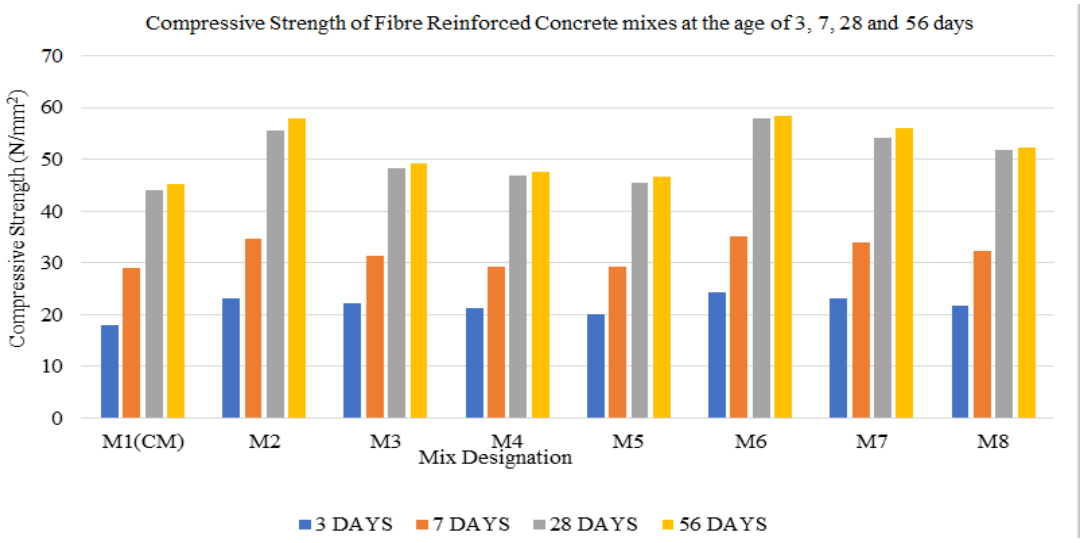
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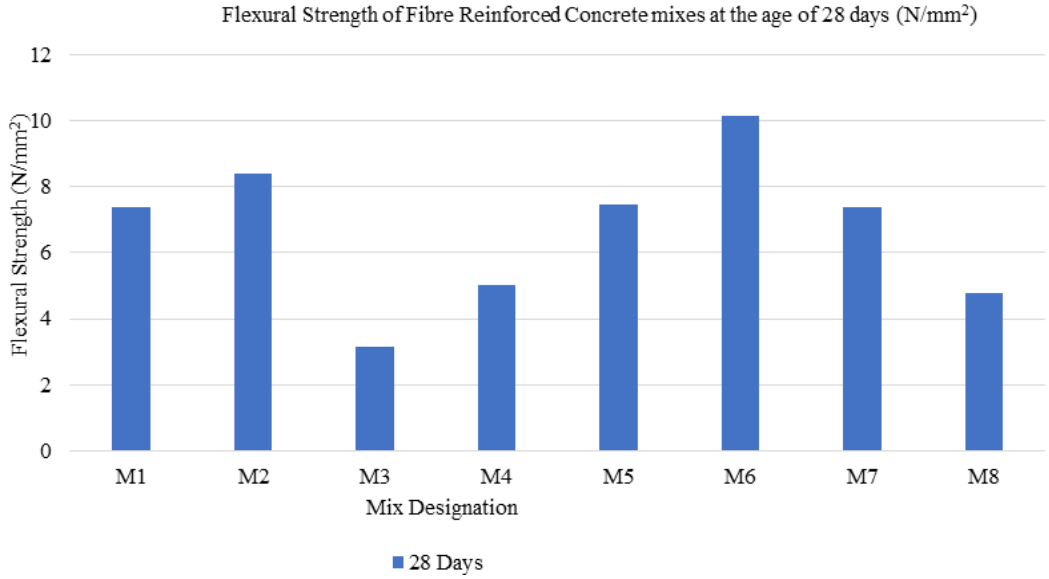
Table: Types of mixes in the project

MIX	STEEL FIBRES (%)	ASBESTOS FIBRES (%)	BANANA FIBRES (%)
M1(CM)	0	0	0
M2	1.5	0	0
M3	1	0.5	0
M4	1	0	0.5
M5	1.25	0.125	0.125
M6	0.75	0.375	0.375
M7	1	0.25	0.25
M8	0.5	0.5	0.5

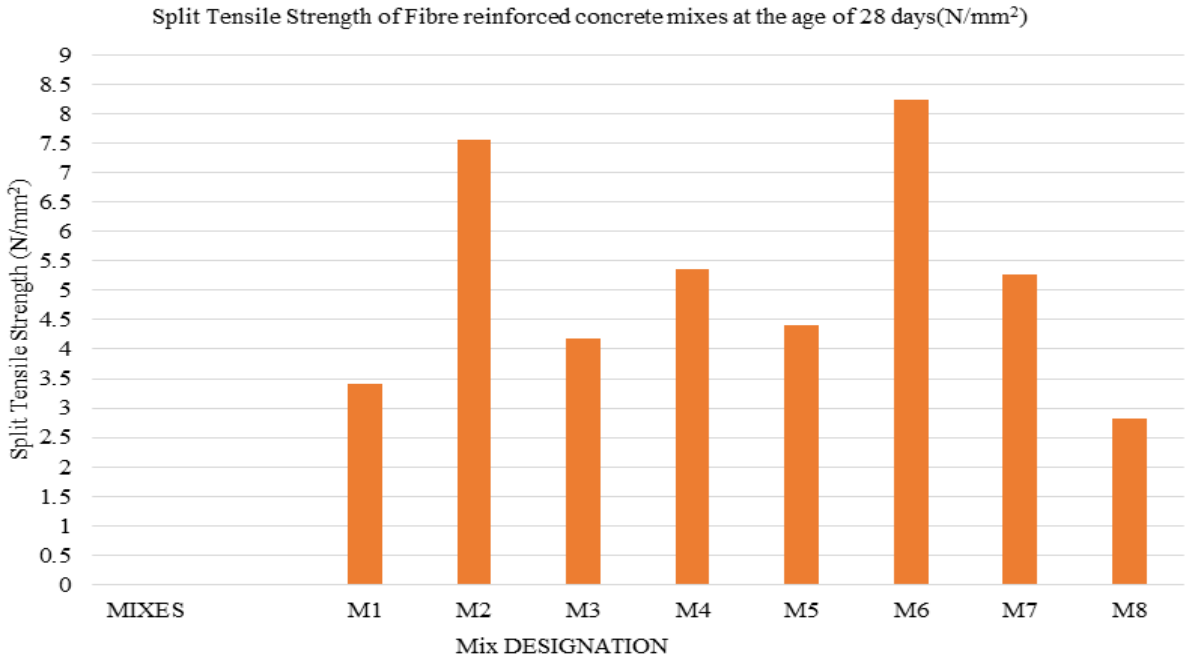
IV. RESULTS AND DISCUSSION

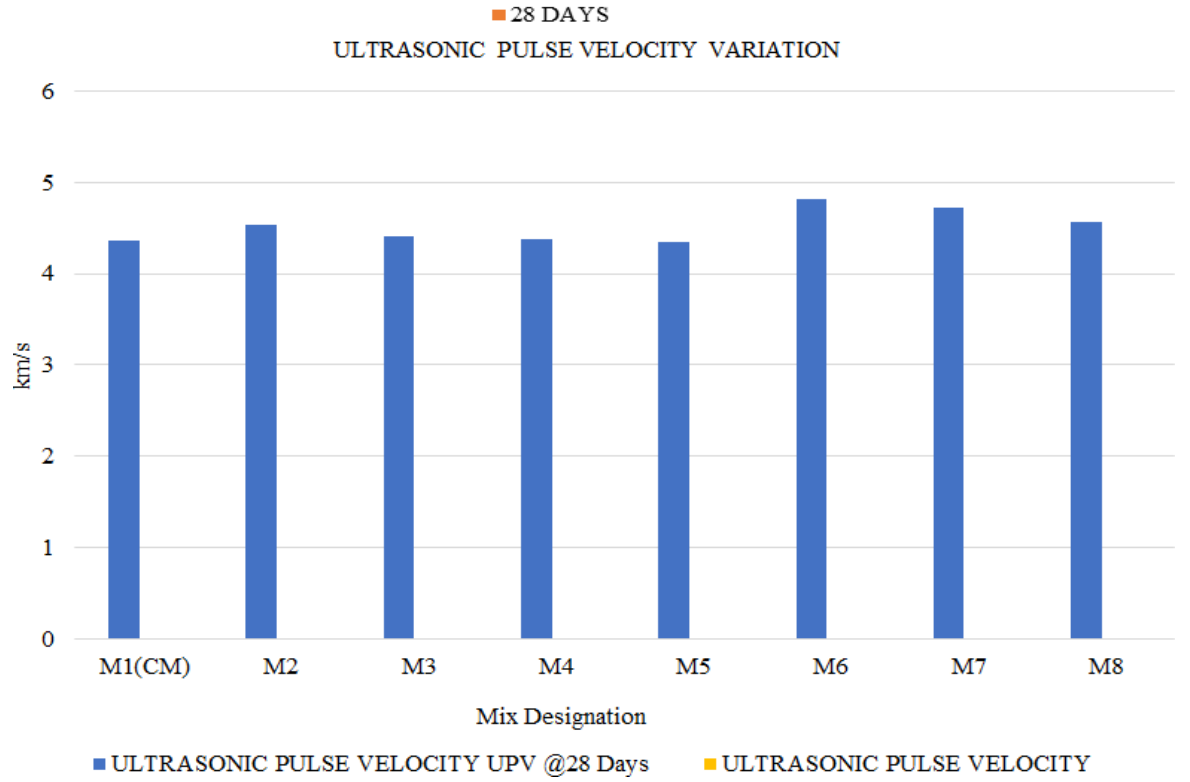
The results obtained in this investigation are shown below.





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V. CONCLUSION

The following are the conclusions of this project:

- The compressive strength obtained for conventional concrete (M35 grade) is 44.06 N/mm². the flexural strength obtained is 7.38 N/mm² and the split tensile strength obtained is 3.42 N/mm².
- The optimum percentage of steel fibres is obtained at 1.5% at which the compressive strength obtained is 55.44 N/mm², flexural strength is 8.40 N/mm² and split-tensile strength is 7.55 N/mm².
- The percentage difference obtained for conventional concrete and optimum steel fibre reinforced concrete is 25.8%, for split-tensile strength is 120%, for flexural strength is 13.82%.

- From the mixes of composite fibres i.e., it is shown that 0.75% steel, 0.375% asbestos, and 0.375% banana fibres mix gives more strength (57.83 N/mm^2) with the percentage difference of 4.31% of optimum percentage of steel mix.
- The percentage difference of the mix (0.75% steel, 0.375% asbestos, and 0.375% banana fibres) and the mix (1.5% steel)) for split tensile strength is 9.13% and for flexural strength is 20.83%.
- From all the results obtained for all the mixes it is concluded that M35 grade concrete with fibres gives more strength i.e., steel fibres.
- From the composite fibres mixes it is concluded that fibre reinforced concrete with the combination of steel, asbestos, and banana fibres gives better results than optimum steel fibres mix as it has high percentage difference with optimum dosage of steel fibres.
- Even though steel fibres gives high strength, it has more weight compared to asbestos and banana fibres and also they are costlier than asbestos and banana fibres. So, replacing 0.375% asbestos and 0.375% banana fibres with steel fibres will give us a lighter weight, lower cost concrete and strength is higher than optimum.

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Deep Learning based Multilingual Speech Synthesis using Multi Feature Fusion Methods

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The poor intelligibility and out-of-the-ordinary nature of the traditional concatenation speech synthesis technologies are two major problems. CNN's context deep learning approaches aren't robust enough for sensitive speech synthesis. Our suggested approach may satisfy such needs and modify the complexities of voice synthesis. The suggested model's minimal aperiodic distortion makes it an excellent candidate for a communication recognition model. Our suggested method is as close to human speech as possible, despite the fact that speech synthesis has a number of audible flaws. Additionally, there is excellent hard work to be done in incorporating sentiment analysis into text categorization using natural language processing. The intensity of feeling varies greatly from nation to country. To improve their voice synthesis outputs, models need to include more and more concealed layers & nodes into the updated mixture density network. For our suggested algorithm to perform at its best, we need a more robust network foundation and optimization methods. We hope that after reading this article and trying out the example data provided, both experienced researchers and those just starting out would have a better grasp of the steps involved in creating a deep learning approach. Overcoming fitting issues with less data in training, the model is making progress. More space is needed to hold the input parameters in the DL-based method.

Keywords: Natural Language Processing, Deep Learning, Machine Learning, Speech to Text.

1 INTRODUCTION

For voice synthesis to sound genuine and understandable, fundamental frequency (F0) modelling is essential. Mandarin speech synthesis is unaffected by the use of a mixed Tibetan train corpus [1]. When compared to the Tibetan monolingual framework, the mixed BBERT-based cross-lingual synthesis of speech framework only requires 60% of the learning corpus to synthesis a comparable voice. Thus, the suggested approach may be used to low-resource languages for voice synthesis by using the corpus of a high-resource language [2]. The process of synthesizing the sounds of numerous voices from a single model is known as "multi-speaker speech synthesis." There have been various proposals for employing deep neural networks (DNNs), however DNNs are vulnerable to overfitting when there is insufficient training data [3]. Utilising deep Gaussian processes (DGPs), which are a complex structure of Bayesian kernel correlations that are resistant to overfitting, we provide a framework for multi-speaker voice synthesis. Voice synthesis studies that convey a speaker's personality and feelings is thriving because to recent advancements in the field made possible by deep learning-based voice synthesis. For speakers with extremely low or very high vocal ranges as well as speakers with dialects,

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Just Accepted

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the present day does not adequately portray a variety of moods and features [5]. Modern neural text-to-speech (TTS) systems are able to create speech that is indistinguishable from normal speech [6] thanks to the remarkable progress in deep learning. However, rather than having extensive prosodic variance, the produced utterances often retain the average prosodic character of the database. To effectively transmit meaning in pitch-stressed languages like English, proper intonation and emphasis are essential [7]. Recognizing feelings in a speaker's voice automatically is a difficult and time-consuming task. Humans' complex range of emotions makes categorization challenging. Extracting relevant speech elements is a significant challenge because of the need for human intervention [8]. Deep learning methods that make use of high-level aspects of voice signals improve the accuracy of emotion identification. One of the primary challenges of employing target-driven models for articulatory-based speech synthesis is representation learning [9]. Computer-aided diagnostic systems that help in clinical decision-making rely heavily on deep learning methodologies. Because of the scarcity of annotated medical data, however, the development of such automated systems is difficult [10, 11]. The purpose of the user interface is to accurately read the user's mood. The most pressing concern in speech emotion identification research is how to efficiently extract relevant speech characteristics in tandem with an adequate classification engine. [12][13]. Emotion recognition and analysis from speech signals need well-fined speech databases as well. Numerous real-world applications, such as those dealing with human-computer interaction, gaming on a computer mobile services, as well as emotion assessment, have made use of data science in recent years. Speech emotion recognition (SER) is a very new and difficult area of study with a broad variety of potential applications. When it comes to SER, current research has relied on handmade characteristics that provide the greatest results but fall short when applied to complicated settings. Later, SER made advantage of automated feature detection from voice data using deep learning methods. Despite the fact that deep learning-based SER approaches have solved the accuracy problems, they still have a long way to go before they can be considered fully comprehensive. [14] [15].

The following is a problem statement we developed to address the aforementioned challenges and provide a solution to the issue of multilingual voice recognition.

- The ability to identify and convert a multilingual sentence into a sentence in a single language.
- Creating a model that can interpret voice navigation questions spoken in many languages and provide a unified response in one of those languages.

Although there are 22 official languages in India, most are only spoken within a single state. As a result, resources for these languages are limited, and high-quality voice data is hard to come by. Furthermore, no publicly accessible multilingual dataset includes these languages and English.

2 RELATED WORK

In this study, we work to refine Isarn's speech-synthesis modelling of F0. For this problem, we recommend an RNN-based model called F0. Supra-segmental aspects of the F0 contour are represented by using sampled values of F0 at the syllable degree of continuous Isarn sound in conjunction with their dynamic features. We investigate several deep RNN architectures and feature combinations to find those that provide the highest performance. We evaluated the suggested technique against different RNN-based baselines to determine its efficacy. Objective and subjective evaluations show that the proposed model outperforms the baseline RNN strategy that predicts F0 values at the frame level as well as the baseline RNN model that depicts the F0 contours of words using a discrete cosine transform [16].

This study introduces a deep Gaussian process (DGP) as well as sequence-to-sequence (Seq2Seq) learning-based approach to voice synthesis, with the goal of producing high-quality end-to-end speech. Since DGP makes use of Bayesian training and kernel regression, it is able to create more lifelike artificial words than deep neural networks (DNNs). Such DGP models, however, need extensive knowledge of text processing since they are pipeline architectures of separate models, including acoustic and duration models. The suggested model makes use of Sequence-to-Sequence (Seq2Seq) learning, which allows for joint training of spectral and temporal models. Parameters are learned using a Bayesian model, and Gaussian process regressions (GPRs) are used to represent the encoder and decoder layers. To adequately simulate character-level inputs in the encoder, we additionally propose a self-attention method based on Gaussian processes. In a subjective assessment, the suggested Seq2Seq-SA-DGP was shown to produce more natural-sounding speech synthesis than DNNs with self-awareness & recurrent structures. In addition, Seq2Seq-SA-DGP is useful when a straightforward input is provided for a complete system, and it helps alleviate the smoothing issues of recurrent structures. Sequence-to-Sequence Deep Neural Network Model. The field evaluations also demonstrate the efficacy of the DGP framework's self-attention structure, with Seq2Seq-SA-DGP being able to synthesise more natural discourse than Seq2Seq-SRU-DGP & SRU-DGP [17].

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In this study, we offer a deep learning-based system for cross-lingual speech synthesis that can simultaneously synthesise Mandarin and Tibetan voices. In order to train the acoustic models, we employ a large size Mandarin multi-speaker corpus as well as a limited basis Tibetan one-speaker corpus due to the difficulty of recording a Tibetan training corpus. Models for analysing sound are taught using a combination of deep neural networks (DNN), hybrids long short-term memories (BERT), and hybrid simultaneous recurrent neural networks (BBERT). To generate context-dependent labels from incoming Chinese or Tibetan phrases, we additionally enhance our Chinese text analyzer with a Tibetan text analyzer. The Tibetan text analyzer has features including text normalisation, a prosodic boundary predictor, a grapheme-to-phoneme converter, and a new Tibetan word segmentation which combines a BBERT with a conditional random field. In order to educate a speaker-independent multilingual average voice model (AVM) using DNN, hybrid BERT, & hybrid BBERT from a mixed corpus of Mandarin and Tibetan, we choose initials and finals from both languages to use as speech synthesis units. Next, a small target speech corpus from an AVM is used in conjunction with the speaker adaption to train a speaker-dependent DNN, hybrids BERT, or hybrids BBERT system for Mandarin or Tibetan. In the end, we use speaker-dependent models of Mandarin or Tibetan to synthesise their respective languages' spoken sounds. Compared to the other two cross-language frameworks as well as the Tibetan multilingual framework [18], the hybrid BBERT-based cross-language speech synthesis framework performs the best in the testing.

This work introduces a technique for improving the effectiveness of meta-learning-based multilingual voice synthesis via the separation of pronunciation and prosody modelling. To forecast mel-spectrograms across languages, the default meta-learning synthesis technique uses a single text decoder with a parameter generation conditional on language embedded and a single decoder. Our suggested approach, on the other hand, models pronunciation and prosody separately using separate encoders and decoders since these two types of information should be exchanged across languages in distinct ways. Our experimental results show that, compared to the baseline meta-education synthesis technique [19], our suggested method significantly enhances the intelligibility & authenticity of multilingual speech synthesis.

In this setup, speaker codes are used to transmit speaker data to duration/acoustic models. To effectively account for speaker similarities and differences, our method concurrently learns the portrayal of each speaker with other model parameters. To test the efficacy of the suggested methodologies, we conducted experimental evaluations of two scenarios. One scenario has an equal quantity of information from all of the speakers (speaker-balanced), whereas the other has less information from some of the speakers (speaker-imbalanced). Evaluation findings demonstrated that the DGP & DGPLVM synthesise multi-speaker speech better than a DNN in a speaker-balanced setting, both subjectively and objectively. We also observed that in the case of speaker imbalance, the DGPLVM performs far better than the DGP. [20].

We present MIST-Tacotron, a Tacotron 2-based speech synthesiser model that incorporates an image style transfer module into the reference encoder. The suggested approach is a method that uses a deep learning model that has been trained to extract the speaker's feature using the reference mel-spectrogram in conjunction with picture style transfer. The speaker's style, including pitch, tone, and length, may be taught using the extracted feature to better convey the speaker's style and emotion. With only the ID value for the individual who speaks and the ID number for the state of mind as inputs, the speaker's style may be extracted completely independently of the speaker's timbre and mood. The mel-cepstral distortion (MCD), the band aperiodicity distortion (BAPD), the voiced/unvoiced error (VUVE), the false positive rate (FPR), and the false negative rate (FNR) are used to assess performance. In comparison to the current designs, GST (Global Style Token) Tacotron & VAE (Variational Autoencoder) Tacotron, the suggested model was shown to have better performance and lower error values. The suggested model's audio quality scored best on MOS measures of both emotional expressiveness and reflection of speaker style. [21].

We provide a Tacotron-based approach for multilingual text-to-speech (TTS) synthesising that can generate high-quality voice in a number of different languages using a single set of speakers. Further, the model can synthesise natural-sounding Spanish speech using the voice of an English speaker, without being trained on bilingual or parallel samples. Even across very distantly related languages like English and Mandarin, such transmission is possible. Use of a phonemic input representation to facilitate cross-language model capacity sharing and the addition of an adversarial loss term to train the model to separate its representation of speaker identity from the speech content are two key ingredients in this recipe for success. integrating an autoencoding opinions to help stabilise attention during training and expanding the model to train on several speakers of each language yields a model that can reliably synthesise intelligible expression for training individuals in all languages seen throughout training, in either their native language's or a language for which they were not originally fluent [22].

In this study, we present a deep architectural model for voice synthesis using deep Gaussian processes (DGPs), which are layered Bayesian kernel regressions. In this approach, we mimic deep neural network (DNN)-based voice synthesis by training a statistical model of transition from contextual data to speech parameters. Our approach employs the approximation technique doubly stochastic

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variational deduction to implement DGPs inside a statistical parametric voice synthesis framework; this method works well with large datasets. When compared to DNNs, DGPs are more robust to overfitting since their training depends on the marginal likelihood, which considers not just data fitting but also model complexity. We conducted experiments to compare the effectiveness of the suggested DGP-based architecture to that of a feedforward DNN-based alternative. Our DGP architecture outperformed the status quo in both subjective and objective evaluations [23], with a higher mean opinion score and reduced distortions to acoustic features.

In this paper, we propose a neural speech synthesis approach that incorporates ToBI (Tones and Break Indices) encoding for fine-grained prosody modelling. Both a text interface for ToBI prediction as well as a Tacotron-based TTS component with prosody modelling make up the proposed solution. The ToBI representation allows us to exert fine-grained control over the system, allowing us to synthesise speech with natural intonation and syllable-level stress. Experiments demonstrate that, in comparison to the Tacotron and the unsupervised technique, our model is able to create more realistic speech with more precise prosody and to exert more precise control over the speech's stress, intonation, as well as pause [24].

In this research, we introduced a system that uses deep learning to identify the emotional state of a speaker based on their speech. Using a time-distributed flatten (TDF) layer, the system integrates a deep convolutional neural network (DCNN) with a bidirectional long-short term memory (BBERT) network. The suggested model has been used using the newly created SUBESCO emotional speech corpus in Bangla, which is audio only. All the models in this study were put through a battery of tests, comparing them in single-language, cross-language, and multilingual training-testing configurations. Compared to previous state-of-the-art CNN-based SER systems that are able to operate on both temporal & sequential representations of emotions, the model with a TDF layer obtains greater performance, as shown by testing data. The Bangla as well as English languages' SUBESCO as well as RAVDESS datasets were used for cross-corpus instruction, multi-corpus training, as well as transfer learning during the cross-lingual studies. Weighted accuracies (WAs) of 86.9% and 82.7% were achieved on the SUBESCO & RAVDESS datasets, respectively [25], demonstrating that the proposed model has achieved state-of-the-art perceptual efficiency.

In this paper, we present a deep learning-based approach for extracting basic characteristics from initial information with good accuracy across languages and speaker demographics (male/female) in voice corpora. To fine-tune the.wav files for Deep Convolutional Neural Network (DCNN), we first transform them into the RGB spectrograms (pictures) and normalise their size to (224x224x3). There are two phases of training for a DCNN model. Stage 2 involves re-training the model using the optimum learning rate determined in stage 1 through the Learning Rate (LR) ranging test. In order to down-sample the characteristics with a smaller model size, a unique stride is employed. Positive, negative, neutral, and a few more emotions are taken into account. The proposed approach is evaluated using the publicly-available German-language EMODB, Italian-language EMOVO, and British-English SAVEE speech corpora. The stated emotion identification accuracy is higher than that seen in previous research across languages and speakers. [26].

In this study, we offer a computational technique for learning underlying articulatory goals from a 3D articulatory speech synthesis model, utilising a simultaneous long short-term memory recurrent neural networks trained with a limited collection of representative seed samples. A bigger training set was produced from the seed data, allowing the model to be exposed to more diverse contexts. The process of articulation was reverse-engineered into a model by training a model that uses deep learning for acoustic-to-target mapping. This technique employs a trained model to map the provided audio data into the articulatory target parameters, allowing for the identification of distributions according to language situations. The perceived accuracy of speech recreated from the predicted articulation was used to assess the model's performance, along with its ability to map acoustics to articulation. The findings suggest that the simulator can successfully mimic speech without a high level of phonemic accuracy [27].

To develop generalizable and domain-invariant representations across a variety of medical imaging applications, including malaria, retinopathy from diabetes, and TB, we offer a unique & a computationally effective deep learning technique. We call the process by which we construct our CNNs Incremental Modular Network Synthesis (IMNS), as well as the resultant CNNs themselves IMNets. Our IMNS method makes use of specialised network components called SubNets, each of which may provide problem-specifically relevant characteristics. Next, we use these smaller networks, called SubNets, to construct bigger and more robust networks using a variety of alternative configurations. Each new SubNet module is only updated once each stage. This lessens the burden on the computer during training and assists in optimising the network. In this research, we evaluate IMNets with established and cutting-edge deep learning architectures including AlexNet, ResNet-50, Inception v3, DenseNet-201, & NasNet. Classifier accuracies of 97.0%, 97.9%, & 88.6%, on average, are achieved with our suggested IMNS architecture for malaria, diabetic eye disease, and TB, respectively. In all benchmarked use cases, our modular deep learning architecture outperforms the competition. Unlike most conventional deep learning architectures, the IMNets built here need less processing power to run. In this experiment, the biggest IMNet had 0.95 million trainable parameters and 0.08 billion MAdd operations (floating point multiplication and addition). The

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simplest IMNets examined [28] outperformed the benchmark techniques in terms of training speed, memory needs, and image processing speed.

In this study, we built a Korean sentimental speech dataset for emotion analysis in spoken language and presented a feature combination to boost recurrent neural network-based emotion detection accuracy. We retrieved F0, Mel-frequency cepstrum parameters, spectral characteristics, harmonic features, among other data to further explore the acoustic features that might indicate discrete instantaneous shifts in emotional expression. Statistical analysis was used to zero down on the best possible set of speech acoustic variables for conveying feeling. An emotional classification model based on a network of recurrent neurons was deployed. According to the findings, the suggested system outperforms its predecessors [29] in terms of accuracy.

To get over such problems, the authors of this research presented a new SER model. Due to a lack of previous study, we zeroed in on Arabic vocal expressions in particular. The suggested model enhances data before extracting features. Emotion identification was accomplished by using the 273 extracted characteristics as input into a transformer model. We test this model on four different datasets (BAVED, EMO-DB, SAVEE, and EMOVO). The experimental results showed that the suggested model outperformed state-of-the-art methods with ease. The best results were achieved using the BAVED dataset, demonstrating the proposed model's suitability for identifying emotions in Arabic speech [30].

The Griffin-Lim vocoding method is a technique used for audio signal processing, specifically for the synthesis of audio signals, including speech and music. It's commonly applied in the field of speech and audio processing, particularly in the context of spectrogram inversion or phase reconstruction.

The Griffin-Lim algorithm is named after its creators Mike Griffin and John Lim, who introduced it in their 1984 paper titled "Signal Estimation from Modified Short-Time Fourier Transform". The primary goal of this algorithm is to reconstruct a time-domain audio signal from its magnitude spectrogram, which contains information about the magnitude of the frequencies present in the signal

3 PROPOSED WORK

3.1 Research Gaps

There is a rich history of research into voice synthesis that led to the proposal of several models. When attempting to forecast parameters, a great deal of contextual data is considered. The acoustic feature incorporates a hierarchical framework to map context data to the waveform of human voice. Convolutional Neural Network (CNN) based approaches are using this idea as a foundation for predicting voice synthesis acoustic feature parameters. In most cases, the linguistic traits will be converted into speech synthesis probability densities for different decision trees. The model for complete voice synthesis from beginning to finish can be trained rather quickly using deep learning. Template-based speech synthesis algorithms struggle with high natural voices because of voice glitches. Features extraction for voice synthesis continues in the presence of obstacles.

In the first stage of VecMap, monolingual word embedded are normalized and orthogonalized. Then, a compact bilingual dictionary is used to provide an approximation of the linear mapping. This eliminates the need for a massive seed dictionary. After that, new terms in the original language are transformed using what was learnt, thereby expanding the vocabulary. Until the convergence condition is achieved, the procedure is iterated [14].

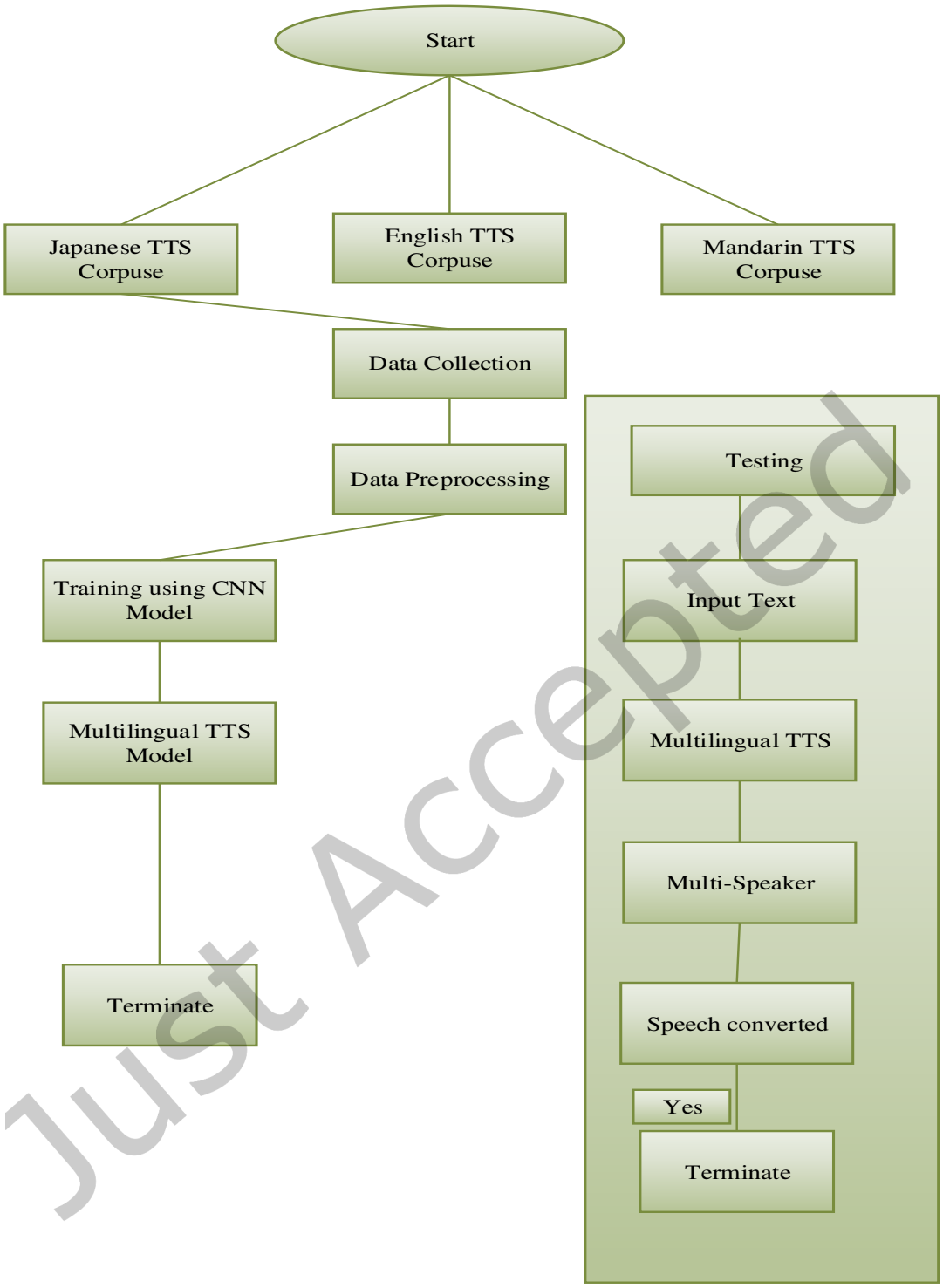
Many studies use the regularisation term Mean Squared Error (MSE) for VecMap:

$$\Omega_{\mathrm{MSE}} = \|\mathrm{W}\mathrm{X}^{s} - \mathrm{X}^{t}\|_{\mathrm{F}}^{2}$$

The given formula computes the Frobenius norm square of the residual matrix.

In this work, we use VecMap under supervision. A 5,000-word English-Persian lexicon is used for teaching and testing purposes under close supervision.

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Fig.1. Proposed System Flowchart

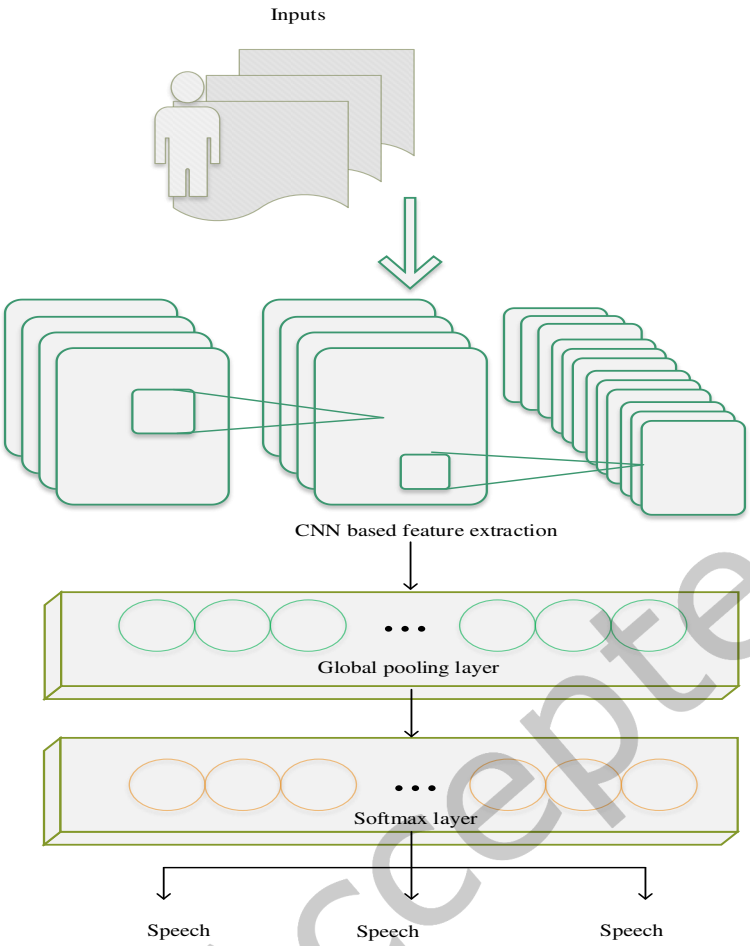


Fig.2. CNN Model for TTS

3.2 CNN

In the figure 2 shows the Words in the system correspond to a real number vector. The words represent the integers 0 through N-1. These word indices are represented as vectors of length N that may be plugged right into a model of the corresponding network. The textual sequences were in time, much as a skip gramme model would predict. The conditional probability of each word is denoted as a vector. Using the softmax function on the vector, as shown in Equation 1, it identifies the most pivotal target word,

$$C_p(w_o \mid w_t) = \frac{\exp(u_0^{\mathrm{T}} v_c)}{\sum_{i \in v} \exp(u_i^{\mathrm{T}} v_c)} \qquad (1)$$

Where v is index set. $\mathrm{v} = \{0,1,\ldots..|v|-1\}\mathrm{T}$ is shorthand for the sequence's duration. The term in context will be found in the lexicon (index). During the approximative training phase, the loss function is built using the path from one node to another in a binary tree structure. Gradient computational, a part of the training process, has complexity that grows as the lexicon does. The serial data is pre-processed using negative sampling. We've developed a model for word embedded that can compare words like "Hi" and "Hai" to determine their level of similarity. Instead of using the morphology function, a separate vector is utilised for word to vector conversion. In other words, the skip gramme model is now live. The minimum and maximum length of retrieved subwords were both set by us. The size of dictionaries, however, is not a fixed parameter. For this purpose, we have used a byte-pair encoding strategy [1]. The Convolution Neural Network (CNN) may be rapidly trained based on the quality of the input voice. Input vectors that are able to conform to the probability distributions are welcomed by the input layers. The parameters of the underlying hidden layers will also be determined. Convergence data is not entered into the hidden layer until it is reached. Based on the length of the recovered subwords, the results layer will interpolate Acoustic characteristics. These variables are trained inside the same network, thus there will be no

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future fragmentation issues. Additionally, the excessively smooth issue is mitigated by correlating the acoustic properties with varying frame size.

Model average is an ensemble method in which all of the individual models' predictions are weighted equally. Overfitting is a major problem in ML jobs, and this might cause it. One variant of this strategy, known as the weighted mean ensemble, gives more credence to members with higher anticipated model performance on an outlier dataset. As a result, models with better performance may contribute more and those with less performance can contribute less. In this study, the model average ensemble has been employed, although it may be better if a weighted average ensemble was used instead. When doing a classification job, we may determine the certainty of each class by using the Softmax activating function, which yields the anticipated probability for each class. The softmax function's output is the class label with the greatest average trust, which is determined by the model averaging method's calculation of the average classification likelihood of base pupils for each class.

$$\text{Softmax}(\mathbf{z})_i = \frac{e^{\mathbf{z}_i}}{\sum_{j=1}^{C} e^{\mathbf{z}_j}} \qquad (2)$$

where Z is the vector of input values and C is the total number of categories in the dataset, e^{z_i} and e^{z_j} are the common exponential equations for the vectors of input and output. Equation 4 describes the model confidence-averaged prediction of a class label. The agrgmax for the anticipated labels in the target class is used to determine this.

$$\hat{y} = \underset{i\in\{1,\cdots,c\}}{\text{argmax}} \frac{\sum_{j=1}^{k} p_j(y=i|B_j,x)}{k} \qquad (3)$$

where B_j is the j_{th} base learner, k is the number of selected base CNN learners, and k = 3 in the proposed TTD; $p_j(y = i \mid Bj, x)$ represents the likelihood that the category value i will be present in a given data sample x B_j.

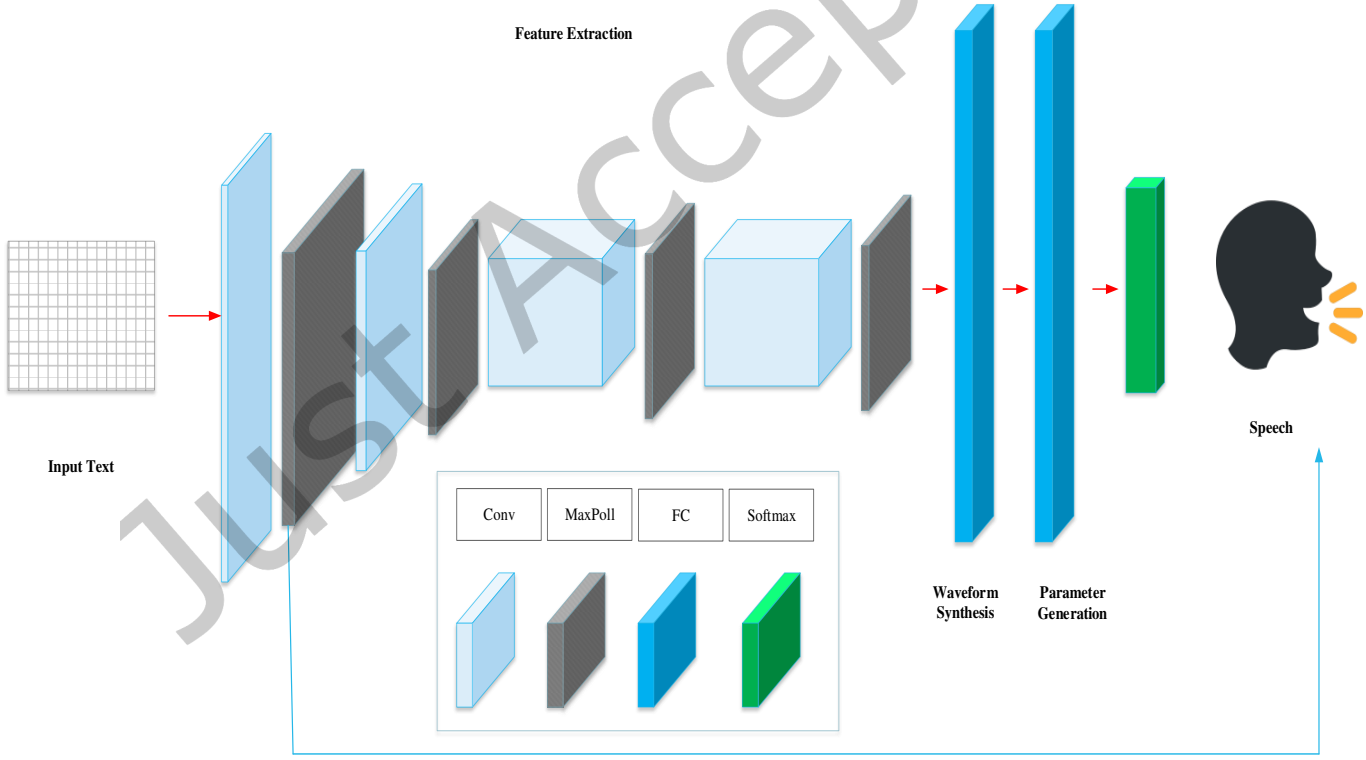


Fig.3. Proposed CNN Architecture for TTS

4 RESULTS & DISCUSSION

We utilised a number of Python packages, including Keras, Pandas, Gensim, and Matplotlib, to put our study into practise. Table 1 provides a brief overview of the model parameters we employed. For BERT and other vector models, we use embeddeds of 300 dimensions.

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In this work, we experimented with voice synthesis to confirm a viable strategy for realising a multilingual synthesis systems. We built each system based on the voice quality of the a Japanese speaker (nicknamed NKY) and tested it using English-only synthesised speech since judging the tone quality of several languages is challenging. (Our English language natural speaker, or ELN, speaks English.) These are the experimental parameters:

- A quiet room with headphones was used to listen to all of the speeches.
- There was no order to the speeches that were offered.
- One native English speaker from the United States was responsible for rating the level of naturalness.

Four native Japanese speakers weighed in on the similarity.

As input text, we employed a training corpus and 30 sentences from English news articles. Auditory assessment samples: The hearing test included both synthetic speech samples from seven different TTS systems (Tables 1, 2) and actual human speech. Information about each speech sample is provided in Table 1.

Each voice sample's CNN architecture is broken out in Table 1.

Table 1. Parameter settings used in the CNN model.

Model	Parameters	Values
CNN	Strides	10
	Activation	ReLU
	Filter region size	(2,3,4,5)
	Feature maps	100
	Dropout rate	0.3
	Pooling layer	$I-$ max pooling
	Optimizer	Adam
	Sequence length	128
	Learning rate	0.0001

The specifics of the ASR systems tested here are listed in Table 3.

The matrix of uncertainty [19] uses the following fundamental terminology.

- Observation is positive and consistent with the expected outcome; this is a true positive (TP).
- The opposite of a true positive is a false negative.
- A true negative (TN) is an observation that matches expectations of negativity.
- A false positive (FP) occurs when an unfavourable observation contradicts a favourable prediction.

To analyse test results, we calculated an Accuracy, Extractness, Recollotion, & F1Score. The performance evaluation techniques are shown by the equations. (4), (5), (6), & (7).

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \quad (4)$$

$$\text{Precision} = \frac{TP}{TP + FP} \quad (5)$$

$$\text{Recall} = \frac{TP}{TP + FN} \quad (6)$$

The accuracy of a model is the easiest to understand when compared to other assessment indices. However, a supplemental index is necessary when the data categories are not evenly distributed. The F1-Score is a useful measure since it takes into account both accuracy and recollotion.

We use the Common voice Semantics (CSS10) voice corpus, which has a single speaker for each of 10 languages. We choose German, Dutch, Chinese, and Japanese to build a work sequence. We use the publicised train/validation splits from, which provide 15.1 hours, 11.5 hours, 5.4 hours, and 14.0 hours of training audio, in that order. For each language, we used the latest 20 examples from the validation set as test samples. We rank the various methods of lifelong learning as follows: German (DE), Dutch (NL), Swiss German (CHZ), and Japanese (JA). Our buffer size for replay-based algorithms is 300 utterances, or around 0.6h of audio. After instruction on each language, random samples are added to the buffer. To maintain linguistic parity in the buffer during the course of the training sequence, old samples are removed at random as new ones are added.

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Framework and tuning settings. Each language undergoes 100 iterations of training. We use the Adam optimizer, which has a learning rate of 0.001 at the outset and decays to 0.049 after 60 iterations. The default batch size is 84. All sequential techniques of language acquisition begin current language instruction using the best possible model parameters gained from the previously learned language.

Table 2. When compared to the results of the baseline monolingual models using CNN as the classifier, the suggested cross-lingual sentiment analysis approach shows significant improvement.

Train data	Static/dynamic	BERT			VectorMap		
		Precision	Recall	F-measure	Precision	Recall	F-measure
English	Static embedded	60.29	58.36	59.31	67.05	66.21	66.63
	Dynamic embedded	68.28	65.99	67.13	73.93	72.81	73.37
Japanese	Static embedded	70.32	68.54	69.42	72.69	71.71	72.18
	Dynamic embedded	79.73	78.18	78.96	81.48	80.01	80.75
Mangarian	Static embedded	73.29	71.64	72.46	80.12	78.33	79.22
	Dynamic embedded	77.73	76.16	76.94	85.33	83.29	84.28

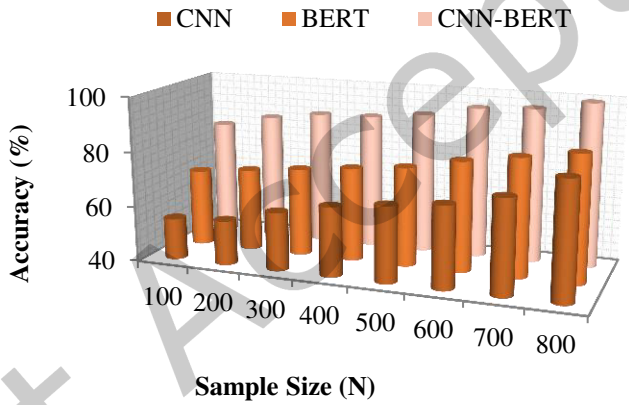
Table 3. When compared to the results of the baseline multilingual model using BERT as the classifier, the suggested cross-lingual sentiment assessment model shows significant improvement.

Train data	Static/dynamic	BERT			VectorMap		
		Precision	Recall	F-measure	Precision	Recall	F-measure
English	Static embedded	63.75	62.13	62.93	69.98	68.51	69.24
	Dynamic embedded	70.03	68.72	69.37	76.38	75.18	75.79
Japanese	Static embedded	70.99	69.25	70.11	75.13	73.68	74.38
	Dynamic embedded	78.33	76.23	77.27	82.04	80.82	81.43
Mangarian	Static embedded	77.24	75.55	76.39	80.92	79.45	80.18
	Dynamic embedded	80.63	79.28	79.96	87.24	86.06	86.65

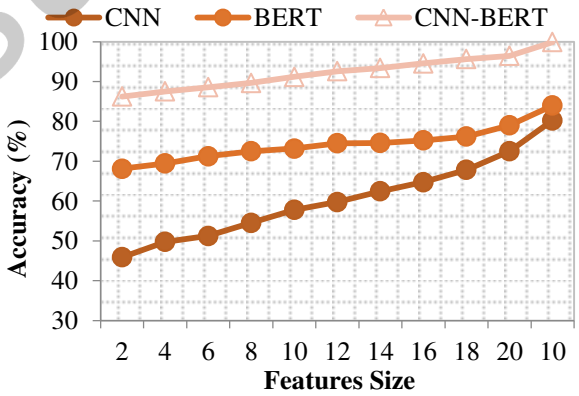
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Table 4. When compared to the results of the baseline multilingual models using CNN-BERT as the classifier, the suggested cross-lingual sentiment estimation model shows significant improvement.

Train data	Static/dynamic	BERT			VectorMap		
		Precision	Recall	F-measure	Precision	Recall	F-measure
English	Static embedded	65.85	64.03	64.93	72.31	70.96	71.63
	Dynamic embedded	71.77	70.44	71.11	78.09	76.74	77.41
Japanese	Static embedded	70.72	68.96	69.83	77.31	76.27	76.84
	Dynamic embedded	78.28	76.91	77.59	84.93	83.48	84.18
Mangarian	Static embedded	76.83	75.28	76.05	84.26	83.26	83.76
	Dynamic embedded	85.03	83.58	84.31	89.69	88.13	88.91



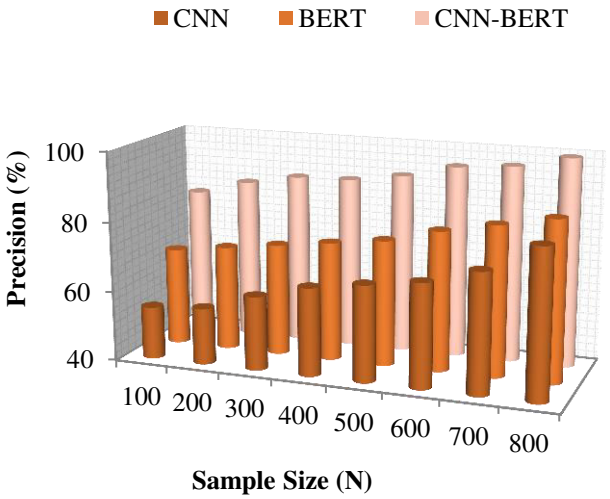
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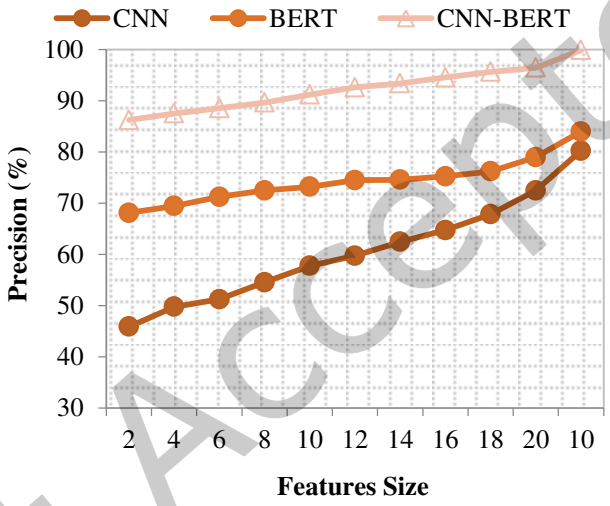
(b)

Fig.4.Comparison of Accuracy (a). Number of Samples, and (b). Feature Size

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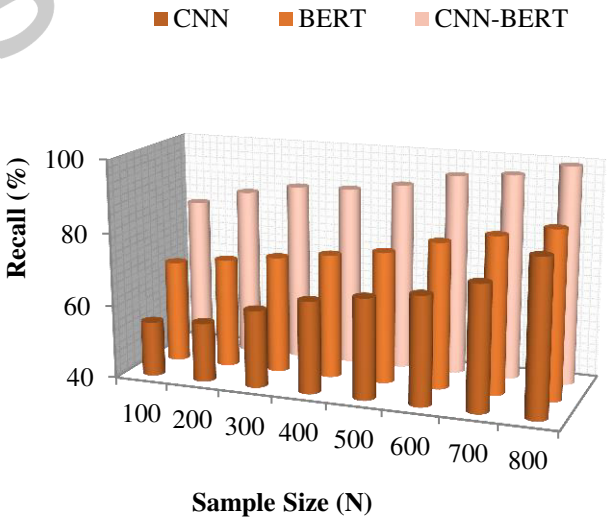


(a)



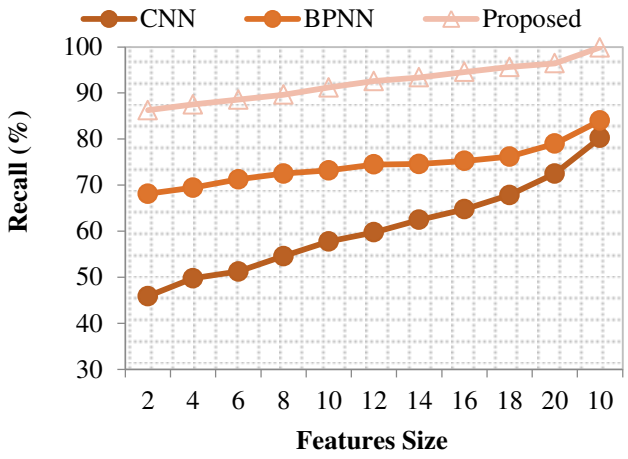
(b)

Fig. 5. Comparison of Precision (a). Number of Samples, and (b). Feature Size



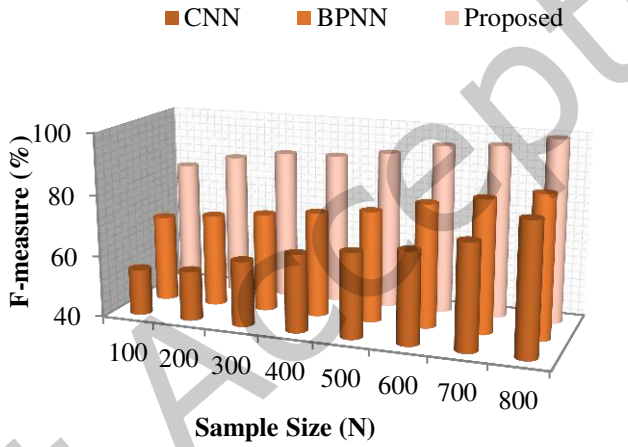
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(a)

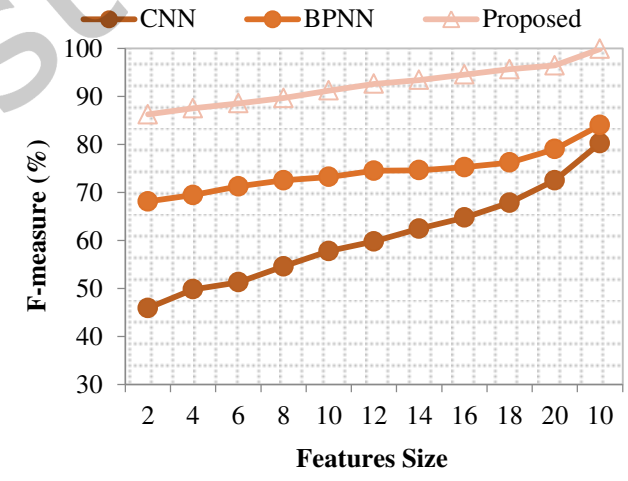


(b)

Fig.6.Comparison of Recall (a). Number of Samples, and (b). Feature Size



(a)



(b)

Fig.7.Comparison of F-measure (a). Number of Samples, and (b). Feature Size

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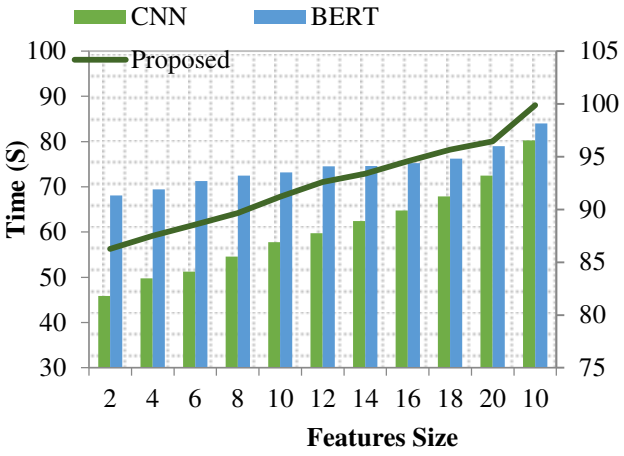


Fig.8.Comparison of Runtime

Two distinct cross-lingual embeddeds (BERT and Vector Map) and classifiers (CNN and CNN-BERT) are employed in our research. Furthermore, we conducted our tests in two modes because to the fact that the cross-lingual embeddeds have been trained with no information from the data used for training of the sentiment evaluation job: There are two types of embedded models: static, which employs the pre-trained vectors directly, and dynamic, which fine-tunes the embeddings using the training data. All experiments are provided with regards to their levels of accuracy, extractness, recollection, and F-measure.

The following are noteworthy insights gleaned from a comparison of the outputs of several training models and cross-lingual embeddeds:

Our suggested model, trained on English data rather than Persian data, consistently outperforms state-of-the-art baseline algorithms in experimental settings.

Although the suggested cross-lingual sentiment analysis performs much better than monolingual models, we may further enhance the model by taking use of English as well as Persian information in a Bilingual training phase, as shown by a comparison of the results from English training as well as Bilingual training. Bilingual training allows for the use of the extensive English data set as well as the study of the language-dependent characteristics present in the Persian dataset.

VectorMap consistently beats BERT, while the performance gaps are small. Because BilBOWA needs parallel data, the corpora available for training the algorithm are restricted, while with VectorMap, this is not the case.

We may further enhance the model by collecting semantic properties that are present in the subject matter of training data, as shown by a comparison of static and dynamic embeddeds.

Figure 8 shows that when all classifiers are compared, hybrid models perform the best. Taking use of the strengths of both models, BERT-CNN and CNN-BERT architectures are able to collect sequential and atypical information from the text, leading to more precise predictions. Furthermore, the fact that BERT- CNN outperforms CNN-BERT demonstrates the importance of gathering sequential data early on in the design. However, with the CNN-BERT model, some sequential information may be lost since a CNN model is performed first. When combined, BERT-CNN and VectorMap provide an F-measure of 95.04, making them the most effective methods.

In contrast to the technique of concatenative speech synthesis, the method that was provided is capable of creating synthetic speech that is not only extremely easily comprehended but also sounds very much like real speech. One of the disadvantages of the existing TTS-based speech synthesis model is that it makes use of context decision trees to trade speech parameters. This is one of the limitations. As a direct consequence of this, the artificially produced speech lacks the necessary degree of realism to fulfill the requirements of expressive speech synthesis. In the suggested method, the clustering phase of the context CNN is replaced by the deep learning-based speech synthesis models. These models employ entire context information and distributed illustration in lieu of the clustering process. They map the context characteristics to high-dimensional acoustic data by using several hidden layers, which leads in the quality of the synthesized speech being better to that of the approaches that were utilized in the past. The enormous representation possibilities of DL-based models, on the other hand, have led to the appearance of a number of brand new difficulties. The models need an increase in the number of hidden layers and nodes so that they can provide more accurate predictions of the world's behavior. This, in turn, will undoubtedly result in a rise in the total number of network parameters, in addition to the amount of

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time and space that is necessary for the training of the network. Over-fitting is a common problem that arises in cases when there is insufficient data for the models to be trained on. As a result, the training of the model necessitates the use of a huge quantity of computing resources in addition to a large number of corpora.

5 CONCLUSION

The poor intelligibility and out-of-the-ordinary nature of the traditional concatenation speech synthesis technologies are two major problems. CNN's context deep learning approaches aren't robust enough for sensitive speech synthesis. Our suggested model may satisfy those voice synthesis needs and alter the associated difficulties. The suggested model's minimal aperiodic distortion makes it an excellent candidate for a communication recognition model. Our suggested method is as close to human speech as possible, despite the fact that speech synthesis has a number of audible flaws. Additionally, there is excellent hard work to be done in incorporating sentiment analysis into text categorization using natural language processing. The intensity of feeling varies greatly from nation to country. To improve their voice synthesis outputs, models need to include increasingly hidden layers and nodes into the updated mixture density network. If we want to assess the model in the best way possible, our suggested method will require a more robust network structure and optimization approaches. We hope that after reading this article and trying out the example data provided, both experienced researchers and those just starting out would have a better grasp of the steps involved in creating a deep learning approach. Overcoming fitting issues with less data in training, the model is making progress. More space is needed to hold the input parameters in the DL-based method.

Authors Contribution: Each author contributed equally in each part.

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The data used to support the findings of this study are available from the corresponding author upon request.

ETHICAL APPROVAL:

This article does not contain any studies with human participant and Animals performed by author.

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Data Augmentation Based Cross-Lingual Multi-Speaker TTS using DL with Sentiment Analysis

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Text to **S**peech (TTS) algorithms have made tremendous strides in recent years in terms of their ability to generate speech in a single language that sounds as natural as possible. However, because to a lack of available training data, the synthesis of speech from the same person in various languages continues to be difficult. It might be challenging to locate people who are proficient in numerous languages at a level equivalent to native speakers. Voice conversion is one method that may be used to create a polyglot corpus, which can then be used to solve this problem. This entails making use of a voice representation model that has been trained on 53 different languages through the application of hybrid deep learning in order to capture speaker-invariant qualities. In this study, we present a novel approach for the conversion of voices across different languages by employing Generated Adversarial Networks (GANs) to train a multilingual TTS system. The concept of individual likeness loss in order to address the special difficulty of maintaining one's individual speaking identity during the training process can be offered. This work is focused to provide the impression that voice data coming from a variety of languages and speakers was produced by the same individual, and one way to do so is by using this word. In order to determine the extent to which our model is useful, two experiments that compared it against benchmarks that made use of varying degrees of parameter sharing between languages are carried out. The purpose of these experiments was to evaluate the accuracy of pronunciation as well as the caliber of the synthetic voice during transitions between different languages.

Keywords: Cross Lingual Multi-Speaker Analysis, Text to Speech Analysis, Sentiment Analysis

1 INTRODUCTION

The application of approaches that make use of neural networks has allowed for great progress to be made in the area of Text to Speech (TTS) synthesis. When a Tibetan training corpus is utilized alongside other languages, Mandarin speech synthesis is unaffected. This is in contrast to previous cross-language frameworks including the Tibetan multilingual framework [1]. In addition, the hybrid BLSTM-based cross-lingual speech synthesis architecture [2] does not need the Tibetan monolingual architecture because it only needs sixty percent of the training corpus to synthesize a voice that is comparable to the Tibetan one. This suggests that a big resource language corpus may be used for voice synthesis of a low-resource language.

Enhancing speech across multiple languages is of paramount importance as it plays a vital role in facilitating effective communication, bolstering accessibility, and enabling diverse applications in our progressively multilingual and interconnected global

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landscape. This enhancement empowers individuals, enterprises, and institutions to transcend language barriers, broaden their audience reach, and ensure the utmost quality and usability of audio data across a spectrum of linguistic environments. Recent research has investigated many approaches to multilingual and multispeaker TTS synthesis. These approaches rely on unique databases of performing artists and require tweaking to accommodate additional voices. However, the expenses associated with these strategies are frequently rather significant. We present a novel solution to this problem in the form of a system that makes use of speakers who are proficient in more than one language to deliver high-quality speeches in a number of different languages.

Deep neural network (DNN)-based systems often require a large amount of data in order to be trained, which presents issues in environments with limited linguistic resources. Despite the fact that zero-shot multi-speaker DNN-based TTS systems have been created based on high-resource languages, their performance on unseen speakers continues to be below average. In this paper, we provide an end-to-end method that increases speaker similarity for both known and unknown speakers, with a special focus on accurate speech encoder modeling. This technique enhances speaker similarity for both known and unknown speakers.

Even when trained exclusively on monolingual datasets, recent developments in multilingual TTS systems have exhibited encouraging outcomes, which is cause for optimism. Cross-language voice synthesis, on the other hand, frequently results in the introduction of audible accents and is unable to match the quality of the speaker's original language. Due to the efficient exploitation of parallel processing throughout the training and/or inference processes, Transformer-based TTS models have demonstrated greater performance when compared to RNN-based models (for example, Tacotron citeshen2018natural). However, in a multi-speaker context with noisy data and diverse speakers, it is more difficult to learn the alignment between the text and the speech, which limits the application of Transformers in multi-speaker TTS.

The capacity to infer speech features from facial expressions has opened up new prospects for multi-speaker TTS technology, particularly in situations where a considerable volume of high-quality voice data as well as related transcriptions are available. However, the collecting of paired data using methods that require a significant amount of time continues to be a significant challenge for many research institutes. The phrase "multi-speaker speech synthesis" refers to the technique of synthesizing the voices of numerous persons from a single model. Deep neural networks (DNNs), despite the fact that various methods based on them have been devised, are prone to overfitting when the amount of training data available is restricted.

- WaveNet, an alternative to vocoders, has demonstrated extraordinary performance in the generation of very realistic synthetic speech in multi-speaker speech-to-text synthesis systems, notably in terms of naturalness and speaker similarity. This is due to WaveNet's ability to generate speech that is highly comparable to the natural speech of several speakers. However, in order for the WaveNet vocoder to work well, it is necessary to make accurate predictions of acoustic qualities, which are then employed as local condition parameters. The process of efficiently training this model is currently underway. The quality of synthetic speech suffers a major hit whenever the predicted acoustic qualities diverge from the actual ones. This causes a substantial decline in the quality of the produced speech.
- In the TSS model, text analysis is a very important component. The majority of traditional methods for analyzing text are predicated on rule-based approaches, which require a large time commitment for the purpose of collecting and learning these rules. Bigram analysis, trigram analysis, HMM-based analysis, and DNN-based analysis are just a few examples of the data-driven methodologies that have arisen as a result of the rapid developments in data mining technologies.
- When doing text analysis using the latter two approaches, the Festival system is typically utilized to carry out phoneme segmentation and annotation on the corpus. This is done so that the results may be better interpreted. This method requires many layers of analysis and considers a variety of factors, including the ones listed below:
- Phoneme level: This level takes into account the phonetic symbols that come before, after, or are located in close proximity to the present phoneme. It also takes into account how far along the syllable the current phoneme is located.
- Syllable level: At this level, the emphasis is placed on aspects such as syllable stress (previous, current, or next), the number of phonemes in the previous, current, or next syllable, the position of the current syllable within the word or phrase (forward or backward), the number of stressed syllables immediately preceding or following the current syllable within the phrase, the distance to the nearest stressed syllable (forward or
- Analysis at the word level takes into consideration the part of speech (POS) of the previous, current, or next word; the number of syllables in the previous, current, or next word; the position of the current word within the phrase (forward or backward); the content word (forward or backward) that is closest to the current word within the phrase; the distance to the nearest content word (forward or backward); and the POS of the previous, current, or next word.
- Phrase level: This level focuses on characteristics such as the number of syllables and words in the previous, current, or next phrase, as well as the location of the current phrase inside the sentence (forward or backward), and the prosodic annotation of the current phrase.
- At the highest level, the analysis takes into account the amount of syllables, words, or phrases that are contained in the sentence at hand.
- Because these several levels of analysis are taken into consideration, the TSS model is able to properly evaluate and comprehend the textual material, which in turn enables correct voice synthesis.

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1.1 Preliminary Knowledge

TTS systems typically consist of three primary components: a text analysis front-end, an acoustic model, and a voice synthesizer. These components are educated independently from one another and need substantial topic expertise. Nevertheless, independent training may be a time-consuming process, and mistakes can compound as they are introduced into each component. The first step in the TTS synthesis process is an analysis of the text, and the second step is the generation of the speech waveform as mentioned in Figure.1. An approximation formula is used in order to convert the phonetic and prosodic information that was gleaned from the analysis into a waveform. In order to generate the correct speech output, the amplitude of each signal contained inside the speech waveform must first be measured. Depending on the circumstances, these speech waves might either take the shape of language or non-linguistic communication. The purpose of this investigation is to create a voice synthesizer that not only converts TTS but also stores the resulting file in the mp3 file format.

End-to-end speech synthesis technologies have become more popular in the industry as a solution to the problems that are related with the training of separate component parts and the potential accumulation of errors. These solutions include all of the components into a cohesive framework, which provides a number of benefits for TTS systems, including the following: (1) They are able to be trained using a large-scale dataset with minimum human annotation; (2) They do not require phoneme-level alignment; and (3) Errors do not compound since they rely on a singular model.

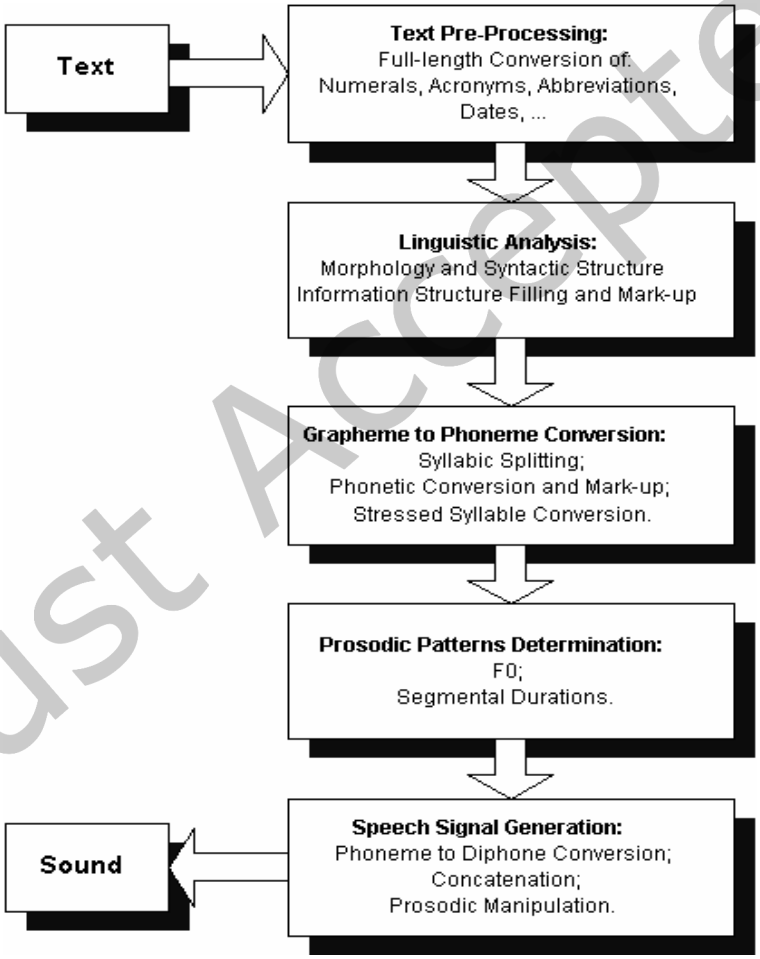


Fig.1. System Model

- The following are the stages that are often included in a TTS procedure:
- Text Input: To create speech in a particular language (for example, Punjabi), you must first provide the system with text written in that language. The text that is inputted might be as simple as a single word or as complex as an entire paragraph or collection of words. This input is subjected to further processing, which includes tokenization and the extraction of phonemes.

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- Tokenization is the process of generating tokens by processing the text. This entails transforming the text into more manageable pieces known as tokens and deleting items such as numerals or special characters that are not desired. This preliminary phase of processing guarantees that the data are free of errors and prepared for the subsequent processing steps. Following this stage, the tokens that were produced are sent on to the subsequent procedure.
- Phonetic Synthesizer: The phonetic synthesizer is in charge of producing the tokens that are used in the game. The phonemes are extracted from each token, and then those phonemes are represented as location numbers within a data format. This operation is performed on each token. Each token is then transformed into a list of numbers, where each number represents the position of a phoneme in the list of phonemes included within the phoneme database. The token list is set to a predetermined size in order to preserve the consistent data form that is necessary for machine learning models. Empty items in the token list are replaced with the integer value '-1'. The model is then trained using this data, and its accuracy may be evaluated using any text that is entered.
- Formant Synthesis: This approach of generating voice from processed text is known as formant synthesis. This requires the utilization of formant frequencies as well as a particular strategy for converting these formant frequencies into the sound that is sought in Punjabi. The finished recording of the speech is saved in a separate file.
- Speech Output: This stage involves processing the speech that was created earlier in the procedure. The formant synthesizer model is used to evaluate the output of the speech generator from the stage before this one. In order to determine whether or not the speech output is accurate, the formant frequencies and any other attributes that have been extracted are compared to the database.

1.2 The Contributions Made to Research

Text is analyzed through the lens of sentiment in order to identify whether it has a good, negative, or neutral tone. This study is absolutely necessary for applications that are dependent on the views of the general population. In this study, the categorization of text based on emotion is investigated. A variety of label categorizations are shown for the text that is supplied as part of this investigation.

In the course of the study, we utilized a number of different cross-lingual transfer learning strategies in order to educate our low-resource TTS models. In the beginning, we just used a tiny amount of data that was already available in the targeted language and paired it with data that was already available in the target language. After that, both datasets to do additional adjustments to the model are used. Following the training of the algorithm with high-resource speech data, which is followed by training with target language data and enhanced target speech data, our studies show that this technique enables the system to generate extremely accurate speech synthesis in the target language. This strategy entails training the algorithm with target language data and augmented target speech data. It received an opinion score of 3.50 on average from native speakers.

It is essential to keep in mind that sentiment analysis models developed for a single language could not work very well when applied to data written in many languages and scripts. On the other hand, by making use of cross-lingual models that were educated on the training dataset, an average F1 score of 95.4% on the test dataset has been attained.

2 RELATED WORK

To analyze speaker attributes and generate synthesized speech in a variety of languages, we propose a neural end-to-end TTS system as part of this study. In our approach, we build a neural speaker modeling network that is uncoupled from linguistic and acoustic input during training. This illustrates that a voice synthesis network trained in English can be used to synthesize speech for Chinese speakers, and that a speech synthesis network trained in Chinese can be used to synthesize speech for English speakers. With just a few minutes of audio from a fresh speaker, our experimental findings suggest that the proposed model may reach acceptable levels of naturalness and similarity in speech synthesis for two languages [16]. Exploration of many options for generalizing the model to new speakers with less extensive speech data is possible.

As a solution to the challenge of adapting TTS systems to a wide variety of languages, it is suggested a speaker adaptation approach that combines domain adaptation approaches with a speaker consistency loss. In contrast to traditional methods, which rely on direct fine-tuning for adapting speakers within a single language, we use speaker verification in conjunction with domain adaptation to train a language-independent speaker encoder using multilingual data that includes both the source language and the language that

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will be used as the target. Then, we use the speaker embeddings generated by the speaker encoder to train a multilingual multi-speaker TTS model on the source language data. In order to fine-tune the source language TTS system utilizing target language data, we provide a speaker consistency loss. This loss seeks to increase the degree to which synthesized speech and the resulting speaker embeddings are highly correlated with one another. The speaker consistency loss is used to optimize this correlation. It can be shown that our proposed technique outperforms the gold standard process in terms of the spoken naturalness of the final translation by doing extensive tests on datasets that include both English and Japanese native speakers [17].

Detailed explanation on a whole learning-based architecture developed for cross-lingual Chinese and Tibetan voice synthesis is done. This approach allows for the simultaneous synthesis of Mandarin voices and Tibetan speech inside a single system. We do this by providing our acoustic models with both a large Mandarin multi-speaker dataset and a smaller Tibetan single-speaker corpus to train on. The system that provides context-based labels for phrases in both Chinese and Tibetan has been enhanced with the addition of a Tibetan text analyst to the textual analyzer. Our approach employs deep neural networks (DNNs), hybrid bidirectional LSTM (BLSTM), and hybrid long short-term memory (LSTM) to train acoustic models. Finally, we use a bilingual corpus of Mandarin Chinese and Tibetan to train long short-term memory (LSTMs), deep neural networks (DNNs), and back-propagation neural networks (BLNs) to construct synthetic voices. Using speaker adaptation approaches and data on Mandarin or Tibetan speech from a limited listener corpus, the models are fine-tuned. Finally, we use speaker-dependent modeling of Mandarin and Tibetan [18] to reproduce the sounds produced by native speakers.

By fixing the issue of lacking data in DNN-based TTS systems for low-resource languages, our study contributes to the advancement of cross-lingual TTS synthesis with multiple speakers. Problems with low-resource languages, such as the transmission of accents and the improper pronunciation of words, may be circumvented by the use of tone preservation methods and data augmentation, respectively. Applying these methods across a range of languages improves intelligibility, target accent ratings, and perceived similarities between speakers of various tongues.

It is proposed in this work that the Normalizing Flows (NF) method, which is used in neural vocoding, be significantly improved upon. To be more specific, we look at the possibility of enhancing expressive voice vocoding by using a modified version of the Parallel WaveNet (PW). Instead of the PW's affine transformation, we propose using invertible non-affine functions for the transformation due to their greater expressiveness. The enhanced PW allows for more expressive waveform reconstruction and TTS results. We test our model on a broad range of speech patterns utilizing data from a number of speakers who each speak a different language in order to determine how well it performs. The results of the waveform reconstruction tests suggest that the model we have presented reduces the discrepancy between the original PW and the recorded waveforms by 10% in terms of the naturalness and signal quality. Furthermore, our model achieves a reduction of over 60% when compared to existing neural vocoding systems presently regarded to be state-of-the-art. When measured on a set created for the express aim of giving feedback, objective measures like as L2 Spectral Distance and Cross-Entropy show gains of 3% and 6%, respectively, over the affine PW. In addition, we extend the approach introduced in the PW study to any non-affine invertible and differentiable function through the distillation of probability densities. [19].

Given the resource constraints of cross-lingual TTS synthesis, we describe a technique that can synthesize speech in various languages using distinct voices. We zero down on synthesizing English and Mandarin voices using limited training data, including only 15 minutes of a female speaker's Mandarin speech. Common problems in low-resource languages, such as mispronunciation and accent transfer, are addressed by our method. We suggest solutions, including tone preservation and data augmentation, to cope with these difficulties. All of these methods enhance intelligibility, target accent ratings, and cross-lingual speaker similarity ratings when applied to a strong multilingual baseline [20].

Authors describe a method that uses tone/stress embeddings as an extension of language embeddings to add tone and stress into the synthesis process. The proposed system can produce synthetic speech with a variety of accents by changing the tone/stress embedding input. To make it simpler to incorporate new speakers into an online application scenario, authors condition a Tacotron-based synthesizer on speaker embeddings generated from a pre-trained x-vector voice encoder using transfer learning. Authors present a common phoneme set to promote further phoneme sharing beyond the International Phonetic Alphabet (IPA). Our Mean Opinion Score (MOS) ratings confirm the intelligibility and fluency of native speakers of every language. Authors also find that L2-norm normalizing and ZCA-whitening on x-vectors significantly improve the system's dependability and audio quality. WaveNet models may be trained on any of the three languages supported by our system, and authors discover that they can produce high-quality speech in the other two languages[21].

In order to increase the similarity of speech for unidentified speakers, this work presents SC-GlowTTS, a zero-shot multi-speaker speech synthesis system. In this paper, authors introduce the idea of zero-shot flow-based decoding and offer an outline of the system's

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architecture. The gated convolution encoder, the transformer-based encoder, and the dilated residue convolution encoder are only few of the text encoding algorithms authors investigate. Furthermore, authors show how the TTS algorithms' suggested GAN-based vocoder, which is specifically designed for spectrograms, may greatly improve the similarity and quality of voice for new speakers. State-of-the-art outcomes in terms of sound quality and speaker similarity [22] are achieved by our system with just 11 speakers.

This research aims to improve the efficiency of zero-shot speaker adaption for unseen speakers as a means of overcoming the data shortage barrier in DNN-based TTS for low-resource languages. To combat this problem, authors provide a unique multi-stage transfer learning strategy that employs a single-speaker TTS system equipped with a d-vector speaking encoder trained on a high-resource language as the starting domain. In addition, authors offer a TTS model that makes use of explicit style direction from target speech to improve zero-shot sentence adaption, as well as speaker representations loss at the phrase level during TTS training. Our study use open-source speech datasets to show how our training strategy efficiently prepares TTS models for languages with few accessible training materials. Our models, as compared to those trained using more traditional approaches, generate more understandable and lifelike speech. Our proposed style encoder networks, in conjunction with the speaker reconstruction loss, also show substantial improvements in speaker similarity over the baseline model in the zero-shot speech adaption test. When applied to the unknown speakers test set, our proposed TTS model and training approach increase the cosine resemblance between native and non-native speakers by 0.468 and 0.279, respectively [23].

A speech encoder utilizing the best-of-breed ECAPA-TDNN models from the speaker verification challenge, a synthesizer based on the FastSpeech2 model, and a vocoder using HiFi-GAN are the three parts of the proposed architecture that have been trained separately. In comparison to existing voice encoder models, our method achieves higher levels of speaker similarity. Authors adopt and evaluate multiple automated Mean Opinion Score (MOS) assessment methodologies based on deep learning, a first in this area [24], to reliably measure the quality of the synthesized speech.

Using a fine-grained style encoder to improve voice quality and allow cross-speaker style transfer to correct inauthentic accents, authors offer M3, a multi-speaker, multi-style, multi-language speech synthesis system. Using a speaker-conditioned variational encoder and adversarial speaker training with a gradient reversal layer, authors are able to block timbre information from entering the style encoder. To further link the textual output of each speaker with their unique extracted style vectors, authors create a Mixture Density Network (MDN). The inference process allows for the transfer of any speaker's style type into the target language, allowing for the production of speech that is both idiomatic and free of non-native pronunciations. Our suggested method routinely achieves a 4.0 [25] on the MOS-speech-naturalness measure, which is much higher than the performance of the baseline system.

In this paper, authors introduce MultiSpeech, a multi-speaker Transformer-based TTS system with a focus on synchronizing text and sound. To avoid training and inferencing twice, authors use two layers of normalization on the phonetic encoding in the encoding phase and a pre-net obstacle in the decoding phase. Authors show the efficacy of MultiSpeech via tests using the VCTK and LibriTTS multi-speaker datasets. Compared to naive Transformer-based TTS, our system's ability to synthesis multi-speaker audio is greatly improved by training a FastSpeech model on top of the MultiSpeech model [26].

This research presents Face2Speech, a new kind of speech synthesis system that makes use of facial image predictions to create realistic speech. The system includes a voice encoder, a text-to-speech (TTS) module with several voices, and a face encoder. While the voice encoder creates an individual embedding vector for each speaker, the face encoder's captured facial picture is used in the multi-speaker TTS module's encoding process. Synthetic speech created from a face-derived encoding vector is equivalent to that generated from a speech-derived embedding vector, as shown by our matching and naturalness assessments [27].

Authors present a semi-supervised learning strategy for multi-speaker TTS. The proposed encoder-decoder system with discrete speech representation allows us to train a multi-speaker TTS model using raw audio alone, eliminating the requirement for transcriptions. A single hour of matched speech data from numerous speakers or a single person is sufficient for the suggested model to create understandable speech in a variety of voices, as shown by experimental findings. Even with noisy paired voice data, authors find that the suggested semi-supervised learning strategy still benefits the model. In addition, authors show how speaker characteristics affect semi-supervised TTS using paired data, which is a major focus of our study. [28].

As a solution, authors offer a framework for multi-speaker sound synthesis that makes use of deep Gaussian processes (DGPs), a complex structure of Bayesian kernel regressions that is resistant to overfitting. In our method, authors use speaker codes to provide information about the speakers to time and sound models. The potential of deep Gaussian process latent variable models (DGPLVMs) is also investigated. Our approach concurrently learns the representation of each speaker along with other model parameters to accurately capture speaker similarities and differences. Experiments were run with both balanced data from all speakers (speaker-balanced) and unbalanced data from select speakers (speaker-imbalanced) to see which strategy performed better. Both DGP and DGPLVM are shown to perform better than a standard DNN in synthesizing multi-speaker speech in a speaker-balanced situation,

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according to the assessment results. Authors also find that DGPLVM performs better than DGP [29] in the speaker-imbalanced situation.

Authors propose novel WaveNet-based multi-speaker sound synthesis frameworks that use a single conditional generative adversarial network (GAN) or its version, the Wasserstein One GAN with gradient penalty (WGAN-GP), to overcome this difficulty. WaveNet's acoustic model takes inputs from the GAN generator and uses them to calibrate local condition parameters. Authors add the discretized mixture of logistics (DML) cost from a well-trained WaveNet to the standard mean-squared-error (MSE) and adversarial-loss (ADL) components of GAN frameworks. Models trained with WGAN-GP with back-propagated DML losses show better accuracy and speaker similarity in subjective testing [30].

The results of pertaining to augmenting data for automatic speech recognition (ASR) systems, particularly in scenarios where resources are limited or moderate experiments reveal that our approach effectively narrows the gap between ASR models trained with synthesized speech and those trained with human speech. This achievement is noteworthy when compared to other methodologies that involve the use of multiple speakers for similar purposes. Moreover, our findings indicate the feasibility of achieving promising ASR training outcomes through our data augmentation method, even when employing only a single real speaker from the target language [31].

3 PROPOSED WORK

3.1 System Model

Deep learning has gained popularity in various natural language processing (NLP) applications, including sentiment analysis. However, these methods typically rely on large annotated corpora, which can be challenging to obtain, especially for languages with limited resources. In order to bridge this knowledge gap and address the scarcity of resources in sentiment analysis, we propose a novel deep multi-task multi-lingual approach. Our system leverages cross-lingual word embeddings to effectively align different languages in a shared semantic space. This enables the seamless exchange of information across languages, facilitating more accurate sentiment analysis even in resource-constrained environments..

3.2 Cross Lingual Word Embedding TTS

Most cross-lingual embedding models either utilize monolingual training models directly or extend existing multilingual word embedding methods to handle cross-lingual contexts. As a result, the foundational techniques used for monolingual word embeddings can be adapted to their respective cross-lingual counterparts. Recent research on cross-lingual anchoring models has revealed that the effectiveness of these models depends more on the choice of multilingual signals rather than the architecture itself.

Cross-lingual procedures can be categorized along two dimensions: comparability and alignment. Comparability refers to the availability of parallel data sources, such as literal translations or equivalent data across languages. Alignment level, on the other hand, is related to the level of supervision provided for bilingual data. Various types of alignment can be performed on bilingual data, including word and phrase alignment similar to machine translation, as well as document alignment.

In our study, we adopt a word-level mapping approach using parallel data to establish a bilingual setting. Furthermore, we aim to maximize the similarity between the source and target word embeddings while imposing the constraint of orthogonality. This constraint ensures that the target-to-source translations remain orthogonal. By employing this method, the computation process is facilitated and streamlined.

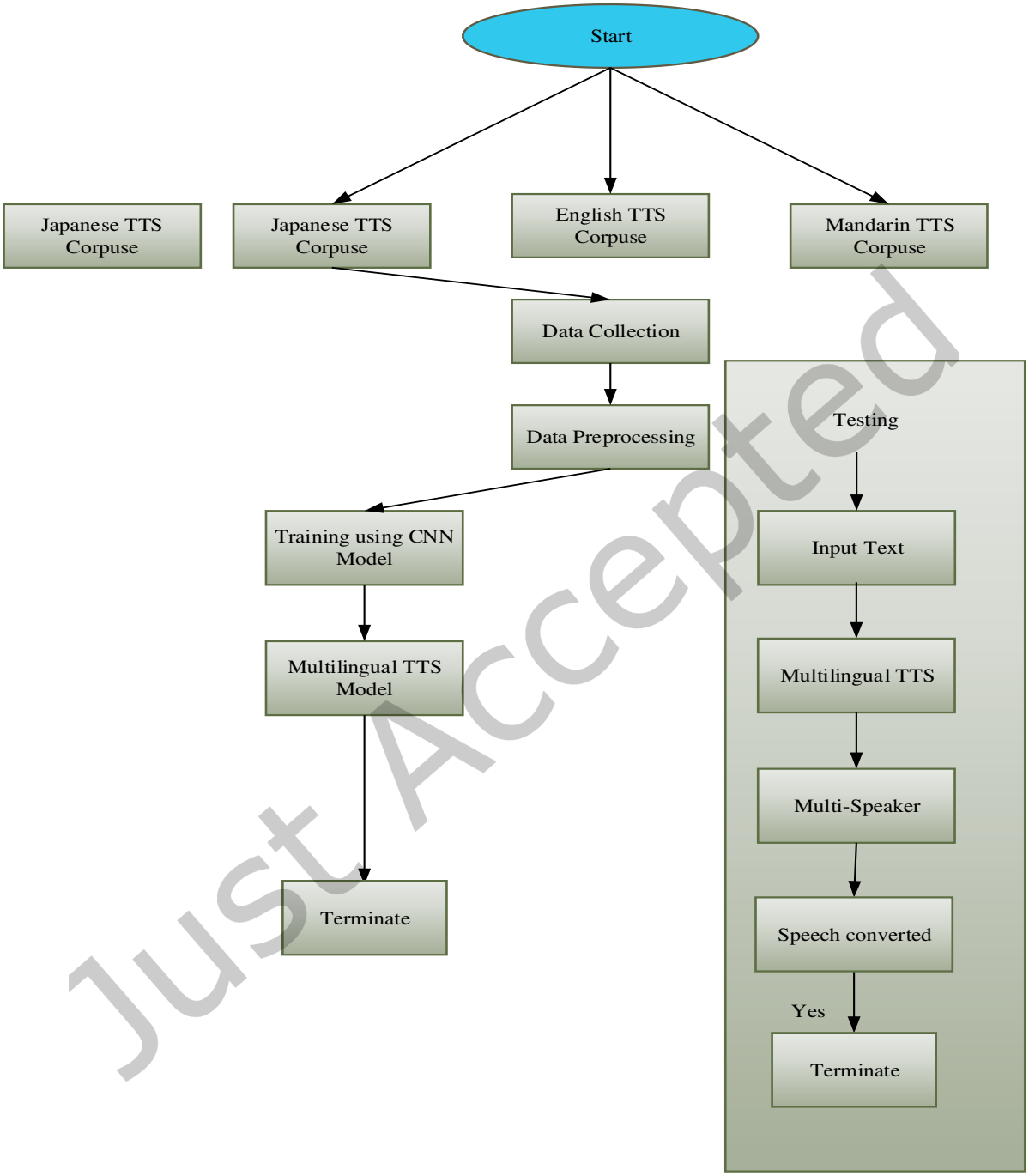
3.3 GAN Model for Data Augmentation

To address the issue of an unbalanced dataset, down sampling is performed to ensure a well-balanced training dataset. This step was taken to improve the model's performance, as the initial dataset distribution was unfavorable. It is expected that the Cross Lingual model will outperform other models, particularly in both low-resource and high-resource languages. By training the GAN Model with a Translation Language Modelling approach, the model can learn common representations across languages, enhancing its ability to perform well.

Data Augmentation (DA) Technique is a valuable approach that allows us to artificially increase the size of the training data by generating various versions of the existing datasets without the need for additional data collection. However, when applying data augmentation in Natural Language Processing (NLP), particularly for language-related tasks, it poses unique challenges compared to computer vision. Unlike images, where it is relatively easy to create augmented versions, language data augmentation is more complex due to the intricacies and context sensitivity of natural language.

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In NLP, we need to be cautious when replacing words with synonyms, as doing so may alter the context and meaning of the text. Therefore, direct word replacement is not always a suitable strategy. Nonetheless, data augmentation techniques are still valuable in NLP, as they help address issues of data scarcity and lack of diversity, ultimately improving the performance of classification tasks.



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Fig.2. Flowchart for Proposed Method

Data augmentation is a technique that increases the size of the training data, leading to improved model performance. Having more data generally results in better model performance. However, it is important to strike a balance with the augmented data's distribution. The augmented data should neither be too similar nor too different from the original data, as this can cause overfitting or poor model performance. Effective data augmentation approaches aim for a balanced distribution. There are several benefits of data augmentation

- **Cost reduction:** Data augmentation helps reduce the costs associated with collecting and labeling large amounts of data.

- **Improved prediction accuracy:** By increasing the size of the training data, data augmentation improves the model's ability to learn and make accurate predictions.
- **Prevention of data scarcity:** Data augmentation addresses the issue of insufficient data, ensuring that the model has enough varied examples to learn from.
- **Reduction of data overfitting:** By creating variability in the data, data augmentation helps prevent the model from overfitting to the training set, leading to better generalization to unseen data.
- **Enhanced generalization ability:** Data augmentation increases the model's ability to generalize its learned patterns to new and unseen data.
- **Addressing data imbalance:** Data augmentation techniques can be used to alleviate the problem of imbalanced classes in classification tasks, ensuring that the model is trained on diverse examples from each class.

The model in question utilizes a 2048 encoder, pooling layers, 12 hidden layers, and a dropout rate of 0.1. Its maximum supported vocabulary size is 30145. Since the dataset consists of code-mixed Tamil and English text, the model incorporates language embedding to handle both languages. Both the training and validation datasets were used to develop the model

To condition a mel-spectrogram generating network, the model utilizes the speech signal of the target speaker. This is achieved by extracting acoustic properties using the speaker encoder. The structure of the speaker encoder is inspired by GAN-TTS, which captures universal speech features irrespective of speaker or language. The convolution layers in this model use filters with sizes of 64, 128, 256, and 512. The Generation Block processes the preprocessed raw audio as input. Figure 2 illustrates the structure and flow of the speaker encoder within the model.

. To achieve temporal smoothing of activations over an extended duration, a temporal average layer is employed. The pooling layer extracts significant features, followed by an affine transformation. Through the affine transformation layer, the utterance-level representation is projected into a 256-dimensional embedding. To create a speaker embedding that encompasses both the speaker's characteristics and language nuances from the latent space, the output undergoes regularization using length normalization. This process ensures that the speaker embedding captures the desired traits while accounting for variations in utterance length.

Let’s first make a brief introduction to their structure that consists of two parts.

A data generator that is capable of learning to provide credible data. The generator component of the GAN architecture receives as input a random vector of a predetermined length, and its goal is to learn how to create samples that have distributions that are similar to those of the original dataset. After that, the samples that were created are sent through the discriminator's training process and utilized as examples of what not to do. The generator's goal is to trick the discriminator into thinking that the simulated instances are real ones by producing realistic samples that are accurate representations of the primary dataset.

A discriminator that is capable of learning to tell the difference between the generator's synthetic data and actual data. The discriminator part of the GAN system accepts a sample as its input and determines whether or not it is "real" (meaning that it was taken from the primary dataset) or "fake" (meaning that it was created by the generator). The discriminator is responsible for determining which samples are authentic and which ones are fraudulent, and providing input to the generator. If the generator produces samples that are impossible or unrealistic, it will be penalized by this feature, and those examples will be labeled as "fake." This adversarial process drives the generator to increase its ability to create samples that closely match the genuine data. The goal of this process is to fool the discriminator and limit the discriminator's capacity to differentiate between real and false samples.

- The generator wants to minimize $\log(1 - \mathrm{D}(\mathrm{G}(\mathrm{z})))$ where z is the element of randomness that is fed into the generator. The discriminator is fooled into thinking that the bogus samples are legitimate since the generator plays down the significance of this phrase.
- The discriminator wants to maximize $\log(\mathbf{D}(\mathbf{x_d})) + \log(\mathbf{1} - \mathbf{D}(\mathbf{G}(\mathbf{z})))$ where $\mathbf{x_d}$ These are representative examples taken from the initial dataset. This phrase refers to the chance of correctly labeling both the genuine examples and the samples that were generated by the algorithm.

The use of Generative Adversarial Networks (GANs) offers several advantages, including the ability to generate high-quality data and their versatility in addressing various problems. However, GANs also come with certain disadvantages and challenges. For instance, generating discrete data such as text can be challenging for GANs. GANs require extensive training and often demand significant computational resources. Similar to other Artificial Neural Networks (ANNs), GAN models can suffer from instability or overfitting issues.

In our GAN model, we employ the following parameters:

The activation function is Leaky ReLU, with a negative slope of 0.2.

- There will be five of each item in each batch.

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- The learning rate is now set at 0.0002 percent per second.
- A dropout algorithm is used in the generator, and its probability is set at 0.3.
- The loss function is represented here by the binary cross-entropy.
- The Adam algorithm is being used as the optimizer at this time.
- Our design does not include any layers that are used for convolution.

In the event that the generator has many layers, those layers are arranged with the larger ones coming first, but in the discriminator, the layers are arranged with the smaller ones coming first. Dropout is a widely employed regularization technique within neural networks, particularly in the realm of deep learning, aimed at mitigating overfitting. Its core concept revolves around the random deactivation, or "dropout," of a specific proportion of neurons during each training iteration. This strategic process bolsters model robustness by reducing its dependence on specific neurons, ultimately enhancing its ability to generalize to previously unseen data.

The Adam algorithm, an abbreviation for Adaptive Moment Estimation, stands as a widely employed optimization technique frequently employed in the training of both machine learning and deep learning models. Distinguished for its efficiency, speed, and commendable performance across a diverse spectrum of tasks, Adam amalgamates the strengths of two other optimization algorithms, namely AdaGrad and RMSprop.

Before fine-tuning the entire model using triplet loss, which maps sound into a feature space where distances reflect speaker similarity, we initially train the speaker anchoring network independently on a speaker authentication task using softmax loss. The triplet loss requires three examples: an anchor, a positive example, and a negative example. During training, the model utilizes pairs of speaker embeddings to increase the cosine similarities between embeddings from the same speaker and decrease the cosine similarities between embeddings from different speakers. In essence, this process helps the model learn to distinguish between speakers based on their embeddings.

$$Loss = \sum_{i=1}^{N} \left[\| f_i^a - f_i^P \|_2^2 - \| f_i^a - f_i^n \|_2^2 + \alpha \right]_+ \quad (1)$$

where f_i^a, f_i^p and f_i^p are the embedded anchor, positive, and negative speakers, $\alpha \geq 0$ is a constant.

Through training the model on data from multiple languages, we enable a two-step cross-lingual reasoning process. Initially, the model generates the voice of a native speaker in the target language, followed by converting that voice to match the target speaker. The evaluation results indicate that, on average, our technique enhances the intelligibility of the generated output compared to the baseline. Furthermore, it suggests that our approach might also improve the pronunciation of cross-lingual output. Notably, the same model demonstrates its efficacy even in low-resource scenarios, requiring only a single training procedure. This is achieved despite the inclusion of speakers in the training set with an average speech duration of 7.5 minutes.

3.4 CNN-Bi_LSTM Model for TTS

The key component of our model that is responsible for categorization is known as an attention-based bidirectional long short-term memory (Bi-LSTM). Though the Convolutional Neural Network (CNN) may minimize the number of characteristics that are input in order to make more accurate predictions, it does not address the connection that each word has with the final classification in the same way. In order to make the most of the capabilities offered by both the models, the authors of this work make use of Bi-LSTM to encode long-distance word relationships in a more efficient manner.

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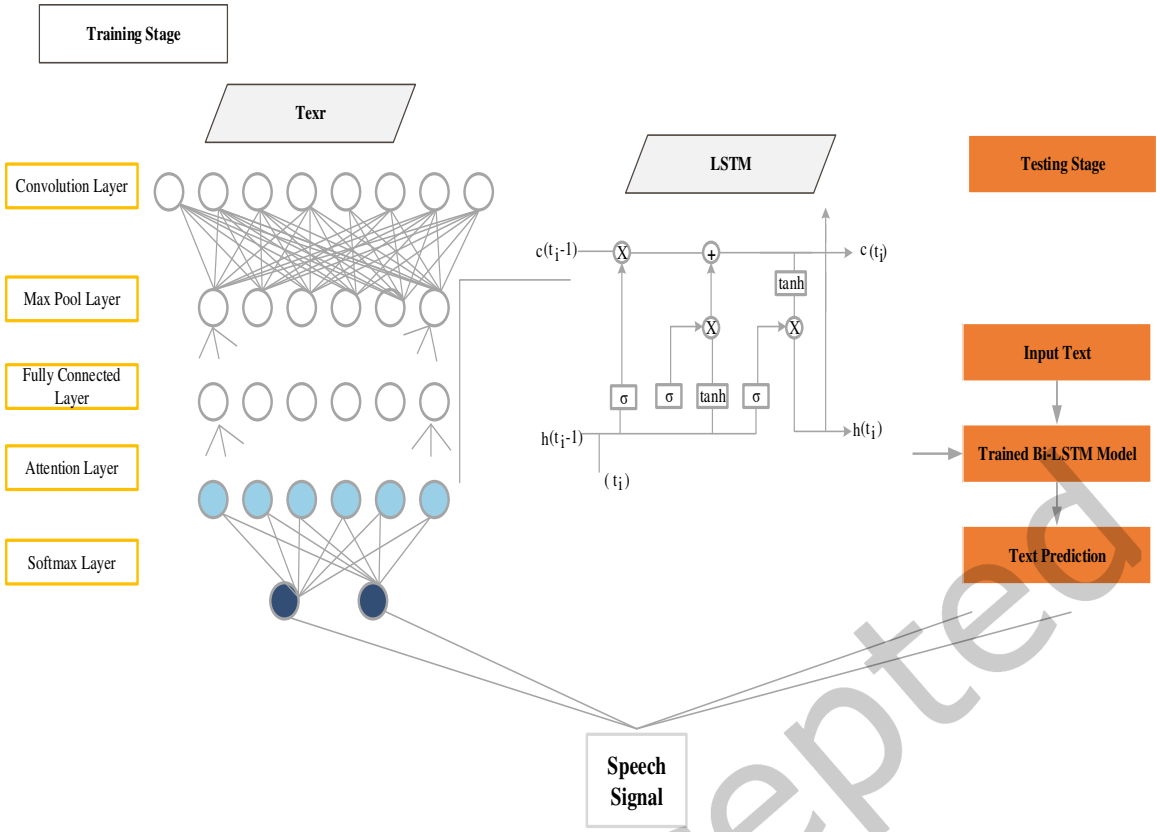


Fig.3. TTS using CNN with Bi-LSTM

Figure 4 is an illustration of the Bi-LSTM method, which depicts how it takes the features created by the CNN stage as input and uses those features to extract features from the final hidden layer. The Bi-LSTM is able to generate two separate textual representations due to the fact that it takes into account both the prior and following contextual information. After having been acquired through CNN_ij, the aforementioned characteristics are subsequently introduced into a Bi-LSTM model in order to provide a sequence representation. The resulting feature representation is then put through an attention layer, which identifies the strongly associated characteristics that will be used for the classification in its entirety.

Take, for instance, the line "Though he is sick, he is happy," which has to be categorized as having a positive mood. "Though he is sick, he is happy" According to the attention technique, the word "happy" is given more weight than the word "sick," showing that the feeling of "happy" is unaffected by the incidence of sickness. The accuracy of predictions may be greatly improved with this attention strategy, and the amount of learnable weights that are necessary for prediction can be reduced. In the context of the model that we have developed, we make use of the Bahdanau attention approach, with attention scores being calculated as follows:

$$\text{score}(querry, key) = V^{\text{T}} \tanh\left(W_{1key} + W_{2query}\right) \quad (2)$$

4 RESULTS & DISCUSSION

In this part of the article, we will discuss the experiments that were carried out in order to evaluate how well the suggested model works. The outcomes of the experiments are analyzed and compared to the most advanced deep learning models that are currently available. Both the number of epochs and the size of the data set were used as independent variables in two separate trials. The following text describes the experimental conditions, data utilized in the experiment, and assessment techniques.

The following is a concise summary of the datasets that were employed in the experiment that we carried out. Following this, the proposed model is disassembled into its component elements, and a variety of different training strategies are presented. At long last, the outcome of the subjective evaluation has been disclosed.

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In order to produce our dataset, we collect four speech corpora in their respective languages from both internal and external sources. The information shown in Table 1 reveals that the dataset contains multi-speaker transcripts in the languages of Mandarin Chinese (ZH), English (EN), Korean (KO), Japanese (JA)and . The frequency of audio files is resampled to 22.05 kHz after the process. Because we have a grapheme-to-phoneme converter in-house, we are able to translate speech transcripts into a string of phonemes. A validation set that excludes 5% of the total phrases is considered complete.

Table 1: Language-specific information about our dataset

Language	EN	KO	JA	ZH	Total
Quantity of speakers	1622	28	111	175	473
Length	72.4hr	43.5hr	27.5hr	60.0hr	203.4hr

Additionally, we performed data augmentation on the selected 30 minutes of multi-speaker speech data, generating approximately 15 hours of augmented target language data. This augmentation involved altering the pitch and speed of the original speech. The pitch shift was conducted in increments of 0.5 semitones, ranging from -2.5 to 2.5 semitones. The speed ratio of the augmented speech compared to the original speech ranged from 0.7 to 1.55 times the original speed, in steps of 0.05. This resulted in 27 variations of each target language utterance.

During the training process, we utilized two NVIDIA A100 GPUs and trained our framework for 200 iterations. The batch size for mixed-precision training was set to 64. The speaker classifying loss in DAT [20] was weighted according to a sequence of scale factors, following the prescribed method.

$$\lambda = \frac{2}{1+\exp(-10 \cdot p)} - 1 \qquad (3)$$

W

The factor p, which ranges from 0 to 1 in a linear manner, is used to determine the loss scale factor during training. Initially set to 0, it gradually increases as the number of training iterations progresses. This schedule helps to mitigate DAT (Discrete Anomaly Training) in the early stages of training and improves the quality of the generated outputs.

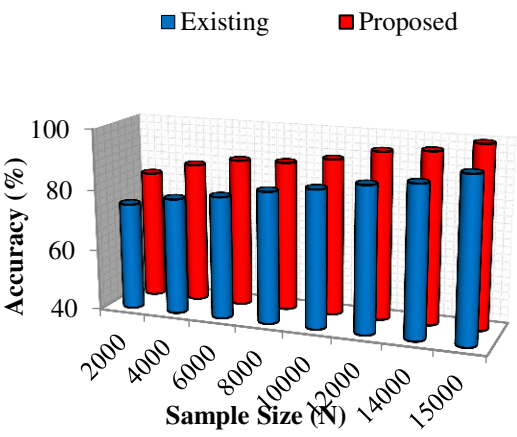
To demonstrate the high-quality statements generated by GAN-TTS during cross-lingual inference, we compare it to an official open-sourced version of a separate multilingual TTS model. The meta-education model is trained with a batch size of 64 for up to 100 iterations, using the Griffin-Lim vocoding method included in the official implementation.

We evaluate GAN-TTS by comparing it to models where a single tweak has been removed. Specifically, we remove the use of DAT, include speaker regularization loss, and switch from SDP (Soft Dynamic Programming) to DDP (Dynamic Duration Prediction). During cross-lingual inference, we input the speaker embedding into the duration predictor after removing the speaker regularization loss. For the international TTS model to function, we do not make any adjustments to the language embedding.

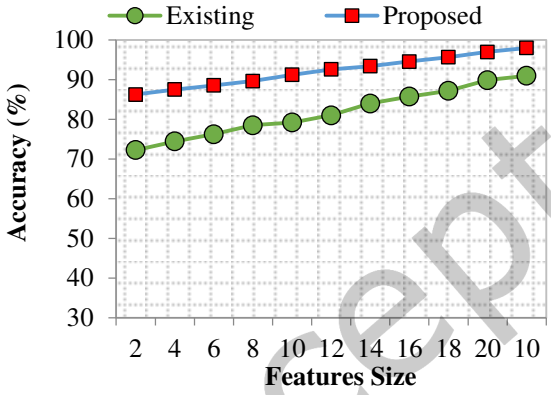
To assess the resemblance of the speaker and the naturalness of the utterances, we use mean opinion scores (MOS) with 95% confidence intervals. The MOS assessment employs an absolute subcategory rating system, where performances are rated on a scale from 1 to 5 with 1-point increments. We collect opinion ratings on English speech from native English speakers, as it is challenging to find native experts for evaluating non-English target languages. Each individual utterance and speech pair is evaluated by a total of five raters. Speaker similarity is determined by comparing synthetic speech to actual speech by the same speaker from the validation set. To establish ground truth, two speeches by the same speaker from the validation set are compared by human raters to assess their similarity. Thirty phrases from the English validation set are randomly chosen as evaluation speech samples. Additionally, we test the intra-lingual and cross-lingual synthesis ability by selecting five male and five female speakers from each of the four languages, resulting in over 1200 different combinations of voices and phrases being synthesized.

Based on the performance metrics of the model, sentiment analysis of code-mixed Tamil-English text still has room for improvement. If the output is affected by an imbalanced dataset, up-sampling procedures can be employed to rectify it instead of down-sampling. The misclassification of text using the test dataset may be attributed to the loss of certain critical characteristics due to down-sampling. Considering that the retrieved YouTube postings may contain symbols and abbreviations, preprocessing the data is as crucial as up-sampling the system.

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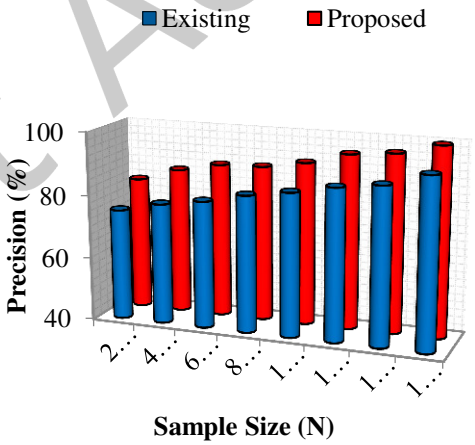


(a)



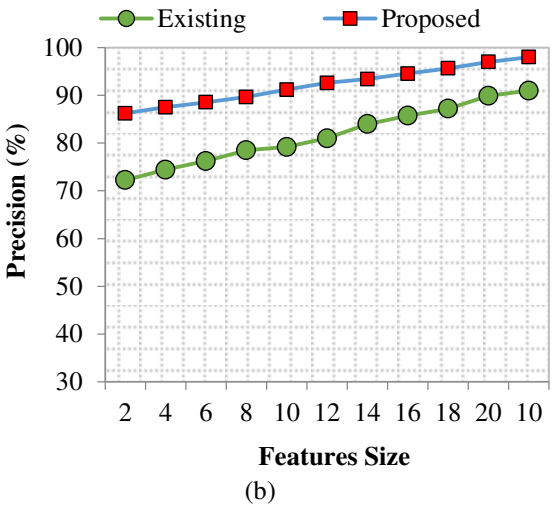
(b)

Fig.4. Accuracy (a). Sample Size, and (b). Feature Size



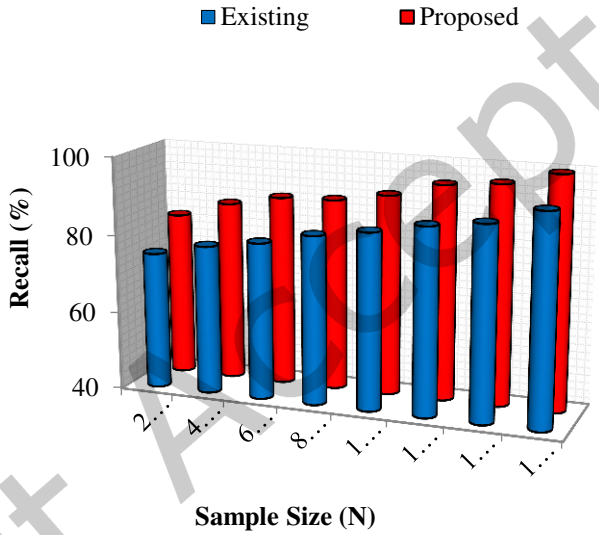
(a)

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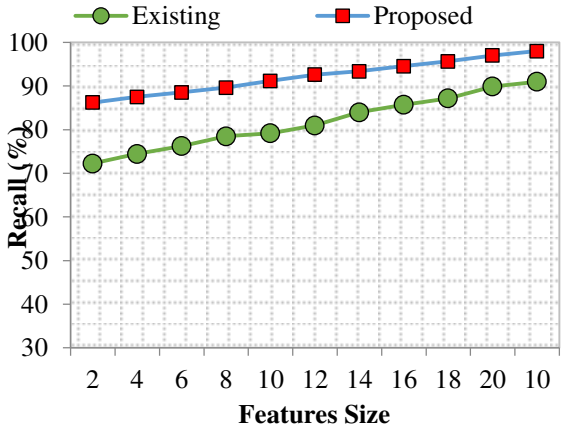


(b)

Fig.5. Precision (a). Sample Size, and (b). Feature Size



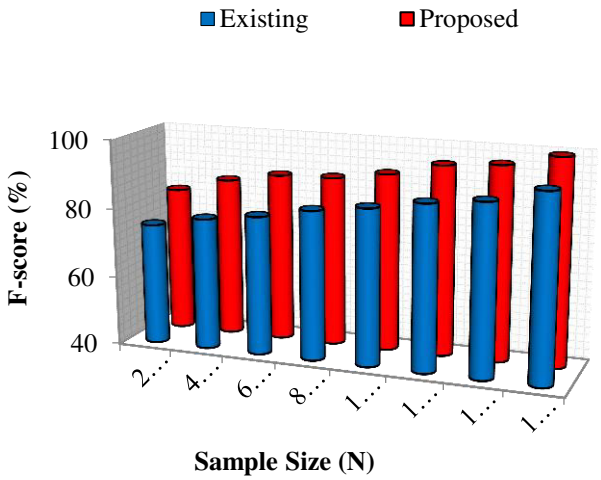
(a)



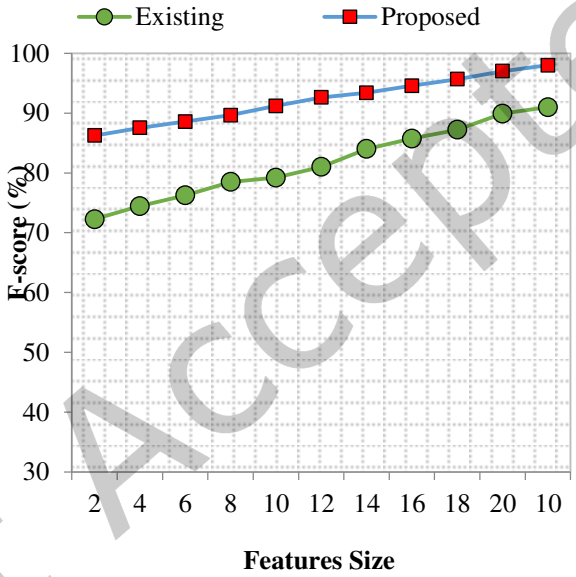
(b)

Fig.6. Recall (a). Sample Size, and (b). Feature Size

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(a)



(b)

Fig.7. F-score (a). Sample Size, and (b). Feature Size

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The observations from the experiments can be summarized as follows:

Data Augmentation Benefit: The model showed significantly lower loss when data augmentation techniques were applied. This suggests that data augmentation was effective in improving the accuracy of estimating acoustic features. By generating additional augmented data, the model had access to a larger and more diverse training set, allowing it to capture a wider range of acoustic variations.

Improved Generalization: In the case of data augmentation, there was a notable reduction in the gap between the training and validation losses compared to the case without augmentation. This indicates that the model's generalization performance was enhanced. The model consistently provided accurate estimation results not only for the training data it had seen but also for unseen data in the validation set. The narrower gap suggests that the model learned more robust and generalizable representations, resulting in better performance on unseen data.

These observations highlight the benefits of data augmentation in improving the accuracy of acoustic feature estimation and enhancing the model's ability to generalize to unseen data. By leveraging augmented data, the model gained a broader understanding of the acoustic variations, leading to more reliable and consistent estimation results.

5 CONCLUSION

In this study, we introduce GAN-TTS, an end-to-end multilingual TTS model that produces natural and human-like speech. Due to the limited availability of multilingual speech data for training, we employ a data augmentation approach to enhance the training corpus. One of the challenges in developing multilingual TTS models is accurately predicting speech in languages other than the target speaker's native language. To address this challenge, we incorporate a speaker regularization loss, allowing the model to learn speaker representations in a language-agnostic manner. This approach enables the model to handle multilingual synthesis effectively.

Furthermore, it is ensured that the model generates consistent phoneme durations regardless of speaker identity by substituting a zero vector for the speaker embedding during cross-lingual duration prediction. Additionally, leveraging DAT (Disentangled Acoustic Representations) and language embeddings, which are commonly used techniques in TTS models. GAN-TTS successfully produced high-quality audio samples in bilingual setups involving languages such as English, Korean, Japanese, and Mandarin Chinese. It achieves high speaker similarity in both cross-lingual and intra-lingual synthesis.

By demonstrating the effectiveness of GAN-TTS in languages beyond English, our research paves the way for future advancements in utilizing GAN-TTS for a wide range of languages, expanding its application and impact in the field of multilingual TTS synthesis.

Authors Contribution: Each author contributed equally in each part.

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ETHICAL APPROVAL:

This article does not contain any studies with human participant and Animals performed by author.

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Article

Prediction of Battery Remaining Useful Life Using Machine Learning Algorithms

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Abstract: Electrified transportation systems are emerging quickly worldwide, helping to diminish carbon gas emissions and paving the way for the reduction of global warming possessions. Battery remaining useful life (RUL) prediction is gaining attention in real world applications to tone down maintenance expenses and improve system reliability and efficiency. RUL forms the prominent component of fault analysis forecast and health management when the equipment operation life cycle is considered. The uprightness of RUL prediction is vital in providing the effectiveness of electric batteries and reducing the chance of battery illness. In assessing battery performance, the existing prediction approaches are unsatisfactory even though the battery operational parameters are well tabulated. In addition, battery management has an important contribution to several sustainable development goals, such as Clean and Affordable Energy (SDG 7), and Climate Action (SDG 13). The current work attempts to increase the prediction accuracy and robustness with selected machine learning algorithms. A Real battery life cycle data set from the Hawaii National Energy Institute (HNEI) is used to evaluate accuracy estimation using selected machine learning algorithms and is validated in Google Co-laboratory using Python. Evaluated error metrics such as Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), R-Squared, and execution time are computed for different L methods and relevant inferences are presented which highlight the potential of battery RUL prediction close to the most accurate values.

Keywords: HNEI battery; machine learning algorithms; heat map; Mean Squared Error; Mean Absolute Error; Root Mean Squared Error; R-Squared Error

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1. Introduction

One of the major challenges facing society today is reducing greenhouse gas emissions Which has prompted the industry's top producers to promote the progress of electric vehicles (EVs). Since the majority of end user electronics are motorized by battery-like technology, and the use of renewable energy sources to generate electricity is expanding quickly, energy storage has emerged as one of the key sectors. Due to their high energy density and lengthy cyclical and calendrical lifetime, lithium-ion batteries (LIBs), which are efficient energy storage systems, have assumed a leading position in powering EVs. RUL is the required amount of time, which is commonly calculated using the numerical subsequent charge–discharge cycles, from the active profile point to the end of a battery's life. A battery's lifespan ends when its remaining capacity reaches 70–80% of its initial value, according to a widely accepted generalization. RUL is a well-liked research area in the realm of electric battery research because it has an obvious significance for the assessment of the safety of batteries. The length of time a machine or asset is liable to function before needing repair or substituent is known as the remaining useful life (RUL). In addition, it is important to highlight that good management and prediction

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of battery use can significantly contribute to improving the efficiency and sustainability of energy storage systems, promoting the adoption of clean energy, reducing emissions, and encouraging innovation and collaboration [1]. In this way, its contribution to several sustainable development goals is interesting, including, for example, Clean and Affordable Energy (SDG 7), and Climate Action (SDG 13) [2]. The Battery RUL problem is directly related to SDG 7 by supporting the development and deployment of affordable, reliable, and clean energy solutions. In systems relying on batteries, knowing the remaining useful life allows for efficient planning and operation. By optimizing the use of batteries and extending their useful life, we can enhance the sustainability of energy systems, promote renewable energy adoption, and work toward the achievement of SDG 7's targets for universal access to clean and affordable energy [3]. In the same vein, solving the Battery RUL problem contributes to SDG 13 by supporting efforts to combat climate change, promote renewable energy, reduce greenhouse gas emissions, and enhance resilience in the face of climate-related challenges. By extending the useful life of batteries and optimizing their use, we can minimize the environmental and economic impact of battery-related activities and contribute to a more sustainable and climate-resilient future [4].

The time period may be expressed in terms of days, miles, cycles, or any other number, depending on the system you are using. RUL prediction offers early failure alerts and has evolved into a crucial part of system prognostics and health management. Figure 1 shows deterioration of a machine over time.

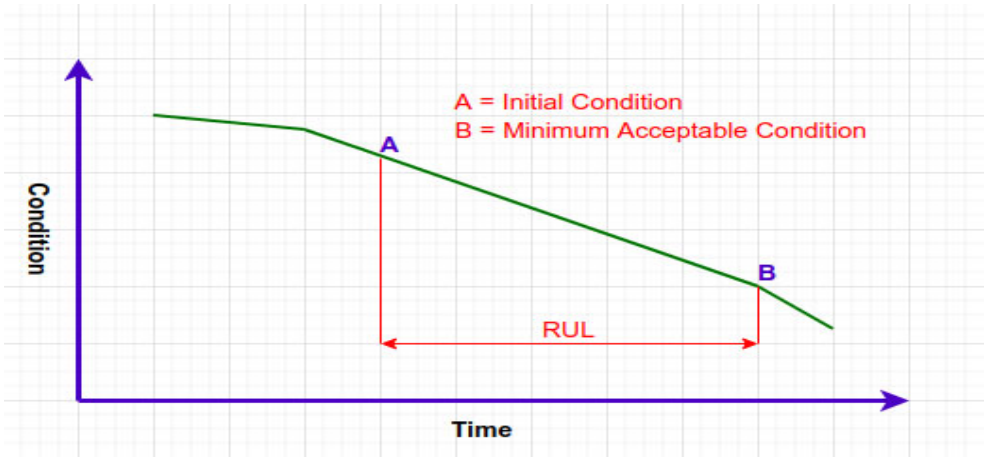


Figure 1. Prediction of RUL.

This picture illustrates how a machine degrades over time. Remaining useful life is calculated as the interval between these two points if A is the current condition and B is the minimal condition beyond which the machine will fail. RUL can be replaced or maintained to prevent unforeseen downtime and financial losses if it is forecast in advance. It is crucial to estimate RUL precisely because it is essential for operations and decision-making. The study of the most precise RUL calculation has recently gained popularity due to the swift advancement of situation and health tracking technology. In the most recent modelling trends for figuring out the RUL the examination places a strong emphasis on statistical methods that are fact-driven and use the finest readily available historical determined records and statistical models.

The different procedures that have been suggested and put into exercise to simulate the degradation of these complex systems have led to the evolution of two techniques: entirely model-based techniques and information-driven techniques. Due to the model's complexity, its universality is also limited and usually impossible to attain. As a result, the generalization impact cannot be determined. The kinetics of SEI generation and solvent transportation are considered in a one-dimensional model to examine possible decline in lithium-ion batteries. This work advises analyzing potential fade at various cyclic

charge–discharge settings within a lithium-ion electrochemical pseudo-dimensional (P2D) battery version.

The model exhibits a stronger relationship between battery performance and electrolyte chemical characteristics by combining porosity exchange with electrolyte partial molar concentration [3]. The changing modern pricing and cut-off voltages are expected to cause fluctuations in the stable electrolyte interface (SEI) layer. The results show that the porosity version and convective heat switch coefficient have a substantial impact on the SEI layer development and battery life.

The semi-empirical cycle aging model for an LFP-based fully cylindrical cell presented here has been improved as a result of better knowledge of aging phenomena under the effect of DOD and Ah-throughput variables [4]. It is based on ability loss and is the primary LLI degradation technique since it takes into account both internal resistance aging and capacity loss. A Thevenin version has been described with a single RC branch and constant values for all model parameters. In this work, parameters of similar circuit models that account for battery aging and qualities for resistance aging, as well as several internal battery capabilities are included [5].

A substitute is used for random initialization, a prediction model with LSTM is initialized, and the system parameters are optimized based on test temperature and test dates, which presents an 89.18% average accuracy [6]. A comparison has been drawn between Naïve Bayes (NB) and Support Vector Machine (SVM): where NB is employed, the RUL of Li-ion batteries exhibit stable and better competitive prediction performance than SVM under constant discharge conditions [7].

A probabilistic-based adaptive estimator is used with caution for both SOE and SOC estimation using neural networks and information-pushed methodology, and accurate battery models are examined [8]. The voltage prediction effects that may be more accurate for the SOC calculation are provided by an electrochemical model and an n ordered RC equal circuit model. For SOE estimation, the relationship between the terminal voltage and the model input is often examined using a sliding window neural network model. The results demonstrate that the proposed voltage mistakes and records pushed neural network models can produce accurate version predictions.

A weighted least squares assist vector device is used for online estimation of the SOH of 2D-use lithium-ion batteries. The suggested method has been tested on a variety of 2D-use lithium-ion battery data units under various environmental conditions and battery types [9]. The results of the application show that, in comparison to the totally BPNN-based technique and the totally GPR-based approaches, the SOH accuracy anticipated via the totally WLSSVM-based approach is the best because the suggested approach has a higher ideal for nonlinear conditions with much less educational information. Battery terminal voltage characteristics during the charge process for RUL prediction has been considered Importance Sampling which has been employed in combination with a Feed Forward Neural Network [10].

In ref. [11] the author worked on a fusion of 3-D CNN and 2-D CNN which yielded a 1.1% test error for battery cycle life and a 36% test error for RUL prediction. The design and development of a lithium-ion cell version battery management system may also be used to execute state machines for charge and discharge current limit calculations, fault management, contactor management, and other duties [12]. The simulation model for designing and testing these methodologies includes Li-ion battery cell parameter estimation, battery packs with 6 and 96 cells, test documents with check cases to confirm state machine logic and linking requirements to models. Bayesian methodology is a probabilistic method for forecasting the RUL of a battery. When we initially offer a framework for feature extraction, we use the RUL estimation model to apply Bayesian inference of linear regression [13].

The lithium battery deterioration model and its RUL can both be accommodated by an integrated mastering approach that is entirely based on tracking records [14]. The relevance vector device (RVM), the random woodland (RF), the elastic net (EN), the autoregressive model (AR), and the lengthy quick-time period memory (LSTM) community are the five

fundamental rookies used by the ensemble learning approach, which aims to improve prediction performance [15]. Remaining useful life (RUL) estimation of drilling pumps and critical components in fossil energy production is carried out with deep feature learning technique that uses a Convolutional Neural Network (CNN), Convolutional Block Attention Module (CBAM) [16].

Rechargeable battery systems with attractive potential for commercial applications are emerging as alternatives to traditional lithium-ion batteries (LIBs). They offer the promise of higher theoretical energy density and lower production costs compared to LIBs. However, despite their potential, these emerging lithium-sulfur Batteries (LSBs) continue to face persistent challenges that hinder their widespread industrial adoption. These issues include the inevitable dissolution of lithium polysulfide intermediates during electrochemical reactions and significant volume expansion, sometimes reaching up to 80%, upon the formation of Li_2S. These challenges result in severe limitations on battery lifespan and safety [17].

In this comprehensive review [18], an overview of the theoretical and experimental advancements in Ge-based monoelemental and binary two-dimensional (2D) materials is presented and encompasses various aspects, including crystal structures, as well as electronic, mechanical, thermal, optical, and photoelectric properties. Furthermore, we delve into the potential applications of these materials across a wide spectrum, including field-effect transistors, photodetectors, optical devices, catalysts, energy storage devices, solar cells, thermoelectric devices, sensors, biomedical materials, and spintronic devices.

Effective monomer design can lead to the creation of a sulfur-containing polymer with advantageous characteristics. These properties encompass ion and electron conductivity, high sulfur content, suitable viscosity, processability, and controllable morphology. These attributes hold significant promise for application in the cathodes of Li-S batteries, facilitating high capacity and consistent discharge even at elevated rates. This review provides a concise overview of the latest advancements in cathode materials based on sulfur-containing polymers [19].

The introduction of lithium iodide (LiI) as a Lewis basic salt serves to prevent the interaction between LiTFSI and the MoS_2 electrocatalyst, thereby inhibiting the formation of a surface gel layer. This electron-deficient center, induced by the trifluoromethanesulfonyl group in LiTFSI interacting with the Lewis acidic sites on MoS_2, triggers the cationic polymerization of the 1,3-dioxolane solvent and leads to a reduction in electrocatalytic activity. As a result of this modification, Li-S batteries incorporating the MoS_2 electrocatalyst and the LiI additive achieve an exceptionally high actual energy density of 416 W h kg^{-1} demonstrated at the pouch cell level [20].

Despite the notable theoretical energy density associated with lithium-sulfur (Li-S) batteries, they grapple with practical challenges, notably sluggish conversion kinetics and the notorious shuttle effect of polysulfides. In response to these challenges, a novel approach has been introduced involving a nitrogen-doped continuous porous carbon (CPC) host that firmly anchors monodispersed sub-10 nm FeS_2 nanoclusters, referred to as CPC@FeS_2. This innovative host exhibits a robust capability for adsorbing polysulfides, holding the promise of mitigating the polysulfide shuttle effect and enhancing the initial stages of the catalytic conversion process [21].

The other sections of this paper are prepared as follows: Section 2 explains the recent relevant works based on model-dependent and data-driven methods. Section 3 presents the pre-requisites of the data set, ML Algorithms, and Problem formulation. Section 4 presents Proposed Methodology of ML Methods for RUL Prediction and estimation of Performance error indices. Section 5 shows the results of our proposed method and discussion. Finally, Section 6 offers a conclusion and directions for future work.

2. Literature Review

To predict the RUL of lithium-ion batteries, completely version-based and statistics-driven techniques are frequently used. Primarily version-based procedures frequently make use of an extension of algebraic, differential, and empirical equations. Records-driven algorithms estimate battery RUL in the realm of mathematical fashions by utilizing latent mappings between inputs and outputs, hidden correlations between developments or features, hidden correlations between qualities and skills, and so on [22]. Several approaches for estimating lithium-ion battery RUL are currently linked. RUL prediction algorithms are classified into three categories: entirely version-based, facts-driven, and hybrid. Figure 2 depicts a thorough evaluation of the RUL prediction methods. The completely version-based approach makes use of modelling that is generally based on physics to enlarge the degradation and an empirical version to disclose how a linked item declines with time. Statistic-driven styles, on the other hand, embellish the degrading version to expand packages using ML approaches and historical statistics. In order to incorporate the respective advantages of the two models, hybrid-based solutions are finally developed.

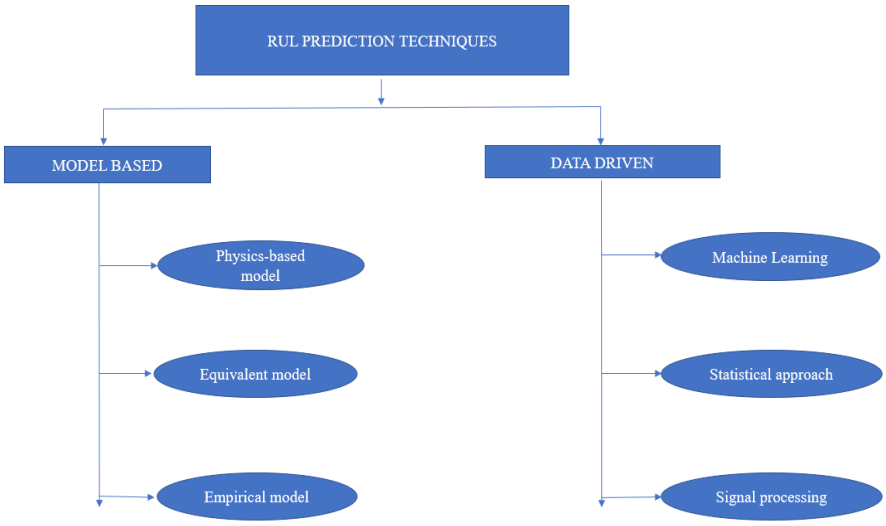


Figure 2. Classification of various RUL prediction methods for lithium-ion battery.

(A) Model Dependent Methods

Algebraic and empirical equations, linked elements, and mathematical models make up the model-based techniques. They also include a significant amount of empirical data gathering via experimentation. A physics or regression model can be used to create the battery's deterioration behavior, and the results can then be extrapolated to estimate battery performance.

(A.1) Physics-based model

The physical and electrochemical phenomena that take place inside the battery serve as the foundation of the physics model. The electrode porosity and reaction kinetics theories are used to create the physics model for RUL prediction. The physical and chemical processes, as well as calculating battery states like SOC and SOH, may also be better understood by using the physics model. The pros and cons of using dynamic models for the operation and diagnosis of Li-ion batteries are discussed in [23]. The summary of models and dynamics is succinct but clear, and it also looks at the necessary advancements for the field's future. The fundamental processes, including their dynamics, parameters, and time, must be understood in order to determine battery diagnostics and operation constants. Compared to other model-based methodologies, the accuracy of physics models is relatively poor [24]. The demand for batteries is rising as new energy electric vehicles

and smart grids emerge quickly. An essential component of a system using batteries for energy storage is the battery management system (BMS). The state estimation approaches are evaluated in terms of ultimate potential and power estimation, strength functioning prediction, lifespan and health forecasting, and other important indicators in BMS.

(A.2) Equivalent circuit model

The equivalent circuit model (ECM), which stands based on knowledge of the physical and chemical processes involved in popular battery production, has been developed. It is entirely predicated on the idea that different electrical element combinations can result in outcomes that are electrically comparable to those of a battery. Consequently, a mathematical model can be developed using circuit assessment techniques. Additionally, the employment of ECM results in the simulation of several significant characteristics, such as the production of power, electricity, and heat under challenging operating conditions [25]. As the SEI movie layer matures, it has been seen that the battery's internal resistance continuously rises. Additionally, the electrochemical impedance spectroscopy (ECM) characteristics may be seen using EIS datasets, and RUL can be predicted using a regression model. One of the most important metrics for assessing the health of lithium-ion batteries is the electrochemical impedance spectrum (EIS). Ref. [26] outlines a method for online implementation that determines the EIS of lithium-ion batteries using a fractional-order equal circuit model (FOECM). The parameters of the fractional-order model are first generated based on measurements of current and voltage using a fractional-order kingdom variable clean out and the recursive least-squares approach. The parameters that were gathered are then used to construct the battery's expected EIS under various ageing scenarios. The regression version of the estimated EIS spectrum is then utilized to show how the battery is deteriorating in terms of the rise in internal resistance. Finally, compared to tests applicable to current FOECM-based regression models, the enhanced regression model is successfully applied in the context of particle filtering to predict the battery's final usable lifetime (RUL).

(A.3) Empirical model

The foundation of the empirical model is built by looking at the association between a wide range of factual aspects. Several battery degradation traits are included in the empirical model for RUL prediction. Empirical models can predict degradation trends using empirical formulas or exceptional regression models to represent degradation behavior. In [27], a framework for RUL prediction based on a logarithmic variant was established, proving its superiority over conventional empirical models. It is important to carefully choose version settings related to scalar quantities to prevent the introduction of complex values for expected ability. A two-term logarithmic variant was built to reflect the 2-segment nonlinear concave degradation of cylindrical-type Li-ion batteries. The proposed design accurately captured the inflection factor of the two-section concave deterioration. Reference [28] recommended a dual EKF (DEKF) based entirely on the Thevenin model for estimating battery kingdom. When a primary-order Taylor expression was employed for country estimate, the DEFK was used to convert a non-linear state and statement expression hooked on a linear feature. The empirical model remains a non-linear system, therefore conventional KF remains appropriate. The equivalent circuit version is constructed from basic circuit components, and the modelling process is challenging. The form acts as a real replacement for the outside function switch of battery charge and discharge. The comparable circuit version's parameter identification is rather straightforward; as a result, it is frequently used. As a result, we created the second-order Thevenin equal circuit version as well as the RC version.

(B) Data-driven-based Techniques for RUL Prediction

Utilizing past data, data-driven context predicts the rate of battery degeneration. At this time, it is still unclear how data-driven models function and propagate. Without using physics-based methods, the weight limitations in the data-driven mathematical context are determined using the training data. Recently, the flexibility and applicability of data

driven models have attracted attention on a worldwide scale. Three categories can be made to classify the RUL estimation techniques created with data-driven methods: machine learning (ML), statistical methods, and signal processing.

(B.1) Machine learning (ML)

RUL can be predicted using model-based, statistics-driven, or hybrid strategies using historical data or direct statistics extraction. Developing version-based strategies in complex devices is particularly challenging, expensive, and time-consuming because it calls for a great deal of skill outside of the realm of machine learning, because data-driven tactics mainly rely on machine learning (ML) techniques.

The component's maximum useful life (MUL) is one of the most significant indicators of expected failure. The studies on RUL prediction using ML approaches are described in [29]. It is difficult, expensive, and time-consuming to develop totally version-based procedures in complex equipment since it requires extensive outside device expertise. Statistics-driven techniques had been heavily reliant on machine learning (ML) procedures.

Machine learning is employed in [30] to predict battery cycle life and early pleasant class throughout manufacture. Information-driven machine learning algorithms have been used to forecast and classify the early success of battery manufacture. The predictive power of linear regression models and artificial neural networks (ANNs) were investigated using a variety of datasets. However, the linear regression shows an equivalent look at errors of about 13% when only a few enter features are used. The focus of the RUL prediction investigation was on three top-ranked regions [31]. The first entails compiling battery data using publicly and commercially available Li-ion battery data sets. The second part of the section involves estimating battery statuses using a battery management system [32]. The symbolic regression machine learning algorithm was used to anticipate the final useful existence of these batteries. A single methodology for batch categorization, unit utilization, and battery recycling is provided by the information-pushed device mastery method used to anticipate strong state battery life. Offline training and online correction of data driven models for RUL prediction has been worked and the author inferred that a reduction of 40% in Root Mean Square Error and 34% in mean uncertainty calibration error is achieved with the augmented model [33].

(B.2) Statistical approach

The method of building a model for RUL prediction is statistical. A capacity deterioration model was created using data from earlier measurements. The application of statistical modelling is straightforward and precise. In the subsections below, a few of the statistical techniques utilized for RUL prediction are displayed.

(a) Autoregressive integrated moving average (ARIMA) technique

For battery RUL estimation, the ARIMA typical mostly substitutes the Autoregressive version due to the predominance of underfitting at some point in version schooling. To alleviate the problems associated with underfitting, ARIMA combines a shifting common approach with an autoregressive model. A novel hybrid Elman-LSTM approach for estimating the amount of usable existence that a battery has left was developed using Elman neural networks, long and short-term memory, and empirical model decomposition. This method is made available by way of [34]. The recorded battery potential versus cycle number data is broken down into several sub-layers using the empirical version decomposition set of rules. Then, utilizing Elman neural networks and recurrent long and short-term memory, high- and occasional-frequency sub-layer forecasting is performed. Large battery test datasets were used to parameterize the models and assess their performance. The appropriate HI for RUL prediction was determined using the capacity regeneration profile data from the state of health (SOH) estimation. When compared to the RVM, echo state network (ESN), and traditional ARIMA models, the determined RUL errors become insignificant. The performance of the model can be enhanced through PDF computation, as shown in [35]. A fractional-order equal circuit device is created using a combined Ge-

netic Algorithm/Particle Swarm Optimization technique. The model is able to predict the voltage response using cycle-based comprehensive testing with a root-mean-squared error below many others. A dual fractional-order prolonged Kalman filter is suggested in order to obtain concurrent SOC and SOH estimates. Combining GM (1, 1), the ARIMA model, and the Variational mode decomposition (VMD) denoising scheme allowed us to forecast RUL, as is shown in Figure 3.

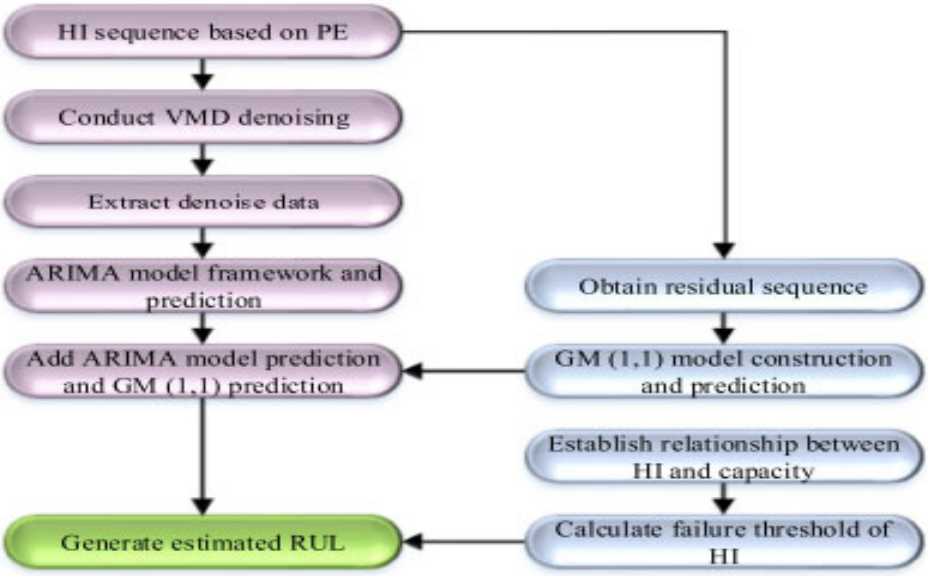


Figure 3. ARIMA based RUL prediction.

(b) Grey model technique

Enhancing the grey prediction classical means that we can use it to predict the number of users in a public road transportation system [36]. For evaluating the behavior of an unknown system, only small amounts of data are necessary. The forecasts are based on a small number of data points. Three different strategies are used in three different grey prediction models that have been presented to boost accuracy. To achieve the prediction of time series, these models convert discrete sequences into a continuous and dynamic differential equation. Each grey model is denoted by the notation GM (H, N), where H is the number of variables and N is the order of the differential equation. Small amounts of data are needed by the grey models to estimate the behavior of an unidentified system. The grey prediction model is described in greater detail in the ensuing subsections.

With the appropriate optimization of the extracted HI, the accuracy of the grey model's performance was increased [37]. The suggested model showed great accuracy, robustness, and dynamic flexibility. However, taking into account dynamic circumstances such as EV application, the provided results may vary. The RUL is predicted using an improved grey model, GM (1, 1), based on the HI that has been given. The experimental findings demonstrate the effectiveness and precision of the suggested strategy for battery degradation modelling and RUL prediction.

(B.3) Signal processing approach

With the help of the signal processing technique, significant data can be extracted. Data augmentation is one of the traits of signal processing methods. To estimate battery RUL, one can utilize a signal processing method. The DWT method is used to split a signal into its component parts. Although the DWT technique is rarely used for battery RUL prediction, it is commonly recognized for removing noise during the pre-processing of battery data. In ref. [38], lithium-ion battery remaining useful life prediction is performed using discrete wavelet transform. The remaining usable life and health are important factors in determining how safely and reliably an electric vehicle operates. Several methods

have been used to estimate the RUL and SOH, with a focus on capacity loss, internal resistance growth, voltage drop, self-discharge, and cycle count. Most works only take batteries into account in specific circumstances. The model and identification techniques are the most crucial elements in figuring out how accurate the prediction results would be.

3. Problem Formulation

(A) Data set

The overall performance of a battery diminishes for a variety of reasons, and the reduction is not necessarily linear. Battery becoming older facts are required to develop an RUL prediction set of rules and compare its balance and correctness. In the early days of lithium-ion technology, battery life was limited. As a result, many ageing checks are required to swiftly acquire battery growing older facts. Numerous charge–discharge charges and ambient temperature are the most commonly utilized pressure parameters. However, apparent battery aging checks take time, and complex and expensive sign collection equipment is required to extract battery attributes from multiple aging cycles. Several researchers have used publicly available battery information to validate their RUL prediction algorithms. The Hawaii Natural Energy Institute evaluated 14 NMC-LCO 18,650 batteries with a nominal capacity of 2.8 Ah after being cycled over a thousand times at a temperature of 25 °C with a CC–CV rate of C/2 and a discharge price of 1.5C. The unique dataset is used to create features that emphasize the behavior of the voltage and current over the course of each cycle. These characteristics can be used to calculate the batteries' ultimate beneficial life (RUL). The dataset contains summaries for the 14 batteries. Finally, voltage, current, and time are used to extract seven functions from the original datasets. The goal is to forecast the battery's RUL using these features. The characteristics are listed in Figures 4–6:

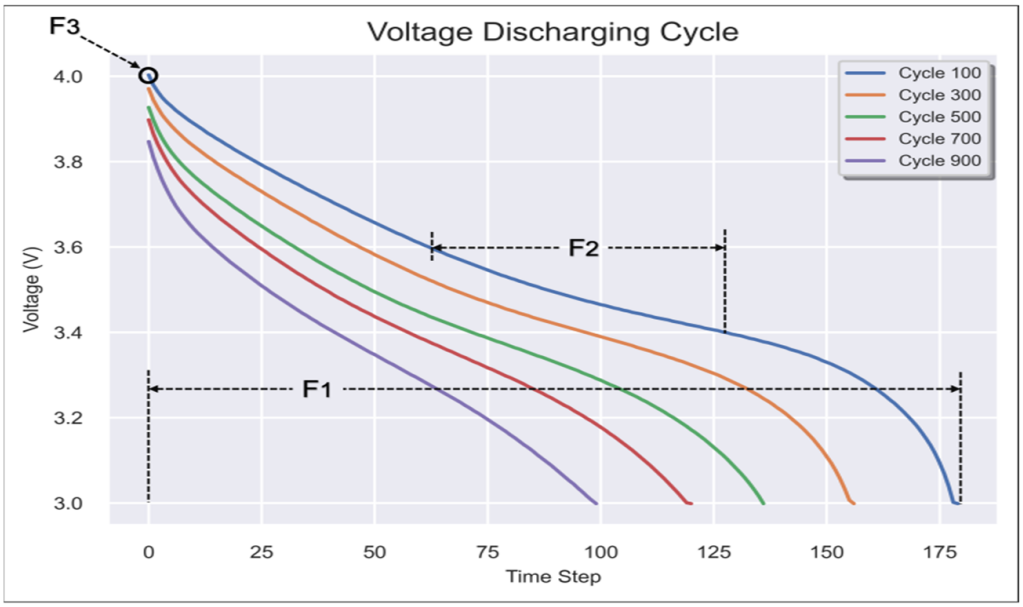


Figure 4. Profile of features F1, F2 and F3 in Voltage Discharge Cycle.

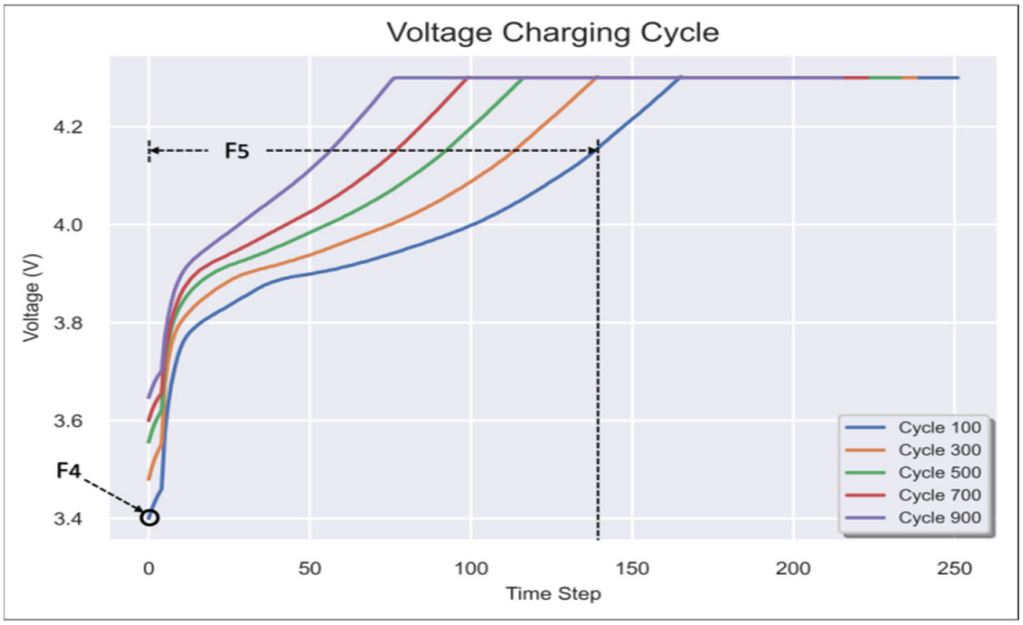


Figure 5. Profile of features F4 and F5 in Voltage charge Cycle.

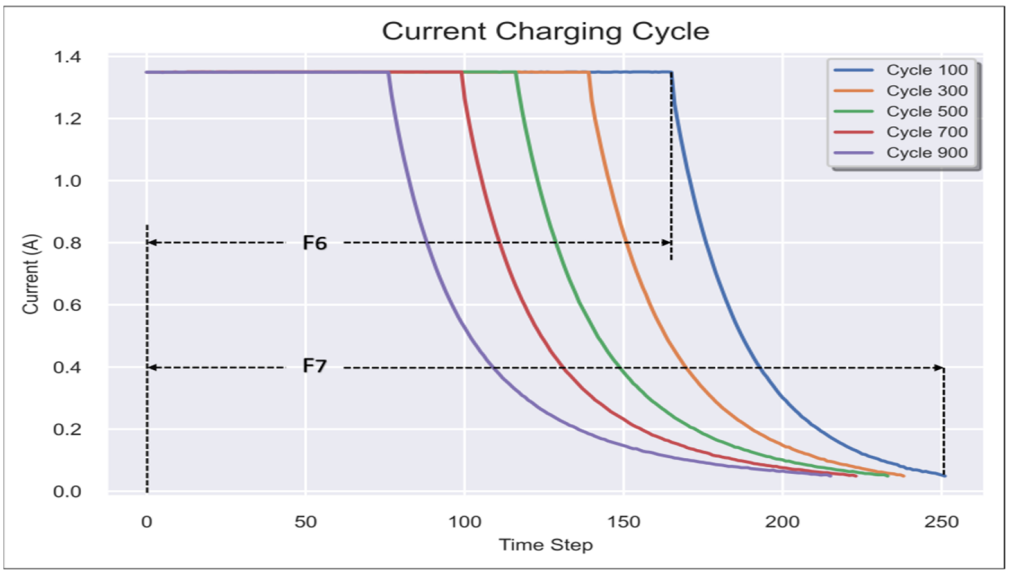


Figure 6. Profile of features F6 and F7 in Current charge Cycle.

Characteristic features:

- Cycle Index: number of cycle;
- F1: Discharge Time (s);
- F2: Time at 4.15 V (s);
- F3: Time Constant Current (s);
- F4: Decrement 3.6–3.4 V (s);
- F5: Max. Voltage Discharge (V);
- F6: Min. Voltage Charge (V);
- F7: Charging Time (s);
- Total time (s);
- RUL: target.

The battery life cycle databases that are available to the general public do not provide ready-to-use data for the assignment in [39]. Despite the fact that they incorporate various

factors such as voltage (V), current (A), time (S), discharge and fee capability (Ah), and charge and discharge energy (Wh), not all of these factors can be employed for this enterprise. Voltage, cutting-edge, and time are the best inputs allowed. However, using such variables as inputs right away is impractical because they provide worthless information and are insufficient to construct a version. As a result, they must be used as a starting point and adjusted to produce new qualities, which the neural community can use to educate.

(B) Elucidation of ML Algorithms

Machine learning (ML), a completely AI-based technique, teaches a machine to mimic human behavior in order to carry out previously impossible tasks. It also encourages communication between individuals and ML systems in order to make ML outcomes intelligible to humans. Figure 7 depicts the extensive classification of gadget learning methods. The ML era has the potential to improve both prognostic accuracy and computing efficiency for predicting the RUL of Li-ion-based batteries. Machine learning aims to discover styles and laws mechanically, using data experiments or in-person interactions [40].

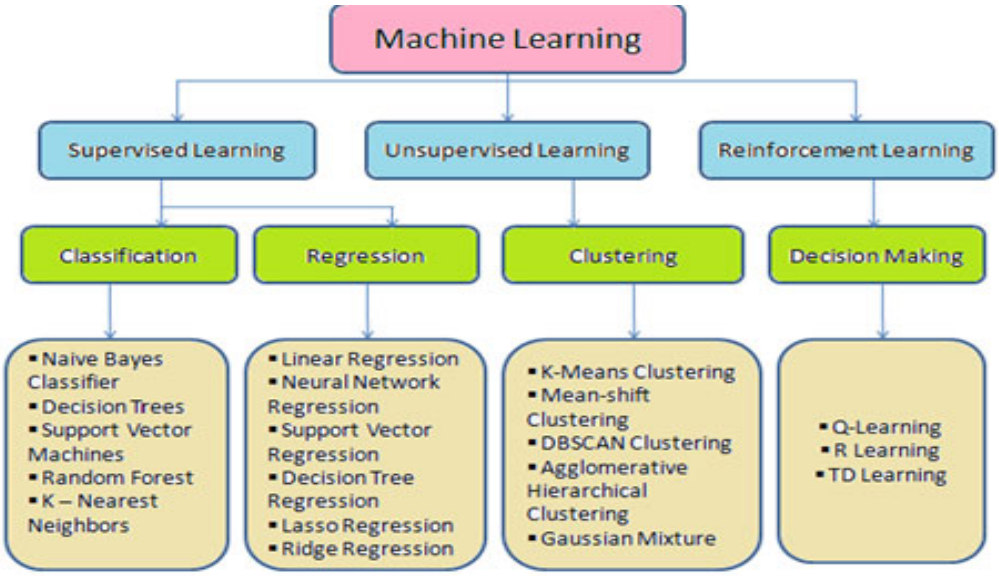


Figure 7. Classification of Machine learning algorithms.

This type of guide vector tool technique has grown in popularity during the last ten years. While using the technique as a regression strategy, its critical functions can be maintained. When records are regressed using the SVM, it is known as support vector regression (SVR). The RUL for Li-ion batteries can be predicted using the SVR technique. We decided to use a hybrid version of the SVR particle elimination technique [41]. For the terminal life cycle, an RUL prediction version that would offer the charge of RUL while updating the possibility distribution was provided. The results confirmed the efficacy of the cautioned RUL function prediction algorithms.

A simple and effective technique called KNN has been widely used in sample recognition for categorization. Using KNN and a specific number (k) of its closest neighbors in the feature area, a testing factor is categorized. These neighbors are chosen from a selection of educational websites with the right established categories. KNN regionally approximates the feature and waits to compute it because it is a lazy studying collection of rules [42].

Supervised Learning:

The supervised learning approach uses an enter-and-output pair-based learning dataset with the goal of implicitly establishing the mapping and intentional links between the inputs and outputs. The enter-and-output pairs' class output for the education dataset addresses a constrained set of discrete classes that need labelling. Information input and output are mapped as the basic goal of supervised learning. As it depends on

supervision, supervised learning is analogous to when a student studies under a teacher's direction. Two further sorts of supervised learning issues can be identified:

(i) Classification;
(ii) Regression.

Unsupervised Learning:

Unsupervised learning is a sort of machine learning in which the computer is free to make decisions based solely on the information provided. The algorithm wishes to act on those records without supervision, thus the unsupervised models may be trained using the unlabeled dataset, which is neither categorized nor labelled. The version in unsupervised learning digs through the enormous number of facts in search of insightful data rather than providing a deliberate outcome. They are used to overcome the Association and Clustering difficulties As a result, they can be split into two groups:

(i) Clustering;
(ii) Association.

Reinforcement Learning:

When an agent uses reinforcement learning, it engages with its surroundings and learns from the feedback it receives. The agent receives feedback in the form of prizes; for instance, he gets a high compliment for every admirable activity and a bad reward for every distasteful conduct. The agent is not subject to any supervision. The decision-making process, which includes reinforcement algorithms, can be further divided into:

(i) Q-learning;
(ii) R-learning;
(iii) TD-learning.

Some of the popular machine learning algorithms which are used for prediction purpose are:

1. Linear Regression Algorithm;
2. Random Forest;
3. Decision Tree;
4. Support Vector Machine;
5. Naïve Bayes;
6. K-Nearest neighbor;
7. Gradient Boosting Regressor;
8. Deep Neural Network;
9. K-means Clustering;
10. Q learning.

(C) Work Objective and Problem Formulation

A twofold objective is proposed for the present work. The first step is to extract and build new features based on voltage, current, and time from the given source datasets. And the second is to predict a battery's RUL by working with machine learning methods using Python 3.6.8 in Google Co laboratory. The methods employed produce the outcome in terms of performance evaluation metrics like MSE, MAE, RMSE, and R2.

4. Proposed Methodology

(A) Framework for RUL Prediction

Although data-driven models can train quickly since they are based on historical data, choosing the right hyperparameters for effective model training requires human judgement. In this research, we suggest a novel RUL prediction framework. RUL prediction implementation is broken down into three stages, which are covered below.

Stage 1: Extraction of characteristics from considered dataset and subsequent pre-processing of data is performed.

Figure 8 shows the stage 1 flow chart. Here the battery dataset is obtained from Hawaii Natural Energy Institute (HNEI). By evaluating the charging profile data and capacity the

input parameters voltage, current, and time are chosen, methodical sampling is employed. The capacity degradation data are attained from discharging cycles, and normalizations of data are done in this process.

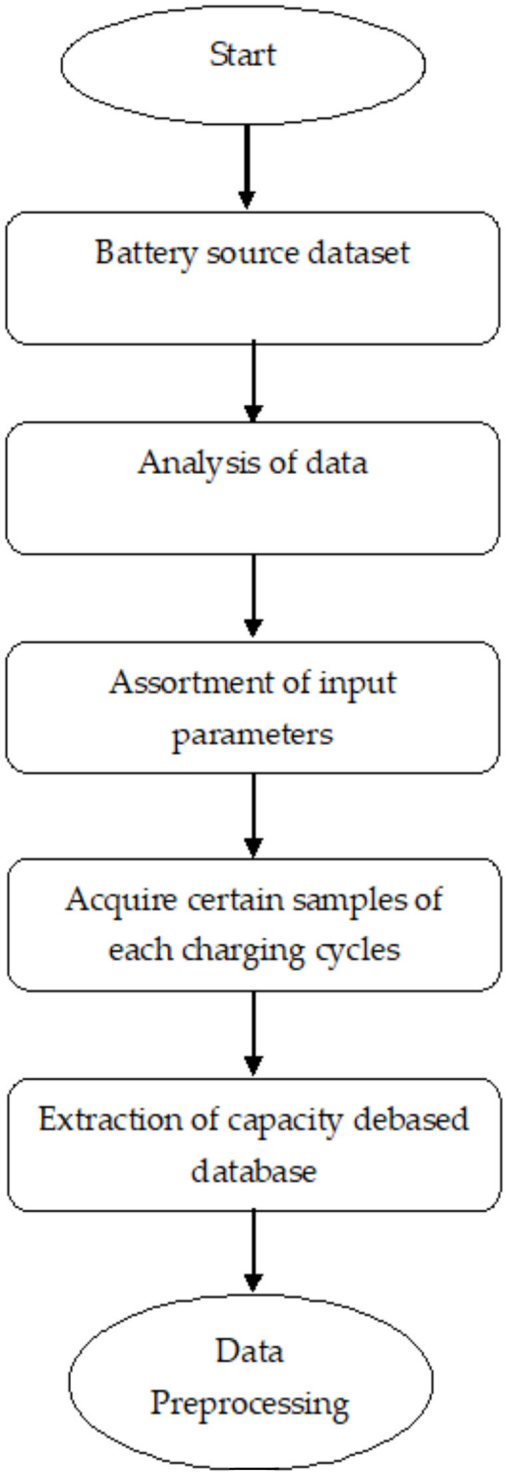


Figure 8. Extraction and Processing of data.

Stage 2: Data Division and Model Training

Figure 9 shows the flow chart of the stage 2 process. In the second stage, the data are divided into two components to facilitate model training, i.e., train and test the data. By

using the hit and trail method for solution of focused parameters input features are selected and suitable algorithms are applied.

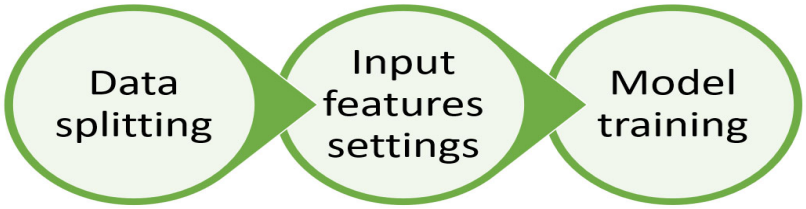


Figure 9. Data division and model training.

Stage 3: Prediction and Investigation

In the last stage, as displayed in Figure 10, RUL prediction and performance indices are calculated by Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Square Error (MSE), and Root Square (R^2), and various training dataset combinations are employed.

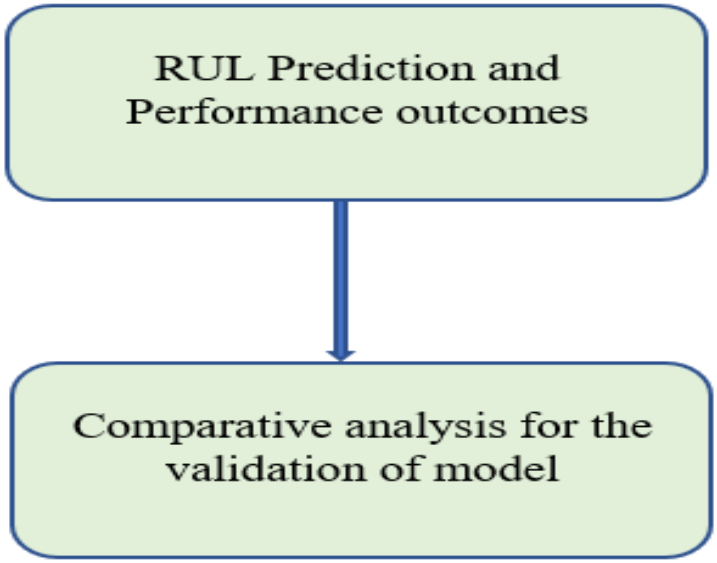


Figure 10. Prediction and Investigation of data.

(B) Selected ML Algorithms

The efficacy of a battery is determined by determining its remaining usable life. Through the identification of elements that will raise and improve their efficiency, it supports the development and testing of numerous EV variations. The method involves a number of parameters. Engineering difficulties with non-linearity and complexity can be modelled using machine learning approaches. ML approaches offer a non-invasive alternative with good accuracy and little processing, in contrast to the temporal constraints of battery degradation. The report provides a thorough and impartial assessment of the difficulties. Individual studies of numerous RUL evaluation methods are conducted. Finally, an overview that focuses on applications is provided, emphasizing the benefits in relations of accuracy and efficiency. The planned technique has six different algorithms that are used for obtaining the values of MSE, MAE, RMSE, and R Squared error. Figure 11 shows the flow chart for the proposed method.

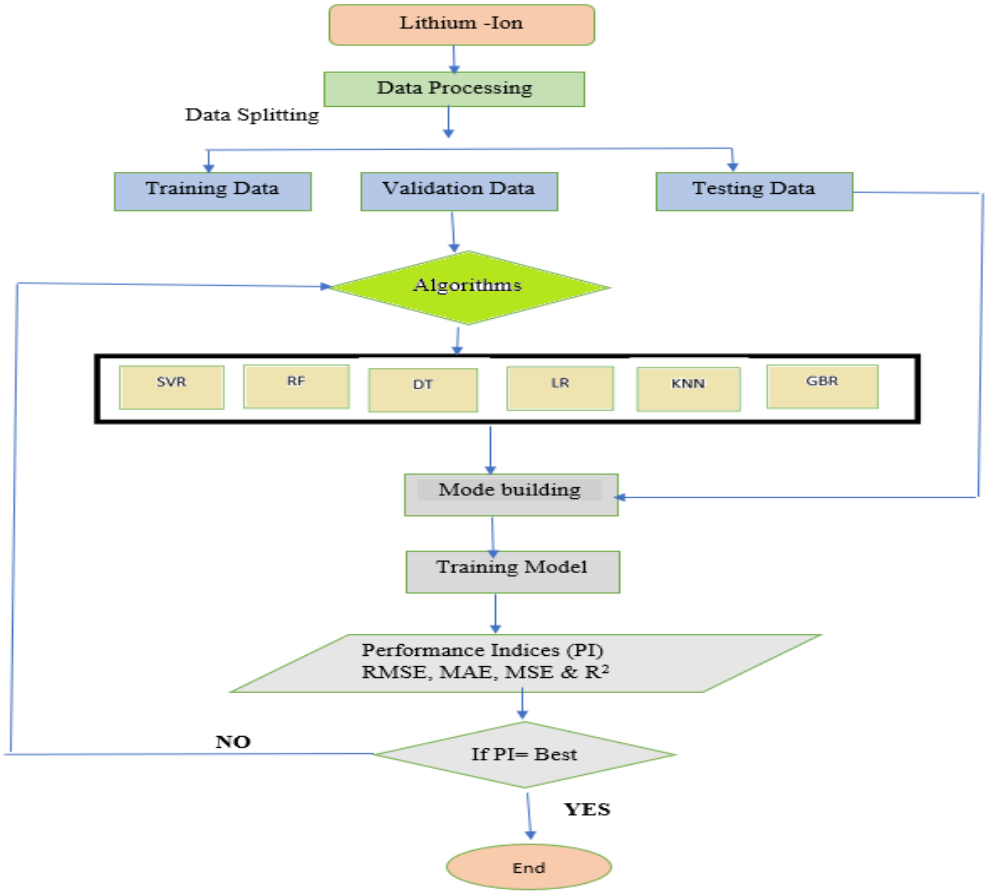


Figure 11. Flow chart for proposed method.

Random Forest Regression:

Random Forest, RF, may be applied for each type and regression, and it can manage a tremendous quantity of information. Many parallels exist between decision tree and random forest. The most basic distinction is that after the set of rules is run at some time in education, RF generates a larger number of DTs. The three primary benefits of using RF are that it eliminates the overfitting problem, has extremely high predictive accuracy, and is simple to use. The Gini index, which is frequently used, must be understood when using random forests that are entirely dependent on categorization data. The formula used to decide how nodes on a decision tree branch is given below.

$$\text{Gini} = 1 - \sum_{i=1}^{c} (p_i)^2 \quad (1)$$

The capacity to anticipate batteries for the purpose of maintaining a consistent supply of energy and the best possible use of that energy, remaining usable life (RUL), must be calculated beforehand. When it comes to accurately anticipating the battery management systems' state of charge, we decided to forecast RUL using a random forest model. With the help of this model, data may be gathered, pre-processed, and classified in order to forecast RUL. In terms of R2 and Root Mean Square Error (RMSE), the simulation is run. According to the findings, the ensemble random forest model has a greater level of prediction accuracy shows in Table 1. The random forest approaches utilized for RUL prediction are depicted in Figure 12.

Table 1. Features of random forest method.

Parameter	Value/Description
n_estimators	42
Max_features	09
Min_sample_leaf	10
Criterion	Gini Impurity
Max_leaf_nodes	10

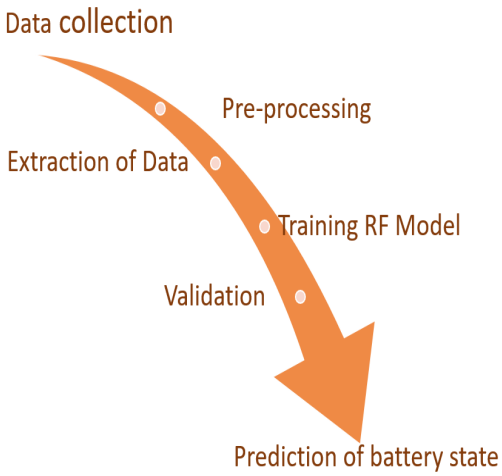


Figure 12. Flow chart for RF method.

Decision Tree Regression:

Although it can also be used to address regression problems, the decision tree approach to supervised learning is commonly used to solve classification problems. It is properly suited to each unique and continuous variable. Figure 13 depicts a tree-like structure with nodes and branches, beginning from the root node and progressing along extra branches to the leaf nodes. The central node represents the dataset's features, whereas branches indicate decision-making techniques, and leaf nodes represent results.

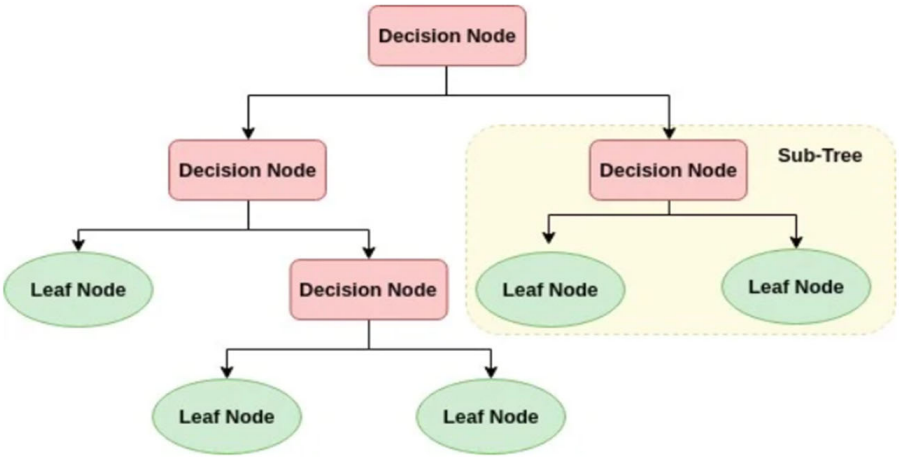


Figure 13. Decision tree Regression.

To determine which direction the node should head in, entropy analyzes the likelihood of a chosen outcome. It is more theoretically difficult to calculate than the Gini index since

it uses a logarithmic feature. Entropy can also be used to analyze the branching patterns of nodes in a selection tree.

$$\text{Entropy} = \sum_{i=1}^{c} -P_i * \log_2 P_i \quad (2)$$

The DT classifier generates a final tree with leaves that reflect the final prediction and branches that represent the observations [43]. The dataset is split up into a number of subsets while the process is running, and these subsets are subsequently utilized to create the DT. The well-known classifier DT is applicable to both classification and regression. DT can therefore be applied to both numerical and categorical data. DTs are useful in a range of applications because they work well when the dataset contains missing values. Figure 14 shows the steps for predicting decision tree regression for RUL calculations shows in Table 2.



Figure 14. Decision tree regression for RUL.

Table 2. Features of decision tree method.

Parameter	Value/Description
Splitter	Random subset of features
Max_depth	-
Min_sample_split	Two
Criterion	Gini
Max_leaf_nodes	-
Min_sample_leaf	One
Max_features	Nine
Class_weight	-
Min_weight_fraction_leaf	-

Linear Regression (LR):

Linear regression is one of the most well-liked and straightforward device mastery procedures for predictive evaluation. Predictive analysis is used to explain what is predicted, and linear regression anticipates continuous values such as age, profitability, and other factors. In response to the unbiased variable (x), the dependent variable (y) adjusts, and the linear dating between the structured and independent variables is confirmed. The regression line is the path that aims to maximize the statistics among the dependent and independent variables. The equation for the regression line is:

$$y = a_0 + a^* x + b \quad (3)$$

where y = dependent variable; x = independent variable; and a_0 = Intercept of line.

Procedures for linear regression are applied if the output is a continuous variable. Instead, grading algorithms are utilized when output is classified into categories like pass/fail, good/average/bad, etc. [44] shows in Table 3. The LR method is the basic regression algorithm, but we also have other regression algorithms or classifying behaviors. Figure 15 displays the flow chart for the linear regression model.

Table 3. Features of linear regression.

Parameter	Value/Description
Linearity	Relationship between x and mean of y
Homoscedasticity	For any value of x, variance of residual is same
Observations	Independent
Normality	For any fixed x, y is normlly distributed

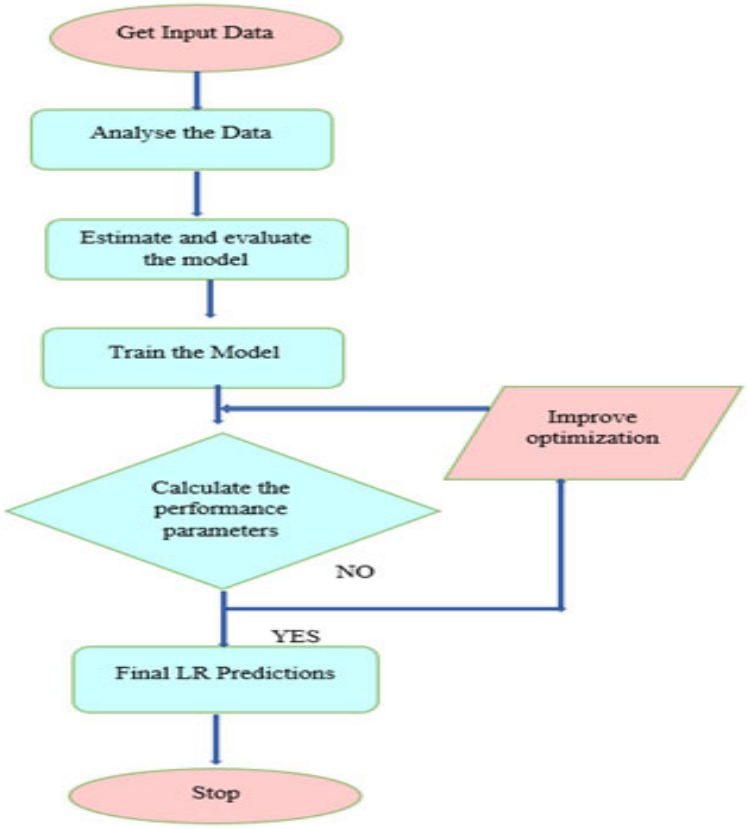


Figure 15. Flow chart for linear regression.

Gradient Boosting Regression:

An electric vehicle's battery management system must be reliable and durable in order to anticipate the state of charge. Lithium-ion batteries are heavily dependent on ageing information, which is occasionally pricey, or no longer accessible online. For the purpose of electrical car programs, it is strongly advised in [45] that the state of rate estimate of lithium-ion battery systems be carried out using a gradient boosting approach, which may also accumulate the nonlinear relationship model through offline training. The intensive gradient boosting methodology, which successfully works and accelerates, is used in the tree-based learning method.

To correct the flaws in the prior model, gradient boosting tree ensembles upload more timber at each stage. Those models are typically applied when the heterogeneity of the features is excessive. Unlike other boosting techniques like AdaBoost, this uses gradients to identify flaws. Additionally, the Gradient Boosting model is more resilient against outliers than the AdaBoost approach [46]. Evidently, gradient boosting is an expanded form of AdaBoost that is capable of handling unique loss features showed in Table 4. Typical loss features used in regression models include "huber" and "absolute" loss capabilities. More protection against outliers is provided by these loss features than by squared loss capabilities. We employed the Huber loss function as the loss function parameter in our gradient boosting regressor model. x Consider a training set (x_i, y_i) with $i = 1, 2, 3, \ldots,$

N and a differential loss function ($L(y_i, z)$, here referred to as "deviance"), where z is the predicted value. Set the model's parameters to:

$$f_0(x) = argmin_z \sum_{i=1}^{i=n} L(y_i, z). \quad (4)$$

Table 4. Features of gradient boosting regression method.

Parameter	Value/Description
n_estimators	500
Max_features	Nine
Learning rate	0.1
Random_state	100

For each observation in each tree calculate the gradient which is given by:

$$\theta_{jm} = argmin_z \sum L(y, z + f(x_i)). \quad (5)$$

Now, update the model of the succeeding tree with the gradient of the previous tree. This is given by:

$$f_m(x) = f_{m-1}(x) + \sum_{j=1}^{j=Jm} l_{jm} * I. \quad (6)$$

For each x which belongs to the region of that tree (i.e., R_{jm}), the overall output is given by $f_m(x)$.

The steps evolved for prediction of RUL using GBR are given below:

Step 1: Load the data.
Step 2: Define the target variables.
Step 3: Split the data into training and test sets.
Step 4: Initialize the GBR.
Step 5: Model the training data.
Step 6: Predict the target.
Step 7: Evaluate the performance.

Known as a Bayesian network, certain types of probabilistic graphics use Bayesian reasoning to calculate probabilities. Bayesian networks represent conditional dependency as edges in a directed graph with the objective of explaining conditional dependence and, by extension, causality. Using factors, these correlations can readily be exploited to extract data about the random variables in the graph [47].

To fully comprehend a Bayesian network, it is necessary to first grasp probability theory. It is vital to remember that the joint probability distribution of the random variables A_0, A_1, . . ., A_n, abbreviated as P(A_0, A_1, . . ., A_n), equals P(A_1 | A_2, . . ., A_n) * P(A_2 | A_3, . . ., A_n) *... * P(A_n). As it comprises N components, each with a localized probability, we can think of it as a factorized representation of the distribution.

$$P(\bigcap_{k=1}^{n} A_k) = \prod_{k=1}^{n} P(A_k | \bigcap_{j=1}^{k-1} A_J) \quad (7)$$

A and B are independent as long as C has a known and stable value. Remember that the conditional independence between the random variables A and B equals C * P B, assuming that C is the only other random variable. This can also be expressed in the way we will utilize it, which is C = A community software.

A Bayesian network's nodes and edges are directed acyclic graphs that represent conditional relationships and discrete random variables, respectively. Because the region (A, B) within the graph that implies A connects the random variables A and B, the joint opportunity distribution explicitly considers this. In order for it to execute inference, we

must be aware of the P(B) possible values of A and B. Bayesian networks satisfy the nearby Markov asset, which asserts that a node is conditionally independent of its non-descendants given its parents. After simplification, In the Table 5 joint distribution of a Bayesian network is equal (mother and father(node)), as shown below:

$$P(X1....Xn) = \prod_{i=1}^{n} P(Xi|X1, ...Xi-1) = \prod_{i=1}^{n} P(Xi|parents(Xi)) \quad (8)$$

Table 5. Features of Bayesian Network.

Parameter	Value/Description
Probability	Posterior—updated after evidence is considered
Conditional independence	Subset of variables
Directed acyclic graph	Continued valued variables

This feature allows us to drastically reduce the amount of processing required in larger networks because most nodes often have few parents relative to the size of the network as a whole.

(C) Performance Error Indices

To assess the model's accuracy and gauge how well it is functioning in its predictions, the process of developing system mastering models must include this step. The evaluation metrics vary depending on the problem type. The main issue with the regression problem—possibly the most famous example of this kind of issue—is that a dataset's objectives can only include real values [48]. The errors display how frequently the version makes erroneous predictions. The fundamental concept behind accuracy evaluation is to use a set of criteria to compare the original aim with the anticipated one. Following are the evaluation metrics:

C.1. MAE (Mean Absolute Error) is the difference between the original and predicted values calculated by averaging the absolute difference over the facts set. As the projected aim is the same, MAE is primarily a degree of accuracy for the labored model expressed on the same scale. If MAE is closer to zero, the more accurate the model is.

$$\text{Mean Absolute error} = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}) \quad (9)$$

C.2. MSE (Mean Squared Error) depicts the variance between the original and predicted values as determined by square rooting the mean variance throughout the data set.

$$\text{Mean Square Error} = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y})^2 \quad (10)$$

C.3. The error rate by the square root of MSE is known as (Root Mean Squared Error) RMSE.

$$\text{Root Mean Square Error} = \sqrt{MSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y})^2} \quad (11)$$

C.4. R-Squared (Coefficient of determination) represents the degree to which the values fit the initial values. the proportions of values in the range of 0 and 1. The model improves as the value increases.

$$\text{R Squared} = 1 - \frac{\sum(\boldsymbol{y_i} - \hat{\boldsymbol{y}})^2}{\sum(\boldsymbol{y_i} - \overline{\boldsymbol{y}})^2} \quad (12)$$

5. Results Analysis

Heat Map:

To show how closely related various factors are, these coefficients are presented as a warmth map. It aids in locating trends that are useful for constructing device learning models. The warmth map converts the correlation matrix into a color-coding system. The correlation matrix displays how the variables are connected to one another on a scale of −1 to 1, with 1 signifying an extremely bad connection and −1 a flawless exceptional correlation. The main function of the Heatmap in Seaborn is to show a color-coded correlation matrix enabling easy visualization of the relationships between the statistical data.

From the heatmap in Figure 16, it can be inferred that:

- Features Time Constant Current' and Charging Time have a strong positive correlation with a value of 0.95.
- Features 'RUL' and 'Maximum Voltage Discharge' also have a strong positive correlation with a value of 0.78.
- Another positive correlation is between features 'Time at 4.15 V' and 'Discharge Time' with a value of 0.78.
- Feature 'Minimum Voltage Discharge' has a strong negative correlation with features 'RUL' and 'Maximum Voltage Discharge' with values −0.76 and −0.72, respectively.



Figure 16. Heat map for the features of the source dataset.

Table 6 illustrates the numeric RUL prediction errors of the Hawaii Natural Energy Institute (HNEI) dataset's batteries. In addition, it compares ML strategies. We looked at five separate machine learning algorithms for predicting assessment metrics and the range of evaluation predictive accuracy. In this case, the records are educated, and the high-quality version forecasts are evaluated using the four outstanding overall performance error indices MSE, RMSE, MAE, and R-Squared. In this case, inputs are defined for a wide range of voltages, moderns, and temperatures for separate charging and discharging cycles. This provides a simple framework for including an expansion of input features for prediction, as well as general elapsed real time for training all algorithms. The battery RUL problem is crucial for the efficient and reliable operation of battery-dependent systems and is an active area of research and development, particularly in industries where batteries play a vital role in powering critical applications. Predicting RUL accurately can help extend the lifespan of batteries, reduce maintenance costs, and enhance overall system performance and safety [49].

Table 6. Comparison of ML methods with evaluation metrics.

ML ALGORITHMS	MSE	RMSE	MAE	R-Squared	TIME
Random Forest Regression	14.1186	3.7574	2.0930	0.9998	0.0651
Decision Tree Regression	26.8489	5.1816	2.2296	0.9997	0.1510
Linear Regression	54.5430	7.3853	4.6441	0.9994	0.0248
Bayesian network	54.5478	7.3856	4.6483	0.9993	1.2356
Gradient Boosting Regression	57.4476	7.5794	4.9842	0.9990	2.5640

In summary, the battery RUL problem is closely related to various Sustainable Development Goals, particularly those related to clean energy, sustainable infrastructure, climate action, responsible consumption, economic growth, and collaboration. Addressing the battery RUL problem through research and innovation can contribute significantly to achieving these global sustainability development goals:

Affordable and Clean Energy (SDG 7): one of the targets of SDG 7 aims to ensure access to affordable, reliable, sustainable, and modern energy for all. Batteries play a crucial role in energy storage and the transition to renewable energy sources such as solar and wind. Extending battery run-time can make these energy sources more reliable and accessible, helping to achieve the goal of clean and sustainable energy for everyone [50]. In systems relying on batteries, knowing the remaining useful life allows for efficient planning and operation. This information helps to ensure that energy storage systems and devices continue to function reliably until the end of their expected lifespan [51].

Climate Action (SDG 13): It's aims to combat climate change and its impacts. Batteries are essential for electric vehicles and renewable energy systems, both of which play a critical role in reducing greenhouse gas emissions. Improving battery run-time can accelerate the adoption of these technologies and contribute to mitigating climate change. Further regarding goal 13.1, one of the key targets is to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters [52].

The comparison graph of RF, DT, LR, BN, and GBR are shown in Figure 17 and it is observed that the random forest regression (RF) method achieves the best value in MSE measurement with 14.1186 which is lower than all the other four methods. Therefore, this learning prediction method has higher robustness and better applicability. Accurate estimation of a battery's remaining useful life is crucial in various climate-related applications, such as renewable energy systems and electric vehicles. By optimizing battery usage and ensuring batteries operate at their full lifespan, we can reduce the need for premature replacements and the associated environmental impacts, such as the carbon footprint of manufacturing and disposing of batteries [53].

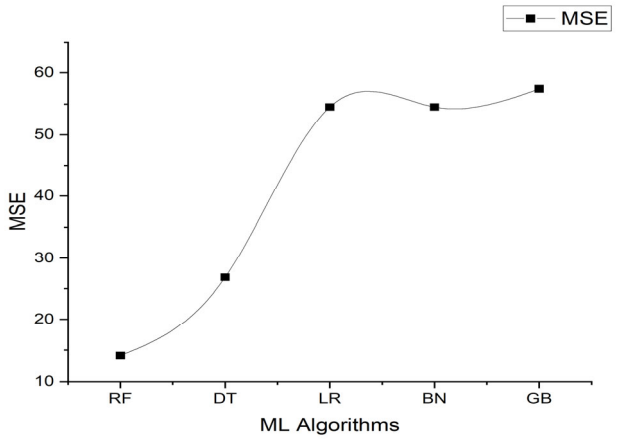


Figure 17. Mean Squared Error for different machine learning methods.

Figure 18 shows the training and prediction result for battery RUL prediction based on RMSE evaluation. It can also be seen that the random forest (RF) model stages the best performance for RUL prediction in terms of RMSE. This also verifies the advantage and superiority of all the five different machine learning algorithms.

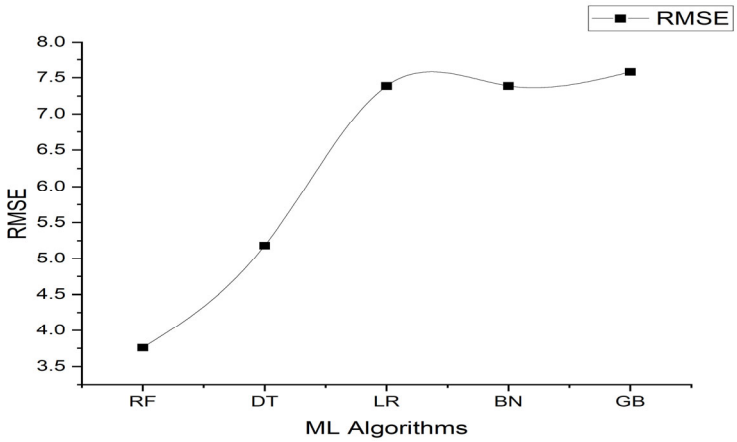


Figure 18. Root Mean Squared Error for different machine learning methods.

The MAE prediction of battery RUL is shown in Figure 19. This also verifies five different ML algorithms for prediction and determines that the random forest regression model has a good prediction capacity for determination of a battery's RUL. This also validates the effectiveness of the model for prediction.

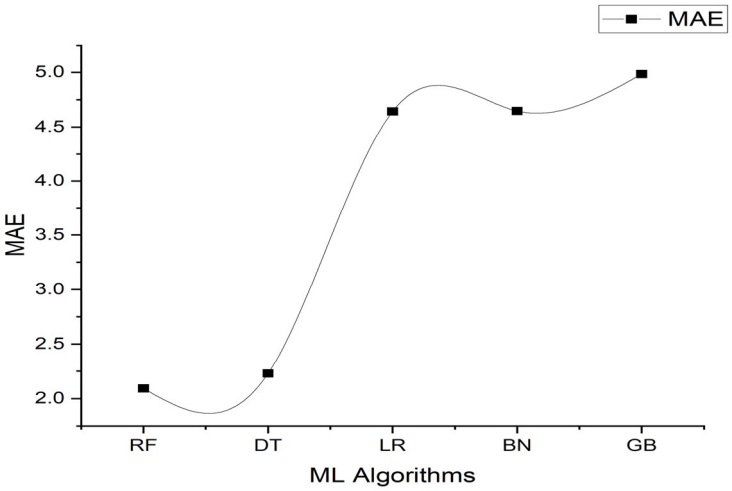


Figure 19. Mean Absolute Error for different machine learning methods.

The statistical indicator R-Squared is predicted for RF, DT, LR, BN, and GB as shown in Figure 20. This performance indicator describes the amount of uncertainty explained by an independent variable. From these performance error indices, it determines which approach achieves good efficiency with the other outperformed all the other methods.

The main contribution of this study is that it finds the optimized version and effectively captures characteristics of RUL model prediction with less execution time. Figure 21 shows the execution time obtained for all five of the ML algorithms to perform different performance error indices. This also shows the shorter training time and advantage features of all the models proposed for prediction of RUL.

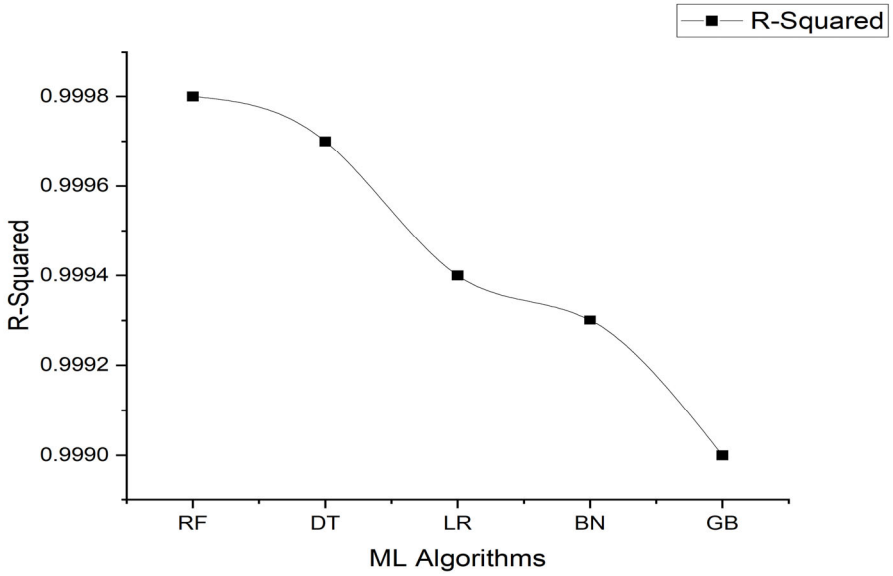


Figure 20. R-Squared Error for different machine learning methods.

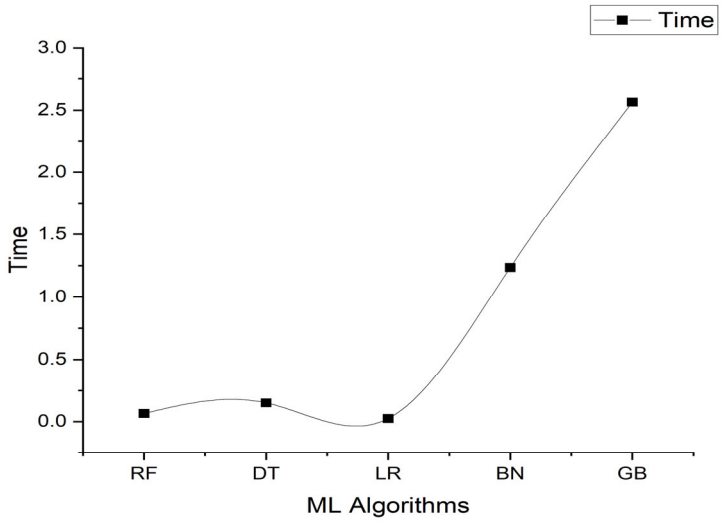


Figure 21. Time taken by different Machine Learning Methods.

In addition, the following two SDGs are also positively impacted by addressing battery run-time problem:

Responsible Consumption and Production (SDG 12): Sustainable batteries that last longer reduce the frequency at which batteries need to be replaced, resulting in less waste and fewer raw materials used in manufacturing. This aligns with SDG 12's target to ensure sustainable consumption and production patterns. Replacing batteries prematurely can be costly, especially in applications such as electric vehicles, where batteries are a significant part of the overall cost. Accurate RUL predictions help optimize the replacement schedule, reducing unnecessary expenses, waste, and raw materials used [54].

Industry, Innovation, and Infrastructure (SDG 9): SDG 9 emphasizes the development of resilient infrastructure and the promotion of sustainable industrialization. Longer battery run-time can contribute to the development of more efficient and sustainable transportation, communication, and industrial systems, reducing energy waste and promoting sustainable infrastructure [55].

The profile of the five performance error indices of the given data set using all five different machine learning algorithms is shown in Figure 22.

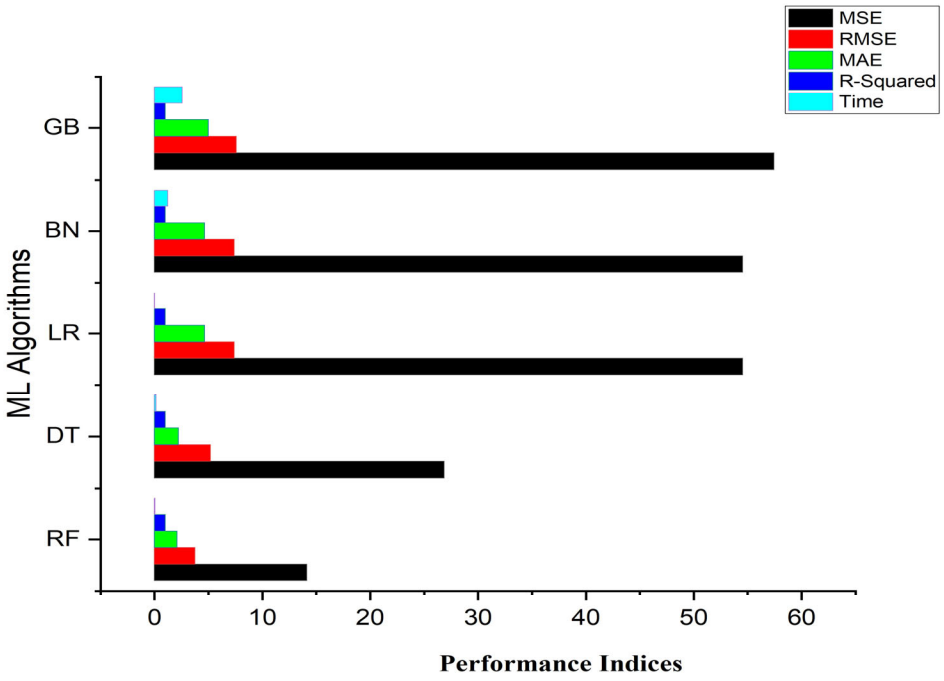


Figure 22. Error indices for different Machine Learning Methods.

6. Conclusions

This article studied the RUL prediction for the Hawaii Natural Energy Institute's (HNEI) real life battery dataset with various machine learning algorithms such as linear regression, gradient boosting, random forest, decision tree, and the Bayesian network. Subsequently the error metrics such as Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), R-Squared, and execution time were determined for the considered battery dataset. The proposed data driven model with all the ML algorithms was executed in python with Google Co-laboratory. Each algorithm exhibited a notable deviated relevancy with regard to the different system error indices. It is observed from the obtained results that the random forest method had better optimized evaluation metrics with less execution time and was also well suited for accurate RUL prediction. A heatmap in seaborn was also generated for the dataset where voltage, current, and time were considered to extract seven functions from the original datasets. A correlation matrix has also been computed to illustrate the association between the coefficients as presented in the warmth map.

In a global context, where energy sector emissions represent more than 75%, it is important to highlight that good management and prediction of battery use can significantly contribute to improving the efficiency and sustainability of energy storage systems. In addition to promoting the adoption of clean energy, good battery management can help reduce sector emissions and encourage innovation and collaboration between members of the supply chain. In this way, the proposed methodology is interesting for its contribution to several sustainable development goals, such as Clean and Affordable Energy (SDG 7), and Climate Action (SDG 13).

The research findings highlighted in this article may be useful for the researchers in predicting the battery RUL accuracy enhancing the overall battery efficiency. Future research can be focused on further improving the accuracy of prediction by employing Deep Learning, Hybrid Learning algorithms.

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Abbreviations

Abbreviation	Explanation
LIB	Lithium-ion battery
RUL	Remaining useful life
SOH	State of health
SOC	State of charge
ML	Machine learning
SVR	Support vector regression
KNN	K-Nearest neighbor
DT	Decision Tree
GBR	Gradient Boosting Regressor
DNN	Deep Neural Network
MAE	Mean Absolute error
MSE	Mean Square Error
RMSE	Root Mean Square Error
HNEI	Hawaii National Energy Institute

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TITLE: HYDROLOGICAL INFERENCE ON THE NANDIVARGAM SUB - WATERSHED FOR WATER RESOURCE ANALYSIS AND MANAGEMENT THROUGH REMOTE SENSING AND GIS TECHNIQUES

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Abstract:
The current study focuses on hydrological analysis for a sub-watershed in Nandivargam, within the Nandyal district, Andhra Pradesh. India. The drainage patterns and acquiring pertinent hydrological inferences related to the sub-watershed using digital elevation model STRM (DEM) imagery. Size, slope, soil type, land use, and vegetation, the drainage area, the length of water courses, hydrological model and morphometric analysis has been successfully accomplished through the integration of remote sensing and geographic information systems (GIS). The watershed's stream order, which travels from first order to fifth order and displays a dendritic type drainage network, it is an indication of the watershed's homogeneous texture. GIS-based watershed model has been developed for this study, Stream network, Stream order, Aspect, land use and land cover, Relief, Contours, Mean and Annual rainfall, the study area, and watershed borders were all generated as GIS layers. The watershed area's drainage density was found to be low to medium, which indicates the area has low relief and highly permeable soils. The bifurcation ratio varies from 1.30 to 2.53 and elongation ratio is 0.83 which reveals that the basin belongs to the oval shaped basin category the mean bifurcation ratio of the basin is 2.15 which indicates that the drainage pattern is not much influenced by geological structures. Mathematical or quantitative measurement helps us in analyzing the landforms accurately for any planning and development purposes. Morphometric Analysis is also very useful as it quantifies the landform features of evolutionary significance.

Key words: Watershed, Nandivargam, Remote sensing, Geographical Information system, Morphometric analysis,

1. Introduction.

The quantitative morphometric analysis of a watershed can yield valuable insights into the hydrological characteristics of the rocks present in the watershed. A drainage map of basin provides a reliable index of permeability of rocks and their relationship between rock type, structures and their hydrological status. Watershed characterization and management requires detail information for topography, drainage network, water divide, channel length, geomorphologic and geological setup of the area for proper watershed management and implementation plan for water conservation measures (Sreedevi et al., 2013). Remote sensing data, along with increased resolution from satellite platforms, makes these technologies appear poised to make a better impact on land resource management initiatives involved in monitoring LULC mapping and change detection at varying spatial ranges in semi-arid regions is undergoing severe stresses due to the combined effects of growing population and climate change. (Singh et al., 2012). Surface hydrological indications are one of the promising scientific tools for assessment and management of water resources. Drainage morphometric analyses are a prerequisite for selection of water recharge site, watershed modelling, runoff modelling, watershed delineation, groundwater prospect mapping and geotechnical investigation. (Magesh et al., 2011; Thomas et al., 2012). The drainage network analysis is generally performed to understand the prevailing geological variation, topographic information and structural set of a basin and their interrelationship. Remote sensing and GIS based drainage basin evaluation has been carried out by number of researchers for different terrains and it is proved to be a very scientific tool for generation of precise and updated information for characterization of drainage

basin parameters (Grohmann, 2004; Korkalainen et al., 2007; Hlaing et al., 2008; Javed et al., 2009; Pankaj and Kumar, 2009). Previously drainage morphometric parameters were extracted from topographical maps or field surveys. Drainage parameter extractions from last two decades are more popular from digital topographical information which is called as digital elevation models (DEM), which is more fast, precise, updated and inexpressive way of watershed analysis (Moore et al., 1991; Maathuis, 2006). One of the most recent near global elevation data sets recorded during the 11 day Shuttle Radar Topographic Mission is based on a C-band interferometric radar configuration. This information, representing the radar reflective surface (which may be vegetation, man-made features or bare earth), was collected in 2000 (Maathuis, 2006). Digital elevation models (DEMs), such as from the Shuttle Radar Topography Mission (SRTM), or the ASTER GDEM product (USGS, Denver, Colorado, USA), have been used to extract different geomorphological parameters of drainage basins, including drainage networks, catchment divides, slope gradient and aspect, and upstream flow contributing areas (e.g. Mark, 1984; Tarboton, 1997). GIS based watershed evaluation using Shuttle Radar Topographic Mission (SRTM) data have given a precise, fast, and an inexpensive way for analyzing hydrological systems (Farr and Kobrick, 2000; Grohmann et al., 2007; Panhalkar, 2014). Recently Bastawesy et al. (2013) utilized remote sensing data and digital elevation models to extract the catchment hydrological parameters to delineate storage areas for the Uganda Equatorial Lakes region. They concluded that digital elevation models (DEMs) are a very accurate tool for morphometrically parameter evaluation and watershed delineation for watershed management. In addition, low-intensity and erratic monsoons create further shortages of surface-water supply. As a result, the demand for groundwater resources has increased tremendously from year to year, causing a drastic decline of groundwater levels. Over-exploitation of groundwater has led to the drying up of the aquifer zones in several parts of the country. It is, therefore, essential to increase the recharge of the basin for the water management program at watershed level (Ellis and Revitt, 2010; subba Rao, 2008); Eyquem, 2007).

The current study focuses on a location where rainfall is the primary source of recharge. An integrated watershed-based morphometric study is essential to get insights into the region's physiographic features. The research analyzes sub-watersheds in Nandivargam, Nandyal, district, Andhra Pradesh, and analyzes their morphology. With the goal of helping in the management of water resources, this research makes use of STRM, satellite imagery, and GIS methods. With the objective to conserve and manage water resources sustainably, the primary objective is to explore and identify multiple drainage factors that might improve knowledge of the watershed's shape. The results of this research can help identify alternate approaches to water harvesting in the study region and can act as a scientific foundation for more in-depth hydrological investigations.

2. Geographical of the Study Area

The study area selected for evaluating morphometrical parameters and conducting watershed delineation for effective watershed management is the Nandivargam sub-watershed, as shown in (Fig-01). This sub-watershed is situated within the Nandyal district, Andhra Pradesh, of India and The watershed is located in between latitudes 15°22'30"N to 15°32'30"N and longitudes 78°7'30"E to 78°25'0"E, covering a total area of 240.80 km^2. The mean elevation of the study area is 425 meters above mean sea level. It experiences a dry climate with an annual average rainfall of 878mm. The mean minimum and maximum temperatures are 21.9 ºC and 38.5 ºC, respectively. Located in the Kundu river basin, also known as Kunderu, Kumurdruthi, it is a tributary of the Penna River in the Rayalaseema region of India. The Kundu valley, known as Renadu, is associated with the term "Renati Pourusham." The Kundu River's flood plains cover an area of around 6,000 acres (24km^2). The study area encompasses the Kunderu river valley, situated between the Erramala and Nallamala hills, forming the western and eastern boundaries, respectively. It includes the entire Koilakuntla and parts of Nandikotkur, Nandyal, Allagadda, and Banaganapalle. The Kunderu River, a tributary of the River Penner, flows southward through the central part of the region. The Madduleru and Jurreru rivers in the west, and the Galeru and Vakkileru Rivers in the east, are the main tributaries of the Kunderu River. The region has an average slope ranging between 200 and 300 meters

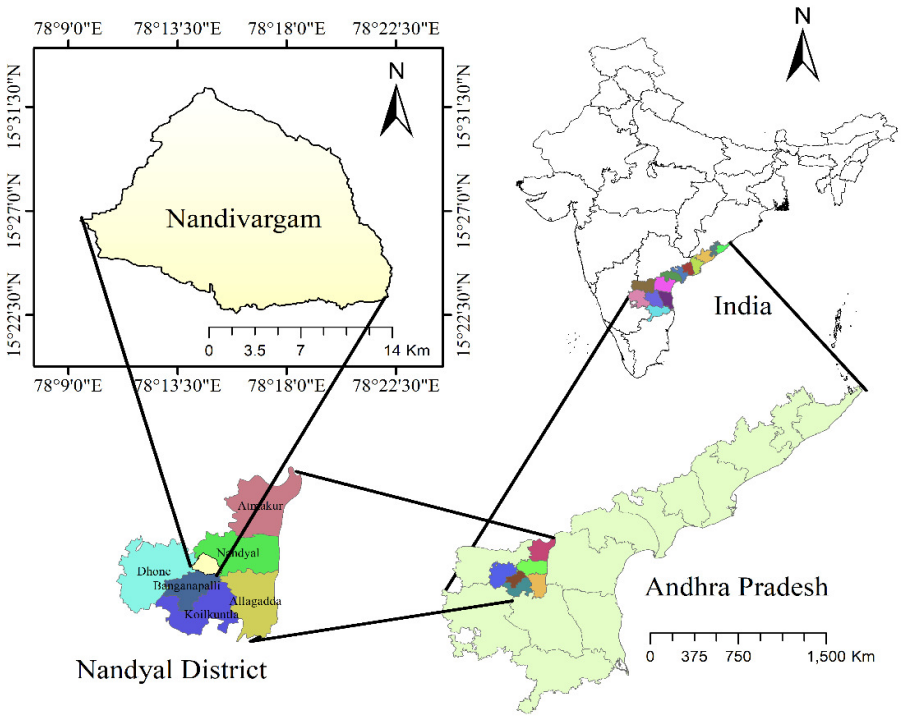


Fig-01: Location map of the study area

2.1 Objective

The primary aim of this study is to explore the morphometric analysis of the watershed in relation to its drainage pattern, utilizing multi-temporal satellite data to examine aspects such as drainage, surface water bodies, and the watershed.

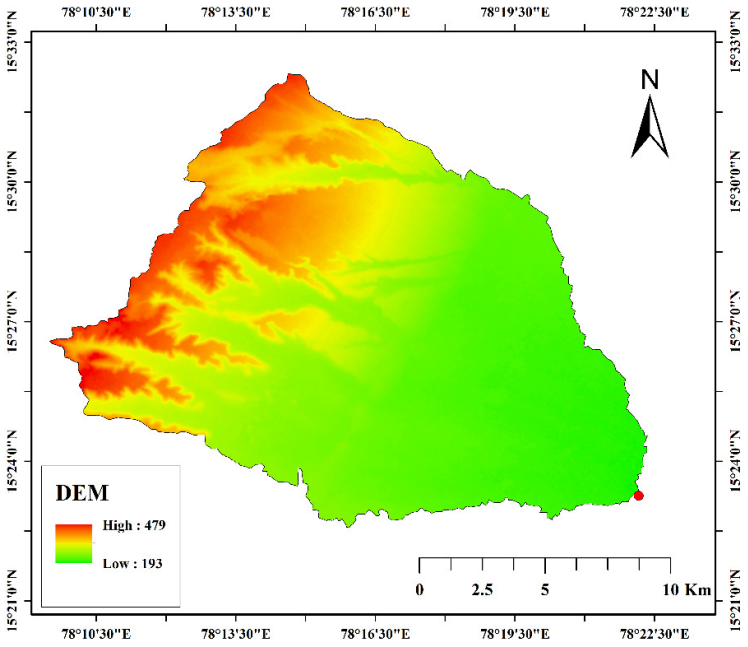


Fig-02: Digital Elevation map of the study area

3.0 Materials & Methodology

3.1 Materials

The source of organisation of data for study area shown in (Table -01) the generation of input parameters for explore the morphometric analysis has been successfully accomplished through the integration of remote sensing and geographic information systems (GIS).

Table -01 Data and resources utilized in the determination of geomorphic in the present area.

S.No.	Source	Map	Description
1	Topo-sheet / Spatial Data	Study area boundary / areas (DEM)	Boundary Topo-sheet was used to demarcate watershed boundary. watershed boundary
2	STRM DEM (USGS website)	Digital elevation model (DEM) and Slope	Digital elevation map (DEM) Contours, a stream network, and stream order watershed borders were all generated as GIS layers
3	Satellite imagery -10m Sentinel – 2 LA2 Thematic	Land use / land cover (LULC)	Land use / land cover (LULC)

3.2 Methods

The present study adopts the following methodology and procedure to achieve its objectives. Collection of satellite data and Topographical maps. Rainfall and other collateral data within the study area. Drainage pattern , stream order, surface water bodies' Contour, Slope, Aspect, and Relief maps based on the Digital Elevation Model (DEM) as shown in (fig-02).Conducting preliminary pre-field interpretation of Hydro geomorphology using Satellite data for delineated sub-watersheds was exported in Arc GIS 10.8 software for used to morphometric analysis. Recommending a land and water resources development plan.

3.2.1 Drainage Morphometric Analysis

In a GIS environment, we conducted an assessment of the basins linear, aerial, and relief characteristics. Subsequently, we generated graphs and performed linear regression analysis to investigate the inter relationships among certain variables. These variables included a range of morphometric parameters of the basin, such as perimeter, stream order, stream length, bifurcation ratio, stream length ratio, basin length, drainage density, texture ratio, stream frequency, form factor, circularity ratio, elongation ratio, and length of overland flow. We thoroughly examined and provided detailed discussions on these parameters. For a comprehensive understanding of the morphometric analysis, refer to the various notations and methodologies outlined in (Table 02)

Table -02 "Methods and sources utilized for the computation of geomorphic parameters."

Ascept	Parameters	Formulae	Values	References
Arial	Area (Km^2)	A	240.80	
Liner	Perimeter (km)	P	*78.96*	
	Length of Basin (km)	L_B	*21.17*	
	Width of Basin (km)	W_B	*15.14*	
	Stream length (L_u)	Length of the stream	*14.67*	Horton (1945)
	Mean stream length (L_{sm})	$L_{sm} = Lu/Nu$	*47.51*	Strahler (1964)
	Stream length ratio (R_L)	$RL = Lu/(Lu-1)$	*1.02*	Horton (1945)
	Bifurcation ration (R_b)	$(Rb) = N_u/N_u+1$	*8.59*	Schumm (1956)
	Mean bifurcation ratio (R_{bm})	R_{bm} = average of bifurcation ratios of all order	*2.15*	Strahler (1957)
Arial	Drainage density (D_d)	$D_d = Lu/A$	*1.82*	Horton (1945)
	Drainage texture (T)	$T = Dd \times Fs$	*5.22*	Smith (1950)
	Stream frequency (F_s)	$F_s = Nu/A$	*2.87*	Horton (1945)
	Elongation ratio (R_e)	$R_e = D/L$	*0.83*	Schumm (1956)
	Circularity ratio (R_c)	$R_c = 4\pi A/P^2$	*0.49*	Strahler (1964)
	Form factor ratio (F_f)	$F_f = A/L^2$	*1.15*	Horton (1945)
Relief	Relief	$R = H - h$	*293*	Hadley and Schumm (1961)
	Relief ratio	$R_r = R/L$	*13.85*	Schumm (1963)
	Basin Relief	Horizontal length (B_h)	*15.14*	
	Ruggdness number	$R_i = (D_d x\ R_r)/100$	*0.25*	

Stream Numbers:

The total number of streams in each order is called as the Stream Number. After Stream Order, the 2nd step in Morphometric analysis is to count the Stream Number. The Stream Number decreases with the increasing order of stream (as shown in Table 02). Stream number is inversely proportional to stream order. Horton has developed 'Law of Stream Number'. According to this Law, when Stream Number (taken in arithmetic scale) is plotted against Stream Order (taken in logarithmic scale), it gives a negative linear pattern. It means number of streams from highest to lowest order in a particular basin tend to give a Geometric Series. In the 5th order river basin shown in (Fig 04), the series is 19, 48, 121, 157, and 352 which is plotted on the logarithmic scale to the Fig-03.

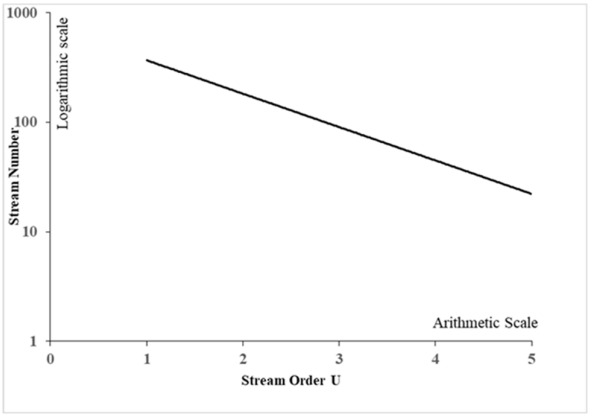


Fig-03: Stream order Vs Stream number (N_u)

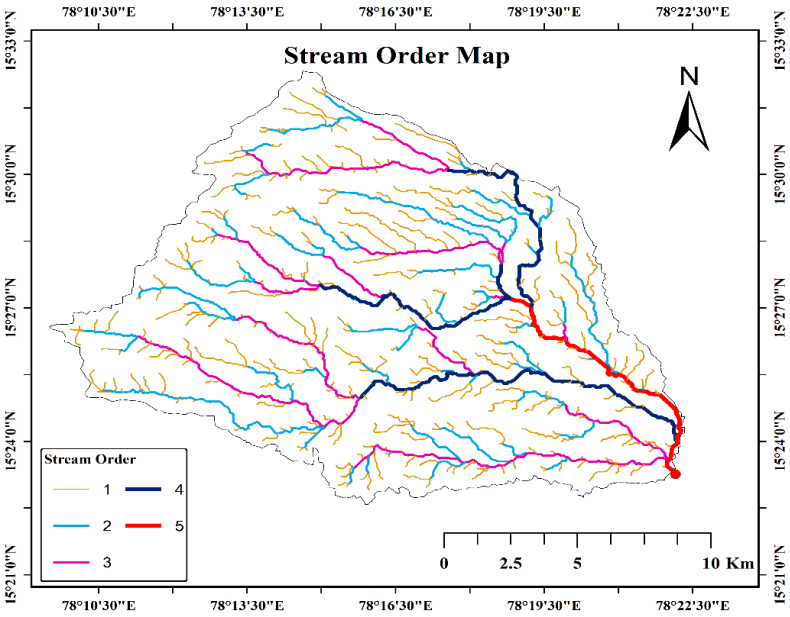


Fig-04: Drainage with stream network and order map of the study area

3.2.2 Stream Order (N_u):

Stream order, also referred to as water body order is a positive whole number utilized in the fields of geomorphology and hydrology to denote the extent of branching within a river system. Various techniques for stream ordering, such as those proposed by (Horton in 1945)[19] and (Strahler in 1952), exist. In this study, Strahler's method, which is a slightly modified version of Horton's approach, was employed to assess stream order. According to this system, the smallest streams, which have no branches, are classified as first order. When two first-order streams converge, they become second order, and two second-order streams joining together become third order, and so on. If streams of different orders merge, they retain the highest order. In the case of the Nandivargam basin, it is classified as a fifth-order stream. In total, 697 streams were identified in the study area, with 352 being first order, 157 second order, 121 third order, 48 fourth order, and 19 fifth order (as shown in Fig-05). The analysis of stream network characteristics is crucial for comprehending the hydrological processes within the basin. Stream magnitude is strongly linked to the portion of the entire basin area that contributes to runoff, making it a reliable indicator of relative stream discharge in smaller river systems. Strahler's stream order classification has been utilized in numerous river systems.

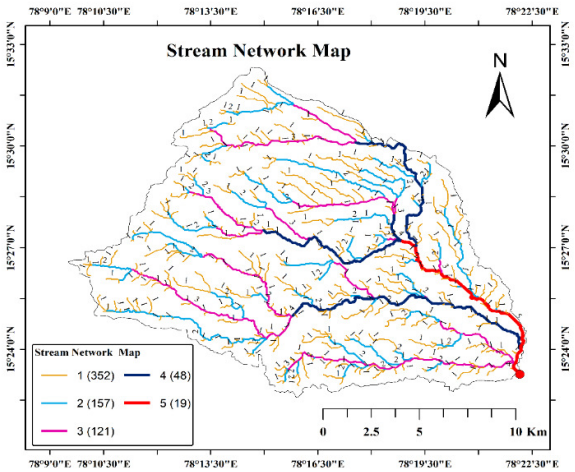


Fig-05: Drainage with stream network and order map of the study area

3.2.3 Stream length (L_u)

The research includes the assessment of the quantity of streams with varying orders inside a sub-watershed, along with the measurement of their lengths from their starting points to the point where they reach the drainage divided. The calculation of stream length (Lu) for 14.67km sub-watersheds has been computed on the proposed by (Horton's 1945) method, as indicated in (Table 2). and according to this law, the cumulative mean length of streams increase in geometrical progression with increase of stream order. If stream order is taken on X- axis on an arithmetic scale and cumulative mean length of stream on Y-axis a logarithmic scale, it gives a positive liner pattern. The relationship Stream length Vs Cumulative stream length which is follows. Stream Order and Total Stream Length exhibit an inverse correlation. Stream Order and Mean Stream Length display a direct correlation. Stream Order and Cumulative Mean Stream Length demonstrate a positive association. Furthermore, (Fig-06) besides, the latter increases geometrically with each successive higher order.

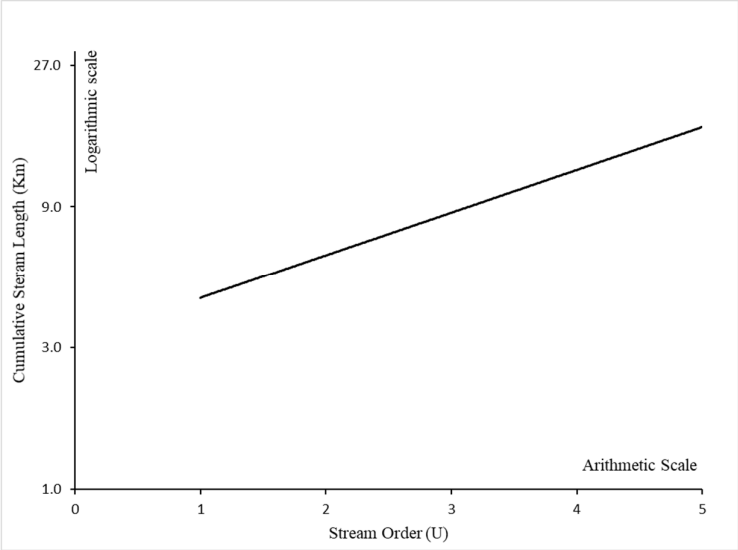


Fig-06: Stream order Vs Cumulative Stream length (L_u)

3.2.4 Mean stream length (L_{sm})

According to Strahler (1964), the mean stream length (Lsm) is an inherent property connected to the drainage network and its associated surfaces. To calculate the mean stream length (Lsm), the total stream length of order 'u' is divided by the number of streams of the same segment or order 'u' (Table 2).

3.2.5 Stream length ratio (RL)

The ratio of the mean length of one stream order to the next lower order of stream segment may be termed as the length ratio (RL). According to Horton's law (1945) of stream length, the mean stream length segments of successive orders in a basin tend to form a direct geometric series, with stream length increasing as the order of streams goes higher. The variation in stream orders within the research area demonstrates sub-basin, likely due to variations in topography, slope. And exhibit an increasing length ratio from lower to higher orders, suggesting a more advanced geomorphic stage. Conversely, the transition from one order to another in the remaining sub watershed indicates a youthful stage (Table-02).

3.2.6 Bifurcation ratio

The term bifurcation ratio (Rb) may be defined as the ratio of the number of the stream segments of given order to the number of segments of the next higher order (Schumn, 1956). Horton (1945) considered the

bifurcation ratio as an index of relief and dissections. Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation for different regions or for different environment except where the powerful geological control dominates.

Table No.03 Liner aspect of the Nandivargam sub-watershed.

Sno.	Stream Order (W)	Number of Stream (Nu)	Bifuration ratio (Rb)	Mean Bifuration Ratio (Rbm)	Total Length of Stream (Km)	Mean length of streams (Km)	Length ratio (R_L)
1	I	352			3.73		
2	II	157	2.24		3.16		
3	III	121	1.30	2.15	3.22	2.93	1.02
4	IV	48	2.52		2.22		
5	V	19	2.53		2.33		
	Total	**697**		**Total**	**14.67**		

Based on the information presented in (Table 3), it can be observed that the bifurcation ratio (R_b) varies between different orders of the drainage system. These variations are influenced by the geological and lithological characteristics of the drainage basin, as explained by (Strahler, 1964). Lower R_b values are indicative of sub-watersheds that have experienced fewer structural disturbances, as noted by (Strahler, 1964) and where the drainage patterns have remained relatively undistorted due to such disturbances, as mentioned by (Nag. 1998). The mean bifurcation ratio (R_{bm}) can be defined as the average of the bifurcation ratios across all orders. In this particular case, R_{bm} ranges from 2.15 in the Nandivargam sub-watershed, classifying it within the normal basin category.

3.2.7 Drainage density

Horton (1932) has introduced drainage density (D_d) into American hydrologic literature as an expression to indicate the closeness of spacing of channels. It is defined as the total length of streams of all orders per drainage area. Langbein (1947) recognized the significance of D_d as a factor determining the time of travel by water and he also suggested a drainage density varying between 0.55 and 2.09 km/km^2 in humid region with an average density of 1.03 km / km^2. Density factor is related to climate, type of rocks, relief, infiltration capacity, vegetation cover, surface roughness and run-off intensity index. Of these only surface roughness has no significant correlation with drainage density. The amount and type of precipitation influences directly the quantity and character of surface run-off. An area with high precipitation such as thundershowers loses greater percentage of rainfall as run-off resulting in more surface drainage lines. Amount of vegetation and rainfall absorption capacity of soils, which influences the rate of surface run-off, affects the drainage texture of an area. The similar condition of lithology and geologic structures, semi-arid regions have finer drainage density texture than humid regions. According to Nag (1998), low drainage density generally results in the areas of highly resistant or permeable subsoil material, dense vegetation and low relief. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture. The average drainage density 1.82km/km^2 indicating low drainage density (Table 2). In the study area, the low drainage density indicates the region has highly permeable subsoil and thick vegetative cover. The drainage density map is shown in (Fig. 07)

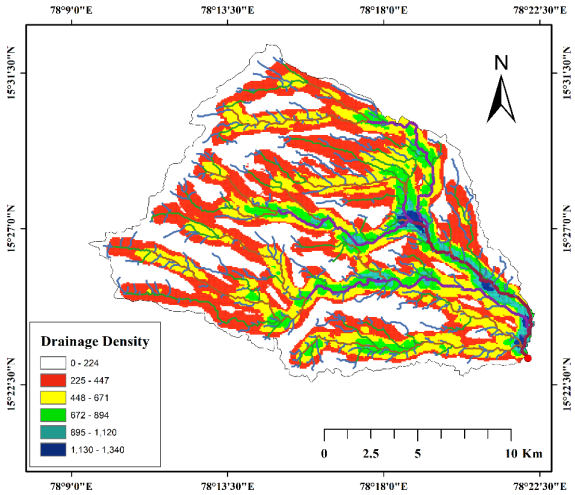


Fig-7: Drainage density map of the Nandivargam sub-watershed

3.2.8 Stream frequency

Horton (1932) introduced stream frequency (F_s) or channel frequency which is the total number of stream segments of all orders per unit area. Stream frequency, also known as channel frequency, refers to the overall count of stream segments of various orders within a given area 2.87(as shown in Table 02). In theory, it is conceivable for two basins with the same drainage density to have different stream frequencies, and conversely, two basins with the same stream frequency may exhibit varying drainage density. Table 2 provides data on stream frequency for the study area. It is noteworthy that there is a positive correlation between stream frequency (F_s) and the drainage density values of these sub-basins, signifying an increase in the number of streams relative to an increase in drainage density.

3.2.9 Drainage texture

Drainage texture (T) is a significant concept within geomorphology that pertains to the relative spacing of drainage lines. It's worth noting that drainage lines tend to be more abundant in impermeable areas compared to permeable ones. According to Horton (1945), "T" is defined as the total number of stream segments of all orders per unit perimeter of a particular area. Horton identified infiltration capacity as the primary factor influencing Rt and considered it as part of drainage texture, which encompasses both drainage density and stream frequency. Smith (1950) further categorized drainage density into five distinct textures. A drainage texture of less than 2 is classified as very coarse, between 2 and 4 as coarse, between 4 and 6 as moderate, between 6 and 8 as fine, and anything greater than 8 is considered very fine drainage texture. In Table 02, it is observed that the drainage texture from 5.22. For instance, sub-watershed exhibits a moderate course.

3.2.10 Form factor

According to Horton (1932), form factor (F_f) defined, as the ratio of basin area to square of the basin length (Table 2). The value of Form factor (F_f) is always less than 0.7854, which is for a perfectly circular basin (Strahler, 1964). The form factor values of the sub watershed in the study area of value 1.15. Basins of low form factor are elongated and have flatter peak flows for longer duration, while the basins with high form factors are circular and have high peak flows for shorter duration.

3.2.11 Circularity ratio

It represents the proportion of the basin's area to that of a circle with an equivalent perimeter as the basin (Miller 1953). Circular ratio (Rc) is affected by various factors such as the length and occurrence of

streams, geological formations, land usage, climate, terrain, and the slope within the basin. In this particular investigation, the Rc value is recorded as 0.49 (as shown in Table 2). The notable Rc value of 0.49 in the Nandivargam sub-watershed indicates that this particular sub-basin possesses a relatively circular shape. Moreover, it features a topography marked by substantial to moderate relief.

3.2.12 Elongation ratio

Elongation ratio (Re) is the ratio defined as the ratio of diameter of the circle of the same area as the drainage basin and the maximum length of the basin (Schumm, 1956). The values of "Re" generally numerical value varies from 0 to 1.0 over a wide variety of climatic and geo- logic conditions. Values close to 1.0 are typical of regions of very low relief, whereas values in the range 0.6–0.8 are usually associated with high relief and steep ground slope (Strahler, 1964). These values can be grouped as a three categories namely (a) Elongated (< 0.7), (b) Oval (0.9 -0.8) (c) Circular (> 0.9). The current research study area computed Re value of Re is 0.83, which is greater than 0.8, this sub watershed has a shape that is almost circular and typically belongs to regions of low relief areas (as shown in Table 2).

3.2.13 Length of overland flow

Surface water movement plays a significant role in triggering the formation of channels. "Overland flow" is the term employed to characterize the movement of water on the basin surface that occurs beyond the boundaries of a defined stream channel. Traditionally, the generation of overland flow is classified into two primary mechanisms: "infiltration excess," by Horton's work (1945). This factor basically relates inversely to the average slope of the channel. The length of overland flow (Lg) approximately equals, to half of the reciprocal of drainage density (Horton 1945). The current research study area calculated Lg value is 0.28.

3.2.14 Relief (R) and Relief Ratio of the Basin.

The term "total relief" refers to the difference in elevation between the highest and lowest points within a basin's valley floor. The "relief ratio," denoted as R_r and introduced by (Schumm 1956), quantifies the minimum relief relative to the horizontal distance along the longest axis of the basin, aligned with the primary drainage channel. This ratio serves as a metric for assessing the overall steepness of a drainage basin and provides insight into the level of erosion occurring on its slopes. the computed R value for the basin is 293, as presented in Table 2. This suggests that a substantial portion of the basin displays a pronounced slope.

3.2.15 Aspect Map

An aspect map typically refers to the orientation of a mountain slope, indicating the direction it faces. This aspect map holds significant importance in understanding the local climate's sensitivity to sunlight within the region. In general, slopes facing west tend to experience the hottest part of the day during the afternoon, and, in most cases, these west-facing slopes are warmer than their sheltered counterparts facing east. The aspect map plays a pivotal role in influencing the types of vegetation found in an area. When derived from SRTM DEM data, the aspect map indicates the compass direction of the slope's orientation, with 0 degrees denoting true north, and a 90-degree aspect pointing to the east (Fig. 8). In the case of the Nandivargam sub-watershed, it predominantly features east-facing slopes. Consequently, these east-facing slopes exhibit higher moisture levels and more abundant vegetation compared to their west-facing counterparts.

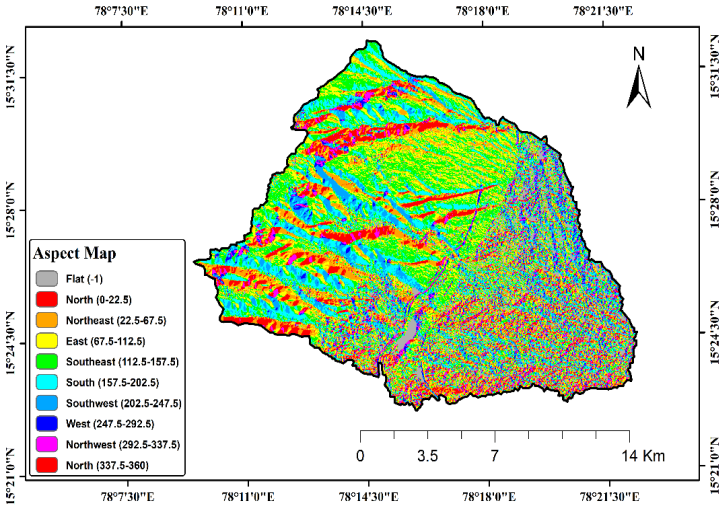


Fig-8: Aspect map of the Nandivargam sub-watershed

3.2.16 Slope Map

Slope is the measure of change in surface value over distance and can be expressed in degrees or as a percentage. In a raster format, the Digital Elevation Model (DEM) is a grid where each cell is a value referenced to a common datum. For extraction of elevation from remote sensing dedicated software packages are required but most GIS packages have routines for point or contour line interpolation. Any two points on the grid will be sufficient to ascertain a slope. Once the slopes have been calculated, then the maximum difference can be found and the gradient can be determined (Burrough and McDonnell, 1998; Maathuis, 2006; Jha et al. 2007). In the present paper topographical elevation map for the study area was developed by Digital Elevation Model (DEM) extracted from the Shuttle Radar Topography Mission (SRTM) data. For this, the DEM was subjected to two directional gradient filters (one in x-direction and another in y-direction).The resultant maps were used to generate a slope map of the study area using ARCGIS Spatial Analyst tools. The highest topographic elevations 395 m and lowest 102m exist in the western and northwestern portions of the area which induces highest runoff and hence less possibility rainfall infiltration. The slope map of the study area has grouped in five classes in degrees viz. 1°–3° (Gentle), 3°–5° (Moderate), 5°–10°(Steep) , 10°–35° (Very Steep) and >35° (Very Very Steep). The current study area observed that the gently slope 0-2.27%, moderate slope 2.28% to 6.28%, Steep 6.29% to12.2%, very steep 12.3% to 18.7%,very very steep 18.8% to34.1%. as shown Fig 09.

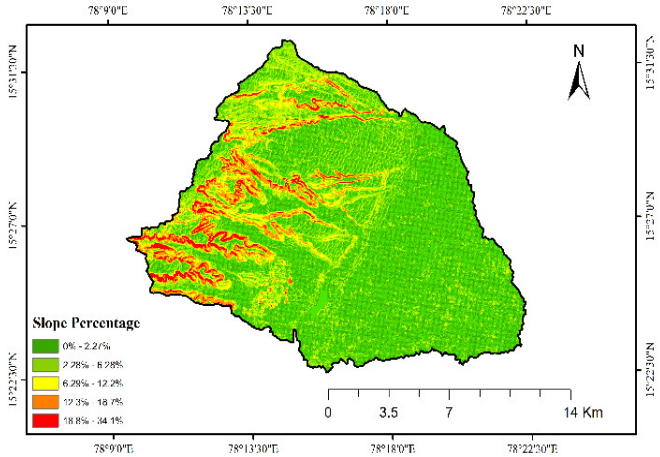


Fig-9: Slop map of the Nandivargam sub-watershed

4.0 Result and discussion

Assessment of watershed using quantitative morphometric analysis can provide information about the hydrological nature of the rocks exposed within the watershed. A drainage map of a basin provides a reliable index of permeability of the rocks and gives an indication of the yield of the basin. The DEM has been obtained with a pixel size of 90 m and furthermore, it has been used to calculate slope and aspect maps of the watershed. The development of drainage networks depends on geology, precipitation apart from exogamic and endogenic forces of the area. Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) data were used for preparing slope, aspect maps and morphometric analysis of the watershed. Linear, areal and relief aspects of the watershed were evaluated in GIS environment using Arc GIS software. Recent development in geospatial technology, the assessment of drainage basin has been more accurate and precise for morphometric parameter evaluation with better accuracy. Satellite data and GIS have been successfully utilized to generate data on the spatial deviations in drainage characteristics thus L providing an insight into hydrologic conditions necessary for developing watershed management strategies (Das and Mukherjee, 2005). Hydrogeological observations, integrated with drainage analysis, provide useful clues regarding broad relationships among the geological framework of the basin. Therefore, the results reveal different levels of agreement using morphometric analysis, which were supposed to be different from one region to another. Factors controlling groundwater storage are different in space and time, and the majority of these factors depend on the following parameters: (1) rainfall availability as the source of water; (2) drainage characteristics have a role in the distribution of runoff and indicate an infiltration scheme and it governs the behaviour of water flow on terrain surface vertically and horizontally; (3) rock type for which the lithologic character governs the flow and storage management; (4) slope is another influencing factor, and it controls water flow energy, which plays a role in facilitating water flow in the basin. The morphometric analysis can be achieved through measurements of linear, areal and relief aspects of basin.

5.0 Conclusion and Recommendation:

The hydrological analysis carried out for the Nandivargam sub- watershed confirms that the watershed is having low relief and circular shape. Drainage network of the basin exhibits as mainly dendritic type which indicates the homogeneity in texture and lack of structural control and helps understand various terrain parameters such as nature of the bedrock, infiltration capacity, runoff, etc. Lower drainage density and stream frequency indicate high permeability rate of the subsurface formation. The observed parameters reveal recharge-related measures and areas where surface-water augmentation measures can be undertaken for water resource management and soil conservation structures. Large scale watershed analysis using GIS, remote sensing data and Digital elevation Model (DEM) has efficient tools for understanding any terrain parameters such as nature of bedrock, infiltration capacity, surface run off etc., which helps in better understanding the status of land form and their processes, drainage management and evolution of groundwater potential for watershed planning and management. This work will be useful for natural resource management at the micro level of any terrain for sustainable development by planners and decision makers for sustainable watershed development programme. The results observed in the present work can be used for site suitability analysis of soil and water conservation structures in the area and subsequently, these parameters were integrated with other hydrological information viz., The study recommended that the watershed needs a hydrogeological and geophysical investigation in future for proper water management and selection

Abbreviations GIS:

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An Experimental Investigation on the Properties of Geopolymer Concrete with Partial Replacement of Marble Powder

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ABSTRACT

This research provides a geopolymer concrete investigation in which fly ash is partially replaced with marble powder. Geopolymer concrete uses waste materials such as fly ash (FA) and an alkaline solution (NaOH&Na2SiO3) to form a strong binder, replacing cement and including marble powder as a partial substitute. This experimental study looks at the tensile properties of geopolymer concrete with different quantities of fly ash replaced by marble powder. The major purpose is to use landfilling waste, such as marble powder, as a binding agent in geopolymer concrete at varying percentages (0, 5%, 10%, 15%, 20%, and 25%) instead of fly ash. The geopolymer mix is designed for a 12M, with an alkaline-to-binder ratio of 0.45. By adding fly ashwith marble powder, the concrete achieves 28-day cube strengths ranging from 40 to 60 MPa utilizing air curing procedures. This formulation allows for rapid strength development, making it appropriate for large structural elements (e.g., precast) without the requirement for extended conventional curing times. Superplasticizers, notably PCE (Poly Carboxylate Ether)-based ones, are used to improve workability. Mechanical property tests were performed, including compressive strength for 100*100*100 mm cubes, split tensile strength for 100*200 mm cylinders, and flexural strength for 500*100*100 mm prisms. When compared to conventional geopolymer concrete, which does not contain partial replacement marble powder, the concrete achieves 28-day cube strengths ranging from 40 to 60 MPa using air curing methods. This formulation allows quick strength growth, making it suited for heavy structural parts.

Keywords: Geopolymer concrete, Fly ash, Marble powder, Mechanical properties, Optimum percentage.

INTRODUCTION

Sustainable development is a crucial topic today due to the deterioration of the human environment and natural resources. Cement manufacture is a large contributor to air pollution, accounting for around 7% of global carbon dioxide emissions. Rapid urban development causes building construction and demolition, resulting in large volumes of waste that are frequently dumped in landfills. To address this issue, researchers are investigating the use of industrial waste materials such fly ash, powdered granulated blast furnace slag, and marble powder as alternatives to ordinary cement in construction. Geopolymer, a cement-free binder, is gaining popularity for its ability to include elements such as fly ash and marble powder. In a recent study, marble powder was studied as a partial replacement for fly ash in geopolymer to determine the impact on strength attributes. Various percentages (0%, 5%, 10%, 15%, 20%, and 25%) of marble powder were examined, and mechanical properties of the resulting geopolymer materials were evaluated. The data were compared to traditional concrete mixes to examine the feasibility and effectiveness of employing marble powder in geopolymer concrete manufacture.

This experimental investigation focuses on the strength behavior of geopolymer concrete when Fly Ash is partially replaced with Marble powder. The primary goal of the study is to determine the optimal proportion of Marble powder in enhancing the strength of Fly ash-based Geopolymer Concrete by partially substituting Fly ash with Marble powder at various percentages such as 0%, 5%, 10%, 15%, 20%, and 25%. The geopolymer is designed for 12M and has an alkaline-to-binder ratio of 0.45 and a sodium silicate-to-sodium hydroxide ratio of 2. The mechanical properties of geopolymer materials including fly ash, marble powder, fine aggregate, coarse aggregate, and alkaline solution were tested. For the compression test, 100mm x 100mm x 100mm cubes were constructed.For the purpose of testing split tensile strength, a 200mm diameter by 100mm length cylinder was used, and 500mm x 100mm x 100 mm prisms were constructed. The results of the flexural strength test were compared with the typical control mix, that is, without partial replacement.

Objectives:

- To find the optimum percentage of Marble Powder in developing the strength in Fly ash based Geopolymer concrete mix.
- To determine the mechanical properties of geopolymer concrete such as Compressive strength for cubes(100mm*100mm*100mm), Split tensile strength for cylinders(200mm*100mm), Flexural strength for prisms (500mm*100mm*100mm) at various replacement levels of Marble Powder dust as partial replacement of Fly ash in geopolymer concrete.
- To compare the mechanical properties of Fly ash based Geopolymer Concrete with partial replacement of Fly ash with Marble Powder to those of control concrete mix of Geopolymer Concrete.

MATERIALS USED

Fly ash

Fly ash, a residue derived from the combustion of pulverized coal in coal-fired thermal power plants, serves as a valuable component in hydraulic-cement concrete, significantly enhancing its properties. When mixed with hydraulic cement during hydration, fly ash contributes to the formation of a binding agent. This study employs class-F fly ash as a supplementary cementitious material, aiming to improve both the initial and long-term characteristics of concrete. Typically, fly ash utilized in concrete applications exhibits a color spectrum spanning from dark grey to yellowish tan.

Coarse aggregate

Well graded coarse aggregate conforming to the provision of IS: 383-2016 is going to use throughout the investigation. The aggregate of nominal size 12mm were blended to a desired proportion and mixed intimately to obtain well graded aggregate.

Table-1: Properties of Coarse aggregate

Specific gravity	2.65
Water absorption	0.73%
Fineness modulus	6.31

Fine aggregate

Locally available river sand conforming to is 383:2016 specifications passing through 4.75 mm sieve and retained on 75µm was used as the fine aggregate in the concrete mix. The fineness modulus, specific gravity were determined and sieve analysis of the fine aggregate and the corresponding grading curve is shown.

Table -2: Properties of Fine aggregate

Specific Gravity	2.58
Fineness modulus	3.15
Grading	Zone-II

Marble Powder

Marble powder entering open areas causes environmental, health and economic losses. Waste marble powders can be used in geopolymers to eliminate these disadvantages and provide sustainable environmental and eco-economic benefits. The Marble Powder is a calcium-rich waste material produced from processing plants sawing and polishing of marble blocks.

Table -3: Chemical composition of Marble Powder

Chemical composition	**Percentages**
Silica (SiO_2)	21.12
Iron Oxide (Fe_2O_3)	3.24
Alumina (Al_2O_3)	5.62
Calcium Oxide (Ca O)	62.94
Magnesium Oxide (MgO)	2.73
Potassium Oxide (K_2O)	0.25
Loss on ignition	38.65
Fineness	Completely passing through 90 Micron sieve

Sodium Hydroxide solution
Generally, the sodium hydroxides (NaOH) are available in solid-state in the forms of pellets or flakes. The price of sodium hydroxide varies a lot depending on how pure of product. The solution of NaOH was prepared by dissolving pellets in water for different molarity. It is recommended that NaOH solution should be made 24 hours before casting and should be used within 36 hours of preparing the solution otherwise it will be converted into a semi-solid state.

Sodium Silicate solution
Sodium metasilicate is also known as sodium silicate and is of industrial grade with SiO2 as 29.4% by mass and Na2O as 14.7%. As per the manufacturer, silicate is used as a bonding agent in detergent industries and textiles industries.

Super plasticizer
AURAMIX 450 is utilized as superplasticizer in this project. It is a polycarboxylate ether (PCE) based high performance super plasticizer. It is used for concrete requiring long workability retention. Appearance is light yellow colored and its pH is of minimum 6.

Water
The locally available potable water, which is free from the concentration of acids, organic substances, is used for mixing solution and concrete which promotes chemical reaction and also helps in the strength attaining of concrete. So bad quality of water affects the strength. It is necessary to follow quality analysis and water purity before being used in the project.

MIX DESIGN

Preparation of Alkaline solution
Alkaline solutions are created by mixing sodium hydroxide solution and sodium silicate at room temperature. When these solutions are combined, they initiate a reaction, known as polymerization, releasing a significant amount of heat. It is advisable to let the mixture sit for approximately 24 hours to allow the alkaline liquid to fully form as a binding agent. In this study, geopolymer concrete is prepared using 12 molarities of sodium hydroxide. The molecular weight of sodium hydroxide is 40. To prepare a 12M solution, 480g of sodium hydroxide flakes are measured and dissolved in distilled water to create a 1-liter solution. This process involves slowly adding sodium hydroxide flakes to distilled water in a 1-liter capacity pycnometer until fully dissolved. Water and Super plasticizer are used only for workability purpose. After many trial mixes by changing water and super plasticizer percentages at finally below mentioned percentages got high workability of 110 mm slump.

Table – 4: Ingredients of Geopolymer concrete

Material	Proportions (Kg/m^3)
Coarse aggregate	924
Fine aggregate	756
Binder	496.55
Sodium Hydroxide	74.48
Sodium Silicate	148.96
Super plasticizer	1% of Binder
Water	10% of Binder
Molarity	12M
Na_2SiO_3: NaOH	2

Mix design
In this design, a 12M solution of sodium hydroxide is utilized for alkaline preparation. The ratio between sodium hydroxide and sodium silicate is set at 2. The aggregate volume is determined as 70% of the total volume of the cube. The ratio of alkaline liquid to fly ash is maintained at 0.45. Fly ash is substituted with different percentages ranging from 0% to 25%, including 5%, 10%, 15%, 20%, and 25%.

Table -5: Various mix proportions of Geopolymer concrete

Mixes	Fly ash (%)	Marble Powder (%)
M0	100	0
M5	95	5
M10	90	10
M15	85	15
M20	80	20
M25	75	25

Mix Procedure

In the lab, the dry mixing of fly ash and aggregates took about three minutes in a pan mixer. Aggregates were prepped in a saturated-surface-dry (SSD) condition. Alkaline liquid was combined with superplasticizer and water. This liquid mix was then added to the dry materials, followed by mixing for an additional four minutes. Workability was assessed via the conventional slump test. Air curing is typically advised for low-calcium fly ash-based geopolymer concrete, with curing time and temperature significantly impacting strength. Specimens were cured at room temperature for 24 to 48 hours, with longer durations enhancing polymerization and strength



Figure 1: Casted Specimens



Figure 2: Failure Specimens

RESULTS AND DISCUSSION

Compressive strength Test

The primary test for strength evaluation is compressive strength, commonly conducted on cube specimens measuring 100mm x 100mm x 100mm. Compaction of each layer is achieved using a tamping rod, followed by leveling the top surface of the mould with a trowel. Specimens are tested after 7 days, 28 days, and 56 days to assess compressive strength across varying curing durations.

Table-6: Compressive strength

Mixes	Compressive Strength (MPa)		
	7 days	28 days	56 days
M0(Std mix)	34.88	39.15	40.80
M5	25.52	44.16	45.74
M10	27.67	52.85	54.43
M15	33.43	59.65	60.75
M20	**33.84**	**60.47**	**62.34**
M25	31.87	53.26	54.20

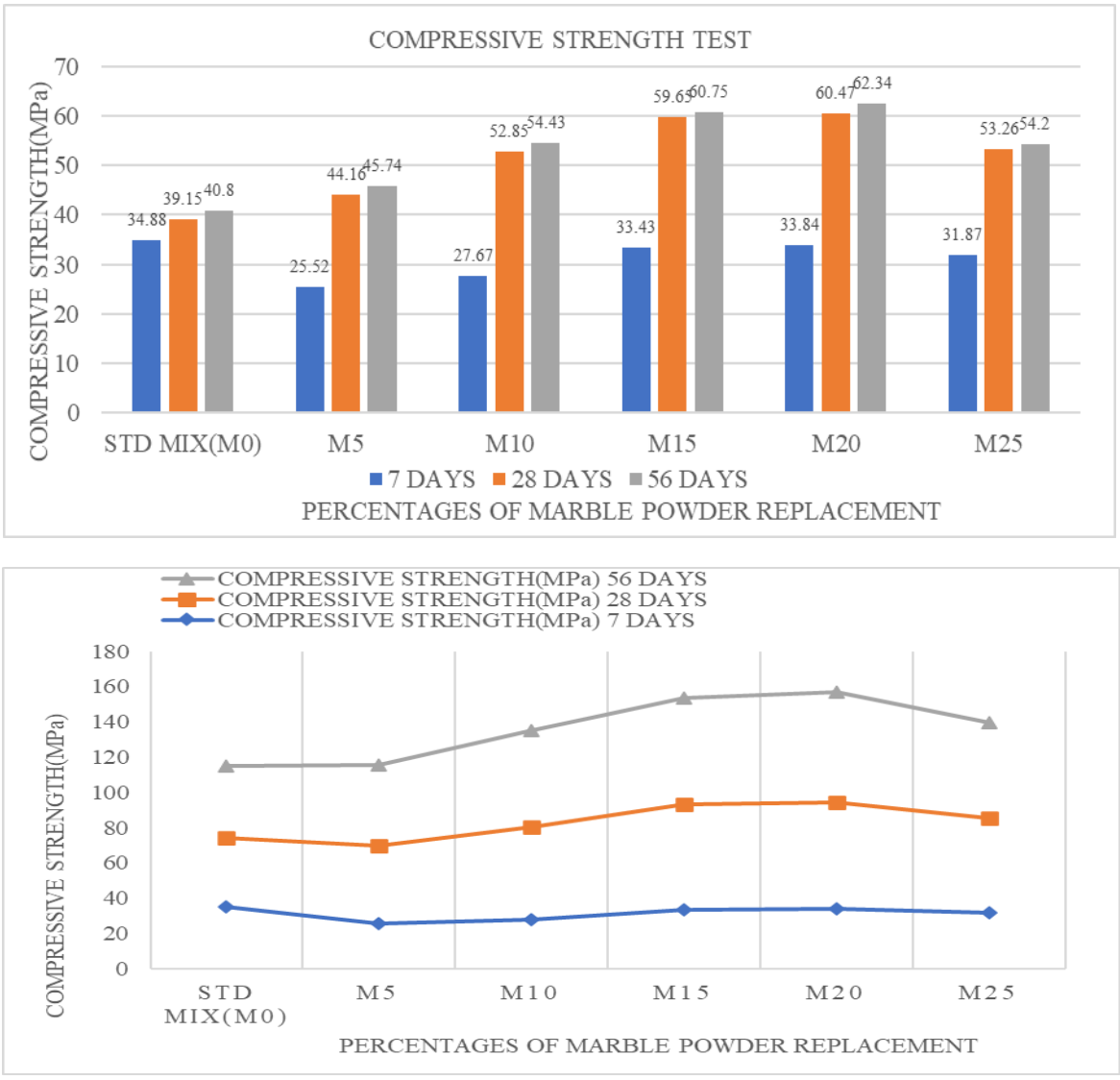


Figure 3: Comparison test of compressive strength on 7, 28 and 56 days with standard mix

Split tensile strength test

This test employs an indirect tension method, involving the placement of a cylindrical specimen horizontally between the compression testing machine's loading surfaces. Load is gradually applied until the cylinder fails along its vertical diameter. Notably, the same compressive testing machine and cylindrical specimen used for compression tests can be utilized. To mitigate high compressive stresses, narrow cracking strips of suitable material are incorporated. The split tensile test is known for its simplicity and ability to produce uniform results.

Table 7: Split Tensile strength

Mixes	Split tensile strength (MPa)
M0(Std mix)	1.71
M5	2.22
M10	2.51
M15	3.05
M20	**3.26**
M25	2.48

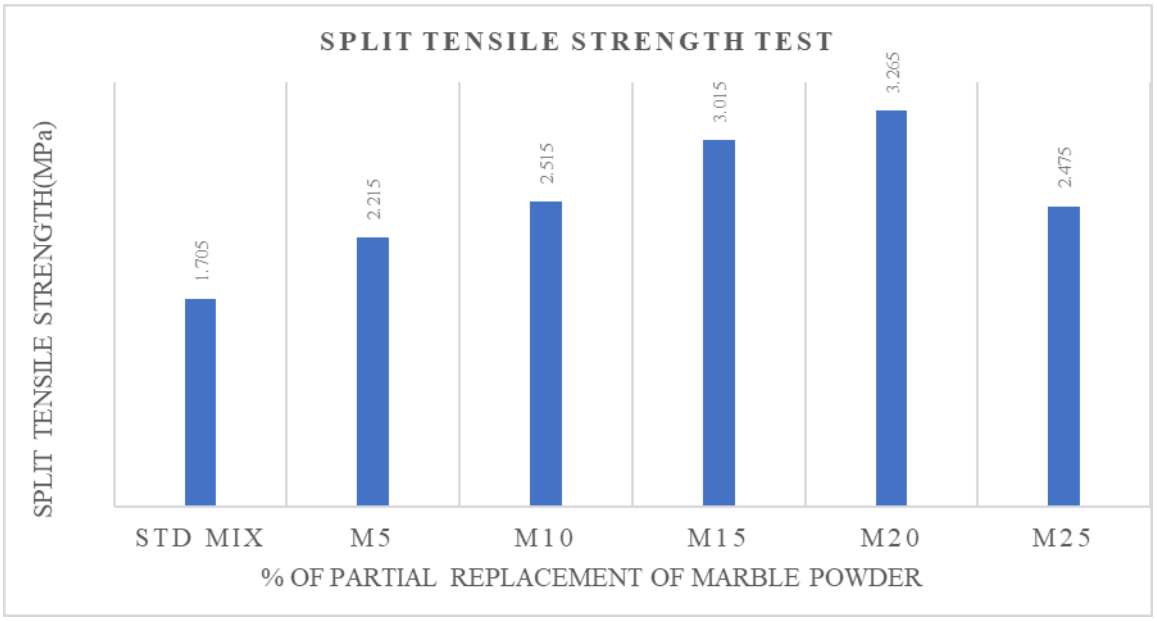


Figure 4: Variation of split tensile strength at 28 days with partial replacement of marble powder

Flexural Strength

The specimen was held on two rollers supports on the testing machine, Until its breakdown, the load was applied hydraulically through two equal rollers placed at the third point of the supporting span. The specimen is of 500 mm length, 100 mm breadth and100 mm height.

Table 8: Flexural strength test

Mixes	Flexural strength (MPa)
M0(Std mix)	4.27
M5	5.46
M10	5.51
M15	5.83
M20	**5.97**
M25	5.94

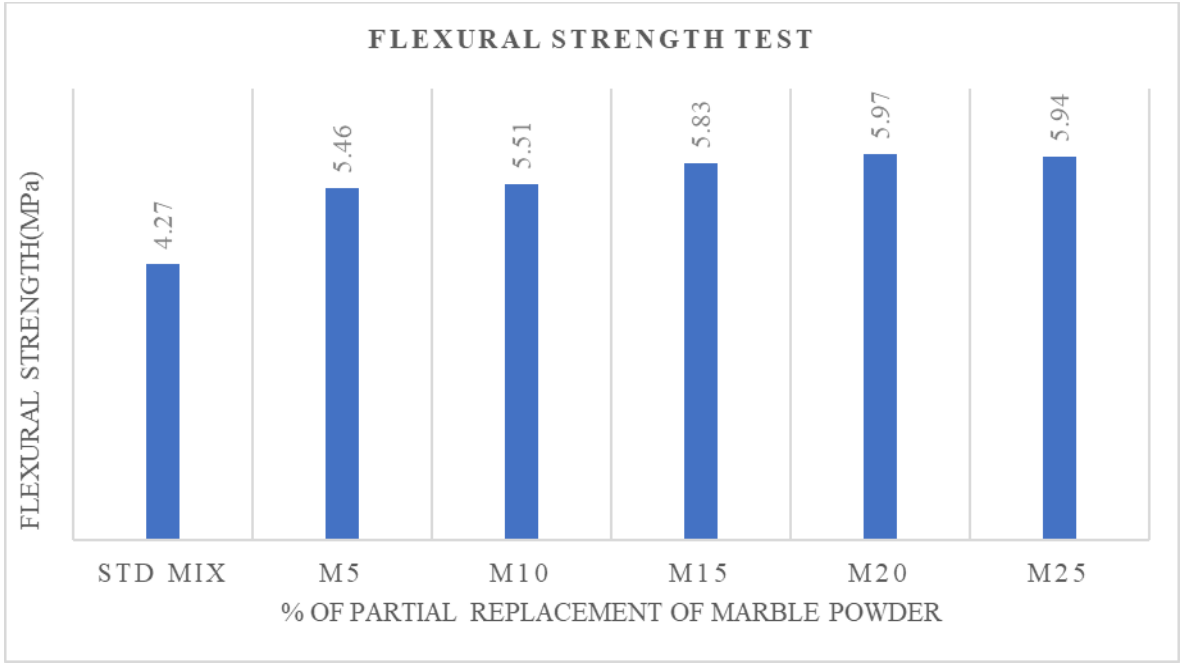


Figure 3: Variation of Flexural strength with partial replacement of Marble powder at 28 days

CONCLUSION

Durable, eco-friendly materials are sought for by the construction sector. GGBS and fly ash provide benefits over regular concrete. Optimizing the use of marble powder is the project's goal. The compressive strength of marble powder substitute peaks at 20% replacement by 28 days, and it is comparable to the regular mix after 7 days. Marble powder can boost the strength of geopolymer concrete by up to 20%. Structure is somewhat impacted by strength when it approaches 20% replacement. Marble powder has a compressive strength of 60.75 MPa at 20% replacement, which is 54% higher than that of normal mix. Marble powder outperforms normal mix, increasing strength by 76% (@M20) at 20% replacement in the split tensile test. At 20% replacement, flexural strength peaks at 5.97 MPa, representing a 40% increase (@M20) above normal mix. Slump value increases with the percentage of marble powder and exceeds that of traditional geopolymer concrete. The ease of geopolymer innovation is especially advantageous for precast applications. Particularly in harsh conditions, geopolymer concrete provides strength and a greater range of applications than regular concrete. Marble powder, an industrial waste that is only used for landfilling, is a very cost-effective addition to geopolymer concrete, and is the primary cause of the compressive strength increase of up to 60 MPa. It also contributes to the geo-polymerization process, which gives strength to the concrete. Instead of using cement, geopolymer concrete employs industrial waste as a binder, which reduces pollution and is also utilized in areas with limited fly ash production. There are therefore numerous benefits to employing these industrial wastes in the geopolymer concrete used for many heavy structural works.

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PSO Trained Feed Forward Neural Network Based SAPF for Power Quality Enhancement in Distribution Networks

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***Abstract*—Power distribution infrastructure is being harmed by the advent of nonlinear devices, which cause harmonics to enter into the power system networks and distort the voltage and current signals. Shunt Active Power Filter (SAPF) is a new power electronics-based technology that can reduce harmonics and improve the power quality in distribution networks. This research provides an efficient and inexpensive strategy to minimizing harmonics and improving the power quality in power distribution networks by employing Shunt Active Power Filter's (SAPF), which uses the Particle Swarm Optimized Artificial Neural Network Controller (PSO-ANN). The goal of the PSO-ANN algorithms have been developed for SAPF is to improve system performance by lowering the amount of Total Harmonic Distortion (THD). In this work, the standard PI controller is initially tuned using the PSO algorithm to obtain the optimal gain values (K_i, K_p) for the PI controller. After that, these values of the PSO-PI controller's input and output will serve as a dataset for the ANN controller. Now, the PSO algorithm is being used to tune this ANN controller in order to acquire the optimal values for the weight and bias. Using the MATLAB/SIMULINK tool, the proposed algorithm's performance is evaluated and compared to that of a PSO-PI based SAPF and the conventional PI based SAPF. The results of the simulation demonstrate that a SAPF which is based on a PSO-ANN controller is capable of achieving superior THD in the drawing source current while maintaining minimum levels and which are acceptable in accordance with the IEEE-519 standard for harmonics.**

***Index Terms*—ANN-controller tuning, particle swarm optimization algorithm, PI-controller tuning, power quality, shunt active power filter, total harmonic distortion**

I. Introduction

Harmful harmonic currents are produced at the Point of Common Coupling (PCC) due to the usage power electronics devices and non-linear load in huge quantities [1]. Because of the many issues that can arise from distribution system current harmonics, loss, instability, noises, heating appliances, etc. It would be preferable to reduce their risk and bring them down to an acceptable level, as specified by the IEEE-519 standards for Total Harmonic Distortion (THD) [2].

To reduce current harmonics, compensate for reactive power, and improve power factor, a Shunt Active Power Filter (SAPF) could be the solution. Fig. 1 (next page) depicts the SAPF setup, this consists of the active filter controller as well as the Voltage Source Inverter (VSI). In order to achieve the desired result of injecting a controlled compensating current into the power system, the VSI requires instantaneous adequate firing signals from the control unit [3, 4]. The reactive power control to the grid is supplied by the DC-link capacitor employed on the front side of the VSI [5]. In order to connect the DC component to the three-phase power distribution system, a VSI is necessary. To reduce the amount of distortion in the source current, VSI injects a compensating current in response to the firing signals [6].

To analyze the VSI switching operation, either reference generating methods or control techniques are used. The SAPF control techniques are able to be implemented in two steps, which are as follows: first, by using reference current generation theories to extract compensating signals from distorted signals, and then, by using signal estimated reference methods to produce appropriate firing signals for the purpose of controlling the SAPF switching devices [7]. Several writers have compared SAPF control techniques ([8, 9]).

The PI-controller, which is an integral aspect of reference current theory, is responsible for minimizing the impact of harmonics. K_i and K_p gain settings of the PI-controller need to be properly tuned in order to obtain the best possible results. The traditional approach for tuning the gains of the PI-controller utilizes linear modeling, which ultimately results in a less-than-optimal setting for the gains [10, 11]. Consequently, PI-controller tuning makes use of a variety of different metaheuristic optimization strategies. There are a variety of control methods that can lower current harmonics and introduce the converter to brand new opportunities [12]. Consider, for example, the Particle Swarm Optimization (PSO) [13−17] method and Genetic algorithm (GA) [18].

Artificial Neural Network (ANN) is a network that is set up and works in a way that is similar to how the human brain works. To simply stated, the brain is a network of cells called neurons. The behavior of the

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whole network depends on how strong the connections between interneuron's are and how they are set up. During the training of the network, the weights are changed and tweaked [19]. At the moment, Artificial Neural Network (ANN) techniques are only used on SAPF for producing reference compensation current, which is used to control the compensation that SAPF gives [20, 21]. Learning weights can be accomplished in a variety of techniques [22]. Some examples include the Widrow-Hoff (W-H) approach, the Steepest Descent method of variable learning, the Levenberg-Marquardt method, and others.

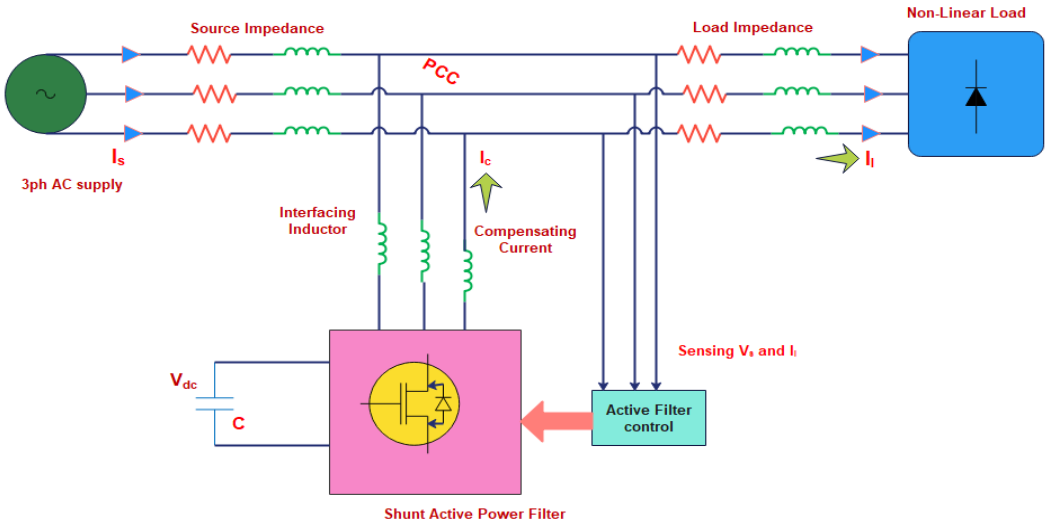


Fig. 1. Basic elements of the shunt active power filter.

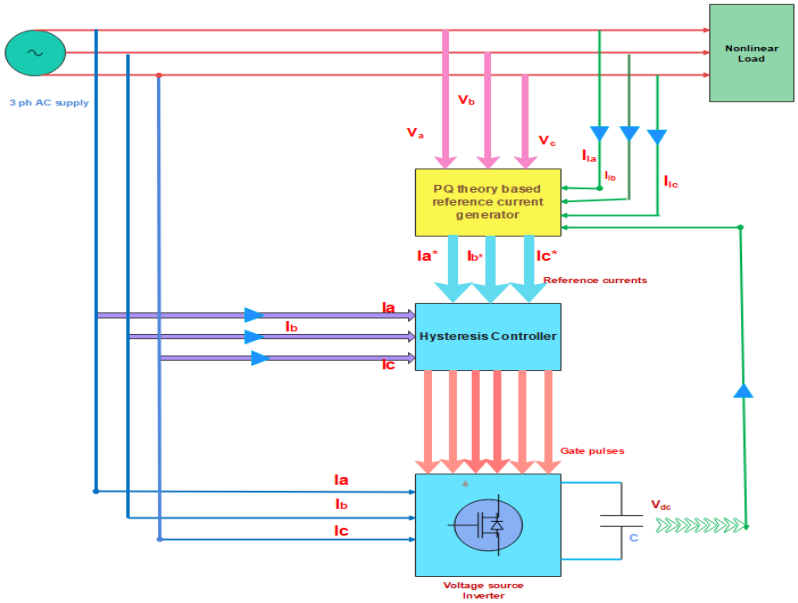


Fig. 2. SAPF controller configuration.

This work uses the concepts of instantaneous active and reactive power to derive the reference current (PQ-theory). Hysteresis current controller technique, as shown in Fig. 2 [23], estimates reference currents to provide necessary gating pulses. For optimum performance of a PQ-theory based ANN-controller for a dc-link voltage requires fine-tuning of weight and bias values. For the optimum ANN-controller weight and bias particle swarm optimization algorithm is implemented in order to identify its optimal state.

II. PQ Theory

In the case of three-phase, three-wire systems that have sinusoidal and balanced source voltages, a PQ-theory-based constant instantaneous power control approach has been developed. The instantaneous power is calculated by sensing the source voltage (V_a, V_b, V_c) and load current (I_{la}, I_{lb}, I_{lc}) and transforming them using Clarke transformation into (α, β) components. Error signal is derived from reference and measured dc-link voltages, then introduced to PI or ANN controller to obtain power losses component of dc-link voltage (P_{loss}). As illustrated in Fig. 3 (next page) [24], the reference current signals are obtained by inverting the components (α, β) with the real and reactive power by use of the inverse Clarke transformation (α, β to three phase values (V_a, V_b, V_c, I_{la}, I_{lb}, I_{lc}).

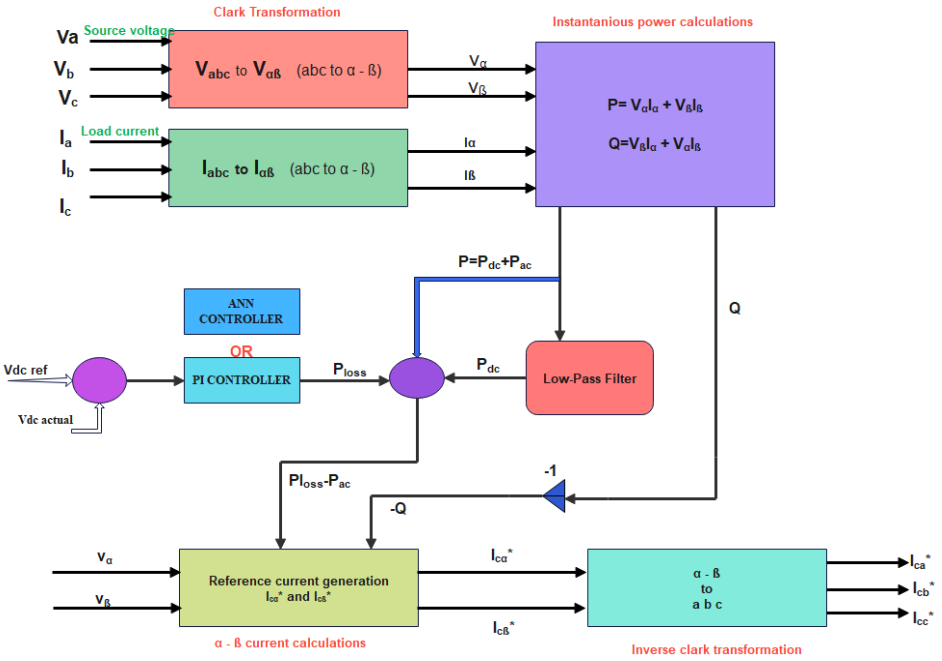


Fig. 3. Work flow of PQ theory based reference current generation.

III. Artificial Neural Network (ANN)

The human brain's structure is built on neural networks, hence the terminology "Artificial Neural Network" is adopted from the neuroscience area. Multiple layers of interactions are present between neurons in artificial neural networks, just like the neurons in the human brain are connected to each other. These nerve cells are called nodes as shown in Fig. 4. A nominal neuron is a processing element that, in general, possesses one or more outputs and n inputs (x_1, x_2,⋯, x_n) which are the independent inputs or outcomes of the different neurons. Fig. 5 provides a visual representation of these inputs and outputs. The neuron begins by computing the sum of its inputs, and then it transfers this value through its activation function in order to form its output, which is indicated by the value Y_i [25].

$$Y_i = f_i\left(\sum_{j=1}^{n} w_{i,j}x_j + b_i\right) \quad (1)$$

where $w_{i,j}$ are the weight of the connection between the input neuron and the output neuron, b_i is the bias of the neuron, x_j represents the neuronal input, and f is activation function that controls the characteristics of the neural network.

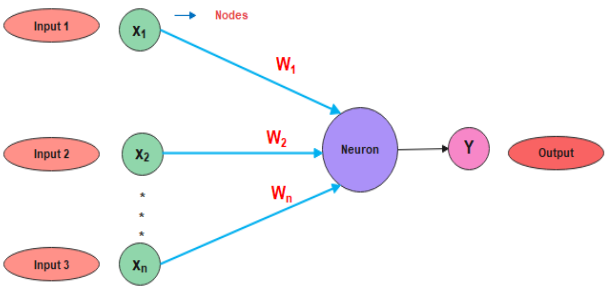


Fig. 4. Basic structure of artificial neural network.

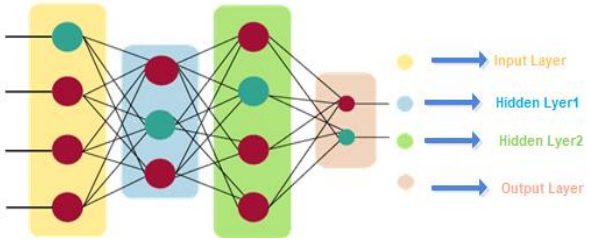


Fig. 5. Architecture of the artificial neural network.

Neural networks adjust to input data by changing connection weights (including biases) and sometimes layer number and neurons number.

IV. Introduction to PSO

The comprehensive implementation of PSO algorithm starts with the movement of a group of possible random solutions, which are represented in the form of moving particles in inside target region. This movement is done in order to find the optimal solution. Every one of the nearby particles that are being assumed has some a speed as well as a selective memory, which enables each other to recall the position and value that corresponds to their optimal level of performance. This is being done by taking into account all of the information that is currently being taken into account. A predetermined objective function that is tied to the problem that needs to be resolved [26] is used to evaluate the efficacy of each individual particle. The velocity of each particle at iteration is determined by linearly combining the velocity and position at iteration, as well as the intervals that separate the existing position of the particle from its preceding best position and finest position, respectively. This information is then used to calculate the velocity of each particle. This leads to the development of a formula for determining the velocity of the particle at the next iteration, which is denoted by t+1. The motion of the

particles is formalized for us by Eqs. (2) and (3), which provide us a representation of the movement of the particles.

$$v_i(t) = wv(t-1) + \left[P_{\text{best}}(t-1) - x_i(t-1)c_1r_1\right] + \left[G_{\text{best}} - x_i(t-1)\right]c_2r_2 \quad (2)$$

$$x_i(t) = x(t-1) + v_i(t) \quad (3)$$

where x_i is the ith particle position, v_i is the ith particle velocity, P_{best} is particle best position, G_{best} is target position, w is coefficient of inertia, c_1 and c_2 are coefficients of acceleration, and r_1 and r_2 are values at random between 0 and 1.

Iterate (2) and (3) until convergence is achieved [27].

V. Proposed Implementation

A. PSO Tuned PI Controller

The primary function of SAPF is dependent on DC link voltage regulation, which is controlled by standard PI controller. This controller requires a great deal of mathematical calculation, and it is possible that it will not produce optimal gain values for k_p and k_i. With the help of the PSO algorithm, we can determine the optimal values for k_p and k_i.

The actual dc voltage as compared to the reference dc voltage and the error that will be fed to the PSO-PI controller can be seen in the Fig. 6. The Integral Absolute Error (IAE) is the objective function that needs to be minimized with the help of the PSO algorithm in order to obtain the optimal gain values. The parameters for the PSO are specified in the Table I.

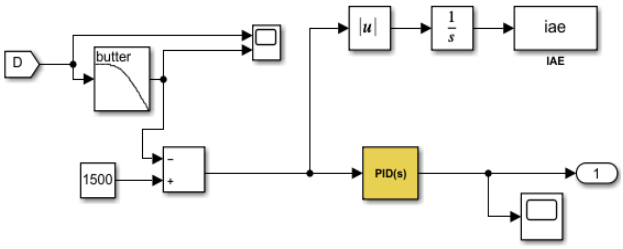


Fig. 6. DC voltage regulation of SAPF with PSO-PI controller.

TABLE I: PSO Parameters

Maximum iterations	1000
Total Population	50
Weight of Inertia	0.89
Constant of Acceleration (C_1)	2
Constant of Acceleration (C_2)	2
Total Variables	2
Higher Limit of K_i, K_p	200
Lower limit of K_i, K_p	0
Optimum value of K_p	5.65119
Optimum value of K_i	7.93019

B. PSO Tuned ANN Controller

The objective of ANN training is to arrive at the most accurate possible values for the network's weights and biases. The right values of the ANN's weights and biases are determined by the application of a variety of methodological approaches. The PSO method was utilized in this paper. According to the Fig. 7, the input (e) and output of the PSO-PI controller will serve as the dataset for the neural network feed forward controller.

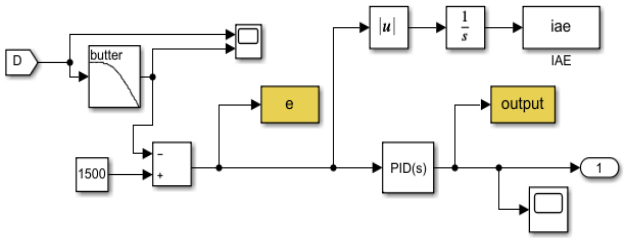


Fig. 7. The workspace representation of the PSO-PI controller's input (e) and output.

The Initialization of the neural network code shown in below says to get the input and target values from the PSO-PI controller, then initialize the hidden neurons are 10, configure the neural network based on the input and output, get the weights and bias of the configured neural network, create the objective function as root mean squire error, and use the PSO algorithm to fine-tune the weights and bias of the pre-trained neural network.

Initialize the neural network problem

- inputs = e';
- expects = output';
- hn = 10; (number of hidden neurons)
- Nn = feedforwardnet (hn);
- Nn = configure (Nn, inputs, expects);
- getwb(Nn) (Getting initial weight and biases)
- Based on weights and bias(y), Nn, inputs, and expects, calculate the objective function which is root mean square error denoted by (g).
- Train the neural network by applying the PSO algorithm .From that we can obtain the updated weights, bias (y), and error (e).
- Nn = setwb(Nn, y');
- getwb(Nn)
- e = expects - Nn (inputs);
- def = mean(e.^2)/mean(var(expects',1));
- gensim(Nn)

The algorithm's operation can be summed up using the steps as follows:

- Initialization at random of all of the local positions X_i (weights and biases).
- Evaluate the fitness function for each initialized particle, which is provided by (4), then establish the local locations $P_{i\text{-best}}$ and the global positions G_{best}.

$$f = \sum\sqrt{(\text{target} - \text{actual output})^2} \quad (4)$$

- Update all $P_{i\text{-best}}$ local positions
- Assess the current best in the area and the fitness function. If $(fP_{\text{best}}) < f(G_{\text{best}})$ then $G_{\text{best}} = P_{\text{best}}$.
- Using (2) and (3), modify the neural networks' weights and biases.
- The process should end if the stop condition holds true. If not, proceed to Step 2 to display the updated weights and biases.

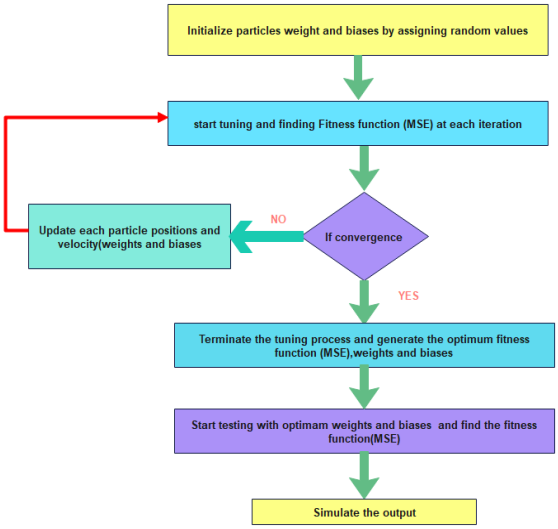


Fig. 8. Flow chart representation of PSO trained ANN controller.

Convergence is reached when the synaptic coefficients settle on a final value and the network's Mean square error (NMSE) drops below a specified threshold. Limiting the number of possible iterations is another way to interrupt the learning process. Fig. 8 depicts the training algorithm's flowchart.

Finally for a given input and an output, we will get the feed-forward neural network as shown in Fig. 9, which will be replaced by the PSO-PI controller.

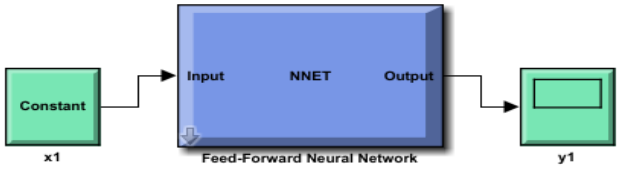


Fig. 9. Simulink block of PSO-ANN algorithm.

TABLE II: SIMULINK MODEL FRAMEWORK

Specification	Values
Source Voltage	415V
Source Frequency	50 Hz
Source Impedance	0.1 ohm, 15mH
Interfacing impedance	15mH
Load Real Power	4472 W
Load Reactive Power	1718 VAR
DC link Capacitance	100μF

VI. MODEL CONFIGURATION

The configuration of the suggested model is shown in Fig. 10, which consists of a three-phase power grid coupled to a three-phase un-controlled diode rectifier coupled to a non-linear load represented by an inductive load on the DC side. SAPF with a VSI design and a capacitor on the DC link are incorporated into the system at the PCC.

The simulation diagram of a PQ theory-based reference control method for SAPF is represented in the Fig. 11. Table II contains a listing of the suggested model's parameters.

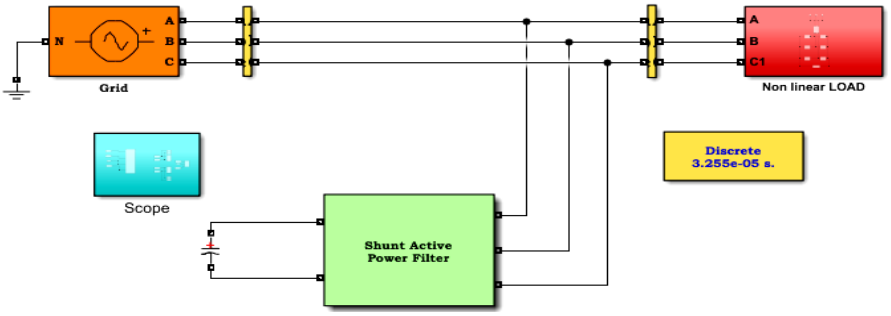


Fig. 10. Simulink model of Grid connected nonlinear load with SAPF.

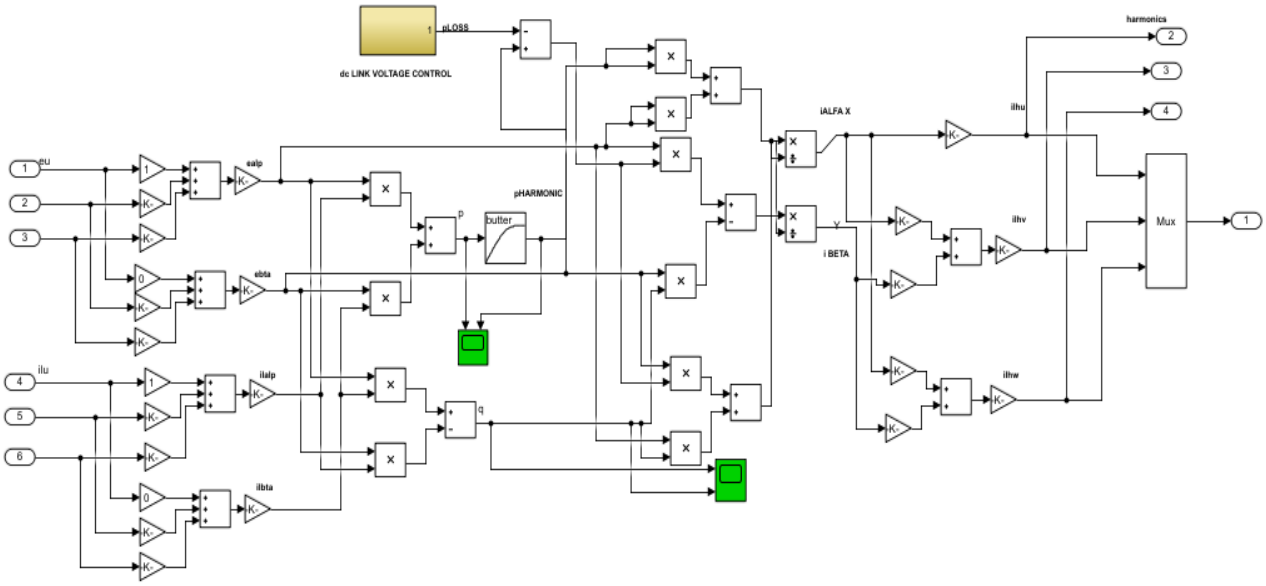


Fig. 11. Simulink model of PQ theory based SAPF.

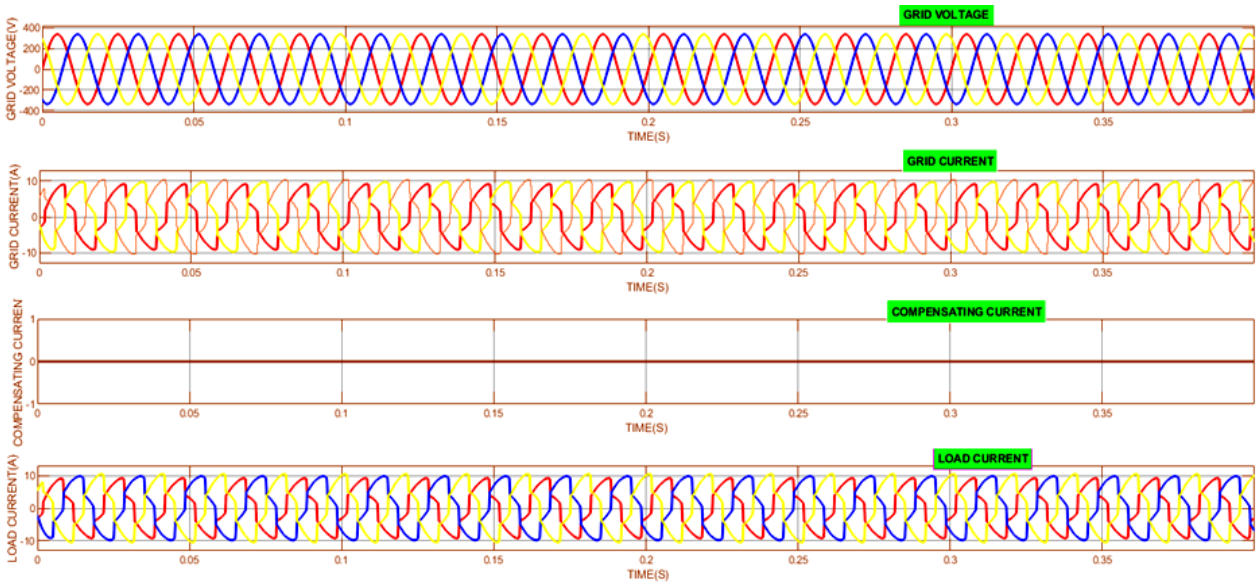


Fig. 12. The source voltage, source current, compensation current, and load current waveforms without SAPF.

VII. Simulation Results

The MATLAB simulative environment was used for the implementation of the proposed reference generation and current control techniques for a SAPF. This research was performed in accordance with the following scenarios.

- Without SAPF
- SAPF with conventional PI controller
- SAPF with PSO-PI controller
- SAPF with PSO-ANN controller

A. Without SAPF

In this scenario, SAPF is switched off, and a distortion in source current induced by a nonlinear load is evaluated using Fast Fourier Transform (FFT) analysis, which came out to be about 18.42%. Fig. 12 shows the source and load current waveforms from the three-phase simulation. Fig. 13 shows the source current FFT harmonic spectrum.

B. SAPF with Conventional PI Controller

In this scenario, SAPF is linked to the PCC, and the results of the simulation are obtained without any adjustment to the PI-controller gains. After SAPF connection, the supply current distortion is brought down to 3.76% of its original value as shown in Fig. 14.

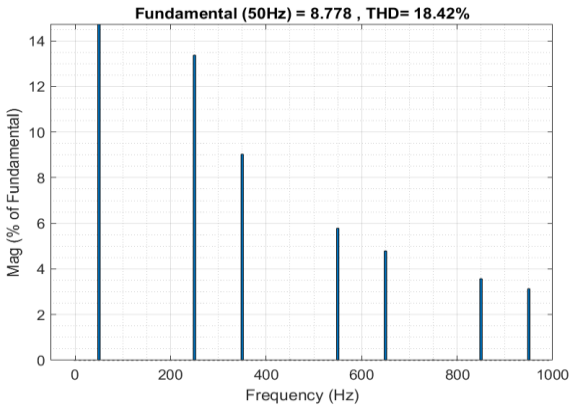


Fig. 13. Grid current THD value of distribution system without SAPF.

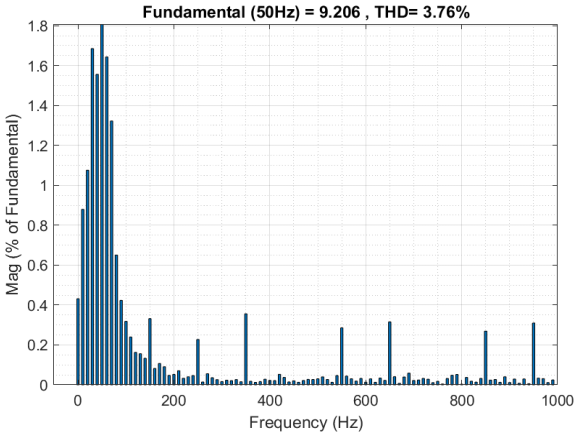


Fig. 14. Grid current THD value of distribution system with PI controller based SAPF.

C. SAPF with PSO-PI Controller

In this particular instance, the simulation was run using the SAPF compensation action, and the PSO Algorithm was utilized to modify the PI-controller gains. The findings that were collected suggest that the THD of the source current has been drastically reduced to 0.93%, as shown in Fig. 15.

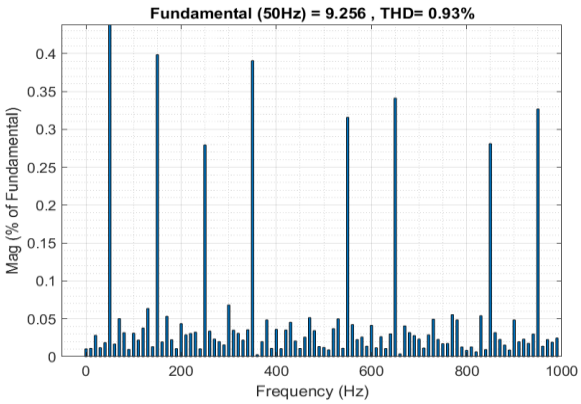


Fig. 15. Grid current THD value of distribution system with PSO-PI controller based SAPF.

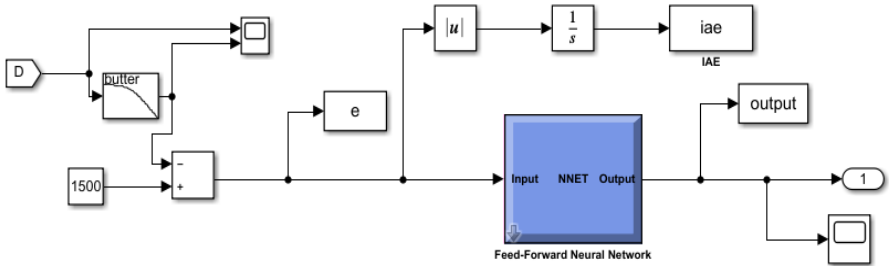


Fig. 16. DC voltage regulation of SAPF by using PSO-ANN controller.

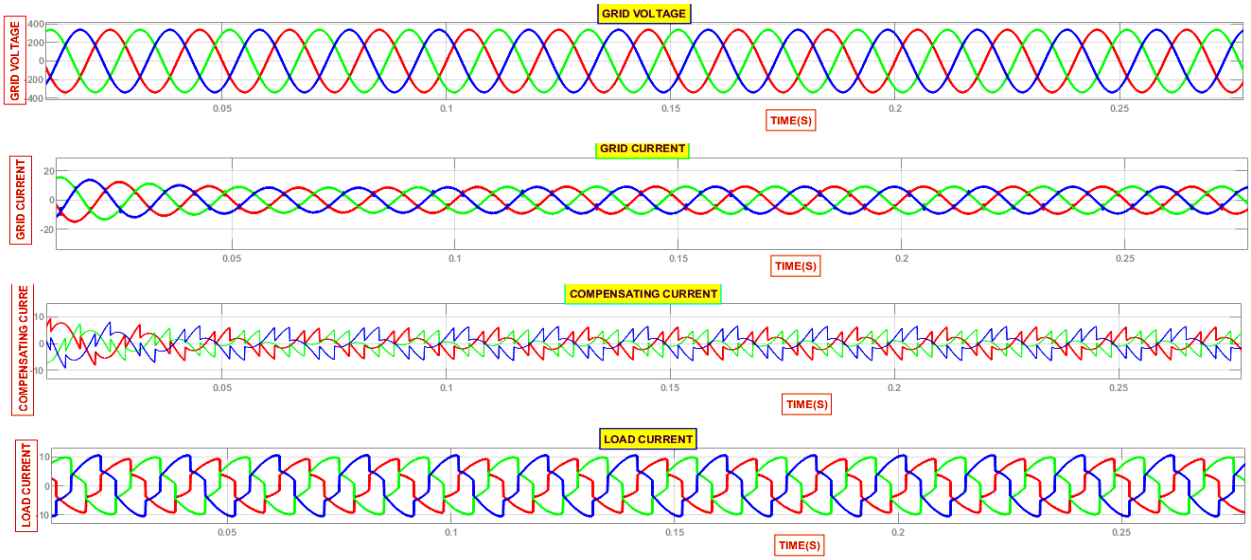


Fig. 17. The source voltage, source current, compensation current, and load current wave forms of PSO-ANN controller based SAPF.

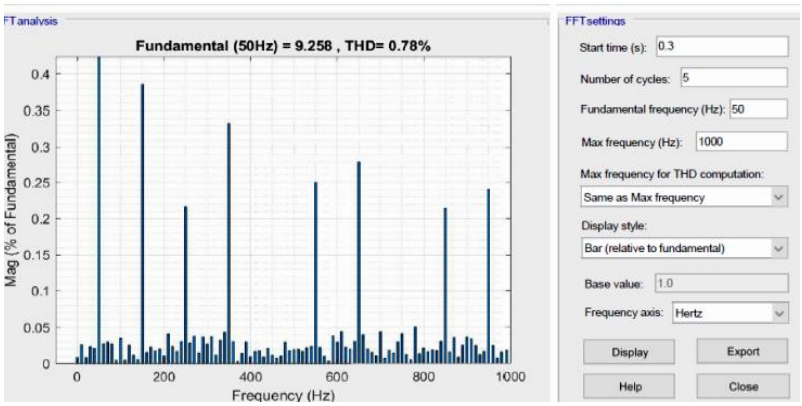


Fig. 18. Grid current THD of distribution system with PSO-ANN controller based SAPF.

D. SAPF with PSO-ANN Controller

In this particular instance, The PSO-PI controller is replaced by PSO-ANN controller Simulink block which was obtained from Fig. 9 Simulink representation with feed forward neural network block as shown in Fig 16. The findings that were collected suggest that the THD of the source current has been drastically reduced to 0.78%.

The source current, load current, and SAPF compensatory current waveforms are depicted in Fig. 17. Fig. 18 depicts the source current's harmonic spectrum. Fig. 19 depicts the converging spectrum for PSO-ANN controller.

PSO-ANN parameters are listed in Table III (next page). The SAPF performances of all four cases are given in Table IV (next page).

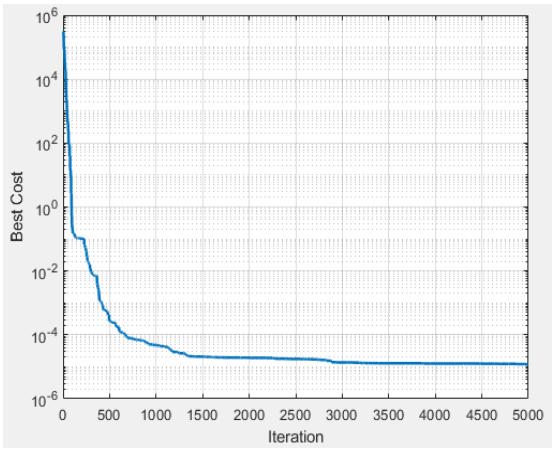


Fig. 19. Converges graph for the PSO-ANN controller.

TABLE III: PSO-ANN PARAMETERS

Maximum iterations	5000
Total Population	50
Weight of Inertia	0.89
Constant of Acceleration(C_1), (C_2)	2
Hidden Neurons	10
Total Variables	1
Higher Limit of weights	200
Lower limit of weights	0

TABLE IV: COMPARISON TABLE

Case studies	FFT -Analysis	Parameters	THD in %
1	Without SAPF	Grid current	18.42
2	SAPF with PI controller	Grid current	3.76
3	SAPF with PSO-PI controller	Grid current	0.93
4	SAPF with PSO-ANN controller	Grid current	0.78

The SAPF performance interns of power factor for all four scenarios as follows: Without SAPF, the power factor is 0.81, with conventional PI being 0.89, with PSO-PI being 0.94, and with proposed PSO-ANN being 0.96.

VIII. CONCLUSION AND FUTURE WORK

The power quality issues, such as harmonics and reactive power, are always expanding and becoming more complex. It has been discovered that implementing strategies derived from artificial intelligence on active filters can produce excellent results in the reduction of harmonics and the correction of reactive power. In this article, the PSO-ANN control method is proposed for use with the SAPF in order to lower the amount of total harmonic distortion occurring on the source side of the distribution system. The SAPF's effectiveness in a wide range of situations is studied and contrasted. The tool MATLAB/SIMULINK is used to perform simulations of four distinct scenarios, and the findings are reported. According to the results of simulations, both the PSO-PI-based SAPF and the traditional PI-based SAPF perform effective in terms of minimizing THD. It has been found that the proposed ANN-PSO-based SAPF is more effective in simulation in terms of achieving a lower THD value. This improved performance has been determined to be acceptable (within 5% of the IEEE standard), according to the findings of the investigation.

In future work, a hardware-in-loop implementation will be added to the proposed shunt active filter. Also, an ANFIS controller with PSO and other optimization methods will be used to make the SAPF's response even better.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Venkata Anjani Kumar G. was responsible for the development of the theoretical formalism, the working out of analytical calculations, and the performance of numerical simulations. Venkata Anjani Kumar G. is responsible for the final draught of the manuscript and M. Damodar Reddy acted as the project's supervisor throughout its entirety.

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TLBO-trained ANN-based Shunt Active Power Filter for Mitigation of Current Harmonics

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Abstract: The increased utilization of nonlinear devices is resulting in damage to power distribution infrastructure by introducing harmonics into power system networks, which in turn causes distortion in voltage and current signals. A novel solution called Shunt Active Power Filter (SAPF) has been developed to address this issue using power electronics. This study aims to provide a method that is efficient and cost-effective for lowering harmonics and improving power quality in distribution infrastructure. The proposed method combines the Teaching learning-based optimization (TLBO) technique with an Artificial Neural Network Controller (TLBO-ANN) in conjunction with SAPF. The primary objective of the TLBO-ANN algorithms in SAPF is to minimise total harmonic distortion (THD) for maximum system efficiency. Initially, Gain values (K_i, K_p) for a regular Proportional-Integral controller are optimised with the Particle Swarm Optimisation (PSO) technique. Those optimized parameters obtained from the PSO-tuned PI controller serve as input and target datasets for training the ANN controller. Subsequently, the TLBO algorithm is utilized to further refine the ANN controller by finding the optimal weight and bias values. Using MATLAB/SIMULINK software, we compare the performance of the proposed algorithm to that of the PSO-tuned PI controller and traditional PI controller. The findings from the simulation suggest that a SAPF utilizing a TLBO-trained ANN controller could improve THD in the supplying current while maintaining harmonics within IEEE-519 accepting levels.

Introduction

Bonding An imbalance between the quality of power available and the power needed by the load apparatus indicates a power quality issue. In order to protect electronic components from power outages, many power enhancement devices have been developed over time (Vishwakarma, 2020). These can be anything from specifically designed power sources to power conditioning devices. Isolation transformers and power conditioning equipment include capacitors, filters, voltage regulators, and uninterruptible sources of power (UPS) to prevent power outages caused by lightning and power surges. Surge capacitors for transient voltage are another type of power conditioning equipment. The Shunt Active Power Filter (SAPF) (Rajeshwari et al., 2017) is an example of a device that enhances power quality. There are many potential sources of damage in alternating current (AC) supply systems. Natural causes include lightning strikes, flashovers, equipment breakdowns and faults, whereas voltage distortions and notches are examples of human-made factors. Because it acts as a nonlinear load and develops non-sinusoidal current, much of the customer's equipment contributes to pollution in the supply system. Power quality is measured in terms of these factors because of the potential for damage to electronic devices due to fluctuations in

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voltage, current, or frequency. Power quality problems can often be traced back to the voltage at the point of common coupling (PCC), where numerous loads are connected (Gowtham et al., 2016; Dorigo et al., 1999; Janga et al., 2020; Huaisheng et al., 2012) Some examples of such problems are harmonics in the voltage, surges of electricity spikes, notches, and sag/dip/swell/imbalance/fluctuations/glitches/flickers/outages.

Non-linear loads, such as heaters, UPSs and variable-speed motors, can place a burden on the power grid and cause outages and other problems in the supply system. Some nonlinear loads can cause power quality concerns by drawing excessive current from the AC mains, creating the low power factor, harmonic currents, reactive power stress, imbalanced currents, and an excess neutral current in three-phase systems are all caused by the unbalancing and harmonic currents that come from using certain non-linear loads. Problems with dielectric breakdown, communication system interference, breaker issues, incorrect measurement, negative sequence currents in rotating electrical machines (especially rotors overheating) and disturbances affecting motor control units and technological control devices., and many others can all contribute to poor power quality (Sabarimuthu et al., 2021).

In some loads, however, the current changes in a way that is out of proportion with the voltage changes that occur at each half-cycle. Non-linear loads refer to this category of conditions. These non-linear loads produce the current and voltage harmonics. Many issues that utilities and power supply organizations face, such as low power factor, inefficient consumption of energy, and voltage fluctuations in the power system, can be traced back to non-sinusoidal current. A perfect compensator is necessary to prevent the harm caused by harmonics (Soliman et al., 2022). Over time, many different types of power enhancement devices have been developed to shield electronics from the consequences of grid failures. Methods that are both effective and efficient include those that are listed below. Implementing power conditioners and substitute energy sources. Power conditioning equipment includes isolation transformers, lightning arrestors, surge capacitors, filters, voltage regulators and an uninterruptible power supply. (Mikkili S et al., 2012; Om P et al., 2016). A Shunt Active Power Filter (SAPF) is one power conditioning device that enhances the supplied electricity's quality. By synchronizing the source current and voltage, current harmonics on the alternating current (Grid) side are cancelled out, and the DC link voltage is maintained at a constant level (Chelli et al., 2015). In order to achieve this goal, the real power flow in the system as well as the there must be no fluctuation in the amount of reactive power flowing into or out of the source.

The SAPF can be controlled by a single controller or multiple controllers working together to maintain a constant DC voltage. This is accomplished by balancing the real power flow in the system with the reactive power flow that comes from or towards the source, which brings the source current in phase with the source voltage (Babu et al., 2020). This cancels out current harmonics on the AC side. SAPF is necessary to eliminate current harmonics. The fundamental compensation principle of the active power filter is depicted in Figure 1. This principle serves as a form of energy storage to provide the real power difference between the load and the source throughout the transient period. When the load state changes, it affects the system's actual power; when that happens, the system will automatically. When compared to the reference voltage, the value of the voltage that is measured across the DC link capacitor is found to be different (Diab et al., 2019; Diab et al., 2018; Wen-guan Wang et al., 2012; Vadi et al., 2021) which leads to the dysfunction of the system. The reduction of the real power disturbance by using different controllers including chicken swarm optimization (Ramesh et al., 2023; Venkata and Reddy, 2023) at the DC link capacitor.

In this study, the utilization of IRP principles is employed to establish the desired current reference (referred to as PQ-theory). The hysteresis current controller technique estimates the reference currents to generate the required gating pulses (Kazemzadeh et al., 2014). Achieving optimal performance of an artificial neural network (ANN)-controller (Tekwani et al., 2020) based on PQ theory for a direct current (dc) link voltage necessitates precise adjustment of weight and bias values (Wilamowski et al., 2010). To determine the optimal state of the ANN controller, a Teaching learning-based optimization (TLBO) (Satapathy et al., 2013) algorithm is implemented, enabling the fine-tuning of weight and bias values.

PQ-Theory-based Reference Current Generation

PQ theory-based constant instantaneous power control is for 3-phase, 3-wire power distribution systems with sinusoidal and symmetrical source voltages. To apply this theory, the three-phase source voltage (V_a, V_b, V_c) and load current (I_{la}, I_{lb}, I_{lc}) must be sensed and transformed by the Clarke transformation into the (α, β) components.

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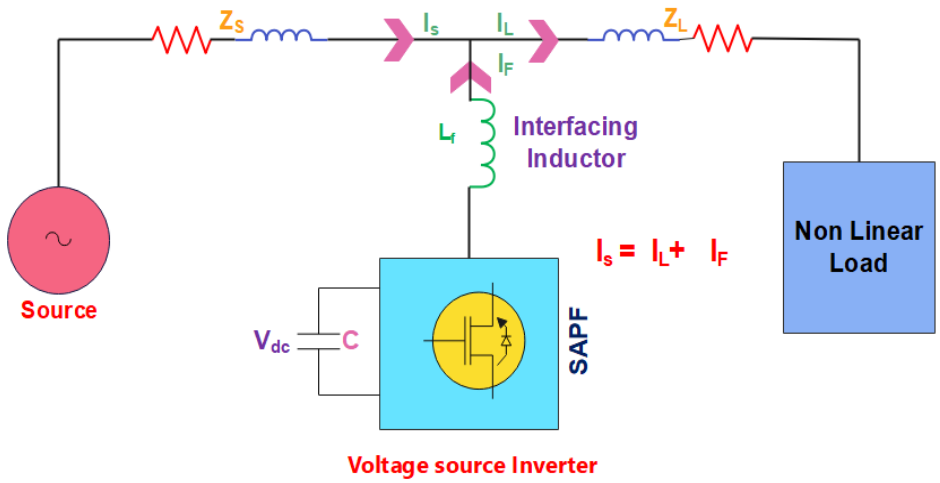


Figure 1. Schematic diagram of a Shunt Active Power Filter (SAPF).

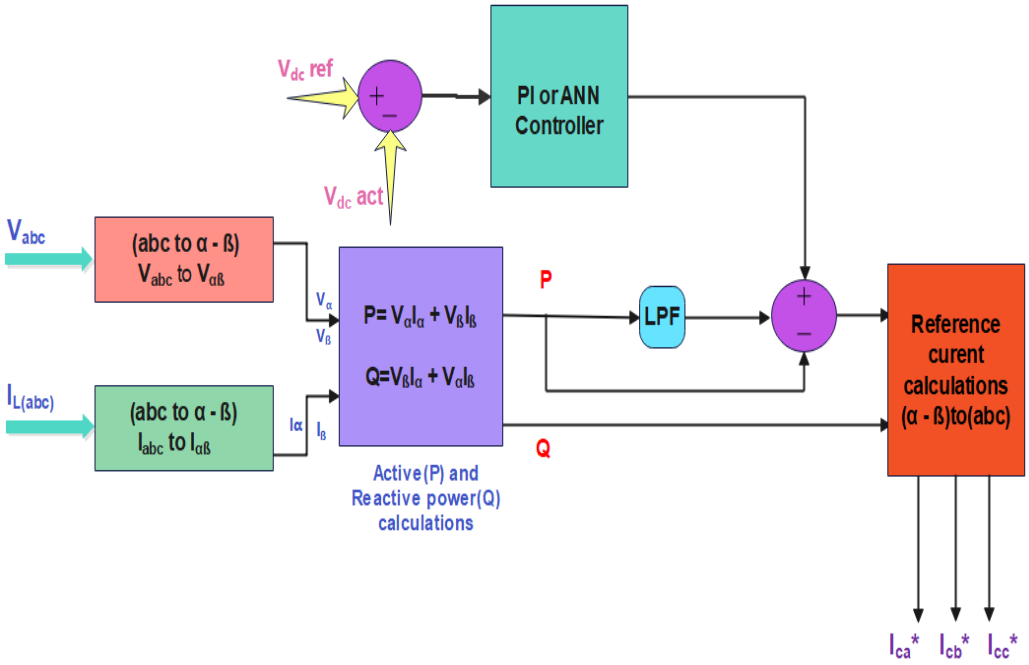


Figure 2. Reference generation diagram with PQ theory.

These components are input for instantaneous power calculations (Akagi et al., 2017). An error signal from the reference and measured dc-link voltages determines the power losses component. A PI controller receives this error signal to calculate power losses (Ploss). The (α, β) components, active and reactive powers, and current calculation are used to estimate the reference (α, β) components. An inverted Clarke transformation transforms these components to 3 phase abc values ($I_{abc,}V_{abc}$) as shown in Figure 2, to obtain the desired reference current signals.

Artificial Neural Network

An "Artificial Neural Network" is a system inspired by the way the human brain works, which is composed of interconnected neural networks Similar to the human brain. Multiple layers of neurons that are coupled to one another constitute artificial neural networks. These neurons, represented as nodes in Figure 3, are responsible for processing information. Typically, a neuron will have a single or multiple outputs and n inputs (x1, x2,... xn) that will receive or send information to other neurons in the network. In equation 1, the neuron's output, denoted by Yi (Asadi et al., 2022), is the result of multiplying the sum of its inputs by the activation function.

$$Y_i = f_i\left(\sum_{j=1}^{n} w_{i,j}x_j + b_i\right) \quad (1)$$

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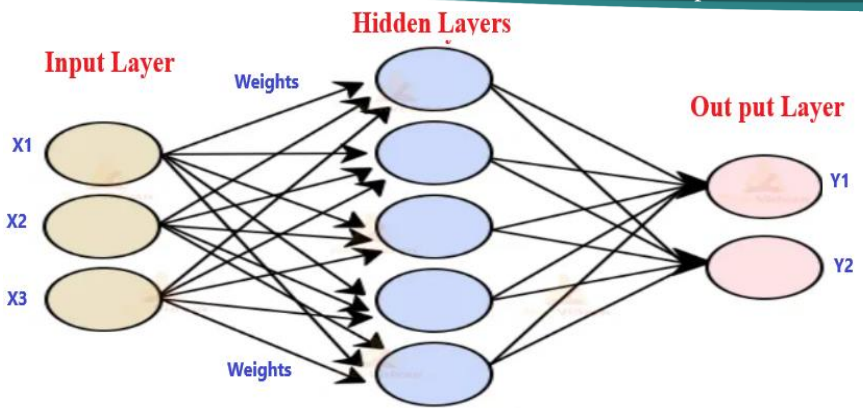


Figure 3. The fundamental structure of an artificial neural network

The $w_{i,j}$ notation represents the connection weight between a neuron on the input and a neuron at target. while b_i represents the neuron's bias. The input to the neuron is represented by x_j and the activation function f determines the neural network's actions. By changing the weights and biases and, in some cases, the number of layers and neurons, neural networks can adapt to new data.

Introduction to TLBO algorithm

Teaching-learning-based optimization, frequently referred to as TLBO, is an acronym given to one of the population-based algorithms that was recently proposed. In the year 2011, Rao et al. presented the teaching learning-based optimization (TLBO) method (Rao et al., 2011). It was inspired by the teaching and learning phenomenon that takes place in a classroom (Rao et al., 2012). In the context of the population-based algorithm TLBO, the class is considered as a population, and each individual learner within the class is considered as an individual member of this population. It is intended that the students in the class will have a greater level of knowledge by the end of the lesson to fulfill this objective. The process has two stages, known as the "teacher phase" and the "learner phase," respectively. This serves as the foundation for achieving this goal.

A. Teacher phase

The student who presents the most outstanding solution in the class is chosen as the teacher. The teacher is regarded as the most proficient learner among the entire population, possessing extensive knowledge and experience in a particular subject. As a result, other students enhance their understanding by leveraging the expertise of the teacher. If a student provides a superior solution compared to the teacher, they will replace the teacher's role. In the k^{th} iteration, the knowledge of the ith learner is updated using the following equation 2.

$$X_i^{new} = X_i + r_I(X_T - T_F{}^i . X_{mean}) \quad (2)$$

In the above scenario, knowledge of the teacher refers to "X_T,","r_I "is a random two-digit number between zero and one, mean results of the learners refers to "X_{mean}," and teaching factor refers to $T_F{}^i$ which can be obtained by the following equation 3.

$$T_F{}^i = round\,[1 + rannd(0,1)] \quad (3)$$

At the end of the teacher phase, all of the learners' knowledge is updated, and these values are now ready to be used as input values in the learner phase.

B. Learner phase

When students are in a real classroom, they can learn more by talking to the other students. This is what the TLBO learner phase is built on. During this step, the knowledge of the i^{th} student is compared to that of a randomly chosen j^{th} student as given in equation 4. When students are in a real classroom, they can learn more by talking to the other students. This is what the TLBO learner phase is built on. During this step, the knowledge of the i^{th} student is compared to that of a randomly chosen j^{th} student as given in equation 5.

If $f(X_i) < f(X_j)$ $then,$ $X_i^{new} = X_i + r_I(X_i - X_j)$ (4)

If $f(X_i) > f(X_j)$ $then,$ $X_i^{new} = X_i + r_I(X_j - X_i)$ (5)

If the knowledge of the **j^{th}** student is better at the end of the learner phase, the knowledge of the **i^{th}** student can be improved as given in equation 6.

If $f(X_i^{new}) < f(X_i)$ $than,$ $X_i = X_i^{new}$ (6)

The TLBO algorithm, consisting of the teacher and learner phases, will continue until either the termination condition or the maximum number of iterations has been reached.

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Proposed Methodology

PI controller tuned by PSO

For SAPF, a particularly important role depends on the abilities of a standard PI controller to regulate the DC link voltage. This controller probably produces for kp and ki will not be optimal values. Because it needs a great degree of mathematical calculation, The PSO method can be used to determine the best possible values for both kp and ki.

As shown in Figure 4, the PSO-PI controller will be given an error signal based on the difference between the actual and reference DC voltages. The PSO method must minimize the Integral Absolute Error (IAE) objective function to acquire the ideal gain values. With 1000 maximum number of iterations and 50 Populations, the Optimum values of gains (K_i, K_p) are 5.65119 and 7.93019 (Venkata et al., 2023).

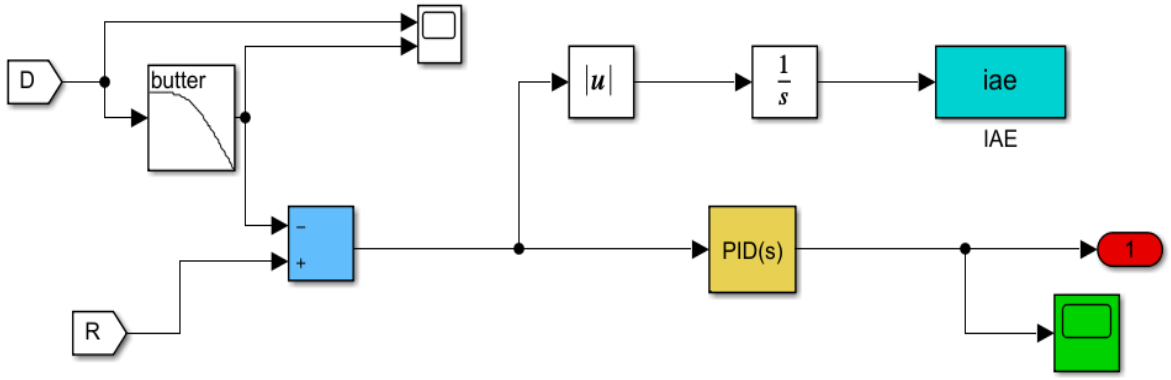


Figure 4. DC link voltage regulation by PSO trained PI based SAPF

TLBO trained ANN Controller

The main objective of a Neural Network algorithm is to obtain the appropriate weights and biases of the network to be as accurate as possible. ANN's weights and biases are given the right values using various methodological approaches. This paper used a method called TLBO. Figure 5 shows that the inputs (e) and outputs (out) of the PSO-PI controller are going to be used as a source of data for the neural network controller.

The necessary code to set up the neural network is provided below. The PSO-PI controller's input and target values are retrieved, hidden neurons are initialised. This data is used to configure the ANN, and finally, the network's weights and biases are extracted. Then, we'll define a pre-trained neural network's weights and bias using the TLBO algorithm, with the objective function defined as the root mean square error.

Step by Step approach of TLBO trained ANN

Step1: Take the input (e) from the workspace of PSO-PI controller.

Step 2: Take the Target (output) from the workspace of PSO-PI controller.

Step 3: Assign the number of Hidden Neurons.

Step 4: Define the Feed Forward Neural network based on hidden Neurons.

Step 5: Set up the Neural Network with the specified input and output values..

Step 6: Generate the initial weight and biases

Step 7: Use the root-mean-square-error as the objective function, by utilizing the weights and bias, Feed Forward Neural network, inputs and target values.

Step 8: The neural network is trained using the TLBO algorithm, resulting in the updated weights, biases and error.

Step 9: With this updated weights and biases again

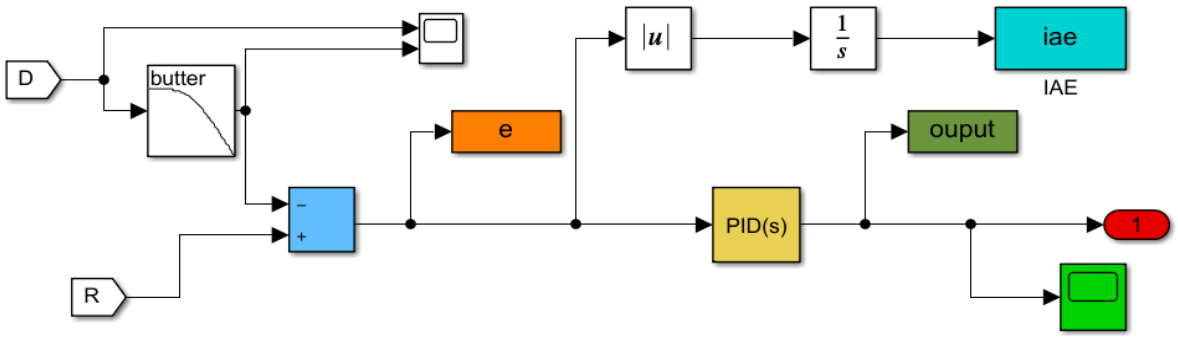


Figure 5. Output (o) and input (e) representation in the workspace for the PSO-PI controller.

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configure the Feed Forward Neural network.

Step 10: Repeat steps 7 to 9 until objective function is at a minimum.

Synaptic coefficients converge when they have settled on steady-state value and the network's Root Mean Square Error (NMSE) decreases below a predetermined threshold. Another approach to stop the learning process is to set a limit on the maximum number of iterations. The flowchart of the training algorithm is illustrated in Figure 6.

We will ultimately obtain the feed-forward neural network block and inside layering structure shown in Figure 7 response to a given input and output. The PSO-PI controller will substitute this feed-forward neural network block.

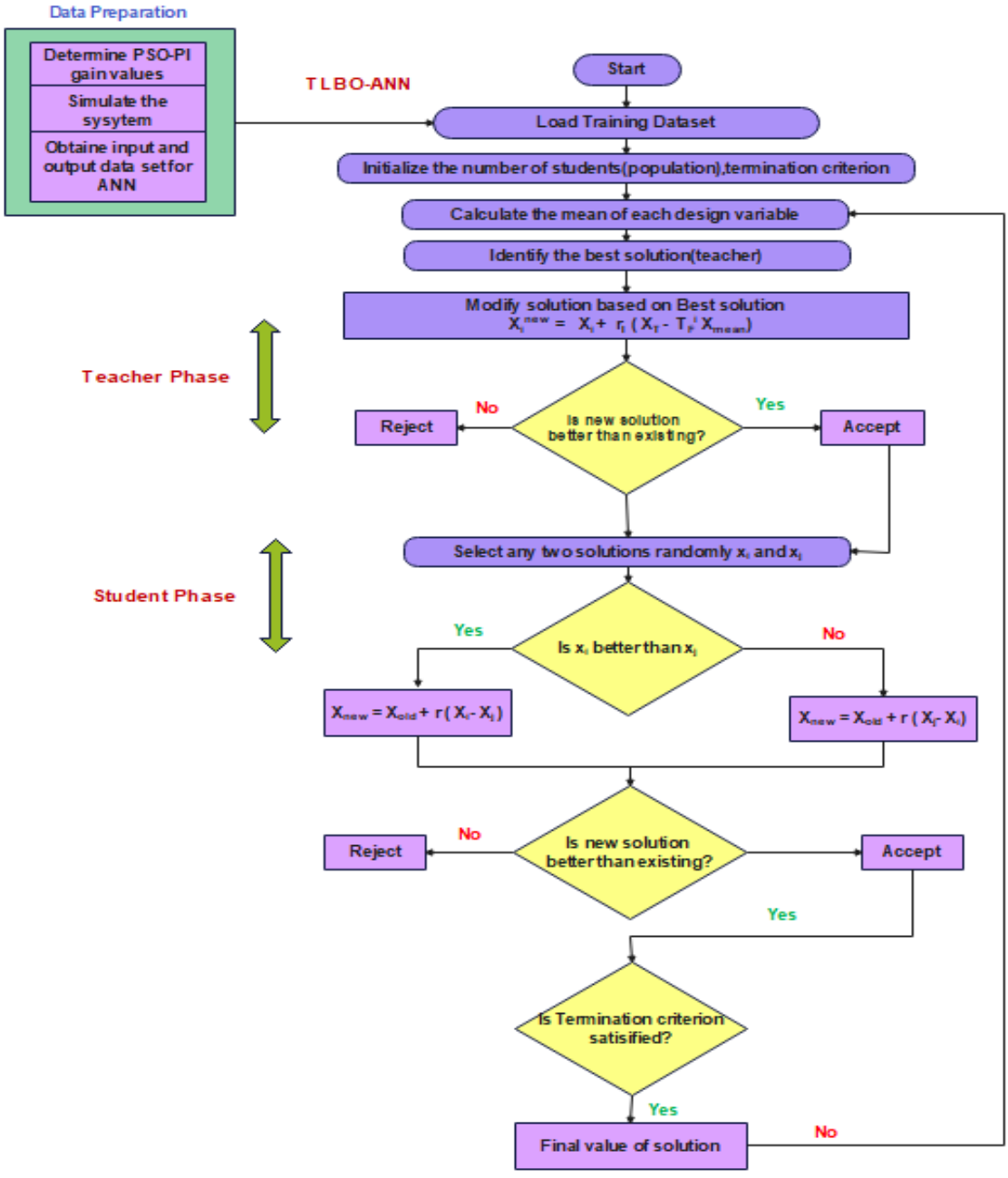


Figure 6. Flow chart of TLBO-ANN.

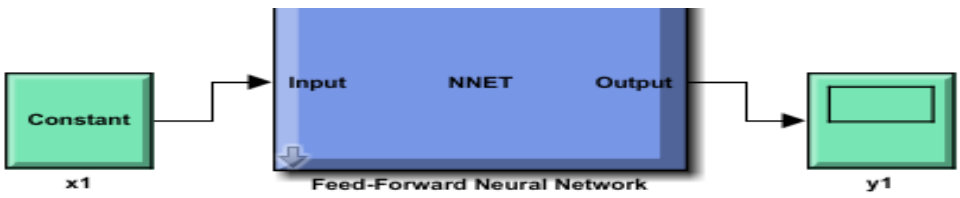


Figure 7. Simulink block of TLBO-ANN algorithm.

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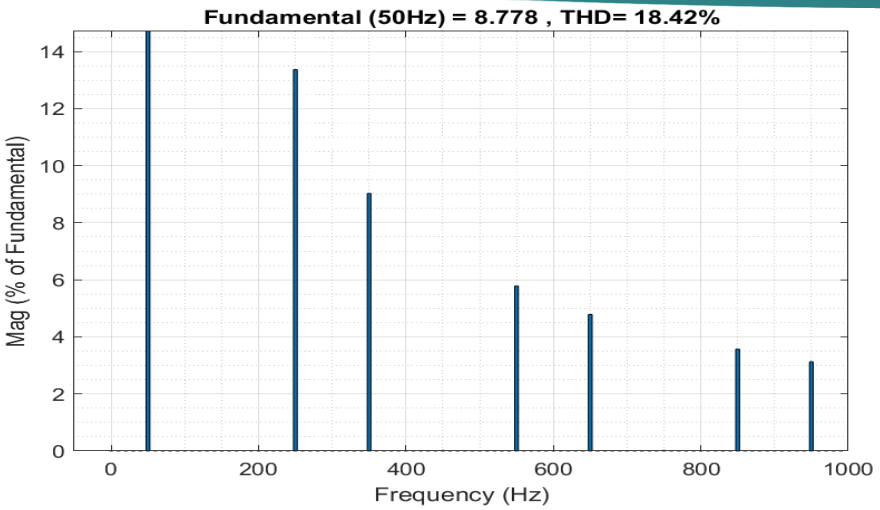


Figure 8. THD result of source current without using SAPF.

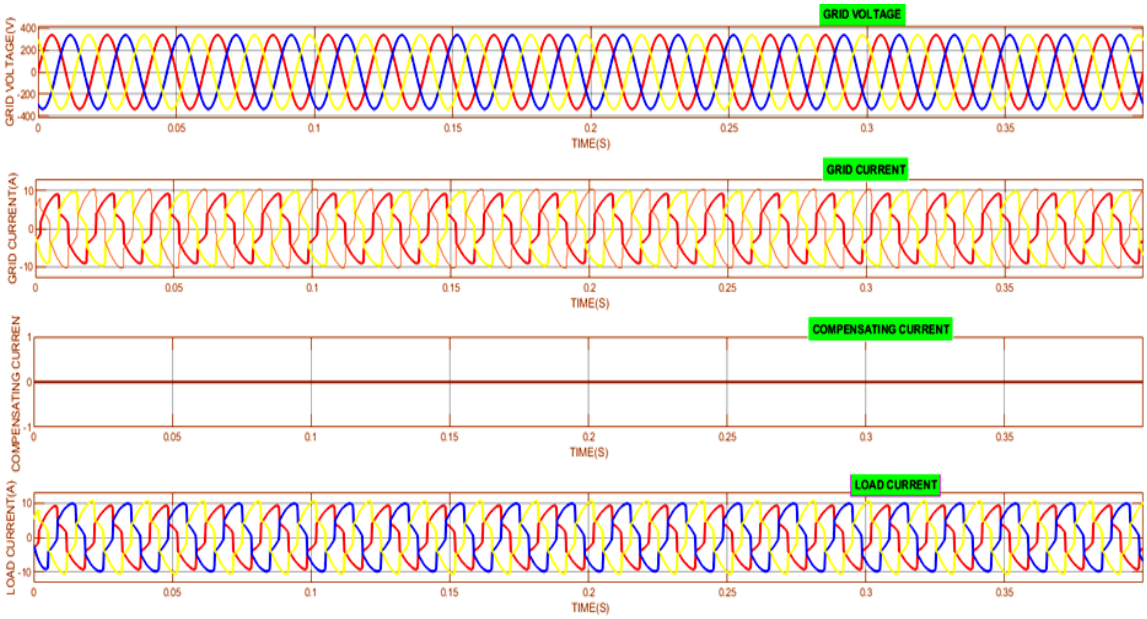


Figure 9. The waveforms of the IL, IS, IC and IS, without using SAPF.

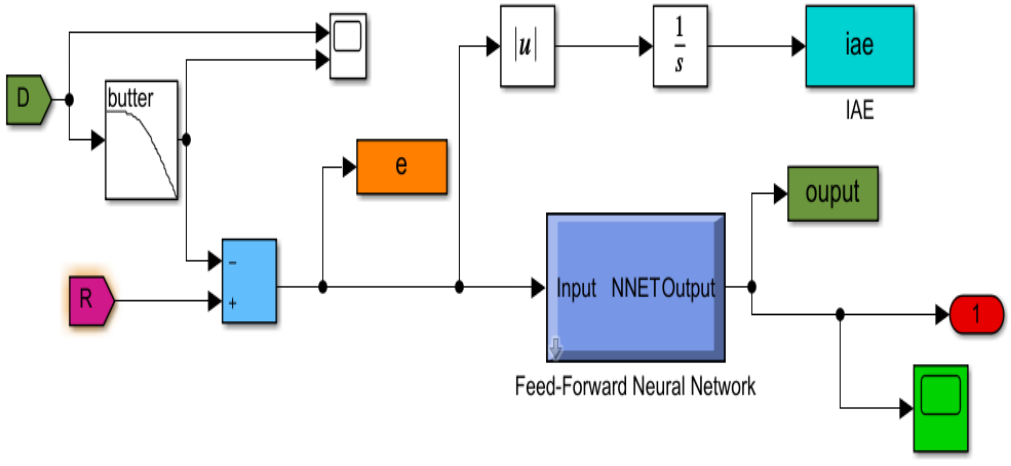


Figure 10. Controlling the DC voltage in a SAPF with a TLBO-ANN regulator.

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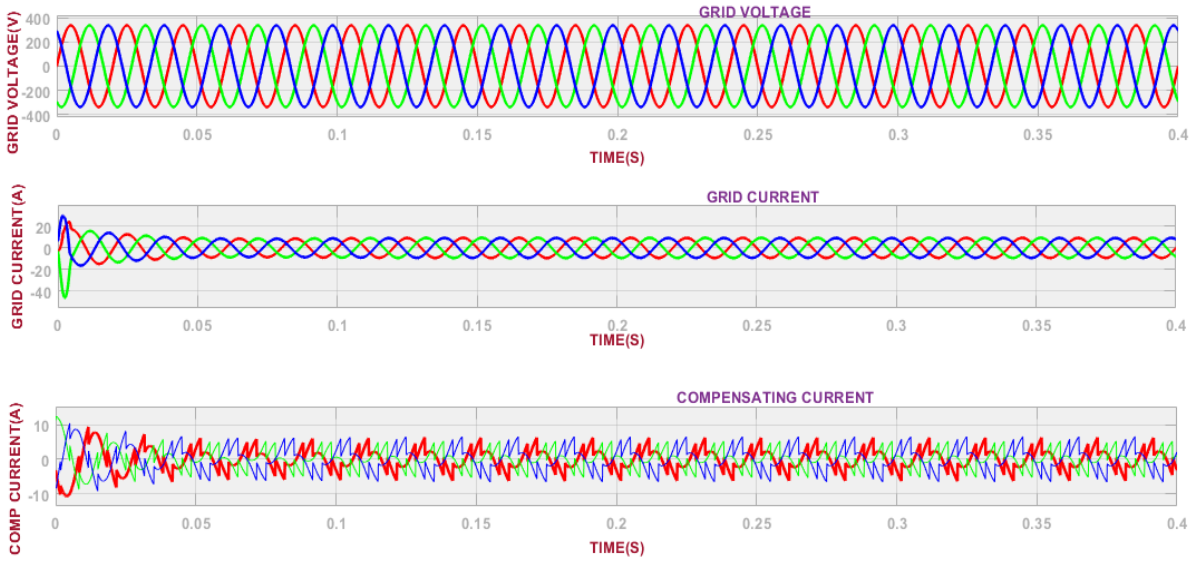


Figure 11. The waveforms of the IL, IS, IC and IS, by using TLBO trained ANN based SAPF

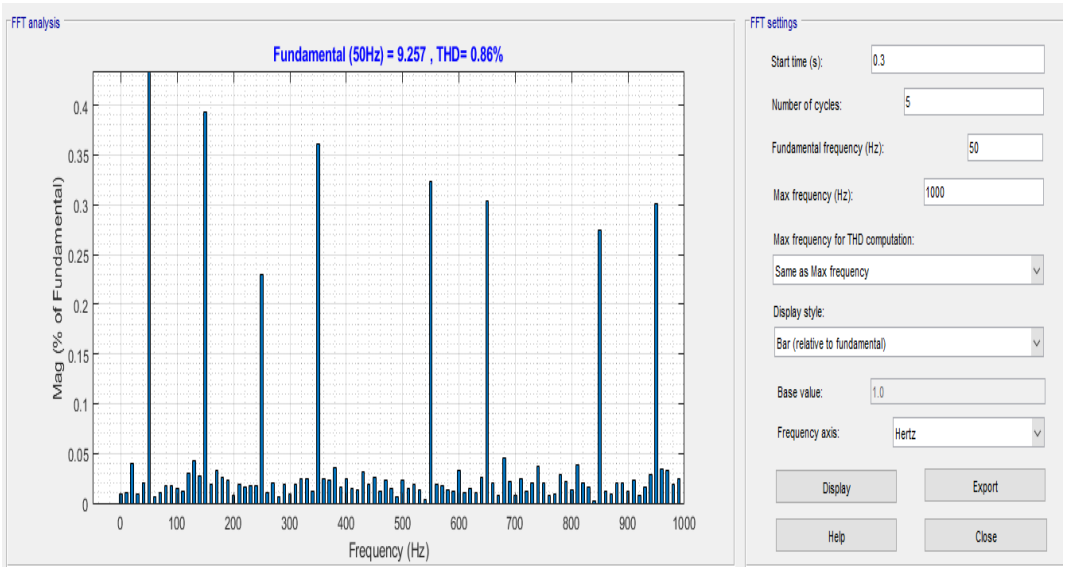


Figure 12. THD result of IS (Grid current) by TLBO tuned ANN-based SAPF.

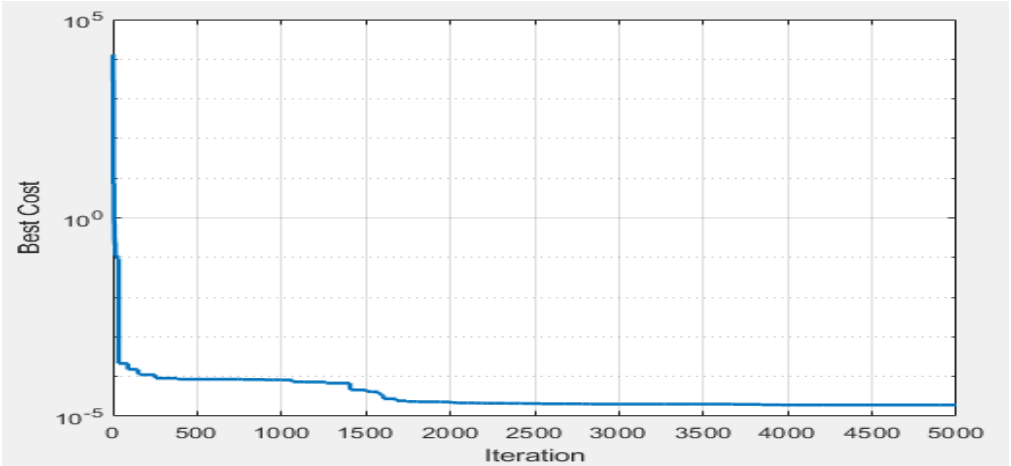


Figure 13. Converges graph for the TLBO-ANN based SAPF.

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Results and discussions

The proposed methods for a SAPF's current control and reference generation were implemented with the help of the MATLAB simulative environment. This study was carried out taking into account the various possibilities that were presented below. A tabulation of the simulation's parameters that were used for the simulation's purposes can be found in Table 1.

Table 1. Modeling framework in Simulink

Particulars	Values
Voltage at the Grid	415V
Frequency at the Grid	50 Hz
Impedance at the Source	0.15 ohm,15mH
Coupling inductance	15mH
Active Power at the Load	4472 W
Reactive Power at the Load	1718 VAR
Connected DC Capacitance	100µF

Without SAPF

In this case, we turn off SAPF and use Fast Fourier Transform (FFT) analysis to look at how the nonlinear load distorts the source current. This analysis showed that the distortion was close to 18.42%. The harmonic spectrum of the source current, as calculated by the fast Fourier transform, is shown in Figure 8. Figure 9 shows the waveforms of the I_S (Grid current), I_L (load current) that resulted from the simulation. The SAPF converter is not injecting a compensating current to reduce grid-side harmonics, as shown in Figure 9.

TLBO-trained ANN-based SAPF

Here, the TLBO-ANN controller Simulink block has taken the place of the PSO-PI controller. This Simulink block was taken from Figure 7 and is shown interacting with a feed-forward neural network in Figure 10. According to the results, the source current's total harmonic distortion (THD) appears to have dropped to 0.86%.

Table 2. Parameters of TLBO-trained ANN

Maximum iterations	5000
Total no of Students	25
Teaching Factor	0.5
Hidden Neurons	10
No of Variables	1
Weight Scale Upper Limits	200
Weight Scale Lower Limits	0

Figure 11 illustrates the waveforms of the currents flowing from the source, the load, and the SAPF compensating current. The harmonic spectrum of the source current is depicted in Figure 12. The TLBO-ANN controller's converging spectrum can be seen as depicted in Figure 13. This indicates that the MSE is steadily reducing and eventually reaching a constant value.

The parameters for the TLBO-ANN are detailed in Table II (on the following page). Table III (on the following page) provides an overview of how the SAPF performed in each of the four scenarios.

Table 3. Table of Comparison

Slno	Type of Controller	Component	THD value(%)
1	Without using SAPF	I_S (Source Current)	18.42
2	PI based SAPF	I_S (Source Current	3.76
3	PSO tuned PI Based SAPF	I_S (Source Current	0.93
4	TLBO tuned ANN based SAPF	I_S (Source Current	0.86

Conclusion

Harmonics and reactive power are just two examples of the increasing complexities of power quality issues.Active filters that employ strategies developed through artificial intelligence are particularly effective at mitigating harmonics and resolving reactive power. Within the scope of this article, we propose the TLBO-trained ANN control technique. as an alternative solution to be used in conjunction with the SAPF. The SAPF's effectiveness is measured and compared in a variety of settings. Matlab-Simulink runs simulations of four different scenarios and presents the findings. According to simulation findings, the proposed ANN-TLBO-based SAPF outperforms alternative scenarios in reducing THD in the source current. The PSO-tuned PI-based SAPF and SAPF with PI controller are also effective. According to the results, this performance improvement is satisfactory (within 5% of the recommended IEEE standard).

A hardware-in-the-loop version of the proposed shunt active filter will be developed for further research. In addition, we plan to improve the SAPF's flexibility by using an ANFIS controller that includes TLBO and other optimization techniques.

Conflict of interest

The authors have no competing interests to disclose.

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Mitigation of Grid Current Harmonics by ABC- ANN based Shunt Active Power Filter

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ABSTRACT

Harmonics are being introduced into power system networks as a result of the increasing use of nonlinear devices. These harmonics cause distortion of current and voltage signals, which in turn causes damage to power distribution systems. As a result, the suppression of harmonics is of extreme significance in power systems. This paper proposes Shunt Active Power Filters (SAPF) based on neural network algorithms like Artificial Neural Network (ANN) as a feasible approach to mitigating harmonic distortion and raising power quality in electrical distribution systems. This research shows that using shunt active power filters (SAPF), which use the Artificial Bee Colony Optimized Artificial Neural Network Controller (ABC-ANN), is an efficient method for enhancing power quality and minimizing harmonic distortion in distribution systems. The ABC-ANN algorithms have been produced for SAPF with the goal of improving system performance by reducing Grid current Harmonics. In the first stage of this work, PSO Technique is used to tune a standard PI controller to its optimum gain values (K_i ,K_p). Then, these target and input data of PSO tuned PI controller will be supplying inputs to the ANN controller. To find the optimal weight and bias values, this ANN controller has been tuned with the help of the ABC algorithm. Using MATLAB/SIMULINK software, we compare the performance of the proposed algorithm to that of other optimization algorithm like Differential Evaluation (DE) algorithm, as well as the PSO tuned PI controller and traditional PI controller. The findings from the simulation suggest that a SAPF utilizing an ABC trained ANN controller could improve THD in the supplying current while maintaining harmonics within IEEE-519 accepting levels.

1. Introduction

Power electronics components and large quantities of non-linear load bring about destructive harmonics in Grid current at the Point of Common Coupling or P.C.C [1]. Because harmonics in distribution system current can trigger an extensive range of problems, including loss, instability, noise, heating appliances, and so on, In order to reduce potential harm, it is essential to reduce them to an acceptable level of Total Harmonic Distortion [2] as defined by the IEEE-519 guidelines.

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In the 1970s, Gyugyi [3] was the first to discuss the power quality problems that arise when the current changes. Power quality analyzers and synthesizers, also known as shunt active power filters, can be used to fix the problem of current variation. Active filters dealing with power quality variations and their measurement in processed control and power utility systems were also stressed by Akagi [4], another notable researcher. Power engineers and researchers are on the lookout for transit solutions to maintain the distributed side of the system in light of the development of flexible AC transmission devices in the transmission line, which lower the operational cost without raising the installation cost. Typically, these are referred to as "custom power devices" (CPDs). Shunt active power filters are one low-cost method for lowering current fluctuations. Topological structures, sizes, optimal placement, and control factors for SAPF have all been investigated. These have left a few gaps, including issues with improper compensation and switching. Researchers looked into improved filter architecture as a solution.

One possible way to deal with current harmonics, reactive power, and poor power factor is to install a shunt active power filter (SAPF). The SAPF configuration shown in Figure 1 consists of a voltage source inverter (VSI) and an active filter controller. For the VSI to inject compensating reverse current at PCC, the control unit must provide timely and accurate firing signals [5,6].This will make it possible for the VSI to accomplish its goal. Reactive power control is provided to the grid via a DC-link capacitor installed on the VSI's input side [7].

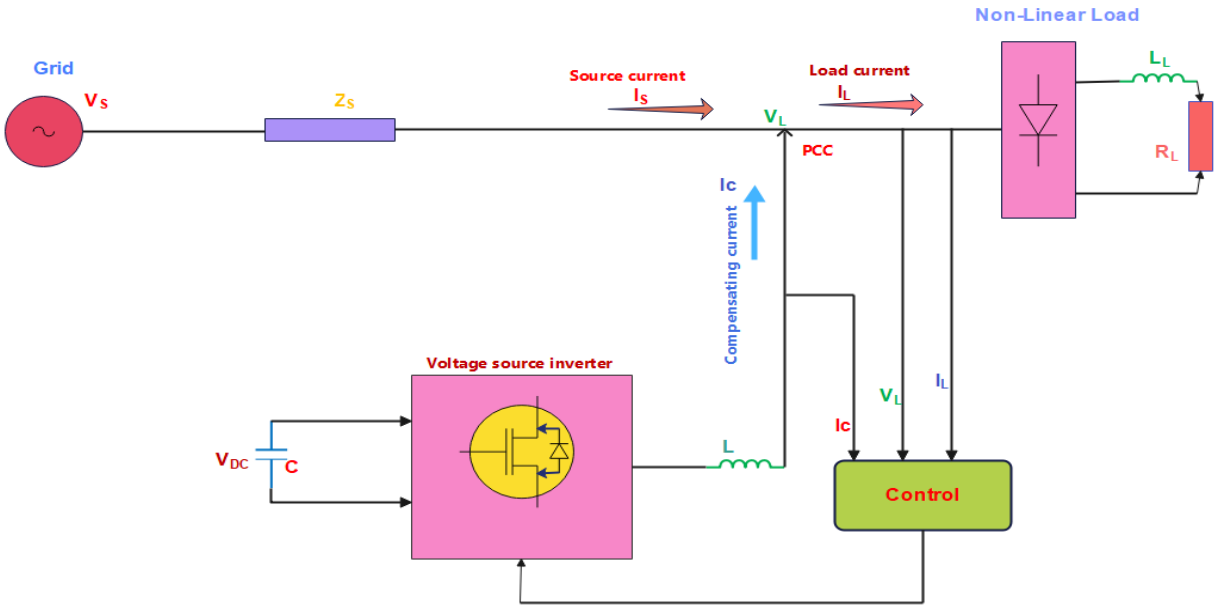


Fig. 1. Circuit diagram of the shunt active power filter

Either reference generating methods or control strategies can be utilized in the process of analyzing the VSI switching operation. Compensating signals are extracted from distorted signals using reference current generation theories, and then appropriate firing signals are generated using signal determined reference techniques to control the SAPF switching devices [8]. These two steps together constitute the SAPF control techniques. These are the two steps that are able to be implemented. Numerous authors have made comparisons between the various SAPF control strategies [9,10].

The harmonic content mitigation is performed by the PI controller that is a part of the control strategy. The PI proportional and integral gain values must be calculated for the controller. Methods such as Ziegler–Nichols and Cohen–Coon, for example, are helpful in determining the K_i and K_p values

explicitly for power systems that have linear loads. These linear control strategies will not function for a system that is subjected to nonlinear loads. In the present day, intelligent and optimal tuning algorithms such as Evolutionary Programming (EP) like Genetic Algorithm (GA) , Particle Swarm optimization (PSO), Simulated Annealing (SA), Differential Evolution (DE) [11-15] .Algorithm have been developed to solve the problems of dynamic electric system problems with enhanced optimal tuning SAPF devices.

The word Artificial Neural Network shortly ANN is used to describe a system which is designed and operates similarly to the human brain. Neurons form a network all over the brain. The overall network's behavior is determined by the strength of the connections between interneuron as well as the configuration of those connections. During network training, the weights are able to and will be adjusted and changed [15]. Only for the purpose of supplying reference compensation current is SAPF currently using Artificial Neural Network (ANN) techniques [16]. This current is then utilized to manage the compensation that SAPF provides. There are a number of approaches that can be used to learn weights. Methods include the Steepest Descent strategy to learning variables, the Levenberg-Marquardt [17] method, and the Widrow-Hoff (W-H) method are just a few examples.

In this work the reference current is calculated using instantaneous active and reactive power (PQ-theory) and hysteresis current controllers estimate reference currents to generate gating pulses [18]. Regulating dc link voltage using an ANN-controller [19] based on IRP theory requires tuning of weight and bias parameters. In addition, the Artificial Bee Colony Optimization Algorithm (ABC), which was proposed and tested against other Optimization algorithm such as Differential Evaluation (DE) algorithm, was used as the motivation for this article in order to find the ideal ANN-controller weight and bias and acquire the objective function while minimizing Total Harmonic Distortion(THD).

2. PQ Theory

PQ theory-based constant instantaneous power control is for 3-phase, 3-wire power distribution systems with sinusoidal and symmetrical source voltages. To apply this theory, the three-phase source voltage (V_a, V_b, V_c) and load current (I_{la}, I_{lb}, I_{lc}) must be sensed and transformed by the Clarke transformation into the (α,β) components. These components are input for instantaneous power calculations [20]. An error signal from the reference and measured dc-link voltages determines the power losses component. To calculate power losses (Ploss), a PI-controller receives this error signal. The (α, β) components, active and reactive powers, and current calculation are used to estimate the reference (α, β) components. An inverted Clarke transformation (α, β) transforming these components to three phase abc values ($I_{abc,}V_{abc}$) as shown in Figure 2 to obtain the desired reference current signals.

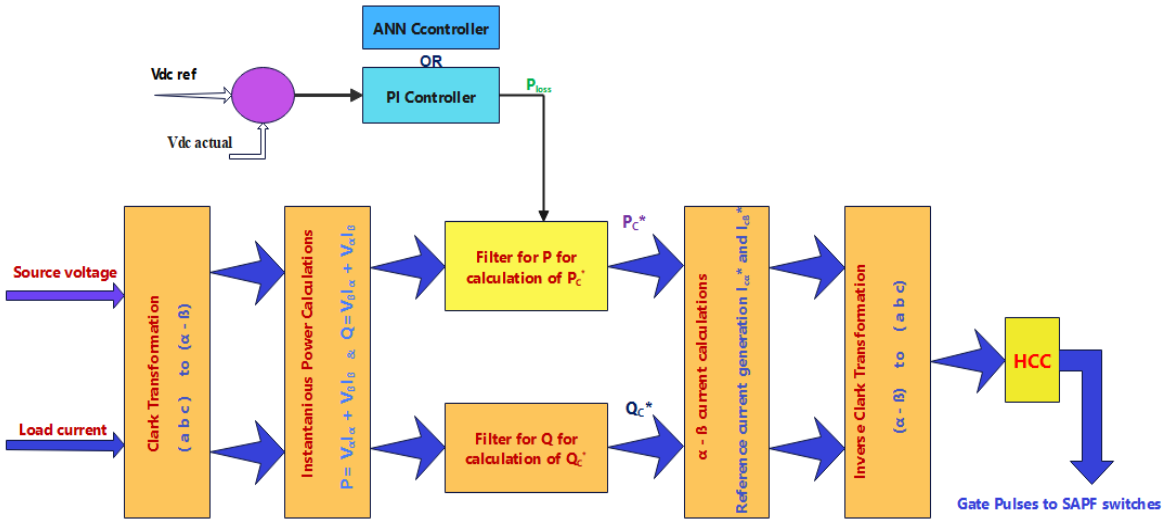


Fig. 2. Reference current generation with IRP (PQ) Technique

3. Structure of Artificial Neural Network (ANN)

The term artificial neural networks or ANN refers to a type of algorithm that is modeled after the way the brain operates and is used to model complicated patterns and predict future events. The concept of the Biological Neural Networks found in the human brain was the inspiration for the development of a technique known as the Artificial Neural Network, or ANN. An attempt was made to model the behavior of the human brain, which led to the development of artificial neural networks (ANN). The functioning of ANN is strikingly comparable to that of biological neural networks, despite the fact that the two systems are not identical. The ANN algorithm will only take in data that is numeric or structured.

- The architecture of the network is composed of three levels: the input layer, the hidden layer and the output layer as shown in Figure 3. As a result of the many layers, they are often referred to as the MLP (Multi-Layer Perceptron).
- The hidden layer can be thought of as a "distillation layer" that takes the most important patterns from the inputs and sends them to the next layer for more analysis. It speeds up the network and makes it more efficient by picking out the most important information from the inputs and getting rid of the rest.
- The activation function is useful for two reasons. First, it enables you to turn on your computer.
  - The presence of non-linear interactions between the inputs is captured by this model.
  - It aids in the transformation of the input into a more useable output.
- To construct an effective model, it's important to find the "optimal values of W—weights" that minimize Mean Square Error. This is done by the "back propagation algorithm," which turns ANN into an algorithm that learns from mistakes.
- The "gradient descent" method is used to measure prediction errors in the "optimization" approach. To find the best value for W, small changes are made and the effects on prediction errors are looked at. Lastly, those W values are chosen as the best because changing W any more doesn't make mistakes less likely.

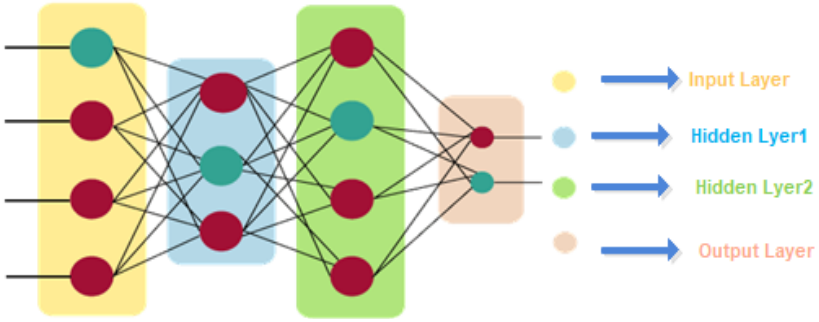


Fig. 3. Architecture of the artificial neural network.

To extract a fundamental component from SAPF while avoiding harmonic pollution, ANN architecture was utilized. For a given source voltage, it can be ensured by accurately predicting the reference current in ideal and real-time load applications. In the context of increasing reliance on nonlinear loads in residential and industrial applications, the mitigation of harmonic pollution has been a significant problem. ANN has been proven to be more applicable than p-q theory in circumstances of inaccurate voltage involving harmonic contamination in the source current and additional harmonic contamination due to the load current.

4. Artificial Bee Colony (ABC)

The ABC optimization method is an example of a meta-heuristic approach. Karaboga [21] came up with this idea first. The main idea behind ABC is how honey bees get food. In the ABC algorithm, there are three groups: worker bees, watcher bees, and scout bees. Bees were sent around the hive at random to find out where food was coming from. This information is shared with onlookers, who then decide which food source to choose. The random search is being done by Scout.

Figure 4 shows how honey bees act in general. Let's say that A and B are food. One of the possible bee starts out as a jobless bee. It has two options: it could be looking for food (S) or it could be doing the waggle dance (R). After it finds a food source, it will remember where it is and start taking advantage of it. Now, the Bee is a working bee. Once the food is turned into nectar, the same bee has three choices. may it lose its job, find new nest mates, and go back to the food source or keep looking for food in the same place.

The probability of a food source is given by the equation (1).

$$P_i = \frac{fit_i}{\sum_{n=1}^{SN} fit_i} \tag{1}$$

where, fit_i fitness value and SN is number of food sources.

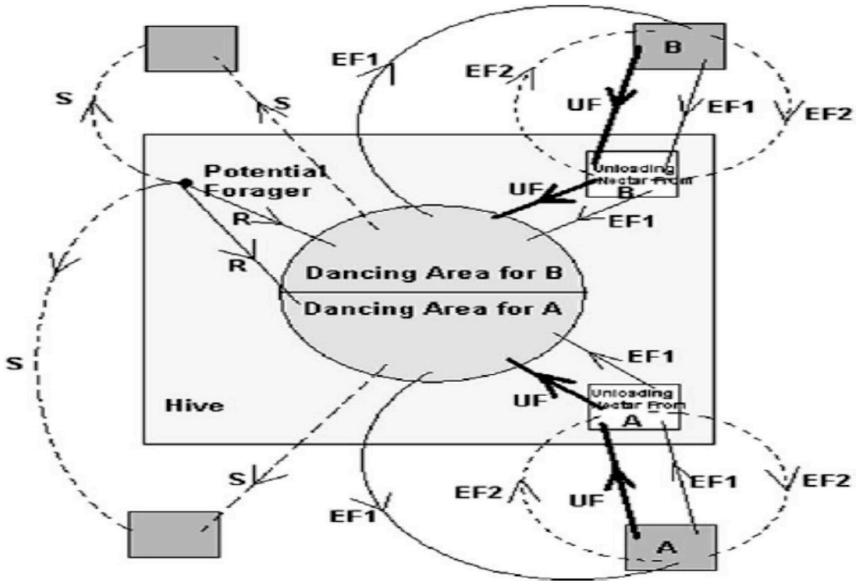


Fig. 4. ABC architecture

The candidate's food position from memory is given by equation (2).

$$v_{ij} = x_{ij} + {}^{\Phi}{}_{ij}(x_{ij} - x_{kj}) \quad (2)$$

$k\boldsymbol{\varepsilon}\{1,2,\ldots..SN\}andj\boldsymbol{\varepsilon}\{1,2,\ldots..D\}$, ϕ_{ij} random [0,1]
The following is a list of the stages that constitute the algorithm's procedure:

1. Read data
2. Read data
3. The distribution of working bees across various food sources
4. Distribute onlooker bees to the food sources in proportion to the amount of nectar they collect.
5. To find fresh sources of food, you should send the scouts to the area that is being searched.
6. In the meantime, keep the knowledge you've acquired regarding the greatest food source in storage.
7. Determine whether or not the requirements have been fulfilled.

5. Proposed Implementation

5.1 PI tuning with PSO Algorithm

The key function of SAPF is dependent on the abilities of a standard PI controller‘s regulation of the DC link voltage. It is probable that this controller produces for K_p and K_i will not be optimal values. Because it needs a great degree of mathematical calculation The PSO method can be used to determine the best possible values for both K_p and K_i.

As shown in Figure 5, the PSO-PI controller will be given an error signal based on the difference between the actual and reference dc voltages. To acquire the ideal gain values, the PSO method must minimize the Integral Absolute Error (IAE) objective function. With 1000 maximum number of iterations and 50 Populations, the Optimum values of gains (K_i, K_p) are 5.65119 and 7.93019. We set the bare minimum and highest possible values for K_p and K_i respectively at 0 and 200.

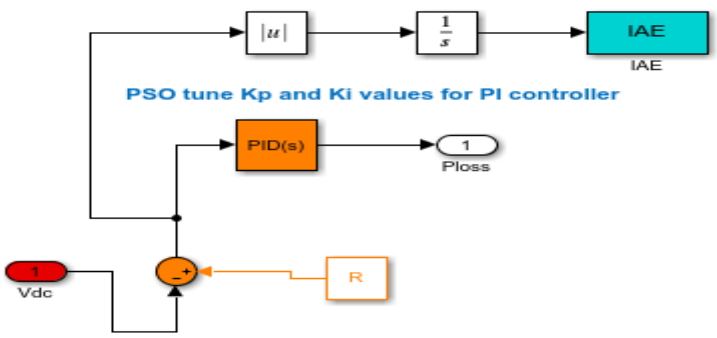


Fig. 5. DC link voltage regulation by PSO trained PI based SAPF

5.2 ABC Trained ANN Algorithm

The goal of ANN algorithm is to get the weights and biases of the network to be as accurate as possible. ANN's weights and biases are given the right values by using a variety of methodological approaches. This paper used a method called ABC. Figure 6 shows that The inputs (e) and outputs (out) of the PSO-PI controller are going to be used as a source of data for the neural network controller.

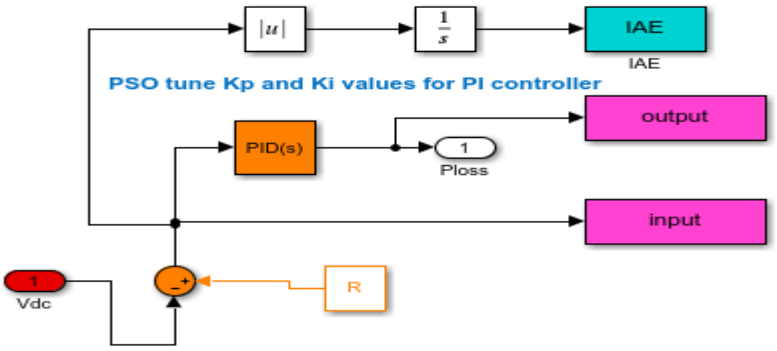


Fig. 6. PSO tuned PI controller's input and target extraction

The necessary code to set up the neural network is provided below. The PSO-PI controller's input and target values are retrieved, hidden neurons are initialised.This data is used to configure the ANN, and finally, the network's weights and biases are extracted. Then, we'll define a pre-trained neural network's weights and bias using the ABC algorithm, with the objective function defined as the root mean square error.

Initialization of ANN

- I = input(e)';
- T = output(out)';
- N = 12;
- Nnet = Feedforwardneuralnet (N);
- Nnet = configurate (Nnet, I, T);
- getingwb(Nnet) (W- weight and B- biases)
- Root-mean-squared error in expressing (g) is the objective function. and it is determined by the weights, bias(y), Nnet, I, and T.
- The ABC algorithm should be used to train the neural network.Weights, bias, and error (y, e), all updated, can be calculated from this.
- Nnet = setingwb(Nnet, y');

- getingwb(Nnet)
- error= T - Nnet (I);
- difference = mean(error.^2)/mean(var(T',1));
- generatesim(Nnet)

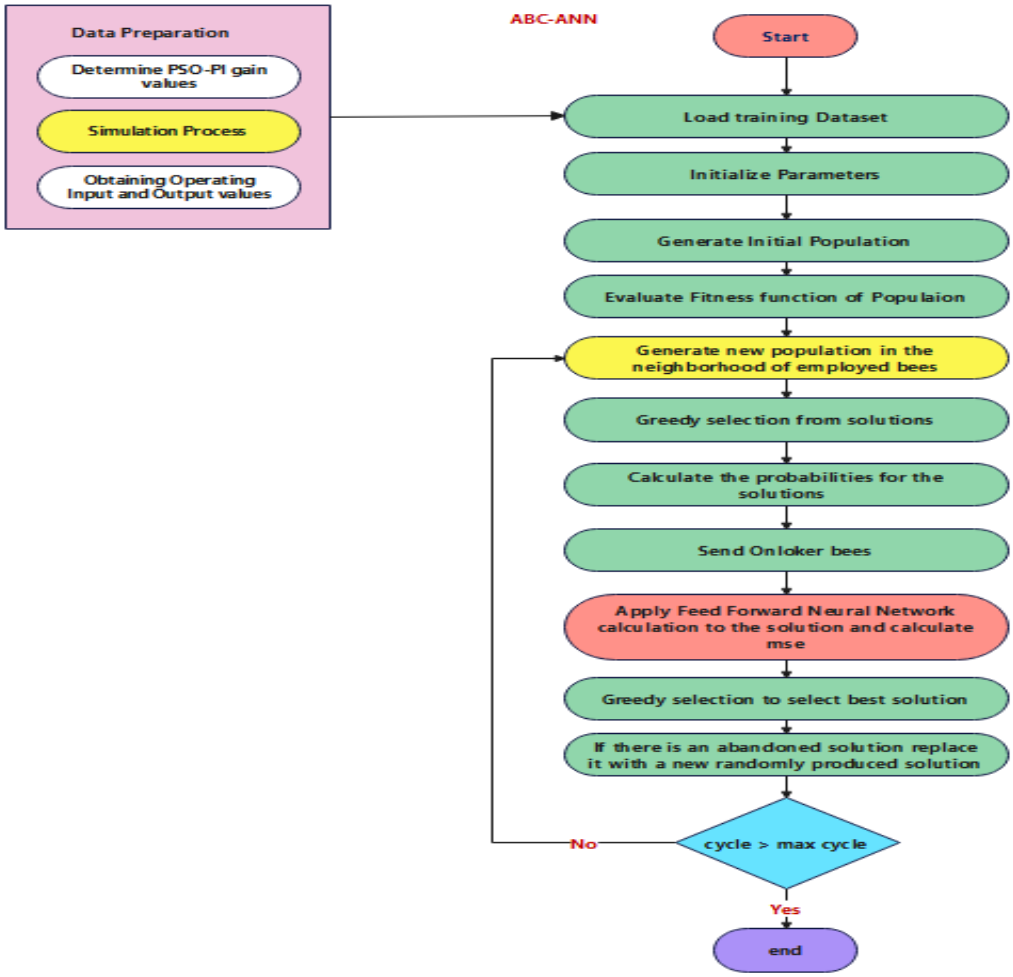


Fig. 7. Flowchart representation of ABC-ANN algorithm

Once the converges reaches steady state and the Mean Square Error (MSE) of the network decreases below a specific threshold, the network has reached convergence. Another way to stop learning is to limit the number of times something can be tried. The flowchart for the training algorithm is shown in Figure 7. Therefore, The PSO-PI controller will replace the feed-forward neural network shown in Figure 8 when input and output data are provided.

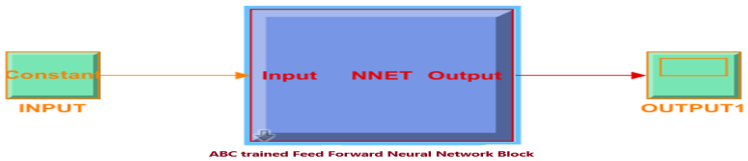


Fig. 8. Simulink block of ABC-ANN algorithm

6. Results and discussions

This section contains a discussion of the simulation results that were obtained using MATLAB. It is simulated both for the proposed ABC-ANN based controller as well as for the TLBO-ANN and DE-ANN controller based SAPF, and then comparing all of the obtained results.

The ANN- controller's weights and bias are adjusted to improve the source current THD value. Then, the controller's performance is measured with a static non-linear load connected to the PCC. The following situations were used to carry out this evaluation.

I. Without SAPF

In this case, SAPF is turned off, and a Fast Fourier Transform (FFT) analysis was used to figure out that the nonlinear load caused a 18.42% of THD change in the source current as shown in Figure 10 and Figure 9 shows how the source and load currents look in a three-phase simulation.

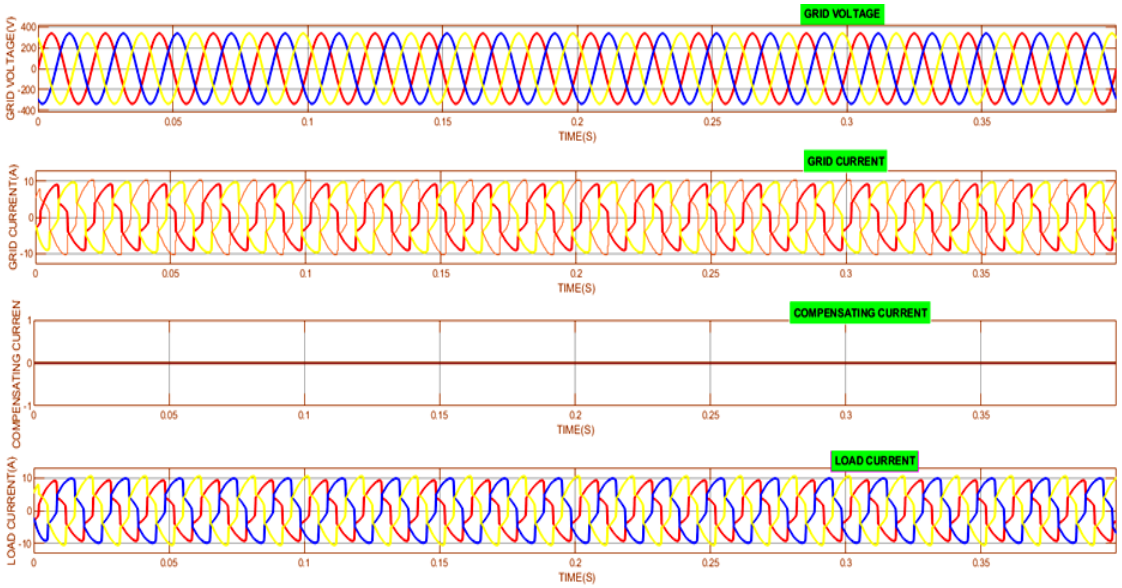


Fig. 9. The waveforms of the I_L, I_S, I_C, I_S, without using SAPF

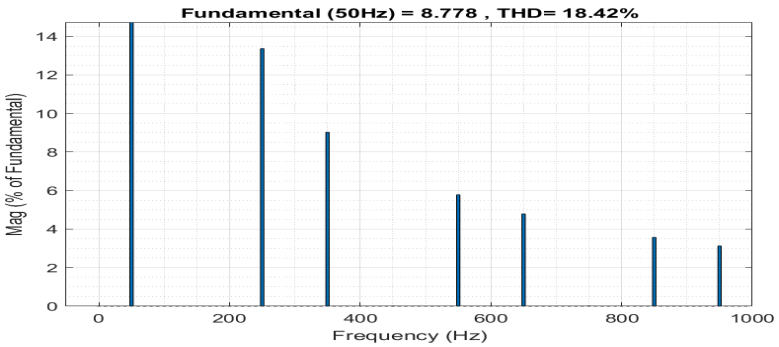


Fig. 10. THD result of source current without using SAPF

II. PI Controller based SAPF

Here, SAPF is attached to PCC, and conventional PI controller gains were used to obtain simulated results. Following the use of SAPF compensation, the distortion in the supply current was cut down

to 3.76 percent from its initial value. Moreover, the harmonic spectrum of the source current may be seen in Figure 11, as depicted correspondingly.

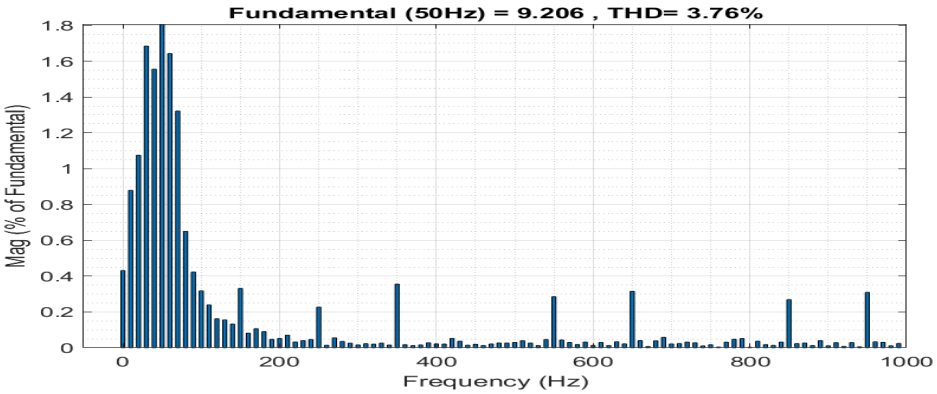


Fig. 11. THD result of I_S (Grid current) by PI based SAPF

III. PSO-PI based SAPF

In this present scenario, the SAPF compensation action was used to run the simulation, and the PI-controller gains were adjusted with the help of the PSO Algorithm. Both of these procedures were carried out in order to achieve the best possible results. According to Figure 12, the findings that were collected point to the possibility that there has been a significant decrease in the THD of the source current to an extremely manageable level of 0.93%.

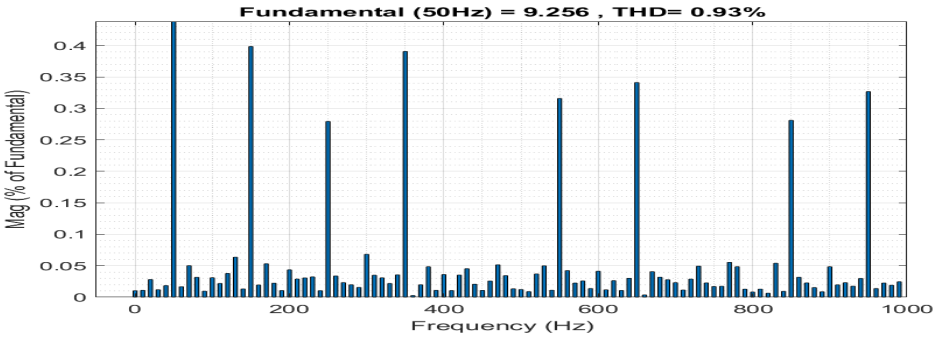


Fig. 12. THD result of I_S (Grid current) by PSO tuned PI based SAPF

IV. DE tuned ANN based SAPF

Here, instead of using a PSO-PI controller, a DE-ANN controller Simulink block was used. THD in the source current was mitigated to 0.90%, as displayed in Figure 13.

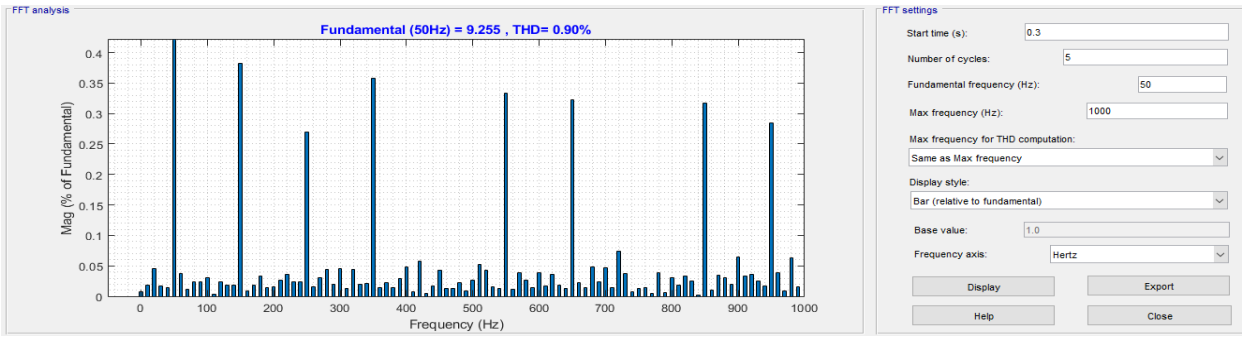


Fig. 13. THD result of I_S (Grid current) by DE tuned ANN based SAPF

V. ABC tuned ANN based SAPF

Here, the PSO-PI controller has been swapped out for the ABC-ANN controller Simulink part. Utilizing block of a feed-forward neural network, depicted in Figure 14. That is acquired from the Figure 9. Based on the results of the measurements, the total harmonic distortion (THD) of the source current appears to have diminished to 0.84%.

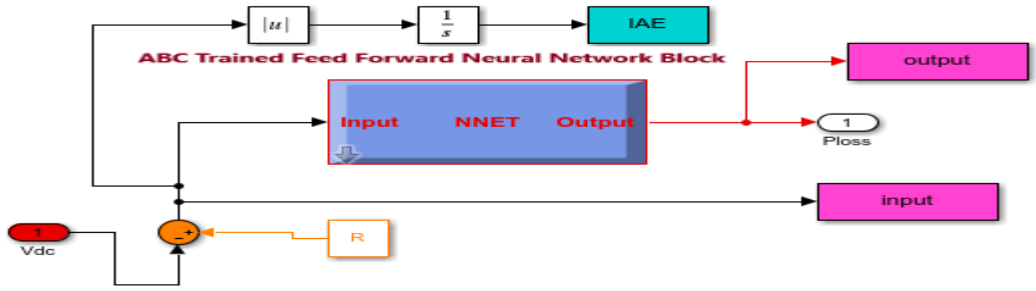


Fig. 14. Controlling the DC voltage in a SAPF with an ABC-ANN regulator

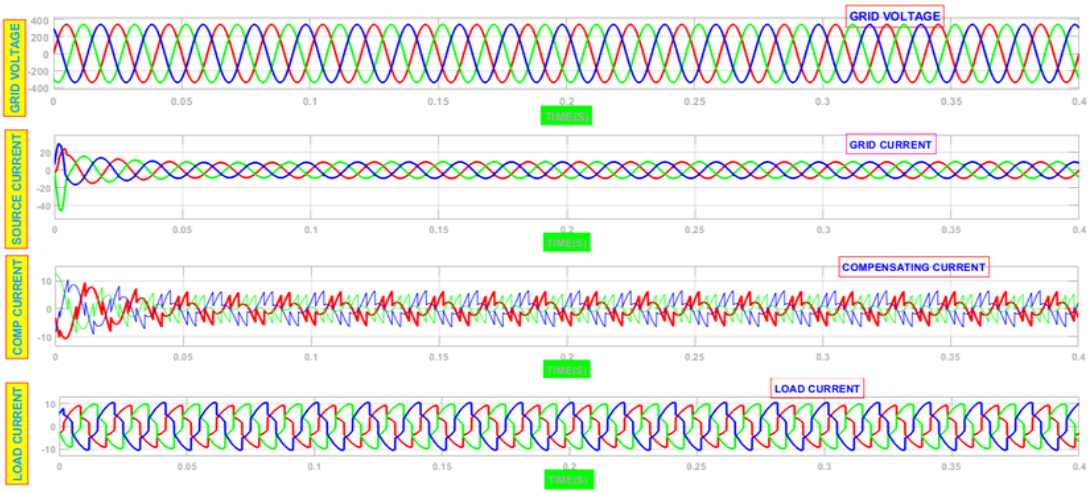


Fig. 15. The waveforms of the I_L, I_S, I_C, I_S, by using ABC trained ANN based SAPF

Figure 15 illustrates the waveforms of the currents flowing from the source, the load, and the SAPF compensating current. In order to maintain a sinusoidal source current, SAPF injects compensating current at the PCC using an ANN controller that was trained using the ABC algorithm. The harmonic spectrum of the source current is depicted in figure 16. The ABC-ANN controller's converging spectrum can be seen depicted in Figure 17. The error measured by the ABC ANN controller is shown to be smaller than that measured by the DE -ANN controller.

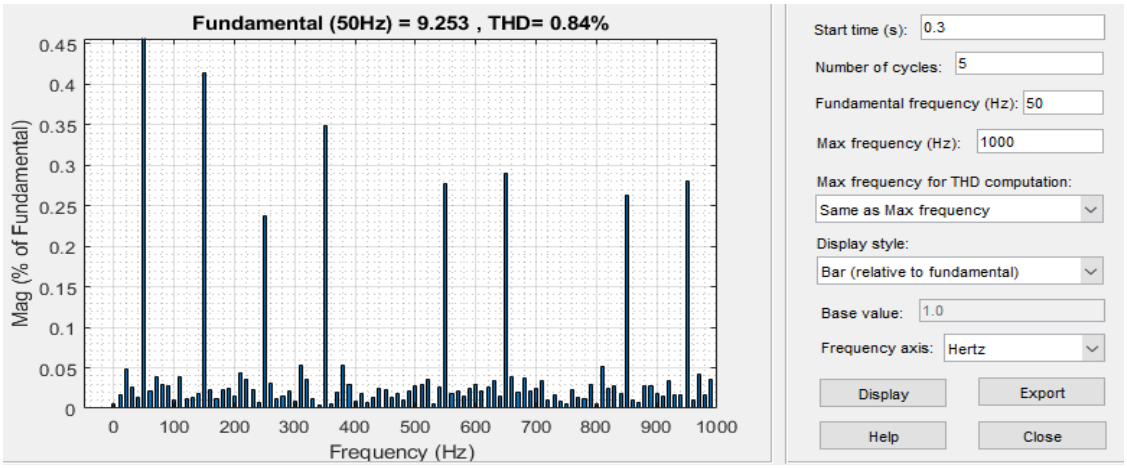


Fig. 16. THD result of I_S (Grid current) by ABC tuned ANN based SAPF

ABC-ANN parameters are listed in Table 1 and Table 2 presents the results of the SAPF investigations into all six incidents.

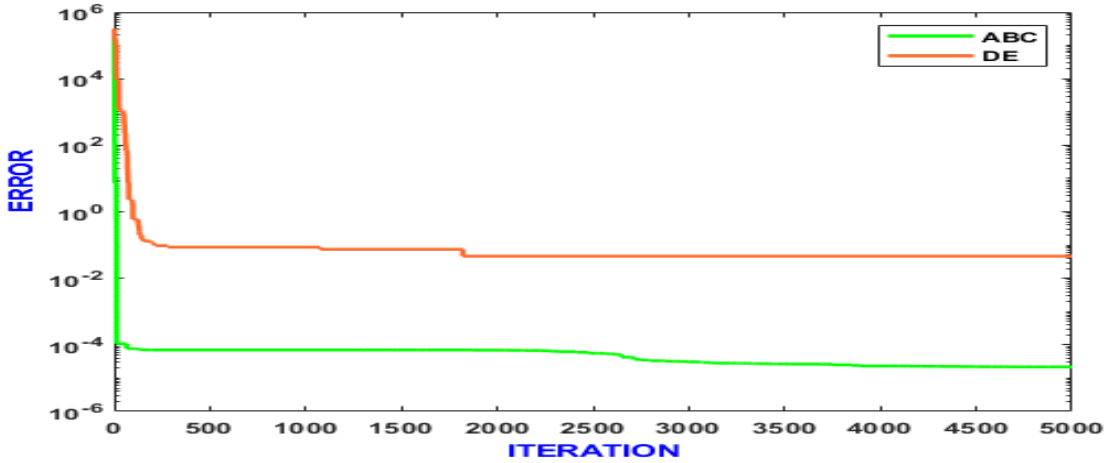


Fig. 17. Converges graph for the three optimization algorithms

Table 1
Parameters of ABC trained ANN

Total number of iterations	5000
Number of Population	25
Number of Onlooker Bees	25
Abandonment Limit Parameter	15
Acceleration Coefficient	1
Hidden number of Neurons	12
Total number of Variables	1
Max weights	200
Min weights	0

Table 2
Table of Comparisons

S_no	Type of Controller	Component	THD value(%)
1	Without using SAPF	I_S (Source Current)	18.42
2	PI based SAPF	I_S (Source Current)	3.76
3	PSO tuned PI Based SAPF [22]	I_S (Source Current)	0.93
4	DE tuned ANN based SAPF	I_S (Source Current)	0.90
6	ABC tuned ANN based SAPF	I_S (Source Current)	0.84

7. Conclusion

A novel Artificial Bee Colony based optimized Artificial Neural Network (ANN) controller is proposed for the purpose of improving the power quality in a SAPF-based power system with non-linear loads. Harmonics from nonlinearities are compensated and THD values are far below norms. This article recommends using the ABC-ANN control approach with the SAPF to reduce the THD in the power grid's source current. The successful implementation of the SAPF is evaluated and compared across a number of circumstances. The Matlab-Simulink software simulates total five situations and reports the results. Simulations show that DE-ANN, PSO tuned PI based SAPF and SAPF with PI controller minimize the THD, The ANN-ABC-based SAPF that was suggested provides better performance in terms of reducing THD in source current in comparison to other scenarios. According to the results, this improvement in performance is satisfactory (that is, within 5% of the recommended IEEE standard).

Future work will involve incorporating a hardware-in-loop implementation of the proposed shunt active filter. To further improve the SAPF's response, an ANFIS controller will be used that is predetermined with ABC and other optimization strategies.

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Optimized PI tuning of DG-Integrated Shunt Active Power Filter Using Biogeography-Based Optimization Algorithm

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biogeography-based optimization (BBO), solar cell, particle swarm optimization (PSO), power quality, distribution generation, THD

ABSTRACT

This article proposes a biogeography-based optimization (BBO) approach to optimizing the PI controller gains of the PV integrated shunt active power filter (SAPF). This method is also used to analyze how these optimum gains affect the performance of SAPF. When nonlinear loads draw reactive power from the source, harmonics are produced, which can lead to power quality issues for the utility. Our ultimate goal is to achieve sinusoidal source current, which can only be accomplished with the help of FACT devices that enhance power quality in the distribution network. SAPF is a commonly utilized device. Solar is the most popular alternative energy source because it is the most cost-effective. Therefore, this article takes into account PV-integrated SAPF for analysis. To get the highest amount of power from a PV panel, a technique called maximum power point tracking (MPPT) is used. This technique is based on perturbation and observation (P&O) in MPPT. When the SAPF converter uses this maximum power, it also sends active power to the load, so that the SAPF converter has dual functionality like reactive power compensation (FACT) and active power supply (DG Functionality) to the load. The performance of this PV-Integrated SAPF depends on many things, like how the reference current is made, how switching pulses are made, how the voltage on the dc link is controlled, etc. In order to obtain the best possible performance from SAPF, certain design parameters, such as the gains of the PI-controller, need to be optimized. Modeling and simulation of a PV-integrated SAPF are performed in Matlab/Simulink. Gain optimization of the PI controller-based PV integrated SAPF is performed using both the proposed biogeography-based optimization method and the PSO algorithm, and the results are compared. The proposed BBO-trained PV- SAPF converter's active power injection was also investigated.

1. INTRODUCTION

Fossil fuels have been burned to meet power demand for decades, but they are nonrenewable and cannot be reused [1]. They aren't ecologically sound. Pollution-friendly and contribute to climate change, so [2] renewable energy sources like solar, wind, and geothermal are essential. There are clean sources of energy generation, such as hydro, etc., and there is an abundance of them. Photovoltaic power plants have widespread application; solar energy is naturally abundant, and electrical power is widely available. Solar power as dc from the arrays, which is converted to an alternating current one that uses an inverter. Due to the energy's reactive power balancing capabilities, this equipment can be used anywhere [3]. There are more harmonics in the network because of the rise in nonlinear electronic loads and devices. Presents of a harmonic nature as well as voltages that are powers of the fundamental frequency led to systemic cases of power degradation, and as a result, the machinery got hot. To better understand the role of alterations that happens when voltage and Currents are not proportional. The impedance of the load [4] Short-circuit current is drawn by these loads. Damage electronic devices with pulses and harmonics. Rectifiers and other electronic devices are examples of non-linear loads. Everything from computers and motors to SMPSs (switch mode power supplies) to get rid of harmonics uses passive filters, but they have a few drawbacks. Have bounds, such as in resonance, and evolve in accordance as the workload shifts. To reduce grid current harmonics, active power filters are being developed; unlike passive filters, which require an external power source, these don't affect demand levels [5, 6]. Active filters can achieve the required gain while simultaneously addressing issues with attenuation. They're diminutive, but they're more effective than passive filtering systems. Their ability to avert major active power filters can handle wider frequency ranges. Photovoltaic shunt-clearing harmonics are a common application for active filters. The module's findings or those found Maximizing power generation from PV systems while keeping costs as low as possible necessitates the use of power point tracking (MPPT) techniques [7]. Additionally, a boost converter is used to increase the voltage output. When PV is implemented, it depends on a variety of factors in the real world, including things like climate and solar radiation. There's been a lot of

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study into improving old power in the grids employing various filtering strategies [8]. SAHF yields the contrasting major-minor harmonics so that it nullifies itself. Turn a nonlinear load into a linear one with linear pressure.

The goal of this work is to lessen harmonic distortion [9] in a distribution system with a non-linear load. By utilizing a shunt active power filter that is integrated with solar panels. Figure 1 represents the PV-integrated SAPF, which typically provides a current that is 90 degrees out of phase with the source current [10, 11]. As a result of the nonlinear load, the converter's output voltage dips, and the filter capacitor draws a greater amount of current than usual during the compensation process. So, in order to mitigate these unforeseen effects, it is proposed [12] that a SAPF be constructed with optimal parameters.

There has been a lot of study done on the topic of using an active power filter with a photovoltaic (PV) system. The filter's structure and tuning parameters are ignored, while a variety of methods for controlling current in a 3-phase, 4-wire distribution network are proposed in the study [13]. An improved current control approach [14] using a maximum power point tracking controller has been implemented to lessen system harmonics via a grid-connected inverter. Filtering techniques, such as a self-tuning PI controller [15, 16], have been used to decrease harmonic distortions in a grid, which comprises a voltage source converter, a hysteresis controller, and a DC voltage capacitor.

The parameters of today's automatic control systems are often optimized with the help of state-of-the-art soft computing techniques. The gains of PI controllers are optimized using particle swarm optimization (PSO) techniques [17, 18]. Evolutionary algorithm optimization techniques such as the genetic algorithm (GA) [19], bacterial foraging (BF) [20], firefly [21], ant colony optimization (ACO) [22], and differential evolution (DE) [23] have all been applied to the problem of determining the best possible gain settings for the PI controller in SAPFs.

In this study, BBO, a stochastic optimization method based on swarm intelligence, has been used for the fine tuning of PV-integrated SAPF PI parameters to control the DC link voltage to achieve the best THD. Using active power control theory, the SAPF converter also works like the DG converter.

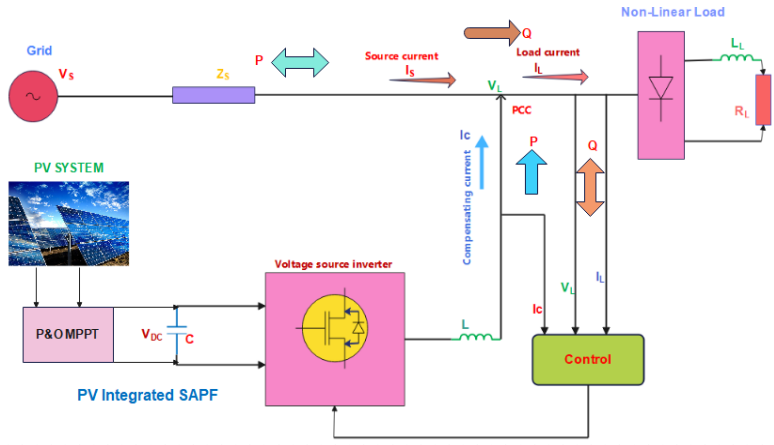


Figure 1. Model configuration of PV integrated SAPF

2. SYSTEM MODEL

The photovoltaic (PV) integrated shunt active power filter model that is the focal point of the present study is depicted in Figure 2. This model in its entirety includes the PV configuration, PV model, and PV array.

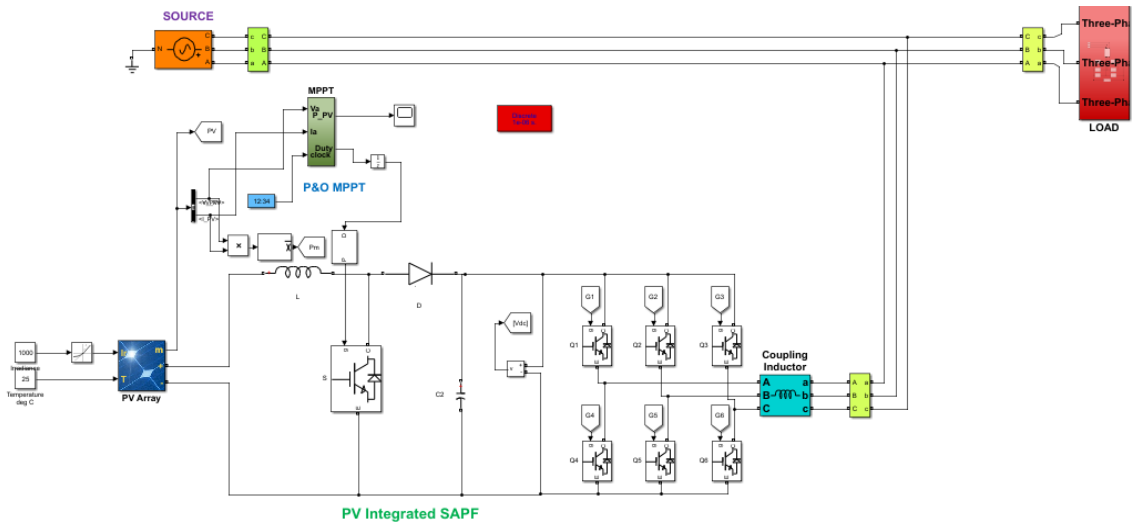


Figure 2. Simulink diagram of PV integrated SAPF when connected to non linear load

2.1 Mathematical modeling of shunt active power filters

The following assumptions need to be made in order to select the parameters for the SAPF, such as the interfacing inductance L_f and the DC capacitor C_{dc} as well as the reference dc voltage.

• The source current needs to have a sinusoidal pattern.
• The amount of distortion in the system current is no more than 5%.
• Converting takes place in a linear fashion.

The Q_C and I_h can be calculated using the two equations that are provided below.

$$Q_C=3V_CI_C = 3V_S \frac{V_C}{\omega L_f} (1 - \frac{V_S}{V_C}) \quad (1)$$

$$I_h = \frac{V_h}{m_f \omega L_f} \quad (2)$$

The V_{dcref} value can be adjusted in response to the rated voltage. The following equation is used to determine the appropriate value of C_{dc} to achieve the desired peak-to-peak voltage ripple level.

$$C_{dc} = \frac{\pi * I_c^{rated}}{\sqrt{3}\,\omega\, V_{PP}^{ripplee}} \quad (3)$$

where,

V_{dc}: The injected voltage from the filter.
L_f: The inductance of coupling for the SAPF.
C: The capacitor on the DC side of the filter.
V_s: The voltage of SAPF.
I_c: Compensating current from filter.
V_h: Harmonic voltage.

2.2 Basics of PV system

In order to convert solar energy into usable electricity, a PV system will use a series or parallel connection of PV modules or panels. Electrical output is generated via photovoltaic (PV) panels and associated mechanical and electrical connections. Solar photovoltaic (PV) output is normally dependent on solar irradiance, or the amount of sunlight available.

PV Cells, Modules, and Arrays PV cells can be connected together to make a module. Adding more modules to a PV plant works the same way, either in series or parallel, to boost the plant's power output.

A solar power plant's crucial fundamental component is PV cells. Silicon (Si) is the primary material used in solar panel construction. To generate an electric field, a thin semiconductor coating is polarized positively on one side and negatively on the other. The layer's surface is the source of the emitted electrons.

A PV cell typically produces a voltage in the range of 0.5 V to 0.7 V. As a result, the necessary output voltage and current can be obtained by connecting a series and parallel array of PV cells. In the event of partial shading, diodes in the PV array may be necessary to prevent the flow of current in the opposite direction. There is a risk of inefficiency when temperatures are very high. To counteract this, PV systems incorporate ventilation systems.

In order to convert the DC power from the PV panels into AC power for use in homes and businesses, inverter systems are installed. By connecting modules in series and parallel, higher voltage and current capacities can be achieved. The configuration is depicted in the Figure 3.

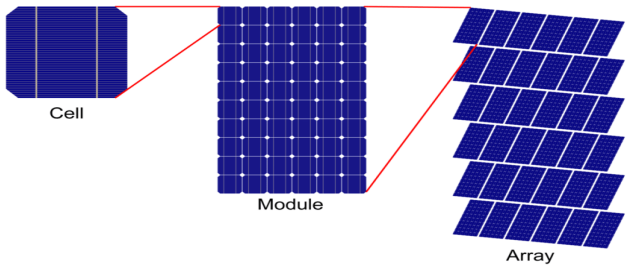


Figure 3. Interconnection diagram of solar cell, module, array

2.3 Module of PV system

The PV cell's circuit is depicted in Figure 4. It consists of only one diode, which is connected in parallel to the power supply. The function of a diode is to permit current to flow smoothly in one direction but substantially prevent it from flowing in the opposite direction. Diodes are sometimes referred to as rectifiers due to their ability to convert AC current into DC current. Both series resistance R_s and shunt resistance R_{sh} are denoted. There are two conditions for the cell, and the amount of current it draws from its source is directly related to the amount of sunlight it receives [24]. One is the potential difference between the terminals in a circuit that is open, and the other is the current in a short circuit.

When the diode is open, the voltage across it is zero, and the current through the short circuit I_{sc} is equal to the current through the current source, Voc.

The equation gives information about PV's properties.

$$I = I_L\text{-}I_0\,(e^{(v+R_s/n_s v_t Q_d)} - 1) - \frac{v+R_s}{R_{sh}}) \quad (4)$$

where, V is the array's voltage, I is the array's current, I_L is the light current, I_0 is the diode's reverse saturation current, Q_d is the diode's ideality factor, ns is the number of series cells, Rs is the series resistance, R_{sh} is the shunt resistance, V_t is the thermal voltage, and I_d is the diode current.

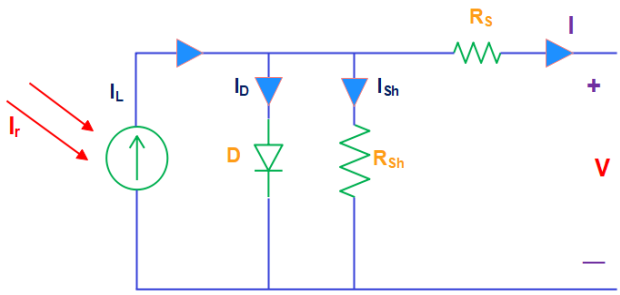


Figure 4. Single line diagram of photovoltaic system

Sun power SPR-315E-WHT-D modules were used in this study; their parameters and technical specifications are listed in Table 1.

Table 1. PV panel specifications

Parallel Strings	12
Series-connected modules per string	7
PV module name	Sun power SPR-315E-WHT-D
Max power	315.072
Open-circuit voltage (V)	64.6
Short -circuit current (A)	6.14
Voltage at MPPT (v)	54.7
Current at MPPT (a)	5.76
Irradiation (w/m^2)	1000

2.4 P&O MPPT algorithm

The P&O method uses the PV module to its full potential by maximizing efficiency in any environment. The primary benefit of this technique is the accessibility and preciseness of its algorithm, so that it can even be performed efficiently with a low-cost processor. However, a current and voltage sensor that measures the array's voltage and current is required for its implementation [25]. The power output of the PV is then calculated based on the data obtained for voltage and current.

If the duty cycle is altered by the expression P(n-1)=V(n-1)×I(n-1), and if the expression P(n)=V(n)×I(n) increases from the previous value, then n is an even number. The direction of the perturbation remains the same as P(n)=V(n)×I(n) grows larger, while when it decreases, the perturbation and, by extension, the duty cycle, switch directions [26]. Using the P&O technique, the system is represented in Figure 5.

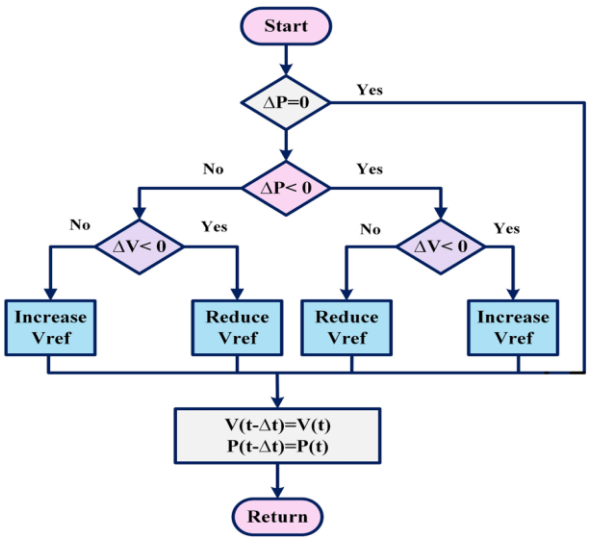


Figure 5. Flow chart representation of P&O MPPT

3. BBO OPTIMIZATION ALGORITHM

The natural phenomenon of biogeography acted as inspiration for a new metaheuristics technique called "biogeography-based optimization" (BBO). Biogeography is the study of how the geographic distribution of different species varies over time and space [27]. Simon [28] first proposed the BBO method for resolving certain continuous functions. Furthermore, this approach was developed on the basis of some principals, including species' ability to travel from island to island, the development of novel species, and the eventual extinction of extant ones. Some crucial BBO concepts are as follows:

3.1 Biogeography

According to biogeography principles, islands that are more favorable to life support systems tend to have more species, while less favorable islands tend to have fewer. Thus, the answers to the issues are like those islands. An excellent Habitat Suitability Index (HSI) value would characterize the ideal island. HSI is more commonly called "fitness" in other algorithms for population-based optimization, like the Genetic Algorithm. Suitability Index Variables (SIV) are the characteristics of the HSI. The HSI is the dependent variable in the habitat, and the SIV is taken as an independent variable.

3.2 Migration

High-HSI (or abundant species) habitats or islands will see high rates of emigration and low rates of immigration. Therefore, the higher HSI habitat is more likely to remain unchanged over time. Since these species have a high emigration rate, they are likely to relocate to nearby habitats. However, the migratory species wouldn't vanish entirely from the island of their ancestry. Those species would simultaneously appear on both islands. In most cases, the migration process would force the inferior solution to adopt the characteristics of the superior ones. If an island has a high emigration rate, it also has a low immigration rate, and vice versa. However, the island's rate of emigration is influenced by the variety of species that call it home. It stands to reason that islands with higher rates of emigration would be home to more species overall.

3.3 Mutation and elitism

In addition to migration, mutation and elitism occur during the BBO process. Mutation is a devastating ecological event. The rate at which mutations occur in various environments is known as the mutation rate. In some ecosystems, the mutation rate is proportional to the number of species present. The mutation rate in high-HSI environments is expected to be lower than in low-HSI environments. As a result, it is unusual for the mutation to preserve the good solution until the next generation is selected. Because of this mutation, novel environments would emerge to replace those with low HSI values. Without mutation, low-HSI solutions would become more prevalent, leading to a possible trap at the local optimum. Each habitat's mutation rate can be expressed as follows:

$$m_k = m_{max}\left(\frac{1 - P_k}{P_{max}}\right) \quad (5)$$

For any given habitat, the probability of having k different species is denoted by P_k, the mutation rate is denoted by m_k, and the maximum mutation rate is denoted by m_{max}, with Pmax being the maximum probability. Becauseof the mutation, a new habitat would appear in its place. The best previous solutions would also survive the elitism. All solutions, except the optimal ones with the highest probability (P_k), are equally susceptible to mutation. BBO's mutation mechanism is flexible in the same way that the mechanism of mutation that has been applied to the GA. Flow chart representation of BBO algorithm as shown in Figure 6.

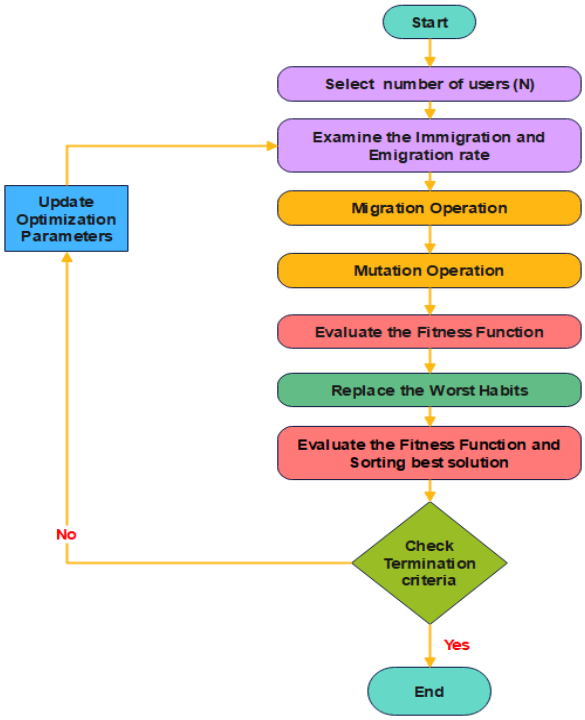


Figure 6. Flow chart representation of biogeography-based optimization (BBO)

4. PROPOSED METHODS

4.1 Tuning of PI controller by using BBO algorithm

The efficiency of a PV-integrated SAPF is dependent on the stability of the DC link voltage, which is regulated by the PI controller. Finding the gain (K_P, K_I) values of the PI controller in the critical controller is a complex mathematical process. The calculated gains are not optimal for the PI controller. To determine the best gains for the PI controller, this work implements BBO. Figure 7 shows the objective function, integral absolute error (IAE), as the discrepancy between the measured and target DC voltages. The BBO algorithm minimizes these objective functions and gives the best possible gains for the PI controller.

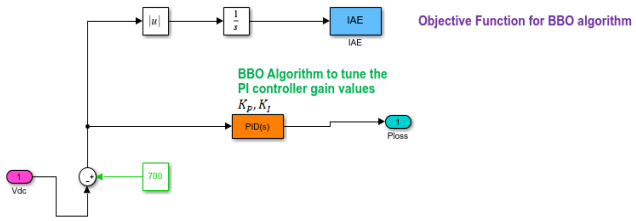


Figure 7. Simulink model of PI controller tuning with BBO algorithm

4.2 Active current coefficient control

This theory is proposed to find the actual active current required by the load, which is supplied from the PV source. Here first we need to sense the grid voltage (phase to phase) that is converted to phase to ground voltage, then these phase to ground voltages are again converted to α-β frame by using the clarck transformation, and again these α-β frame voltages are converted to an a-b-c reference frame by using the inverse clarck transformation. From that, we will get grid voltages in the a-b-c reference frame (Vg_a, Vg_b, Vg_c). These voltages pass through a band pass filter in order to remove some higher-order harmonics, and here we generate some unique vectors for synchronization of the grid with PV. And again, we need to sense the load current. With these load currents and the unique vectors, we need to find the active current coefficients for lines a, b, and c, as shown in Figure 8. Finally, we will take the average of these and get the actual active current requirement for the load (I_L).

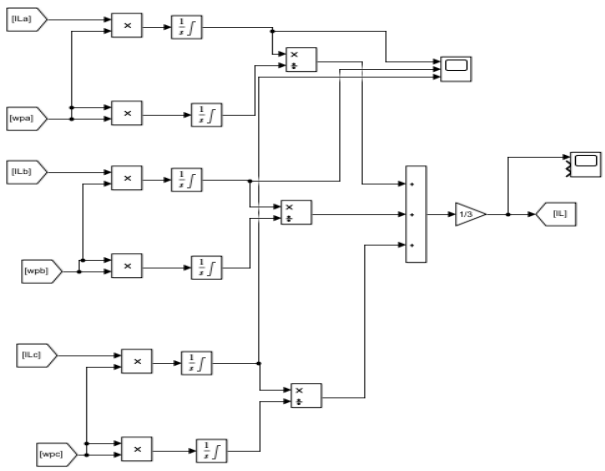


Figure 8. Simulink representation of active power coefficient theory

5. RESULTS AND DISCUSSION

This model implements a photovoltaic (PV)-based shunt active filter to mitigate undesired harmonics and enhance the power quality of the system. In order to produce gate pulses for the inverter, a hysteresis controller is built into the voltage source inverter (VSI). The model utilizes the P&O-based Maximum Power Point Tracking (MPPT) technique in order to optimize solar power extraction. The model is evaluated both with and without the inclusion of SAHF in order to analyze the network. By analyzing the data, we can determine the V-I characteristics. The shunt active filter based on photovoltaic (PV) technology is evaluated and examined using the MATLAB/SIMULINK software in order to mitigate current harmonics and facilitate power enhancement. The input supplied to the photovoltaic panel consists of solar irradiance of 1000 w/m^2 and a temperature of 25°C.Max power, open circuit voltage, and short circuit current are shown in Figure 9.

Since PV cells and other nonlinear loads are used, the source current is mostly made up of harmonic components, which affect all other loads in the distribution system. Here, the effects of a nonlinear load and the PV cell on harmonics have been looked into. A nonlinear load is used in the FFT analysis. Also, the gains of PV-SAPF's PI controller are chosen at random using trial and error. So, to improve the performance of SAPF, getting the gains of the PI controller to be as good as possible can be accomplished by employing the BBO optimization technique. In this study, the active power injection from this PV-SAPF is further examined.

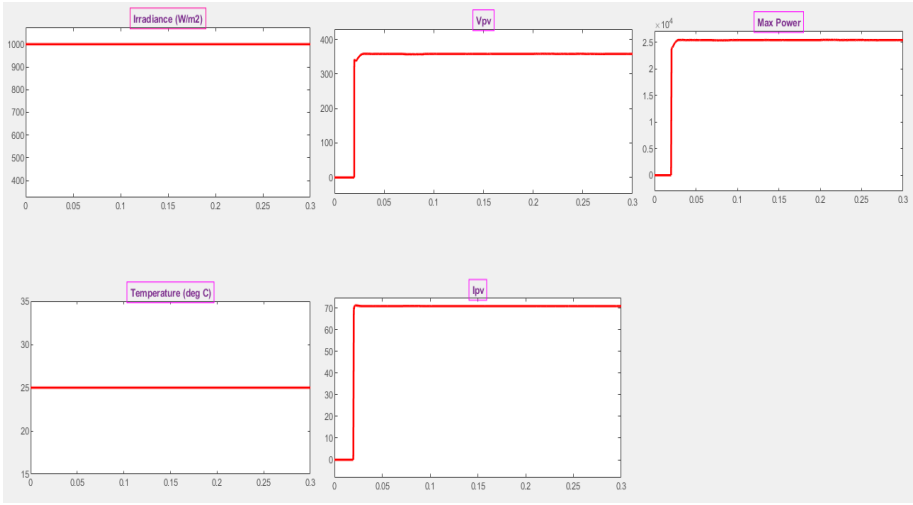


Figure 9. Output characteristics (P_{max}, V_{PV}, I_{PV}, Irradiation) of PV module

5.1 Harmonic spectrum of PV-SAPF with PSO-PI controller

Here, the PV-integrated SAPF utilizes a PSO-PI controller to control the voltage on the DC capacitor. Conventional controllers involve a lot of mathematical calculation, which is not accurate, so the gain values of the PI controller are tuned with the support of PSO's optimization algorithm. The PSO technique uses a minimization of the objective function known as the integral absolute error (IAE) to find the best possible values for the gains. With a maximum number of 100 iterations and 25 populations, For K_p and K_i, we chose 0 and 200 as the absolute minimum and maximum values, respectively.

Figure 10 shows the harmonic spectrum of PV-SAPF with the PSO-PI controller, where the THD in the grid current is 1.18%, and it shows that it is reduced from 3.08% to 1.18%.

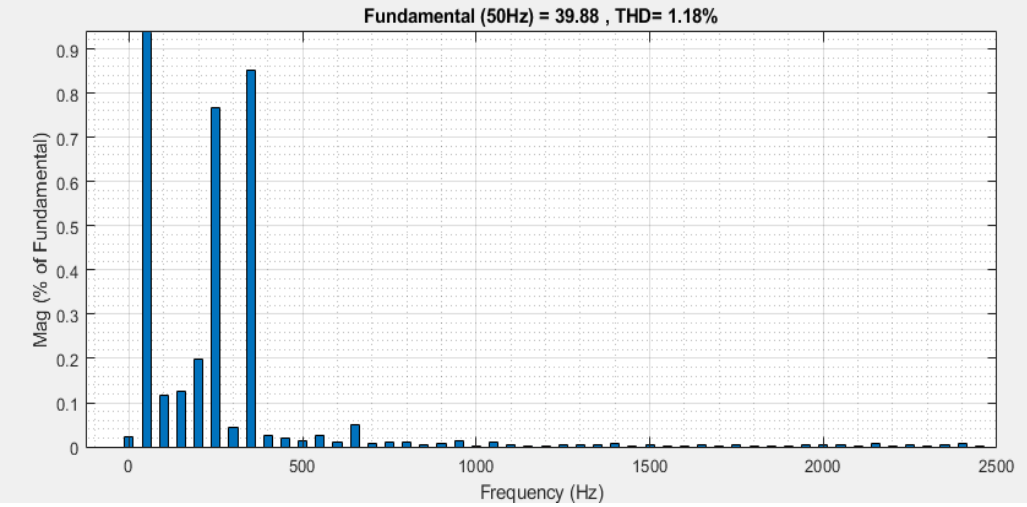


Figure 10. Grid current THD of PSO trained PI controller based PV-SAPF

5.2 Harmonic spectrum of PV-SAPF with BBO trained PI controller

Here, the PV-integrated SAPF utilizes a BBO-trained PI controller to control the voltage on the DC capacitor. A biogeography-based optimization (BBO) strategy will be used to make the necessary correction of the error voltage (IAE), which is the objective function, by adjusting the K_p and K_i gains of the PI controller. Figure 11 provides a graphic representation of source-side voltage (V_S) and source-side current (I_S) that are generated by a PV-SAPF that is controlled by a BBO-PI controller. In the event that a nonlinear load is connected to the grid at the same time, for the grid current to continue to have its normal sinusoidal shape maintained, SAPF will inject the compensating current at the PCC. Figure 12 represents the harmonic spectrum of PV-SAPF with a BBO-PI controller. From observing the figure, it is very easy to see that the THD value at the source current is 0.91%, and it shows that it is reduced from 1.18% to 0.91%. Table 2 represents the parameters of the BBO-PI controller.

Table 2. BBO configurations

BBO Parameters	Values
Maximal Iterations	100
Tuned Parameters	2
Keep Rate	0.2
Total Quantity of Reatained Habitats	5
Total Quantity of Fresh Habitats1	20
Total Populations	25
Alpha	0.9
Mutation	0.1
Emigration and Immigration Rates	1

5.2.1 Active power (P) & reactive power(Q) from PV-SAPF inverter

When PV is integrated into SAPF using active power coefficient theory, the SAPF converter will have dual functionality.

The PV-SAPF-SAPFrter works like DG; it will inject active power into the load.

The PV-SAPF-SAPFrter works like a FACT device; it will inject reactive power into the load.

Figure 13 represents the active and reactive power from the PV-SAPF inverter. From that, we can clearly observe that the PV-SAPF inverter is injecting 25.4 KW of active power and 2.054 KVAR of reactive power at the PCC.

5.2.2 Active power (P) & reactive power(Q) at load

Figure 14 represents the active power (P) and reactive power (Q) at the nonlinear load. From that, we can clearly observe that the load requires active power of 5.226 KW, which is taken from the PV-SAPF converter, and reactive power of 2.058KVAR, which is also taken from the PV-SAPF inverter.

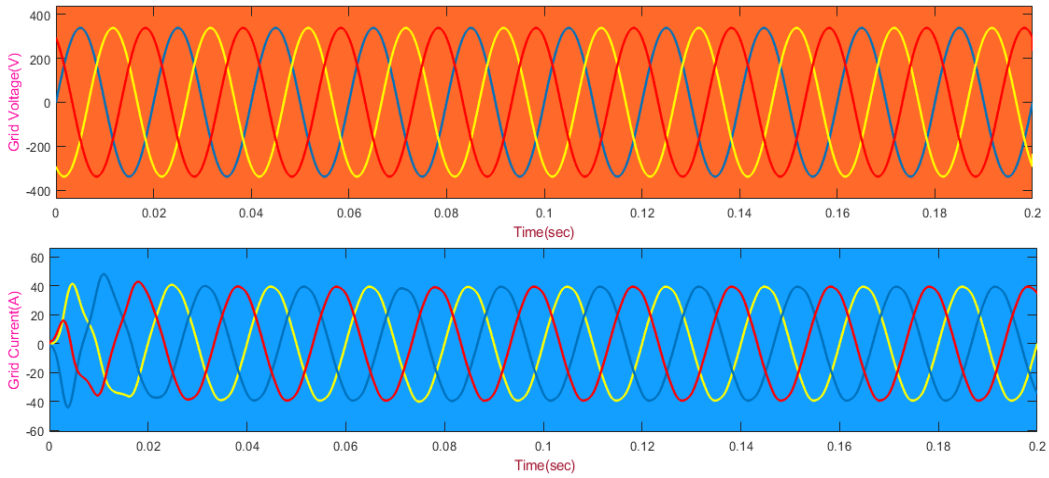


Figure 11. Source voltage and source current wave forms of BBO trained PI based PV-SAPF

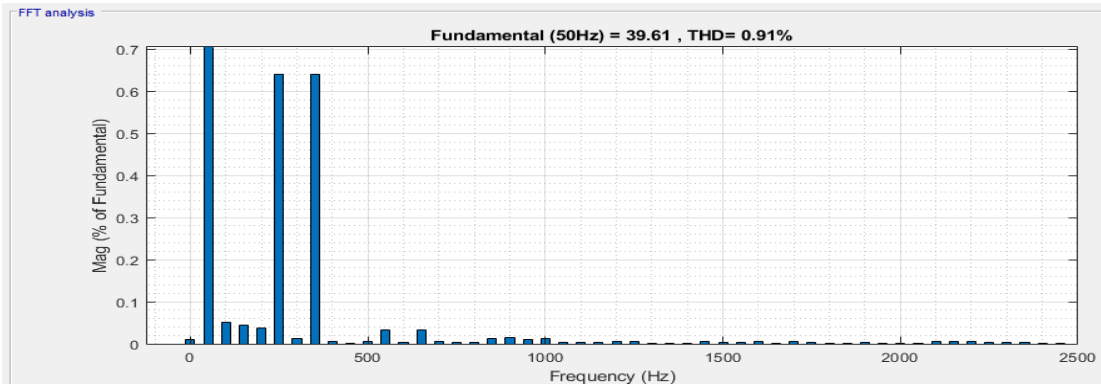


Figure 12. Grid side current THD of BBO trained PI controller based PV-SAPF

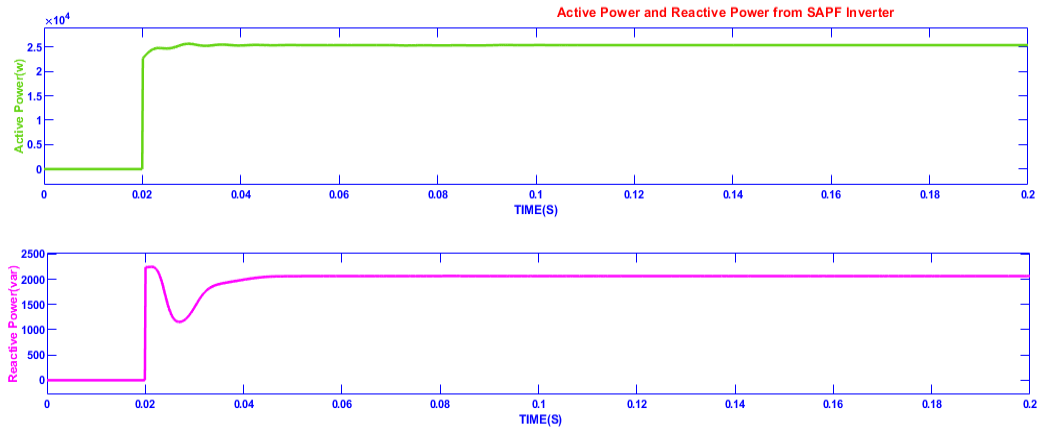


Figure 13. Active power and reactive power wave forms from PV-SAPF converter

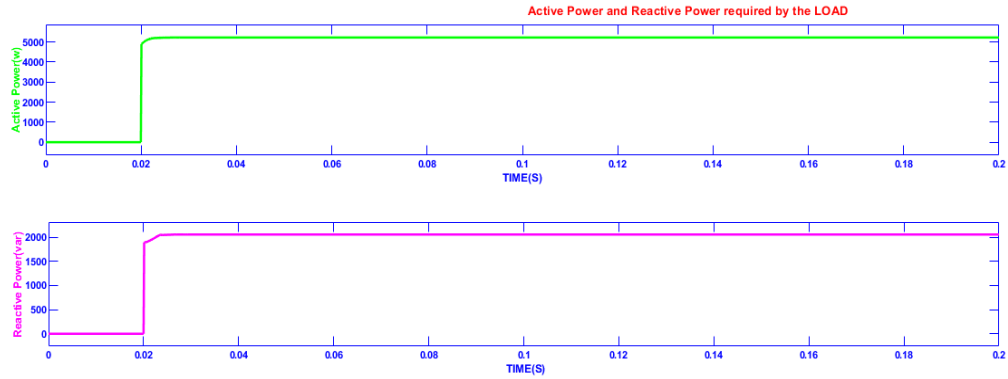


Figure 14. Active power and reactive power wave forms required by the load

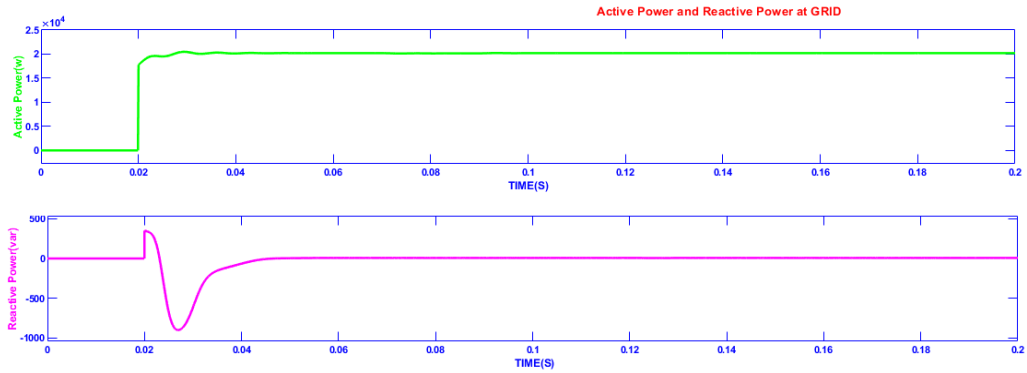


Figure 15. Active power and reactive power wave forms at GRID side

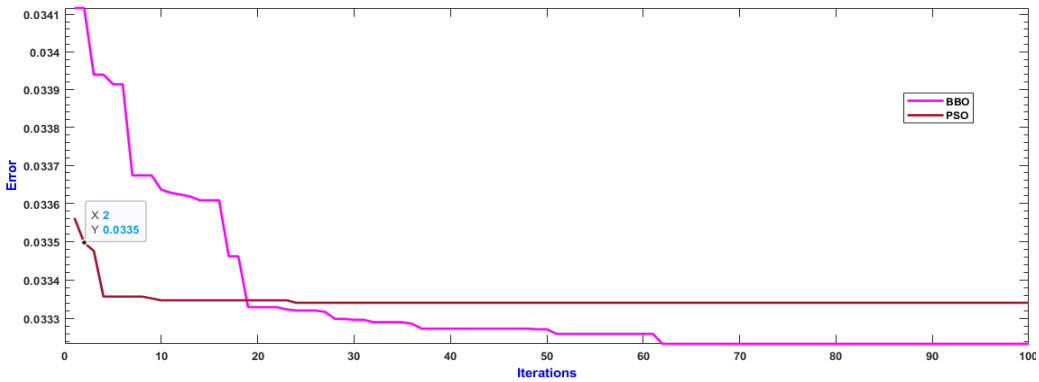


Figure 16. Converges spectrum of PSO & BBO trained PI controller based PV-SAPF

Table 3. Quantification comparisons

S_no	Type of Controller	Component	THD Value (%)
1	Without SAPF	I_S(SourceCurrent)	18.42
2	PI based PV- SAPF	I_S(SourceCurrent)	3.08
3	PV-SAPF with PSO-Trained PI cotroller	I_S(SourceCurrent)	1.18
4	PV-SAPF with BBO-Trained PI controller	I_S(SourceCurrent)	0.91

5.2.3 Active power (P) &reactive power(Q) at grid

Figure 15 represents the active power and reactive power (P&Q) at the source side; from that, we can clearly observe that the grid is not generating any reactive power (Q) for the load. At PCC PV-SAPF injecting 25.4 KW of active power, the load is taking around 5.226 KW, and the remaining 20.17 KW of active power is sent to the grid.

The converging spectrum of the BBO-PI-based PV-SAPF controller is depicted here in Figure 16, as it can be seen. It has been demonstrated that the error that is measured by the BBO-PIcontroller is less than that which is measured by the PSO-PIcontroller. The SAPF investigation findings for different incidents are listed in Table 3.

From the Table 3, we can clearly observe that the THD with a PSO-tuned PI-based PV-SAPF is 1.18%, and the proposed BBO-tuned PI-based PV-SAPF achieves a THD of 0.91%, which means the quality of grid current is better with BBO-trained PV-SAPF when compared to PSO algorithm-based PV-SAPF.

Active Power and Reactive power from SAPF inverter, Load, Grid at irradiation 0 w/m^2 and 10000 w/m^2 as given in Table 4.

Table 4. Power comparisons

Power/Irradiation	With Out DG Integration (0 W/m^2)		With DG Integration (1000 W/m^2)	
	Active Power (KW)	Reactive Power (KVAR)	Active Power (KW)	Reactive Power (KVAR)
Grid power ((P_s) & (Q_s))	5.239	0.3186	20.17	0.006
Load power ((P_L) & (Q_L))	5.226	2.058	5.226	2.058
SAPF inverte power ((P_F) & (Q_F))	0.0139	2.058	25.4	2.054

6. CONCLUSION

In this paper, we investigate the effectiveness of a PV-based shunt active filter with nonlinear loads in reducing harmonic distortion and improving overall power quality. Active filters are not the only option available, and passive filters are used for this purpose too. However, passive filters have issues such as load variation that active filters do not. It's a more cost-effective system because active filters are cheaper than passive ones. Solar irradiation and ambient temperature are two of the variables used in the PV module simulation. The P&O algorithm is used in conjunction with maximum power point tracking techniques to extract the maximum amount of power possible from PV. To increase the array's voltage, a boost converter is connected to it.

This study presents a proposed configuration for a photovoltaic (PV) integrated shunt active power filter. The configuration incorporates a biogeography-based optimization (BBO) for DC-link control, operating under ideal voltage conditions. The objective of this configuration is to improve power quality by reducing total harmonic distortion (THD). The Matlab-Simulink software runs simulations of two different scenarios and then presents the findings. The simulation results show that the THD with a PSO-tuned PI-based PV-SAPF using a PI controller is 1.18%, and the proposed BBO-tuned PI-based PV-SAPF achieves THD 0.91%, which is even better results in reducing THD in the source current than the PSO-tuned PI-based PV-SAPF. The proposed BBO-trained PV-SAPF provides not only reactive power compensation but also injects active power as required by the load.

7. FUTURE SCOPE

This suggested shunt active power filter will be implemented in hardware-in-loop in the future. The response of the PV-integrated SAPF can be improved through the implementation of an ANN, an ANFIS controller using BBO, as well as additional optimization strategies.

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Experimental study on flexural strength of slurry infiltrated fibrous concrete (SIFCON) produced with various percentages of waste steel fibers recovered from used tires

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Abstract. Slurry Infiltrated Fibrous Concrete (SIFCON), a modified version of Fiber Reinforced Concrete (FRC), addresses the challenge of increased fiber volume fractions. Commercially produced steel fibers are typically used in FRC and SIFCON. Efforts to reduce energy use in making commercial steel fibers have led to seeking alternative sources. Vehicular tires are typically recycled when no longer usable, yielding steel fibers among the products. Emphasis lies in recovering steel fibers from used tires as part of resource recovery from waste. Experimental work explored flexural strength in SIFCON with waste steel fibers at volumes from 4% to 7%. The study extended to assess SIFCON's flexural strength with commercial steel fibers at similar volumes, aiming to correlate with those from waste steel fibers. M20 grade concrete and SIFCON slurry matrix specimens were cast as reference mixes for comparison. The flexural strength of SIFCON specimens with waste steel fibers recovered from used tires notably surpasses that of reference mixes and is comparable to SIFCON specimens with commercial steel fibers. Additionally, the two-layer technique proves effective in SIFCON using waste steel fibers from used tires, up to 6% volume. The test results show successful production of SIFCON from waste steel fibers recovered from used tires.

Keywords: Slurry Infiltrated Fibrous Concrete, Flexural strength, Waste steel fibers, Aspect ratio.

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1 Introduction

Globally, energy crises and their impact on the environment are significant challenges faced in the present scenario. These issues arise due to the increase in population, rapid urbanization, and the generation of substantial quantities of solid waste. The production of automobiles and trucks has significantly increased to meet the growing demand, leading to a proportional increase in the generation of waste tires. In today's modern world, the use of

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vehicles for the transportation of people and materials is steadily rising, resulting in a problem with the disposal of scrap tires at the end of their life [1, 2, 3]. Less than 40% of the embedded energy in tires that have been scrapped can be recovered as fuel energy, based upon studies [4]. The majority of discarded tires are utilized as a source of energy for cement kilns because of the high carbon content in tires [5]. It is better to embrace the concept of reusing and recycling to obtain resources from waste, which offers environmental benefits [6, 7]. Rubber recovered from scrap tires in recycling plants is used as a source of energy in industries, and the steel fibers with high strength that were extracted from scrap tires serve as raw materials for steel manufacturing plants. The focus has been made on extracting steel fibers with high strength from used tires as a concept of resource recovery from waste, reducing the need for using high-strength manufactured commercial steel fibers. Pyrolysis methods, cryogenic methods, or mechanical methods are generally employed for the recovery of rubber and steel fibers from scrap tires [8, 9]. Steel fibers extracted from used tires may not have a straight or definite aspect ratio, unlike manufactured commercial steel fibers.

It has been demonstrated that steel fibers with various aspect ratios that are extracted from used tires may be used as an alternative material while producing steel fiber-reinforced concrete. [10]. However, due to the balling effect, there is a limitation in using higher amounts of fibers in the preparation of fiber-reinforced concrete. A special form of steel fiber-reinforced concrete is Slurry Infiltrated Fibrous Concrete (SIFCON), a high-performance cementitious composite [11, 12]. The production of SIFCON is different from the conventional fiber-reinforced concrete, wherein molds are prepacked with the fibers and infiltrates the cement mortar slurry matrix. Due to the procedure of prepacking, higher amounts of fibers can be used in the manufacture of SIFCON using cement mortar slurry matrix with a low water-cement ratio, resulting in higher energy absorption or toughness compared to conventional steel fiber-reinforced concrete, as well as higher post-cracking strength. In the production of SIFCON, the fibers are placed by hand and infiltrated with a cement mortar slurry matrix, in which the balling of fibers will not be a limitation and facilitates the convenient use of the waste steel fibers extracted from scrap tires. Furthermore, waste steel fibers extracted from scrap tires are less expensive than industrial steel fibers, which is also an added advantage for SIFCON applications. Studies regarding the usage of waste steel fibers in the production of SIFCON are limited based on the available literature [13, 14, 15, 16, 17].

The maximum flexural strength of SIFCON is obtained at 9% of fiber volume with an aspect ratio of 80, and it is noted that SIFCON's flexural strength, split tensile strength, and compressive strength are optimum at 9% fiber content [18]. It is proved that the three-layer technique with hand tamping is effective in prepacking fibers in the casting of SIFCON specimens. It was observed that beyond 10% volume of hooked-end steel fibers with an aspect ratio of 70 and a length of 35 mm, the placement of fibers manually in the mold is very tedious [19]. It was shown that the compression, split tensile, and flexural strengths of SIFCON specimens will increase with an increase in the volume of the steel fiber fraction [20]. SIFCON slab specimens show superior performance in load-carrying capacity, stiffness, and energy absorption compared to fiber-reinforced concrete and plain cement concrete slab specimens in flexure [21]. Higher levels of waste fibers in SIFCON have improved its splitting and flexural strengths. However, the use of waste steel fibers had no effect on compressive strength. Waste steel fibers have the potential to be a desirable substitute in the manufacture of SIFCON, as shown by multi-objective optimization. [22]. It has been concluded adding SIFCON to regular concrete reduces the possibility of cracks spreading, improves strength, ductility, load carrying capacity, and energy absorption capability (toughness) [23].

Steel fibers are being utilized in the manufacturing of steel fiber-reinforced concrete in the construction industry. Slurry Infiltrated Fibrous Concrete (SIFCON) has been termed 'the

advanced version of Fiber-Reinforced Concrete (FRC)' due to the increased volume fraction of fibers, which contributes to improved hardened properties such as strength, toughness, and impact resistance. Generally, the fibers used in the preparation of SIFCON offer benefits similar to what reinforcing bars offer in Reinforced Cement Concrete (RCC). The improved properties of SIFCON elements depend on the type, geometry, shape, and orientation of the fibers utilized in experimental work. The main aim of this experimental work is to study the flexural strength of SIFCON, which is produced using waste steel fibers recovered from used tires.

2 Materials

2.1 Binding material

Grade 43 Ordinary Portland Cement (OPC) has been used as the binding material throughout the experimental work and conforms to Indian standards [24]. Tests were conducted on the cement used in the experimental study to determine its fineness, specific gravity, consistency, and initial-final setting times. The physical properties of the cement are shown in Table 1.

Table 1. Physical properties of Cement

Physical Properties	Test Result	Test method	Requirement
Specific gravity	3.13	IS 4031 (Part II):1988	-----
Fineness [m^2/Kg]	311.5	IS 4031 (Part II):1988	Min. 225
Normal consistency	33%	IS 4031 (Part IV):1988	-----
Initial setting time [minutes]	47	IS 4031 (Part V):1988	Min. 30
Final setting time [minutes]	252	IS 4031 (Part V):1988	Max. 600

2.2 Fine aggregate

Natural sand obtained from the riverbed has been used throughout the experimental work for the preparation of the reference mix and SIFCON specimens. However, a maximum aggregate size of 0.60 mm has been considered and used in the preparation of the SIFCON slurry matrix, and this size has been kept constant for the production of SIFCON throughout the experimental work. The fineness modulus, specific gravity, bulk density, and water absorption of the aggregates were determined according to IS codes. Table 2 shows the physical properties of the fine aggregate utilized in the experiment. However, natural sand obtained from the riverbed, conforms to Indian standards has been used fine aggregate in the preparation of M20-grade concrete.

Table 2. Fine Aggregate Test Results

Type of Test	Fine Aggregate
Fineness Modulus [%]	2.80
Specific Gravity	2.65
Water Absorption [%]	0.25
Bulk density [kg/m^3]	1750

2.3 Coarse aggregate

The maximum size of 20 mm obtained from the granite quarry, which conforms to Indian standards, has been used as coarse aggregate in the preparation of M20-grade concrete in the experimental work.

2.4 Mixing water

The laboratory's potable water has been utilized for mixing the SIFCON slurry matrix, reference mix, and curing of the specimens.

2.5 Chemical admixture

To achieve the necessary workability and flowability of the SIFCON slurry matrix, a high-range water-reducing admixture (superplasticizer) of polycarboxylic ether has been used. Manufacturer's data have been considered for the chemical admixture used in the study. Properties of the superplasticizer, i.e., AURAMIX 450 from M/s. FOSROC Chemicals, are shown in Table 3.

Table 3. Characteristics of Super plasticizer (AURAMIX 450)

Appearance	Light yellow colour liquid
pH value	Minimum 6.0
Volumetric mass @ 20°C	1.09 to 1.11
Chloride Content	Nil

2.6 Steel fibers

A survey was conducted to obtain waste steel fibers from used tires. Fibers recovered from scrap tires through a mechanical process at the recycling plant were used in this experimental study for preparing the SIFCON specimens. In the tire recycling plant, initially, collected scrap tires are shredded into small pieces using industrial shredders. After shredding, the tire pieces undergo a process called magnetic separation, in which powerful magnets are used to attract and separate the steel fibers from the shredded rubber. The shredded material is then passed through screens or filters to further separate any remaining steel fibers from the rubber particles. The steel fibers obtained from the recycling plants contained a small quantity of textiles and rubber fragments, which were manually removed to the extent possible before being used in the preparation of SIFCON. The waste steel fibers obtained from the recycling plant are irregular in shape. Waste steel fibers recovered from the used tires utilized in the study were tested to determine the diameter, length, aspect ratio, etc. Fig. 1 displays the waste steel fibers chosen for the experimental program. The length and diameter of the waste steel fibers, measured on randomly selected fibers, are shown in Table 4. Furthermore, round crimped steel fibers have been used as the commercial steel fibers in the experimental work. Manufacturer's data have been considered for the commercial steel fibers used in the study and are shown in Table 5. Fig. 2 displays the commercial steel fibers that were selected for the experiment.



Fig. 1. Waste steel fibers recovered from used tires.



Fig. 2. Commercial steel fibers.

Table 4. Properties of waste steel fibers

Diameter of Fiber [mm]	Length of Fiber [mm]	Average Aspect ratio	Contribution of Fibers (% by weight)
0.15 ± 0.01	26 ± 23	173	9.70 %
0.19 ± 0.01	13 ± 2	68	3.20 %
0.27 ± 0.02	37 ± 17	137	11.30 %
0.31 ± 0.01	45 ± 28	145	46.80 %
0.34 ± 0.01	30 ± 15	88	11.30 %
0.39 ± 0.03	46 ± 19	118	12.90 %
0.46 ± 0.01	68 ± 4	148	4.80 %

Table 5. Properties of commercial steel fibers

Type	Crimped
Diameter	0.45 mm
Length	35 mm
Aspect ratio (l/d)	78
Tensile Strength	1260 MPa

3 Methodology

M20 grade concrete was designed in accordance with the guidelines specified in Indian Standards. [25]. The proportions of ingredients for the M20 grade concrete are presented in Table 6.

Table 6. Mix proportions of M20 grade design mix concrete

	Water	Cement	Fine Aggregate	Coarse Aggregate	20 mm CA	10 mm CA
By Weight [kg]	160	320	667	1131	679	452
By Volume [m^3]	0.50	1	2.08	3.53	2.12	1.41

A flow test was conducted using a mini flow cone, as recommended by EFNARC [26]. The mini flow cone measures 60 mm in height, 70 mm in the top inner dimension, and 100 mm in base inner dimension. The equipment used in this study for the mini flow test is shown in Fig. 3. The SIFCON slurry was poured into the mold, lifted, and the spread diameter of the slurry matrix was measured. The slump flow ranged between 240 mm and 260 mm, in accordance with the guidelines stipulated in EFNARC [26]. Another test conducted on the fresh SIFCON slurry matrix is the mini v-funnel test. Fig. 3 illustrates the dimensions and form of the equipment utilized in this study. The SIFCON slurry was poured into the test equipment, and the time to empty the equipment was measured. The time to empty the test equipment ranged from 7 seconds to 11 seconds, in accordance with the guidelines stipulated in EFNARC [26].

Fresh tests, as described above, have been conducted using cement and fine aggregate in the proportion of 1:1, with a water-cement ratio varying from 0.30 to 0.40 in increments of 0.01 and superplasticizer from 0.50% to 2.00% by weight of cement, in increments of 0.1%. The procedures for the flow test and mini v-funnel tests are shown in Fig. 4 and Fig. 5, respectively. After detailed test trials, it was decided to use the SIFCON slurry matrix with a proportion of 1:1 (cement: fine aggregate) using a water-cement ratio of 0.33 and a superplasticizer content of 0.80% by weight of cement. The mix proportion of the SIFCON slurry matrix is provided in Table 7.

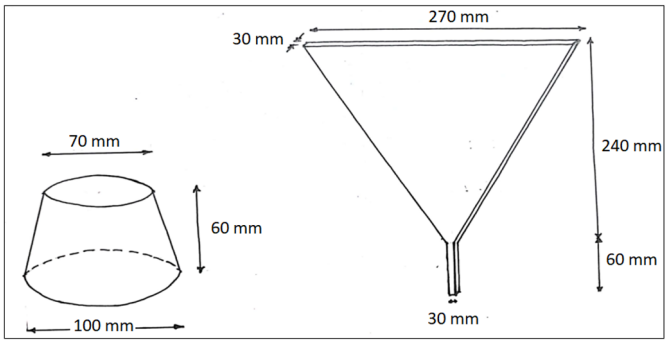


Fig. 3. Equipment for mini slump and v-funnel tests.



Fig. 4. Mini slump test.



Fig. 5. Mini v-funnel test.

Table 7. Mix proportion of SIFCON slurry matrix

Cement	Fine aggregate	W/C ratio	Super plasticizer
1	1	0.33	0.80 % by weight of cement

Upon finalizing the ratio of the SIFCON slurry matrix, the production process for SIFCON is as follows: The molds used for specimen production will be cleaned and coated with waste oil to facilitate easy demolding. Cement and fine aggregate, in a 1:1 proportion, are to be dry mixed. Subsequently, water and superplasticizer, as per the finalized ratios, are to be added to the dry mix. The total slurry must be mixed for a minimum of 2 minutes to ensure proper mixing of the slurry matrix.

A two-layer technique is employed for filling the fibers in the molds to ensure proper compaction and prevent honeycombing. Accordingly, 50% of the volume fraction of fibers is randomly hand-spread as the first layer in the mold. Once the first layer is in place, the prepared SIFCON slurry matrix is poured onto the fiber bed and compacted using hand tamping and a table vibrator.

Subsequently, a second layer of fibers is also randomly spread, followed by pouring of the SIFCON slurry matrix and compaction. The cast samples are left for 24 hours at room temperature. On completion of this time, the samples are demolded and placed in a curing chamber for the designated curing periods. Difficulties were encountered during the production of SIFCON specimens with a 6% volume fraction of steel fibers due to the irregular shape of waste steel fibers and their random placement. In consideration of this, a three-layer technique has been employed for the production of SIFCON specimens with 7% steel fibers. Fig. 6 depicts the production process of the SIFCON.

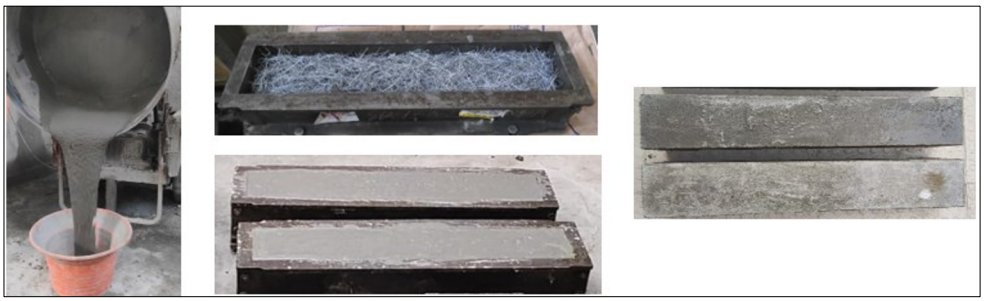


Fig. 6. Production process of SIFCON.

4 Experimental Programme

Flexural elements of 100x100x500 mm, with various volume percentages of waste steel fibers, commercial steel fibers, and reference elements, are casted. The quantity of fiber content used in the preparation of SIFCON specimens, corresponding to 4%, 5%, 6%, and 7% of the concrete volume, is 314 kg/m^3, 392.50 kg/m^3, 471 kg/m^3, and 549.50 kg/m^3, respectively. The designations for the specimens are provided in Table 8.

Table 8. Designation of specimens.

Type of Prism	Cross Section [mm]	Steel fibers		No. of speci-men	Designation
		Type	Vol.		
M 20 grade	100x100x500	----	----	9	RMPM20-1 to RMPM20-9
SIFCON slurry	100x100x500	----	0%	9	RMPF0-1 to RMPF0-9
SIFCON with fibers	100x100x500	Waste steel fibers	4%	9	S1PWF4-1 to S1PWF4-9
			5%	9	S1PWF5-1 to S1PWF5-9
			6%	9	S1PWF6-1 to S1PWF6-9
			7%	9	S1PWF7-1 to S1PWF7-9
SIFCON with fibers	100x100x500	Commer-cial steel fibers	4%	9	S1PMF4-1 to S1PMF4-9
			5%	9	S1PMF5-1 to S1PMF5-9
			6%	9	S1PMF6-1 to S1PMF6-9
			7%	9	S1PMF7-1 to S1PMF7-9

All specimens were tested for flexural strength using two-point loading. The universal testing machine has been used for testing the specimens, and the tests were carried out in accordance with the procedures outlined in IS: 516-1959. Fig. 7 depicts the test setup of the flexural strength. At the ages of 3, 7, and 28 days, tests were performed on the specimens. All necessary safety precautions have been followed during testing of the specimens.



Fig. 7. Test setup of flexural strength.

5 Results and Discussions

In Table 9, the flexural strength results of SIFCON specimens at 3, 7, and 28 days of age, produced with various percentages of waste and commercial steel fibers and the reference mixes, are displayed.

Table 9. Flexural strength of specimens

Sl. No.	Type of Specimen	Steel Fibers		Specimen designation	Average Flexural strength [N/mm^2]		
		Type	Per-centage		3 days	7 days	28 days
I	M20 grade prism	----	----	RMPM20	2.98	4.32	5.77
II	SIFCON slurry prism	----	0 %	R1MPF0	3.89	5.61	7.19
III	SIFCON prism	Waste steel fibers	4 %	S1PWF4	5.33	9.95	10.96
IV	SIFCON prism		5 %	S1PWF5	8.24	10.77	12.52
V	SIFCON prism		6 %	S1PWF6	11.66	12.97	13.42
VI	SIFCON prism		7 %	S1PWF7	16.33	16.21	15.04
VII	SIFCON prism	Commer-cial steel fibers	4 %	S1PMF4	17.17	21.64	21.98
VIII	SIFCON prism		5 %	S1PMF5	24.24	25.58	27.59
IX	SIFCON prism		6 %	S1PMF6	25.59	27.60	28.83
X	SIFCON prism		7 %	S1PMF7	27.53	29.91	32.49

From Table 9 and Fig. 8, it is observed that the average flexural strength of the M20 grade reference mix and the SIFCON slurry matrix at 3 days is 2.98 N/mm^2 and 3.89 N/mm^2 respectively. Additionally, at 7 days, the average flexural strength of the M20 grade reference mix and the SIFCON slurry matrix is 4.32 N/mm^2 and 5.61 N/mm^2 respectively. Furthermore, at 28 days, the average flexural strength of the M20 grade reference mix and the SIFCON slurry matrix is 5.77 N/mm^2 and 7.19 N/mm^2 respectively. The higher difference in flexural strength in the SIFCON slurry matrix is due to the increased amount of binding material and the absence of coarse aggregate.

From Table 9 and Fig. 8, it is observed that the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% waste steel fibers at 3 days is 5.33 N/mm², 8.24 N/mm², 11.66 N/mm², and 16.33 N/mm² respectively. Similarly, the average flexural strength of SIFCON with the same fiber percentages at 7 days is 9.95 N/mm², 10.77 N/mm², 12.97 N/mm², and 16.21 N/mm² respectively. Furthermore, at 28 days, the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% waste steel fibers is 10.96 N/mm², 12.52 N/mm², 13.42 N/mm², and 15.04 N/mm² respectively.

The results indicate that at 3 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers exhibits flexural strengths 79%, 177%, 291%, and 448% higher than M20 grade concrete, and 37%, 112%, 200%, and 320% higher than the SIFCON slurry matrix respectively. Similarly, at 7 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers shows flexural strengths 130%, 149%, 200%, and 275% higher than M20 grade concrete, and 77%, 92%, 131%, and 189% higher than the SIFCON slurry matrix

respectively. Furthermore, at 28 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers exhibits flexural strengths 90%, 117%, 133%, and 161% higher than M20 grade concrete, and 52%, 74%, 87%, and 109% higher than the SIFCON slurry matrix respectively. The increase in flexural strength of SIFCON produced with waste steel fibers, compared to reference mixes, is attributed to the SIFCON slurry matrix with various percentages of fiber volume fraction.

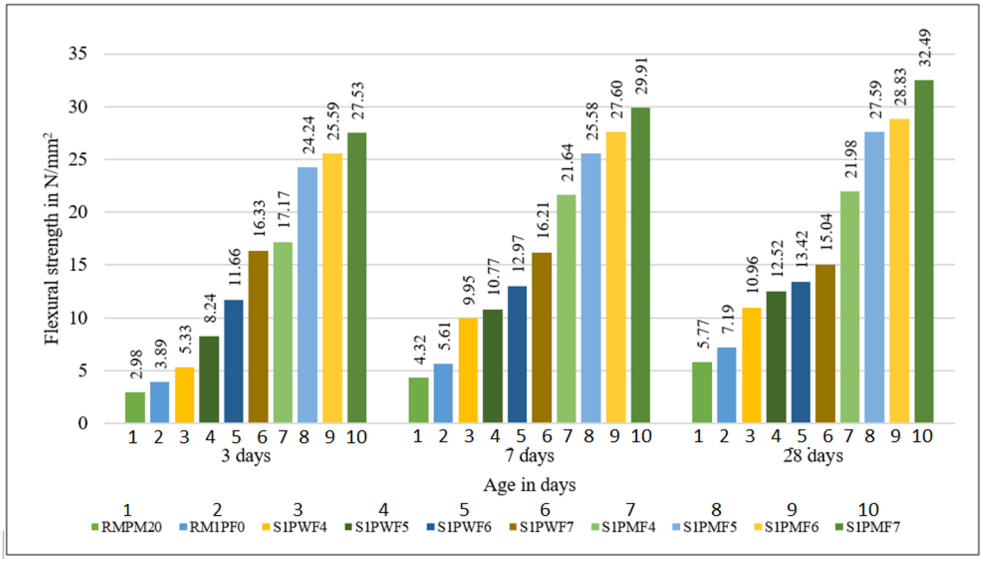


Fig. 8. Comparison of Flexural strength of SIFCON and reference mixes.

From Table 9 and Fig. 8, it is observed that the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% commercial steel fibers at 3 days is 17.17 N/mm², 24.24 N/mm², 25.59 N/mm², and 27.53 N/mm² respectively. Similarly, the average flexural strength of SIFCON with the same fiber percentages at 7 days is 21.64 N/mm², 25.58 N/mm², 27.60 N/mm², and 29.91 N/mm² respectively. Furthermore, at 28 days, the average flexural strength of SIFCON with 4%, 5%, 6%, and 7% commercial steel fibers is 21.98 N/mm², 27.59 N/mm², 28.83 N/mm², and 32.49 N/mm² respectively.

The results indicate that at 3 days of age, SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers exhibits flexural strengths 476%, 714%, 759%, and 824% higher than M20 grade concrete, and 341%, 523%, 558%, and 608% higher than the SIFCON slurry matrix respectively. Similarly, at 7 days of age, SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers shows flexural strengths 401%, 492%, 539%, and 592% higher than M20 grade concrete, and 286%, 356%, 392%, and 433% higher than the SIFCON slurry matrix respectively. Furthermore, at 28 days of age, SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers demonstrates flexural strengths that are 281%, 378%, 400%, and 463% higher than M20 grade concrete, and 206%, 284%, 301%, and 352% higher than the SIFCON slurry matrix respectively. The increase in flexural strength of SIFCON produced with commercial steel fibers, compared to reference mixes, is attributed to the SIFCON slurry matrix with various percentages of fiber volume fraction.

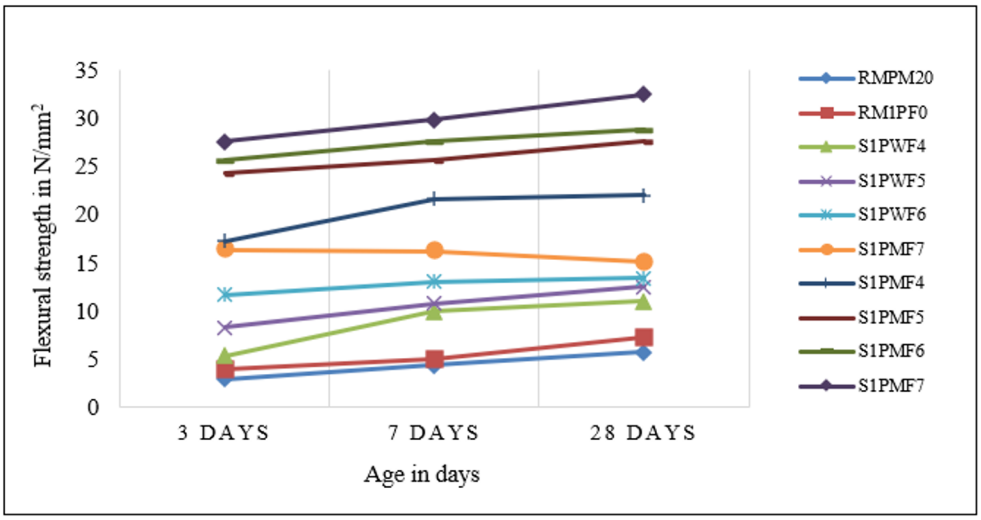


Fig. 9. Comparison of Flexural strength of SIFCON and reference mixes.

From the results, it is observed that at 3 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers exhibits flexural strengths 69%, 66%, 54%, and 41% less than SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers, respectively. Similarly, at 7 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers shows flexural strengths 54%, 58%, 53%, and 46% less than SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers, respectively. Furthermore, at 28 days of age, SIFCON produced with 4%, 5%, 6%, and 7% waste steel fibers demonstrates flexural strengths that are 50%, 55%, 53%, and 54% higher than SIFCON produced with 4%, 5%, 6%, and 7% commercial steel fibers, respectively. The increase in flexural strength of SIFCON produced with commercial steel fibers, compared to SIFCON produced with waste steel fibers, is attributed to the shape and aspect ratio of the waste steel fibers utilized in the experimental program.

6 Summary and Conclusions

The experimental work has been conducted in order to find out the flexural strengths of the SIFCON produced with waste steel fibers recovered from used tires and commercial steel fibers. Waste steel fibers recovered from used tires can be utilized in the production of Slurry Infiltrated Fibrous Concrete (SIFCON), despite their irregular shape and varying aspect ratios.

The slurry matrix used for the production of SIFCON exhibits flexural strengths that are 31%, 30%, and 25% higher than M20 grade concrete at 3, 7, and 28 days respectively. This increase in strength is attributed to the absence of coarse aggregate in the SIFCON slurry matrix and its richness in cementitious material.

It has been demonstrated that the flexural strength of SIFCON produced with 4% to 7% waste steel fibers increases by 90% to 161% compared to the M20 grade reference mix at the age of 28 days. Furthermore, it has been shown that the flexural strength of SIFCON produced with 4% to 7% waste steel fibers increases by 52% to 109% compared to the SIFCON slurry reference mix at the age of 28 days.

It has been demonstrated that the flexural strength of SIFCON produced with 4% to 7% commercial steel fibers increases by 281% to 463% compared to the M20 grade reference mix at the age of 28 days. Furthermore, it has been shown that the flexural strength of

SIFCON produced with 4% to 7% waste steel fibers increases by 206% to 352% compared to the SIFCON slurry reference mix at the age of 28 days.

It has been exhibited that the flexural strength of SIFCON produced with 4% to 7% waste steel fibers has a decrease of 50% to 54% with respect to SIFCON produced with 4% to 7% commercial steel fibers at the age of 28 days. The decrease in flexural strength of SIFCON produced with waste steel fibers, with respect to SIFCON produced with commercial steel fibers, is due to small fragments of rubber present on the surface of the waste steel fibers, their irregular shape, different aspect ratio, and fiber orientation.

From the experimental study, it can be mentioned that 6% of waste steel fibers with the two-layer technique is found optimal in producing SIFCON with waste steel fibers. The flexural strength of SIFCON produced with waste steel fibers recovered from used tires significantly increases compared to reference mixes and is comparable to SIFCON produced with commercial steel fibers. Waste steel fibers recovered from used tires can be effectively utilized up to a fiber volume fraction of 6% with a two-layer technique in the production of SIFCON.

It can be summarized that the waste steel fibers recovered from used tires exhibit significant variations in their geometrical properties, with lengths ranging from 3 to 73 mm and diameters from 0.14 to 0.47 mm. The dimensional diversity and bulk nature of the waste steel fibers have been shown not to be a concern in the production of SIFCON. There is a significant increase in the flexural strength of SIFCON produced with waste steel fibers, making it suitable for applications where there are flexural stresses that need to be handled. The cost-effectiveness of SIFCON elements with waste steel fibers is approximately 67% lower than that of SIFCON elements with commercial steel fibers. The multiple benefits confirm that the waste steel fibers recovered from used tires are an alternative reinforcement in the production of SIFCON.

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Control Strategies for Enhancing Power Quality with Unified Power Quality Conditioner in a Solar-PV Integrated Utility System

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Abstract: The electrical utility systems are well-liked as local energy systems because of their capacity to incorporate renewable energy, enhance energy effectiveness and strengthen the resilience of the power system. These benefits do, however, come with specific complications regarding control and power quality (PQ). PQ within a utility system is paramount to ensure the appropriate operation of connected devices and the well-being of the overall system. As a result, both voltage quality & current quality are significant. Control strategies in conjunction with cutting-edge power electronics devices (PED) offer a solid framework to handle PQ challenges. Hence, this paper's proposed work discusses the application of a Solar-Photovoltaic (PV) fed Unified Power Quality Conditioner (UPQC) for power quality enhancement towards the supply grid network. The Solar-PV fed UPQC enhances PQ and maximizes solar energy utilisation, leading to an eco-friendly and cost-effective solution while injecting clean, renewable energy into the grid. In this paper, the control strategies for UPQC are based primarily on the Adaptive Leaky Least Mean Square (AL_LMS) algorithm as compared with the Synchronous Reference Frame (SRF) based theory for switching of series and shunt active converters of UPQC. This AL_LMS approach extracts reference signals to switch UPQC's shunt and series voltage source converters (VSCs) by iteratively updating the weights. Thus, the control strategy applied to Solar-PV fed UPQC mitigates voltage problems like voltage sag and swell, current harmonic distortions and other PQ issues. The work is done in MATLAB/ Simulation software and simulation outcomes show the effectiveness of Solar-PV fed UPQC in improving power quality by maintaining within the IEEE-519 Standards.

Introduction

Supplying consumers with electricity in the custom of sinusoidal voltages and currents with adequate magnitudes and frequencies near the point of common coupling (PCC) is one of the Utility system's main responsibilities. System and user equipment are designed and inspected based on sinusoidal voltages and currents with standardized/rated amplitudes and frequencies (Sabin et al., 2022). Power Quality (PQ) has always been a regular issue, and with the increase in the number of electrical appliances, these issues have increased significantly over the years. PQ problems, like voltage sag, voltage swell, harmonics, and flicker, can lead to disruptions, damage to sensitive equipment, and reduced efficiency in power supply systems. In this context, the application of Power Quality Enhancement (PQE) techniques has gained significant attention to mitigate power disturbances and voltage fluctuations (Bollen, 2000). To improve the functionality and stability of electric power systems and resolve issues with power quality, numerous devices and technologies have been proposed and put into practice. Flexible AC Transmission Systems (FACTS) devices are cutting-edge technological solutions for enhancing voltage regulation, besides stable and immediate apparent controlling of active and reactive powers at the fundamental frequency. Supplementary

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methods rely on distinctive power apparatuses that provide a range of alternatives, such as both shunt and series compensation of active along with reactive power to enhance power quality, voltage control associated with performance at fundamental and harmonic frequencies w.r.t. steady-state and dynamic situations (Fuchs et al., 2023; Hingorani and Gyugyi, 2000; Watanabe et al., 2018). UPQC is regarded as a customized power device that has emerged as a promising solution in alleviating both Voltage and Current PQ issues to electrical supply systems and it can be installed at the PCC in the distribution network (Agarwal et al., 2021). Its primary objective is ensuring continuous power quality improvement by regulating voltage and mitigating various PQ issues, such as voltage sags, swells, and harmonics. It consists of two components: an active power filter in series (SeAPF) and in the shunt (ShAPF) with a common DC link. The SeAPF is responsible for compensating voltage-related conflicts, such as sags and swells, while ShAPF mitigates current-related issues, such as harmonics and reactive power demand and makes regulations of DC-link voltage (Heenkenda et al., 2021; Satish et al., 2023).

Currently, a major area of research in industry and academia is the network interaction of renewable energy sources (RES) for improved system performance (Alam et al., 2021; Bajaj and Singh, 2020; Mlilo et al., 2021). The increasing integration of RES, particularly Solar-Photovoltaic (PV) systems, into the power grid has brought numerous benefits in terms of sustainability and reduced carbon emissions. Several advantages can be realized by integrating solar-PV system with UPQC. Firstly, Solar-PV system can serve as a clean RES, reducing the inevitability of traditional fossil fuel-based electricity generation and contributing to a more sustainable electricity supply. Secondly, the PV system can provide dynamic support to the active power, enabling the UPQC to regulate voltage under different load conditions and maintain a stable power grid (Jha et al., 2023; Suresh et al., 2018). To switch the series compensator and the shunt compensator, respectively, a reference load voltage signal and source current signals must be generated via the proper control structure for UPQC. Conventional time-domain techniques like Instantaneous Symmetric Component Theory (ISCT), Synchronous-Reference-Frame (SRF or d-q-0) technique, Instantaneous-Reactive-Power (IRPT or p-q) Theory have been utilized in several studies (Diab et al., 2021; Venkata and Reddy, 2023). The performance of these classical algorithms formed on p-q and d-q-0 theories is unsatisfactory when the load is unbalanced due to the low pass filters' insignificant performance. Several frequency domain methods are realized by means of Wavelet Transform and the Fast Fourier method, but these approaches consume more memory, elasticities, slower response, and require additional computational efficacy (Chawda et al., 2020; Martinez et al., 2022). A modified generalized second-order integrator-based control system is used to remove DC Offset current from the load (Chandrakala Devi et al., 2020). Soft Computing Techniques based control schemes (e.g., Neural Networks) are likewise used to distinguish and categorize power quality issues (Khetarpal et al., 2020; Sudheer et al., 2022; Venkata and Reddy, 2023).

In order to regulate a 3-Φ DSTATCOM providing harmonic and reactive power compensation for linear and nonlinear loads, research (Patel et al., 2019) affords an optimum step size Least Mean Square (LMS) algorithm. This algorithm adaptively calculates the step factor conditioned to calculate the active and reactive weights, establishes reference currents, and sets the VSC trigger pulses. In (Devena et al., 2023) study, a Variable Leaky Least Mean Square (VLLMS) control is used with an adaptive shunt active filter. By using the suggested method, a non-linear load's harmonic content, power quality, power losses, and power factor can all be improved. To lower THD in the Solar-PV system, study (Alhafadhi et al., 2022) suggests a strategy focusing on the Leaky LMS adaptive filter algorithm. The suggested filter significantly lowers the input's signal harmonic content and delivers to the load.

This paper is structured as follows: The main system architecture is discussed in Section-II. The procedure of the control mechanism is elucidated in Section-III. Section-IV suggests controlling examination and explanations of MATLAB/Simulink results for non-linear load conditions and Section-V states the conclusions of the paper.

Proposed System Model

Figure 1 depicts the schematic representation of a proposed system model comprising of Solar-PV fed UPQC in a grid-connected mode. A coupled inductor (L_{se}) and a 3-Φ series injection transformer (T_{se}) are used to link the series VSC component of UPQC in series with the distribution grid. The Shunt VSC component has joined in parallel to the load point over the interface inductor (L_{sh}) and a capacitor (C_{dc}) links amongst the two compensators. To cut out the high-frequency constituent of voltage as a result of switching of VSCs, Ripple filters (L_r & C_r) are used. A reverse blocking diode across the DC-link capacitor links a Solar-PV module.

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A Non-Linear (R-L) load is connected to the circuit using the 3-Φ diode bridge rectifier.

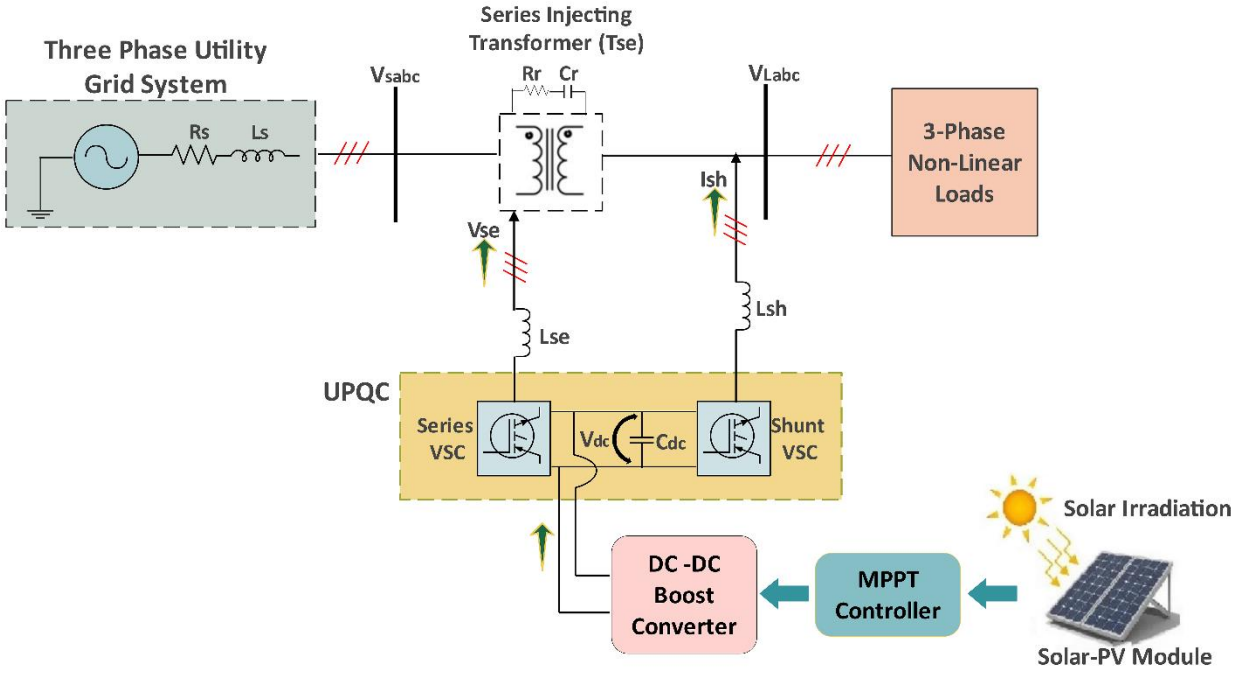


Figure 1. Illustration of a proposed Solar-PV fed UPQC system model

UPQC Control Methodologies

In the proposed Solar-PV fed UPQC integrated into the grid system, the main objective is meant to address the PQ challenges brought on by the 3-Φ non-linear load. Here, Shunt VSC is ensured by reducing the harmonics in the network source current and retaining DC-link voltage significantly. Additionally, it helps PCC meet its demand for reactive power. The load voltage's harmonics, Voltage sag and swell are all reduced through the series VSC. In this paper, in order to conjecture the reference signals meant to directive together shunt and series VSCs of UPQC, controlled approaches based on the SRF theory and the proposed AL_LMS algorithm are discussed to estimate the reference voltage and current for operating both series and shunt compensators. The proposed method gives a superior condition than the conventional SRF theory as the adaptive leakage parameter feature of the AL_LMS method offers higher performance in both steady-state and dynamic circumstances without the drift of weighted parameters exceeding the limits. So, the Solar-PV fed UPQC's performance is enhanced by fast and more precise estimate of the reference signals used for switching the VSCs.

Conventional SRF technique

The Synchronous Reference Frame (SRF) technique is often referred to as direct-quadrature-zero (or d-q-0) axis theory (Ahmad et al., 2020). This transformation results in the combination of Clarke's and Park's transformations. At first, voltages and currents in "a-b-c coordinates" are transfigured into "α-β-0 coordinates" by Clarke's transformant. Again, these are changed from "α-β-0 coordinates" to rotating "d-q-0 coordinates" through Park's transform in the process. In this case, 'θ = ωt' denotes the angle through which d-q-0 frame rotates. The source voltage is considered when calculating this 'θ = ωt' and Phase Locked Loop (PLL) method (Hoon et al., 2019) is employed to this aspect.

SRF Control Scheme for Shunt VSC

The Figure 2 shows the d-q-0 Control Strategy for shunt VSC and reference signals to estimate are described as below. Firstly, Source's Currents (I_{sa}, I_{sb}, I_{sc}) & Voltages (V_{sa}, V_{sb}, V_{sc}), Load Currents (I_{La}, I_{Lb}, I_{Lc}) and DC-link voltage (V_{dc}) are detected. The load currents being then transfigured from "a-b-c coordinates" to "d-q-0 frame" using the below equation 1.

$$\begin{bmatrix} I_d \\ I_q \\ I_0 \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos\theta & -\sin\theta & \frac{1}{2} \\ \cos(\theta - \frac{2\Pi}{3}) & -\sin(\theta - \frac{2\Pi}{3}) & \frac{1}{2} \\ \cos(\theta + \frac{2\Pi}{3}) & \sin(\theta - \frac{2\Pi}{3}) & \frac{1}{2} \end{bmatrix}\begin{bmatrix} I_{La} \\ I_{Lb} \\ I_{Lc} \end{bmatrix} \ldots\ldots (1)$$

The components 'Id and Iq' are processed via a filter to obtain constant DC-components. The current signal Iddc is paired with the loss component produced by the tuned dc link error signal to obtain the direct axis reference current (Idref) as given in equations 2 and 3.

$$I_{l(t+1)} = I_{lt} + k_{pd}(V_{dc(t+1)} - V_{dc(t)}) + k_{id}V_{dc(t)} \ldots\ldots (2)$$

and

$$I_d^* = I_l + I_{ddc} \ldots\ldots (3)$$

Similarly, the current Iqdc is paired to tune supply voltage error signal for getting quadrature reference current (I_{qref}) as given by equation 4.

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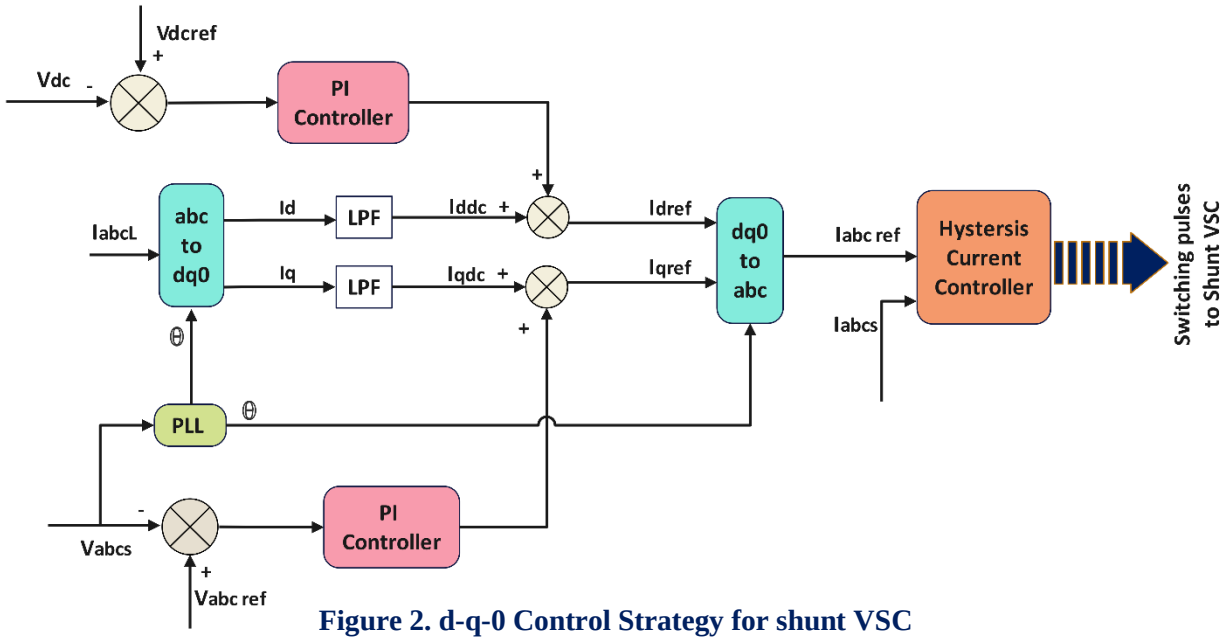


Figure 2. d-q-0 Control Strategy for shunt VSC

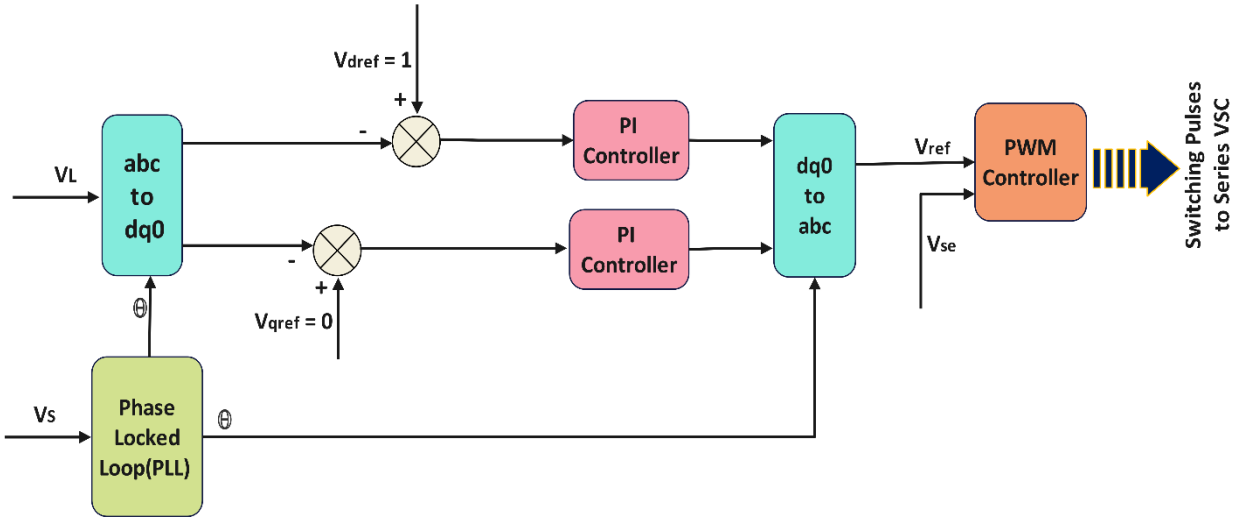


Figure 3. d-q-0 Control Strategy for Series VSC

$$I_{qr(t+1)} = I_{qr(t)} + k_{pq}(V_{t(t+1)} - V_{t(t)}) + k_{id}V_{t(t)} \text{.....(4)}$$

These reference currents (I_{dref} and I_{qref}) are transfigured back to "a-b-c reference" coordinates using the Inverse Park's transformant, through which the final reference currents can be obtained and as given by equation 5.

$$i_q^* = i_{qr} + i_{qdc} \text{ ……..(5)}$$

By means of Hysteresis Current Controller (HCC) controller (Pengaluru Suresh et al., 2019), Switching Gate pulses are formed using the variance among the reference currents and actual source currents. With these Gate pulses, at PCC point, the ShAPF inoculates the currents for suppressing the harmonics within the current in addition to paying off the reactive power demand.

Control Scheme for Series VSC

The Figure 3 illustrate the "d-q-0" control strategy for Series VSC and reference signals to estimate are described as below. At first, source voltages are transformed into synchronous "d-q-0 reference" frame with the equation 6.

$$V_s^{dq0} = \frac{2}{3}\begin{bmatrix} \cos\theta & -\sin\theta & \frac{1}{2} \\ \cos(\theta - \frac{2\Pi}{3}) & -\sin(\theta - \frac{2\Pi}{3}) & \frac{1}{2} \\ \cos(\theta + \frac{2\Pi}{3}) & \sin(\theta - \frac{2\Pi}{3}) & \frac{1}{2} \end{bmatrix} * V_s^{abc}$$

$$= V_{sp} + V_{sn} + V_{s0} + V_{sh} \text{ ……..…….. (6)}$$

Where V_{sp}, V_{sn}, V_{s0}, and V_{sh} are positive, negative, zero sequences and harmonic components respectively.

The primary aim is in obtaining sinusoidal voltages, accordingly "d-q-0 reference" frame of load voltage is given by the equation 7 below.

$$V_L^{dq0} = V_s^{*abc} =$$

$$\begin{bmatrix} \cos\theta & -\sin\theta & \frac{1}{2} \\ \cos(\theta - \frac{2\Pi}{3}) & -\sin(\theta - \frac{2\Pi}{3}) & \frac{1}{2} \\ \cos(\theta + \frac{2\Pi}{3}) & \sin(\theta - \frac{2\Pi}{3}) & \frac{1}{2} \end{bmatrix} \begin{bmatrix} U_m \\ 0 \\ 0 \end{bmatrix} \text{……..…. (7)}$$

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The compensating "d-q-0 reference" coordinates voltage is given by equation 8 and this voltage is transformed again back to "a-b-c reference" frame.

$$V_{dq0}^{ref} = V_s^{dq0} - V_L^{dq0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Using the Sinusoidal PWM technique (Pal et al., 2020), the switching gate pulses are produced to compensate for the load voltage disturbances.

Proposed Adaptive Leaky LMS (AL_LMS) Technique

In a customized filtering application, a modified conventional LMS method called as the Adaptive Leaky LMS (AL_LMS) algorithm is employed. In this context of adaptive filtering, the determination is to find an optimal set of filter coefficients (weights) that minimizes the eeriness amongst the desired output and the filter's output. Here, in the applied AL_LMS algorithm, a leakage factor is introduced to regulate the rate at which the filter coefficients are updated, thus achieving a trade-off between tracking speed and stability. The mathematical equation correlated to AL_LMS and its estimator (Ray et al., 2022; Bag, A. et al., 2020) are described by below equations 9 and 10.

$$W(t+1) = [1 - \mu\,\lambda(t)] * W(t) + \mu E(t) * X(t) \ldots. (9)$$

$$\text{and } Y(t) = W^T(t) * X(t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where

X(t): Input vector at time step 't'

W(t): Weight vector of filter coefficients at the time step 't'

μ: Step-size or learning rate, controlling the adaption rate

λ(t): The leakage factor, which can vary at each time step 't' based on system conditions

E(t): The instantaneous error signal at time step 't', defined as desired output 'D(t)' minus predicted output 'Y(t)' i.e.

$$E(t) = D(t) - Y(t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

The cost function $F_c(t)$ is specified by

$$F_c(t) = E^2(t) + [\lambda(t) * W^T(t) * W(t)] \quad \ldots\ldots\ldots (12)$$

And updating of weights are accomplished such that it attains a minimal value. The weight update expressions are obtained thru the equations 13 – 16.

$$W(t+1) = W(t)[1 - 2\mu(t) * \lambda(t)] + [2\mu(t) * E(t) * X(t)] (13)$$

$$\lambda(t+1) = \lambda(t) - [2\mu(t) * \rho * E(t) * X^T(t) * W(t-1)] \ldots (14)$$

$$\mu(t+1) = [\alpha * \mu(t)] + [\lambda(t) * R^2(t)] \quad \ldots\ldots\ldots\ldots\ldots (15)$$

$$R(t) = [\beta * R(t-1)] + [(1-\beta) * E(t) * E(t-1)] . (16)$$

Here, **R(t):** Autocorrelation between E(t) & E(t-1)

β : Exponential weighing parameter used to control averaged estimated time so that $0 < \beta < 1$

α and ρ : Time convergence control constraints such that $0 < \alpha < 1$ and $\rho > 0$.

Here, in this research of Solar-PV fed UPQC, The UPQC can be controlled adaptively by using the AL_LMS algorithm to produce appropriate reference signals for operating the device. The main objective is to ensure that UPQC effectively compensates for power quality issues by adaptively adjusting the control signals based on the real-time measurement of the electrical parameters. This algorithm computes the variance amongst the desired (ideal) values and the measured values of these parameters such that the difference indicates the power quality error and is used to adaptively adjust the reference signals provided to the UPQC to minimize the error. The algorithm updates the reference signals based on the error signal and a learning rate (μ), which determines the adaptation rate. The adapted reference signals generated by the algorithm are used to control the UPQC's operations. This comprises generating appropriate compensation signals to correct the power quality problems. The process continues in a feedback loop, with the UPQC continuously adjusting its control signals based on the changing electrical conditions in the system.

Proposed Control for Shunt VSC

The proposed controller representation of shunt VSC is illustrated in Figure 4. The strategy aims to produce a balanced sinusoidal source current while controlling DC-link voltage. The first step is to sense the instantaneous phase voltages (v_{sa}, v_{sb} and v_{sc}) at PCC for all the phases. Following that, the phase voltages are applied to compute the PCC voltage's phase amplitude (Vsp) as follows:

$$V_{sp} = \sqrt{\frac{2}{3}(v_{sa}^2 + v_{sb}^2 + v_{sc}^2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

The source voltage's in-phase unit templates are defined with the formula as

$$v_{pa} = \frac{v_{sa}}{V_{sp}}; \quad v_{pb} = \frac{v_{sb}}{V_{sp}}; \quad v_{pc} = \frac{v_{sc}}{V_{sp}} \ldots\ldots\ldots\ldots\ldots (18)$$

By means of in-phase unit templates, the voltage quadrature unit templates are calculated as follows:

$$v_{qa} = \frac{-v_{pb}+v_{pc}}{\sqrt{3}}; \; v_{qb} = \frac{\sqrt{3}}{2}v_{pa} + \frac{1}{2\sqrt{3}}(v_{pb} - v_{pc});$$

$$v_{qc} = -\frac{\sqrt{3}}{2}v_{pa} + \frac{1}{2\sqrt{3}}(v_{pb} - v_{pc}) \ldots\ldots\ldots\ldots\ldots (19)$$

W.r.t the control technique, the grid, and the PV array supply the load active power requirement. The grid also affords the UPQC's internal losses by keeping the constant voltage over DC-link. The predicted DC-link voltage (V_{dcref}) given by MPPT of Solar-PV output is correlated to the measured DC-link capacitor voltage (V_{dc}), and then an error signal (E_{dc}) is attained, which is given for PI controller so as to minimize the error. Thus, the required loss component (W_{loss}) is obtained and expressed by equations (20) and (21).

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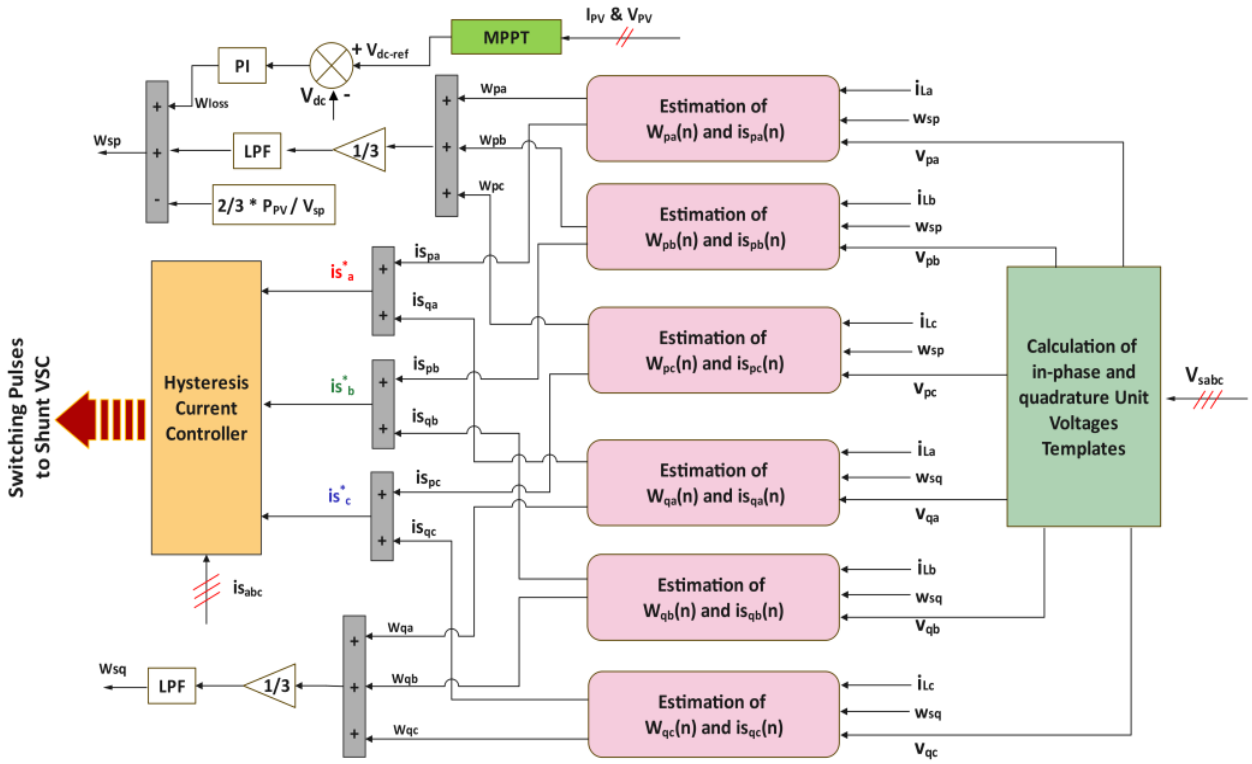


Figure 4. Proposed schematic control diagram of shunt VSC

$$E_{dc}(t) = V_{dcref}(t) + V_{dc}(t) \quad \text{..... (20)}$$

$$W_{loss}(t+1) = W_{loss}(t) + K_p * [E_{dc}(t+1) - E_{dc}(t)] + K_i * E_{dc}(t+1) \quad \text{..... (21)}$$

The fraction of active current supplied by Solar-PV array (W_{PV}) is specified by:

$$W_{pv} = \frac{2}{3} * \frac{P_{PV}}{V_{sp}} \quad \text{..... (22)}$$

Now, the fundamental constituent of phase 'a' active load current can be determined with help of basic weight update expressions given in (13), (14), (15) and (16) as follows:

$$W_{pa}(t+1) = W_{pa}(t)\left[1 - 2\mu_{pa}(t) * \lambda_{pa}(t)\right] + [2\mu_{pa}(t) * E_{pa}(t) * v_{pa}(t)] \quad \text{..... (23)}$$

$$\lambda_{pa}(t+1) = \lambda_{pa}(t) - [2\mu_{pa}(t) * \rho * E_{pa}(t) * v_{pa}(t) * W_{pa}(t-1)] \quad \text{..... (24)}$$

$$\mu_{pa}(t+1) = \left[\alpha * \mu_{pa}(t)\right] + [\lambda_{pa}(t) * R^2_{pa}(t)] \quad \text{..... (25)}$$

$$R_{pa}(t) = \left[\beta * R_{pa}(t-1)\right] + [(1-\beta) * E_{pa}(t) * E_{pa}(t-1)] \quad \text{..... (26)}$$

And the predicted error will be now as

$$E_{pa}(t) = i_{La}(t) - v_{pa}(t) * W_{pa}(t) \quad \text{..... (27)}$$

Where i_{La} is load current of phase 'a'. In a similar way, at any time instant, weights of active components (W_{pb} and W_{pc}), leakage factors (λ_{pb} and λ_{pc}), step size (μ_{pb} and μ_{pc}), error autocorrelation (R_{pb}, R_{pc}) and predicted error (E_{pb}, E_{pc}) can be updated similarly to the phases 'b' and 'c' for the shunt VSC. Hence, weighted average of the fundamental active component (W_{pave}) is specified as:

$$W_{pave} = \frac{W_{pa}(t) + W_{pb}(t) + W_{pc}(t)}{3} \quad \text{..... (28)}$$

From (22), (23) and (28), the reference grid current's total weight of active component (W_{sp}) and active components of reference grid current (i_{spa}, i_{spb} and i_{spc}) are computed as

$$W_{sp} = W_{pave} + W_{loss} - W_{PV} \quad \text{..... (29)}$$

$$i_{spa} = W_{sp} * v_{pa};\ i_{spb} = W_{sp} * v_{pb};\ i_{spc} = W_{sp} * v_{pc} \quad \text{..... (30)}$$

In the same way, load current's reactive components are obtained by having quadrature unit vector voltage templates and corresponding updated weights related towards reactive current components and are expressed as

$$i_{sqa} = W_{sq} * v_{qa};\ i_{sqb} = W_{sq} * v_{qb};\ i_{sqc} = W_{sq} * v_{qc} \quad \text{..... (31)}$$

Here, weight average of fundamental reactive components are equal to the weight of total reactive components (W_{sq}). Thus, the extracted resulting reference source currents are attained by summing up the components in (30) and (31) obtained above.

$$i^*_{sa} = i_{spa} + i_{sqa};\ i^*_{sb} = i_{spb} + i_{sqb};\ i^*_{sc} = i_{spc} + i_{sqc} \quad \text{..... (32)}$$

Henceforth, comparing the resultant reference (i^*_{sa}, i^*_{sb} and i^*_{sc}) and measured (i_{sa}, i_{sb} and i_{sc}) network source currents and also the attained erroneous signals are enumerated toward the Hysteresis Current Controller (HCC) in engendering the estimated switched signals meant for shunt VSC.

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Proposed Control for Series VSC

The representation of schematic control for series compensator is shown in Figure 5. The control objective is in obtaining the nominal magnitude and pure sinusoidal load voltages. The reference load voltages are evaluated using the proposed AL_LMS algorithm as described below. The 3-Φ load currents (i_{La}, i_{Lb} and i_{Lc}) are sensed for calculating the magnitude (I_{Lp}) and the load current unit templates are given by equations 33 and 34 respectively.

$$I_{Lp} = \sqrt{\frac{2}{3}(i_{La}^2 + i_{Lb}^2 + i_{Lc}^2)} \quad \ldots\ldots (33)$$

$$u_{pa} = \frac{i_{La}}{I_{Lp}};\ u_{pb} = \frac{i_{Lb}}{I_{Lp}};\ u_{pc} = \frac{i_{Lc}}{I_{Lp}} \quad \ldots\ldots (34)$$

These in-phase unit templates are used in computing the quadrature current unit templates and are given as

$$u_{qa} = \frac{-u_{pb}+u_{pc}}{\sqrt{3}};\ u_{qb} = \frac{\sqrt{3}*u_{pa}}{2} + \frac{1}{2\sqrt{3}}(u_{pb} - u_{pc});$$

$$u_{qc} = -\frac{\sqrt{3}*u_{pa}}{2} + \frac{1}{2\sqrt{3}}(u_{pb} - u_{pc}) \quad \ldots\ldots (35)$$

$$R_{vpa}(t) = [\beta * R_{vpa}(t-1)] + [(1-\beta) * E_{vpa}(t) * E_{vpa}(t-1) \quad \ldots\ldots (39)$$

And error predicted will be obtained as

$$E_{vpa}(t) = V_{sa}(t) - u_{pa}(t) * W_{vqa}(t) \quad \ldots\ldots (40)$$

where, V_{sa} is the source voltage of phase 'a'. Likewise, at any instantaneous, in-phase weights component (W_{vpb} and W_{vpc}), leakage factors (λ_{vpb} and λ_{vpc}), step size (μ_{vpb} and μ_{vpc}), error auto correlation (R_{vpb} and R_{vpc}) and error prediction (E_{vpb} and E_{vpc}) can be similarly updated in the phases 'b' and 'c' of series VSC. The in-phase component weighted average (W_{vpave}) is calculated as:

$$W_{vpave} = \frac{W_{vpa}(t) + W_{vpb}(t) + W_{vpc}(t)}{3} = W_{Lp} \quad \ldots\ldots (41)$$

The components of in-phase reference load voltage are measured as:

$$V_{Lpa} = W_{Lp} * u_{pa};\ V_{Lpb} = W_{Lp} * u_{pb};\ V_{Lpc} = W_{Lp} * u_{pc} \quad \ldots\ldots (42)$$

In the same way, the load voltage's quadrature component weights (W_{vqa}, W_{vqb} and W_{vqc}) using proposed

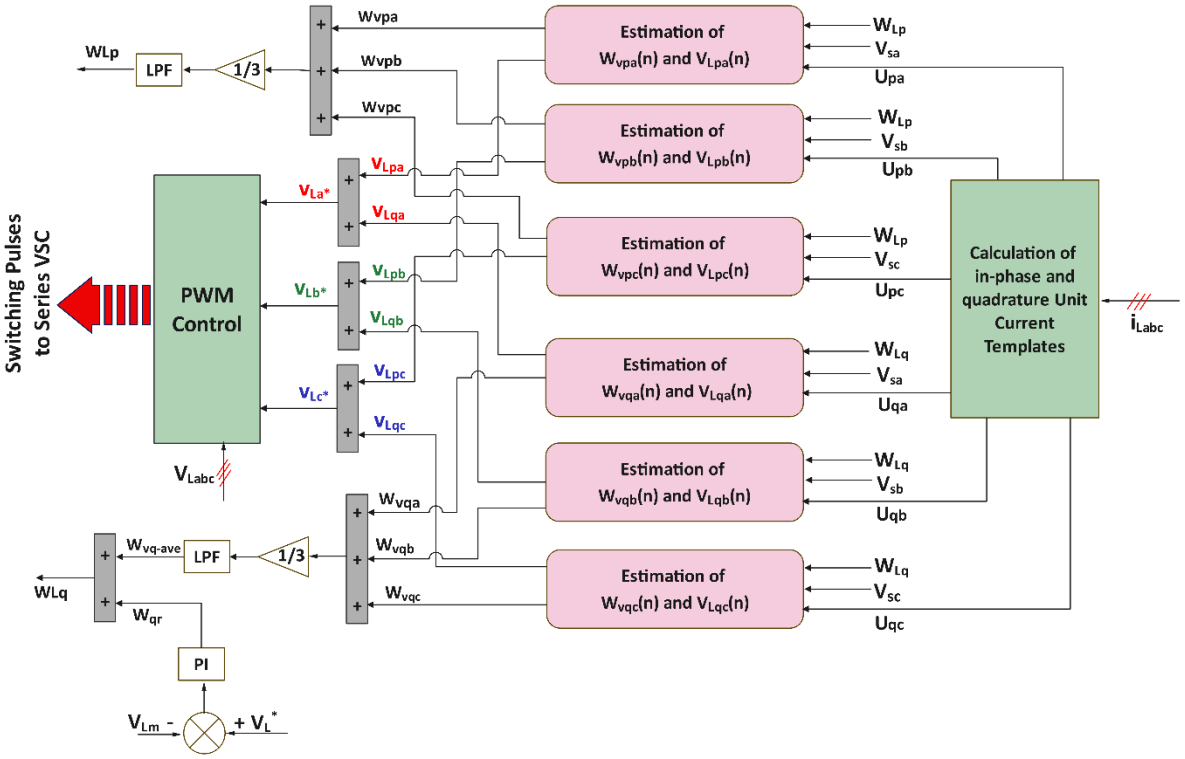


Figure 5. Schematic control representation for Series VSC

Now, load voltage weighted in-phase component (W_{vpa}) of phase 'a' is computed by means of basic weighted updated expressions given in (13), (14), (15) and (16) as follows

$$W_{vpa}(t+1) = W_{vpa}(t)[1 - 2\mu_{vpa}(t) * \lambda_{vpa}(t)] + [2\mu_{vpa}(t) * E_{vpa}(t) * u_{pa}(t)] \quad \ldots\ldots (36)$$

$$\lambda_{vpa}(t+1) = \lambda_{vpa}(t) - [2\mu_{vpa}(t) * \rho * E_{vpa}(t)] * [u_{pa}(t) * W_{vpa}(t-1)] \quad \ldots\ldots (37)$$

$$\mu_{vpa}(t+1) = [\alpha * \mu_{vpa}(t)] + [\lambda_{vpa}(t) * R_{vpa}^2(t) \quad \ldots\ldots (38)$$

AL_LMS algorithm are attained. Then, the reactive component weighted average is given by

$$W_{vqave} = \frac{W_{vqa}(t) + W_{vqb}(t) + W_{vqc}(t)}{3} \quad \ldots\ldots (43)$$

Now, a loss component (W_{qr}) is taken here into account for the regulation of the load voltage and stated as

$$W_{qr}(t+1) = W_{qr}(t) + K_{pq} * [E_{ac}(t+1) - E_{ac}(t)] + K_{iq} * E_{dc}(t+1) \quad \ldots\ldots (44)$$

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By comparison of the magnitudes of measured load voltages (V_{La}, V_{Lb} and V_{Lc}) and rated load voltage (V^*_L), produces an error signal and it is been fed to a PI controller for keeping load voltage's magnitude at desired value as given by the below equations

$$V_{Lm} = \sqrt{\frac{2}{3}(V_{La}^2 + V_{Lb}^2 + V_{Lc}^2)} \quad \ldots\ldots (45)$$

And $$E_{ac}(n) = V_L^*(n) - V_{Lm}(n) \quad \ldots\ldots (46)$$

The over-all quadrature component weight (W_{Lq}) of reference load's voltage is expressed as

$$W_{Lq} = W_{vqave} + W_{qr} \quad \ldots\ldots (47)$$

The over-all quadrature component of reference load's voltage is specified by the equation below

$$V_{Lqa} = W_{Lq} * u_{qa};\ V_{Lqb} = W_{Lq} * u_{qb};\ V_{Lqc} = W_{Lq} * u_{qc} \quad \ldots\ldots (48)$$

Thus, the considerable reference load voltages for all the three phases are given as

$$V^*_{La} = V_{Lpa} + V_{Lqa};\ V^*_{Lb} = V_{Lpb} + V_{Lqb};\ V^*_{Lc} = V_{Lpc} + V_{Lqc} \quad \ldots\ldots (49)$$

At last, by comparing the reference and measured load voltages, the variance is fed to a PWM generator to produce switching pulses to the series VSC. Hence, the operation of UPQC is done for the PQ enhancement.

Simulation Results and Discussions

The suggested Solar-PV fed UPQC configuration is modelled in the MATLAB/Simulink platform as shown in below Figure 6, and is then simulated for examining the performance analysis of Non-linear load condition, Voltage Sag and Swell situations using the conventional SRF theory and proposed AL_LMS algorithm. The parameters of the described system are tabulated below.

Table 1. Parameters used for Simulating the Proposed System

Parameters	Value
Supply Voltage (V_s)	415 V (L-L)
Coupling inductors (L_{se} and L_{sh})	1.5mH
DC-link capacitor (C_{dc})	8000 µF
DC-link Voltage (V_{dc})	700 V
Gains of Shunt VSC (Kp and Ki)	2 and 0.1
Gains of Series VSC (Kp and Ki)	4 and 800
Solar-PV voltage and current at MPP	700V, 60A
Non-linear load	15 KW, 7.2 KVA

Series VSC's Performance Analysis for Voltage Sag and Swell Conditions

Using Conventional SRF theory

The performance of the series component of UPQC using conventional SRF theory for voltage sag and swell conditions is shown Figure 7 below. At t=0.1Sec, a 0.5 P.U. voltage sag and on t=0.3Sec, a 1.2 P.U voltage swell has created and has been mitigated by series VSC of UPQC, resulting in rated load voltage.

From the Figure 7, it is shown that the voltage sag and swell are mitigated by UPQC using the conventional SRF theory. The %THD of load voltage using conventional SRF theory applied to UPQC is obtained as 4.8% as depicted in Figure 8. Further, it is investigated with proposed method for better enhancement of power quality as described below.

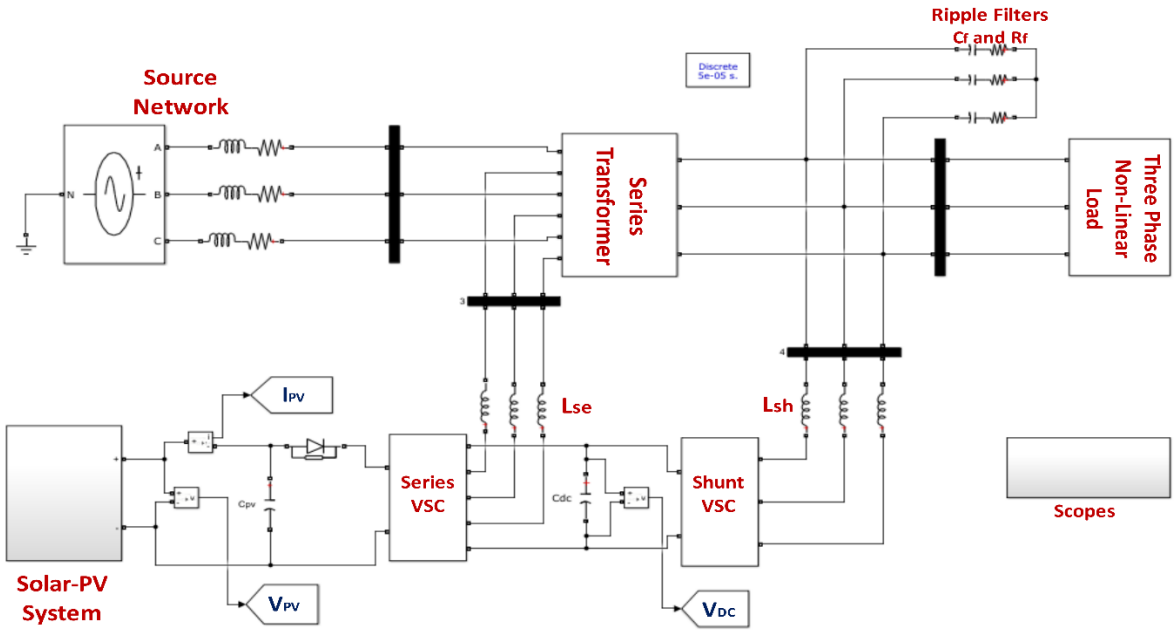


Figure 6. Simulation diagram of proposed Solar-PV fed UPQC system

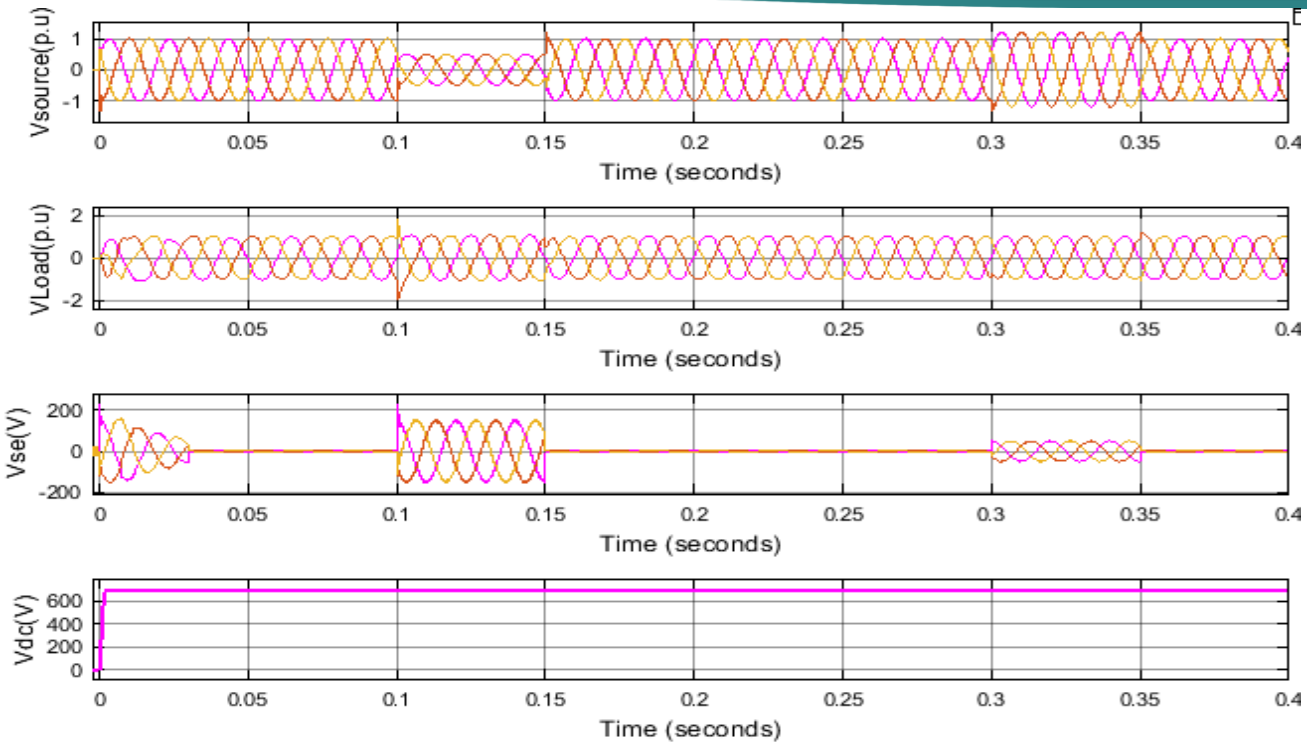


Figure 7. Compensation of Voltage Sag and Swell conditions by UPQC-SRF theory

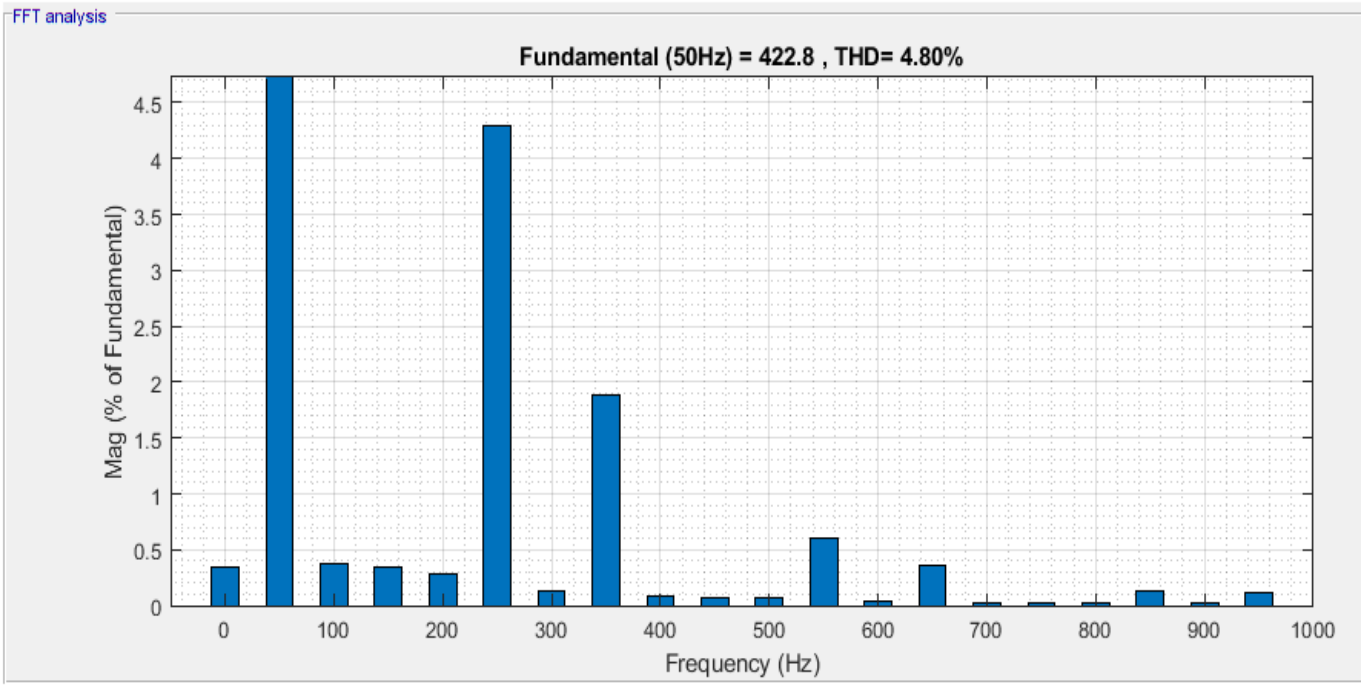


Figure 8. %THD of Load voltage by conventional SRF theory

Using proposed AL_LMS Algorithm

The performance of the series component of UPQC using the proposed AL_LMS algorithm for voltage sag and swell conditions is depicted in the graph below. At t=0.1Sec, a 0.5 P.U. sag and at t=0.3Sec, a 1.2 P.U swell has created which can be mitigated by series VSC of UPQC and results rated load voltage.

Figure 9 shows that the proposed AL_LMS algorithm better compensates voltage sag and swells with improved performance of %THD. The obtained %THD of the load voltage is 2.41% as compared to the conventional SRF theory of 4.80% as depicted in Figure 10.

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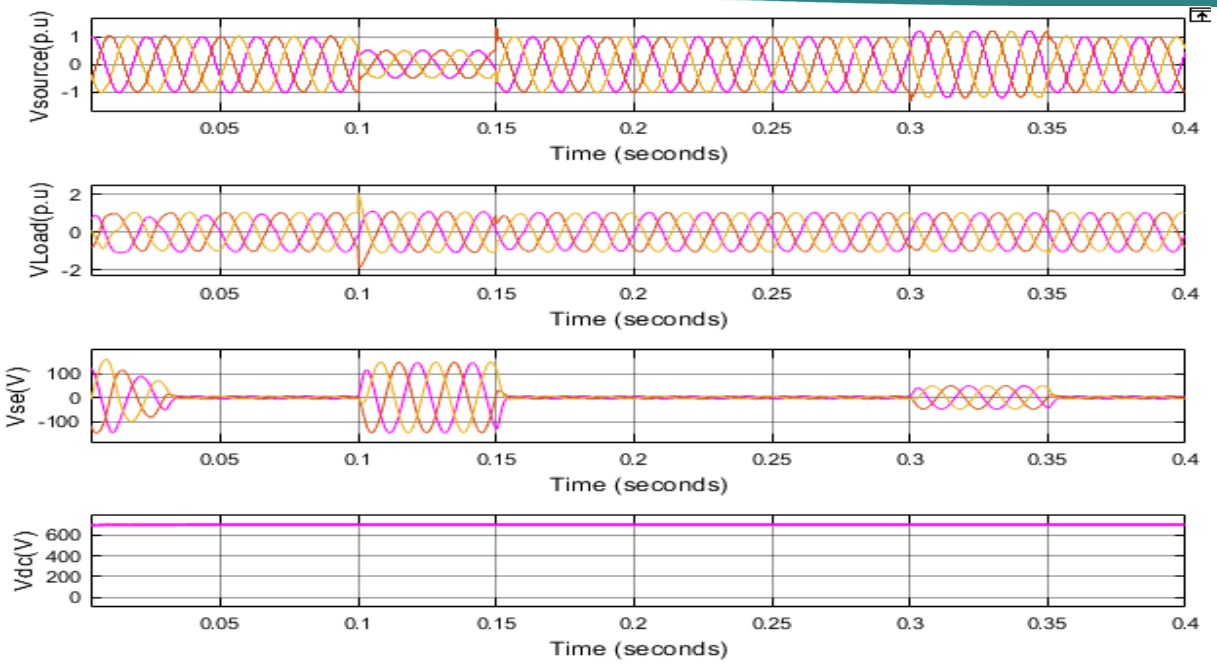


Figure 9. Compensation of Voltage Sag and Swell by proposed AL_LMS algorithm

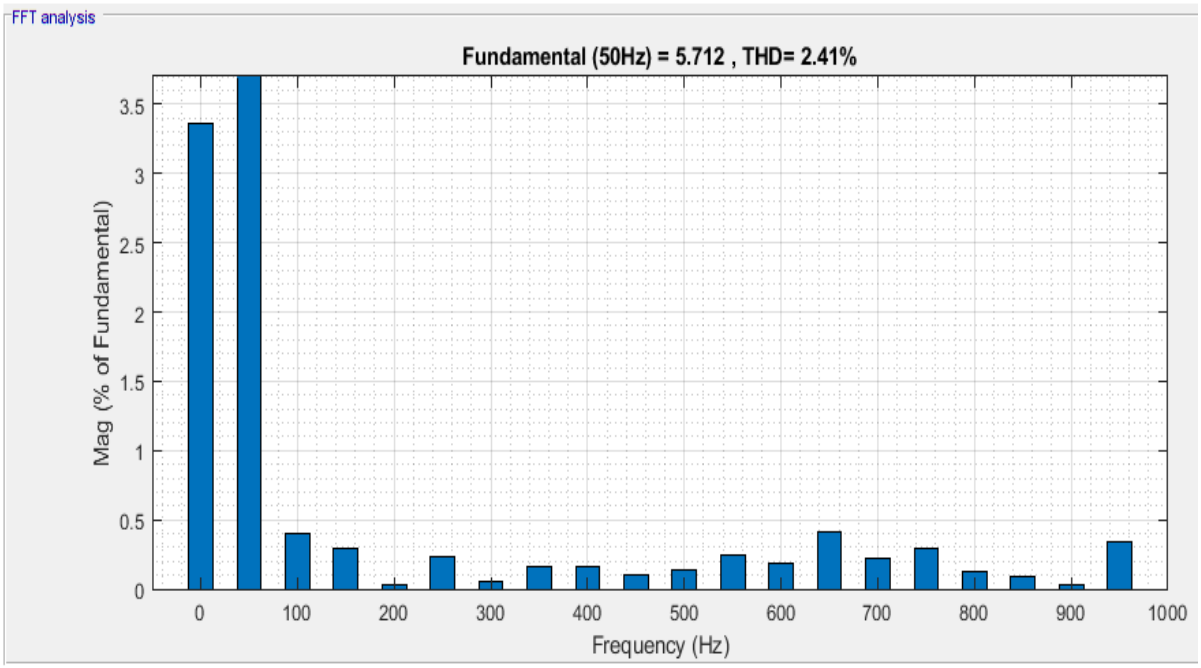


Figure 10. THD of Load Voltage with proposed AL_LMS algorithm.

Performance Analysis of Shunt VSC for Non-linear load condition

Using Conventional SRF theory

From the Figure 11, it can be observed that before t=0.04Sec, the harmonics due to non-linear load are reflected into the network source current. At t=0.04Sec, UPQC has been associated to the network. The shunt VSC of UPQC compensates the non-linearities injected into the network source current, resulting in a sinusoidal grid current.

The performance of shunt VSC for non-linear load conditions is depicted in the Figure 11 and 12 below. Using conventional SRF theory, the shunt VSC of UPQC compensates the non-linearities present in the network source current and is made sinusoidal, as depicted in a Figure 11. The Figure 12 shows %THD of source current obtained is 4.82% using conventional SRF theory. Also, W.r.t the control technique, the grid, and the PV array supply the load active power requirement and keep the DC-link voltage at a significant level.

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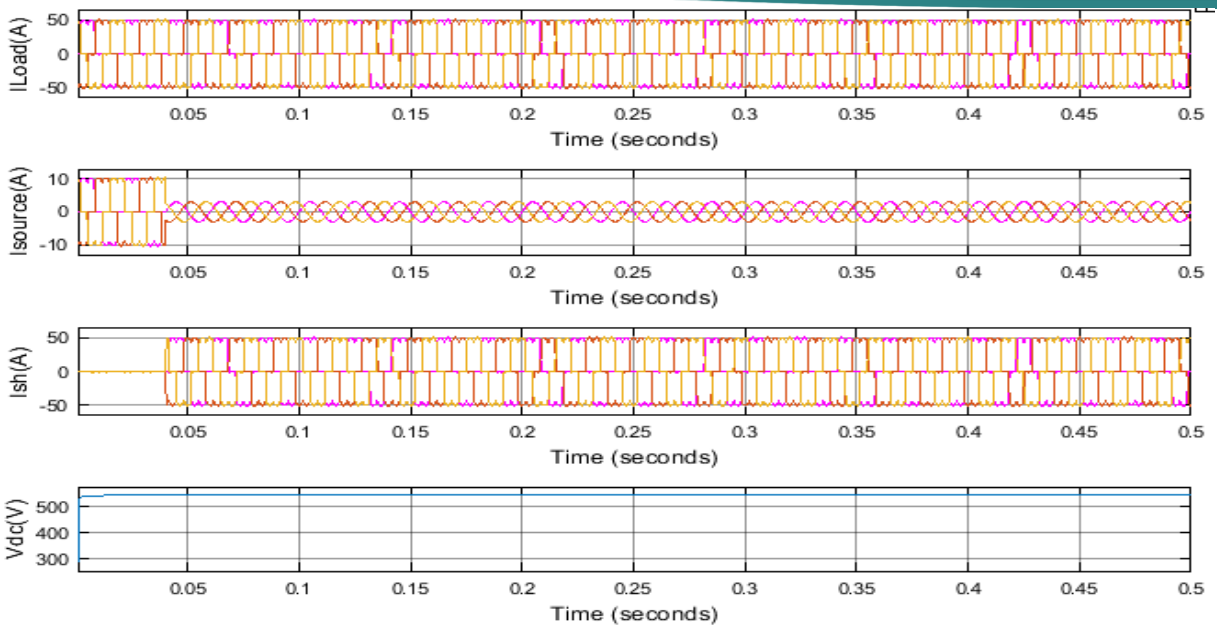


Figure 11. Performance of Shunt VSC with Non-linear load by conventional SRF theory

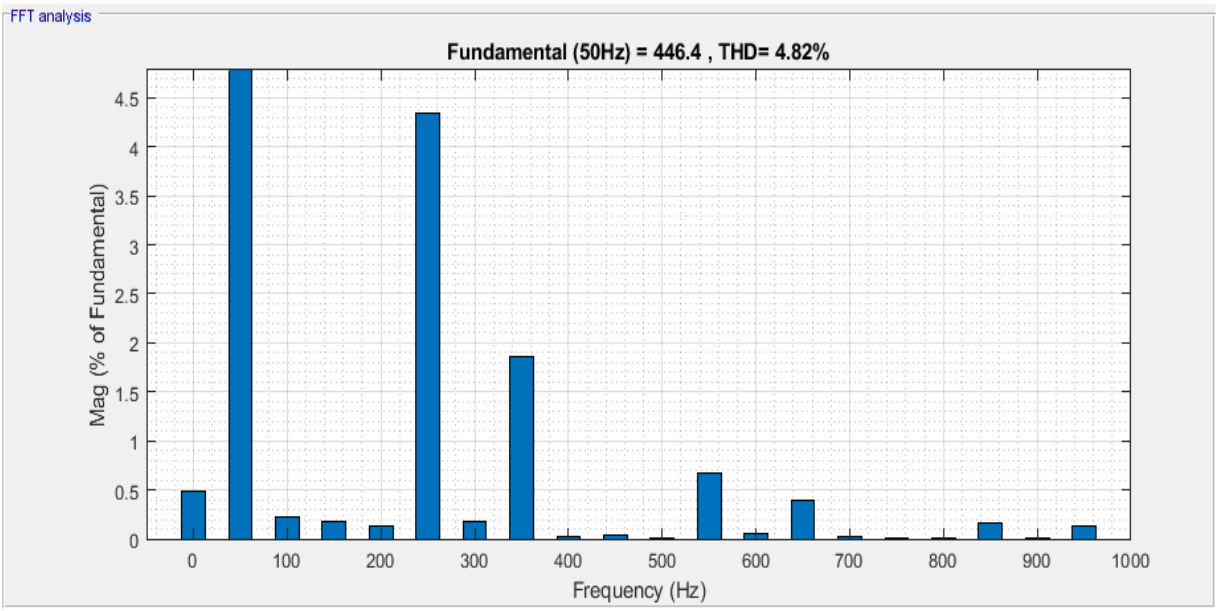


Figure 12. %THD for source current with conventional SRF theory

Using proposed AL_LMS Algorithm

Furthermore, the system is investigated for non-linear load conditions with proposed algorithm. At t=0.04Sec, the shunt VSC of UPQC compensates the non-linearities injected into the network source current, resulting in sinusoidal grid current while maintaining the constant DC-link voltage, as depicted in Figure 13.

The non-linearities in the source current and load current are further reduced by using proposed AL_LMS algorithm compared to SRF theory and %THD obtained in the source network current is 3.49% as of 4.82% in the conventional SRF theory as illustrated in Figure 13 and 14 below. Thus, it can be proved that the enhancement of power quality is superior by using the proposed AL_LMS algorithm. The outputs of control strategies of the system are featured in Table 2 below.

Table 2. %THD comparison of UPQC Control Strategies

S.No.	Parameter	Conventional SRF Theory	Proposed AL_LMS Algorithm
1	Load Voltage (Sag and Swell)	4.80%	2.41%
2	Source Current (Non-linearities)	4.82%	3.49%

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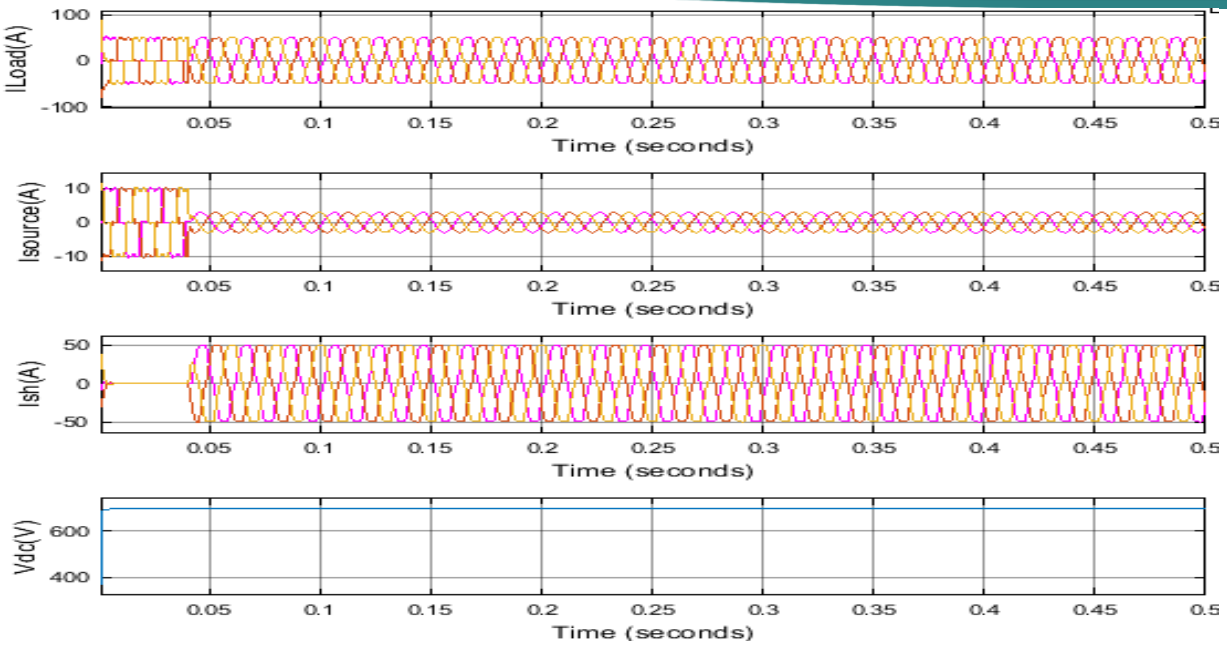


Figure 13. Performance of Shunt VSC with Non-linear load by proposed algorithm

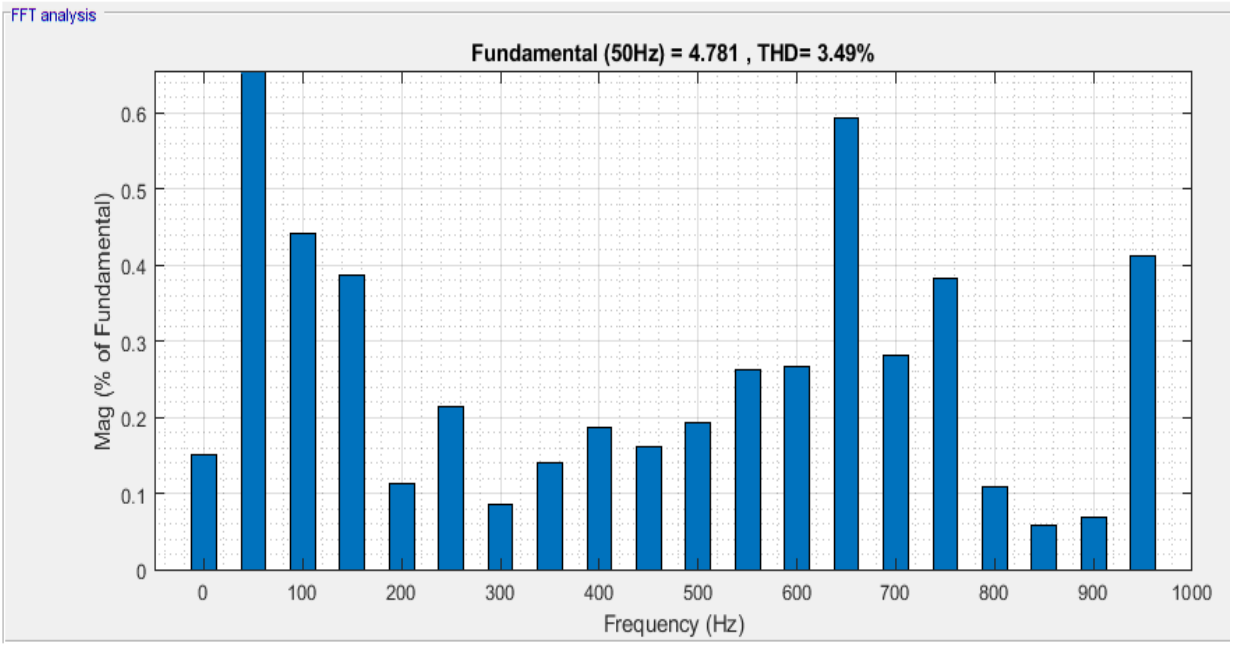


Figure 14. %THD for source current with proposed AL_LMS algorithm

Conclusion

A new control strategy based on the AL_LMS algorithm for the enrichment of the power quality with Solar-PV fed UPQC in the distributed network has been proposed in this paper. The proposed algorithm assesses the system's performance compared to the conventional SRF theory with %THD of non-linear load condition, voltage sag and swell conditions. The proposed AL_LMS algorithm has achieved better results in these conditions by generating proper reference currents to both the shunt and series VSCs of UPQC. Even in instances of voltage sag and swell situations, the load voltage is satisfactorily kept at its nominally rated voltage of 1 P.U. at a decrease in %THD of 2.41% and also source current %THD had been reduced significantly to 3.49% and made sinusoidal for non-linear load currents condition as compared to conventional SRF theory. Furthermore, the suggested strategy assists in meeting the active power requirement for loads by capturing solar-PV energy and, consequently, reducing the load burden upon the network grid.

Conflict of Interest

The authors declare no conflict of interest.

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Microgrid Power Quality Enhancement with Adaptive Control Strategies: A Literature Survey

Abstract. *Renewable energy technologies are becoming more and more common for generating electricity because they are environmentally friendly and can meet local electricity needs. They reduce network congestion and also lighten the load on conventional based power plants. Within the last few decades, grid-connected renewable energy systems have seen a rise in the significance of Power Quality issues, particularly as a result of the extensive usage of nonlinear electronics and the sporadic nature of these systems. With the emergence of power electronic converters through powerful control technology, renewable energy systems be interconnected to a large extent with the power grid or used as isolation systems in remote areas. Using additional competent control strategies can enhance not only improve the concert of these systems, but also calibre the quality of energy generated, distributed and used at the load side of Power System. Hence, this paper reviews various control strategies adopted for alleviation of power quality problems of renewable energy coordinated microgrid system and can be useful as research study for further research.*

Streszczenie. *Technologie energii odnawialnej stają się coraz bardziej powszechne w wytwarzaniu energii elektrycznej, ponieważ są przyjazne dla środowiska i mogą zaspokoić lokalne zapotrzebowanie na energię elektryczną. Zmniejszają przeciążenie sieci, a także zmniejszają obciążenie konwencjonalnych elektrowni. W ciągu ostatnich kilku dekad systemy energii odnawialnej podłączone do sieci odnotowały wzrost znaczenia kwestii jakości energii, szczególnie w wyniku szerokiego wykorzystania nieliniowej elektroniki i nieciągłego charakteru tych systemów. Wraz z pojawieniem się przetwornic energoelektronicznych dzięki zaawansowanej technologii sterowania, systemy energii odnawialnej mogą być w dużym stopniu połączone z siecią energetyczną lub wykorzystywane jako systemy izolacji w odległych obszarach. Zastosowanie dodatkowych kompetentnych strategii sterowania może nie tylko poprawić działanie tych systemów, ale także poprawić jakość energii wytwarzanej, dystrybuowanej i wykorzystywanej po stronie obciążenia Systemu Elektroenergetycznego. W związku z tym niniejszy artykuł zawiera przegląd różnych strategii sterowania przyjętych w celu złagodzenia problemów z jakością energii w skoordynowanym systemie mikrosieci energii odnawialnej i może być przydatny jako studium badawcze do dalszych badań. (**Poprawa jakości energii w mikrosieciach za pomocą strategii sterowania adaptacyjnego: przegląd literatury**)*

Keywords: Power Quality, Microgrid, Power Converter Control, Renewable Energy.
Słowa kluczowe: Jakość energii, mikrosieci, sterowanie przetwornicą mocy, energia odnawialna.

1. Introduction

Now-a-days, some environmental issues arise due to carbon emissions from fossil fuel power plants, which cause environmental pollution and global warming. Alternatively, Renewable Energy (RE) based generating systems are regarded clean and cheap in comparison with conventional electricity generation. Various RE sources are Solar PV energy, Wind energy, Small Hydroelectric plants, Biogas, Geothermal energy, and Tidal and Wave energy. Of these resources, Solar PV and Wind energy systems hold the majority promise owing to the low cost of electricity production and the ability to track maximum power points over an ample range of wind and sunlight discrepancies [1]. Because of this, governments and some private firms are solicitude in increasing the production of energy from renewable sources by replacing production based on fossil fuels. By 2030, in compliance with the International Renewable Energy Agency, the worldwide plan for the integration of RE resources are of 36% of global energy demand and is expected to come from renewables [2]. Due to the unavailability and pollution of traditional energy resources, the integration of RE resources into the grid has completely changed the structure of modern power systems. Hence, the microgrid (MG) concept has attracted a lot of attention from system operators in order to improve operational efficiency and ensure a more reliable, sustainable and economical power system [3].

Microgrid can be considered an alternative to the consumption of traditional plants based on fossil fuels to reduce the energy supply deficit. It enables the benefits of efficient and sustainable energy supply, reduced carbon emissions, and delayed expansion of distribution infrastructure. A Microgrid has the ability to operate as a single system, and if there is a problem with the grid, it can be disconnected or independent from the main power system and reconnected to the grid when the problem is resolved [4]. One-off the core intention for the progress of the MG structure is the incursion of RE sources. Thus, the basic characteristic parts of MG have Dispersed Energy Resources (DER), consumers, and regulators, as depicted in the Fig.1. below. However, integrating renewable energy into the main grid becomes an exigent task due to the intermittency of energy sources nature and so adaptive control strategies are required for power converter control [5] as described in the following sections to improve Power Quality (PQ) in a microgrid.

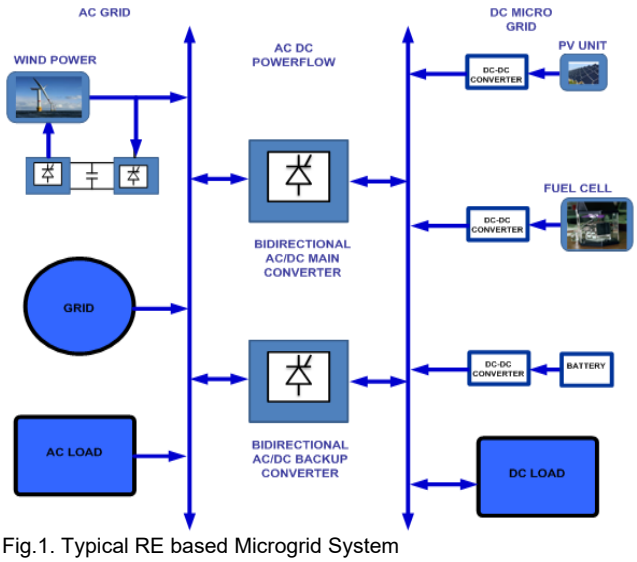


Fig.1. Typical RE based Microgrid System

In this paper, an introduction is dealt in section-1, section-2 mention Power Quality issues, challenges and possible solutions in microgrid, section-3 explains the different power quality enhancing methods, section-4 describes power converter controller strategies for PQ issues and conclusion part in section-5.

2. Power Quality Issues in a Microgrid

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The term "Power Quality" (PQ) in general refers to distribution bus voltage that remains nearly sinusoidal at rated amplitude and frequency. Furthermore, the energy made available to customers has got to be well-thought-out from a reliability viewpoint [6, 7]. The impact of power quality problems once microgrid connected to the main grid have concern due to the augmented penetration of non-linear loads and distributed energy systems with power electronic converter (PEC) interfaces. Challenging problems of grid integration are related to power quality issues related to current harmonics and that of voltage like voltage sag/swell, voltage imbalances & distortions caused by grid failures; frequency fluctuations, energy optimal layout and system isolation in abnormal conditions [8]. Proper control of the RE resources connected power electronic converter is essential that ensures stable operation in a period of transients and changes in AC system parameters. Renewable energy must be controlled using PEC to meet load requirements in stand-alone system applications and meet grid codes in grid-tied mode. It is reported that the Islanded mode is more likely to experience disturbances, such as voltage distortions and unbalances, since load distribution is unbalanced and line impedance is very high compared to grid-connected mode. To filter harmonics and smother unbalances, PE interfaced converters (inverters) could be effectively controlled [9]. In the grid-connection mode, disturbances such as grid voltage imbalance and voltage drop are the most common problems. Power Quality and stability of the system can be achieved via suitable control techniques incorporated to the power converter control circuit. Due to these impacts, improvement of the power quality of electric systems becomes a mandatory requirement. Hence, power quality problems get remunerated in control strategies applied to the interfacing inverter as mentioned in following section.

2.1 PQ Challenges and Solutions in a Microgrid

Now-a-days, some progressive technologies and techniques are being used continuously to develop and address the power quality challenges and their mitigation brought about by the incorporation of renewable energy in a microgrid [10]. Table 1. outlines the foremost challenges faced by grid-connected and islanded microgrid systems along with feasible remedies or mitigations.

Table 1. PQ Challenges and possible mitigating remedies in a microgrid [11]-[15]

Operational Mode	Challenges	Mitigating Solution
Grid Connected	Irregular Solar (PV) radiation and Voltage fluctuations due to variations in the wind speeds	Series &Shunt APFs. Power compensators like Fixed and/ or Switched Capacitor or Static Compensator. Utilities line conditioning systems and less sensitive consumer's equipment's to power disturbance/ voltage distortions.
Grid Connected	Frequency fluctuations for unexpected variations in active power caused by loads	PWM inverter control for regulating the frequency and voltage of a 3-Φ AC local bus in a Microgrid.
Grid Connected	Harmonics due to Power Electronic Controllers and non-linear appliances	Switching PWM Converter and applying the proper filters.
Grid Connected	Synchronization	Phased Locked Loop (PLL). In addition, grid voltages can be monitored for zero crossings and filter combinations can be used in conjunction with non-linear transformations
Stand-alone	Discontinuous in Energy and Power Quality	Incorporating RE resources with BESS or fuel cells, in a few situations with Diesel generator support systems.
Stand-alone	Protection	Appropriate protection & control equipment have to be incorporated for security reasons including upgrading existing systems when RE resource is connected.
Stand-alone	High Cost of Energy Storage	Incorporating both solar PV and Wind energies will curtail storage necessities and eventually on the whole system cost.
Stand-alone	Storage come to an end	Assimilate PV, Wind energies with Fuel-Cells.

3. Microgrid Power Quality

Currently, a major area of research in industry and academia is the network interaction of RE's for improved system performance. In the incidence of non-linear loads, a microgrid powered by a RE's integrated into the main grid generates harmonic currents that are in phase opposite to the reactive currents of the load [16]. Harmonic components are introduced by RE integration, which lowers the quality of the power at the point of common connection (PCC) into the network which must not exceed certain limits. The various measures have been carried out to enhance the quality RE resources generation, including that of the application of improved management strategies and the usage of various auxiliary equipment [17]. This section discusses controllers that encompass premeditated literature intended for mitigating power quality problems in a microgrid.

Power Electronics Converters are known to be the heart of the REs; these devices are responsible for injecting harmonics into the system. Various advanced methods of controlling inverters of RE systems for harmonic suppression are presented in [18]. The improvement of power quality with the use of filters or auxiliary equipment was suggested in [19] for hybrid PV/wind power plants. PQ issues namely power oscillations, harmonics, power factor, and voltage imbalances are significantly improved by FACTS controllers in highly RE perforated systems [20]. The power quality is improved by using a variety of energy storage devices, particularly for the purpose of power smoothing in RE systems discussed in [21, 22]. These include batteries, supercapacitors, and flywheel energy storage. Additionally, various techniques such as electric springs [23], soft computing-based approaches [24], and modular multilevel converters (MMC) are used in refining the power quality of RE systems [25]. The summary of the different strategies discussed in this section for improving the power quality of the system are as shown in Fig.2 below.

4. Controller Strategies for Power Quality Enhancement

This section provides an enhanced Islanded/grid-connected converter control techniques using adaptive control to enhance performance and repress harmonics in a microgrid where local steady and dynamic AC/DC loads are also coupled to the point of common connector (PCC). Controllers for these microgrids must include fast transitions between grid-tied as well as islanded modes of operation to mitigate the effects of mains outages and reduce the impact

of RE's intermittency and compensate for the existence of harmonic or unbalanced loads, thereby improving microgrid power quality.

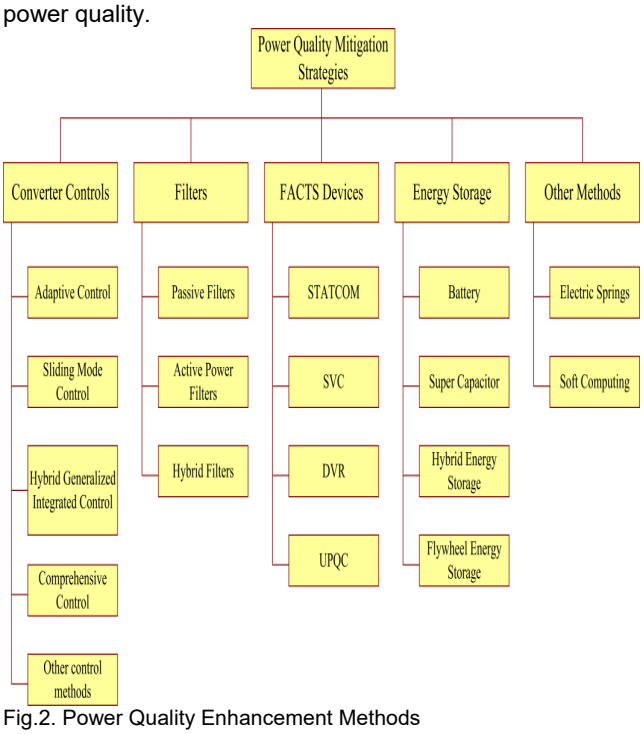


Fig.2. Power Quality Enhancement Methods

Hence, power quality problems get remunerated in control strategies applied to the interfacing inverter as shown in the Table 2. below.

Table 2. Different Power Converter Control Strategies

Reference	Controller Strategy	Features
[26, 27]	PI Controller (Natural Reference Frame)	Simple control structure. Regulates the basic component. Unbalanced systems cannot be guaranteed to perform effectively.
[28, 29]	PI Controller (Synchronous Reference frame)	It shows satisfactory performance in the regulation of DC variables. Ensure zero error in the steady-state. Poor lower order harmonic compensation
[30, 31]	Proportional Resonant (PR) Controller	Robust current controller. Ensure zero error in the steady-state. Obtains high gain values. Resonance problems are caused by changes in load parameters and in operating conditions.
[32, 33]	Hysteresis Current Control	Simple structure. Essentially robust. Not considering of changes in load parameters. It provides great dynamics. Lower order harmonics has no concern. There is no fixed switching frequency.
[34, 35]	Repetitive Controller	Periodic disturbances eliminated. Essentially robust. Ensure that the Steady-State Error is zero for all harmonic frequencies. Stability is a problem when the load disturbance is aperiodic. Slow response when load varies.
[36, 37]	Deadbeat Control	Simple in nature. Highly tracking speed and control accurateness is obtained. Performance relies on the sample frequency. Sensitive to system parameter variations.
[38, 39]	H∞ Control method	Suitable for Multi Input Multi Output (MIMO) systems. It offer less THD and better performance. Considers plant complexity, uncertainties, perturbations or dynamics. It makes sure of good performance under each type of loads. Slow dynamics. Because modelling is complex, it requires knowledge of advanced mathematics.
[40, 41]	Fuzzy Controller	Able to control the nonlinear behaviour of complex control structures using heuristic and expert knowledge of controlled process. Insensible to system changes. Slow control method.
[42, 43]	Neural Networks method	Used by current controllers because they are robust in nature. Offline training methods lack efficiency.

Table 2. lists some of the different features of distinct controller's methods. Hence, from the above discussion it can be found that PI controller, Hysteresis Current control and Fuzzy method controllers are extensively used as the power converter controller strategies. Although, many deliberations are made in the studies on control methodologies in improving power quality of the microgrid systems, no single control technique can solve all power quality problems simultaneously. Therefore, future research will capable of focusing on the development of control techniques that meet the requirements and highly dependent on proper system modelling with the application of advanced control strategies such as optimization techniques [44, 45, 46] applied to the microgrid system controller design.

4.1 Power Quality Enhancement with Optimization/AI techniques

The goal of power quality in microgrids is solved using a variety of AI-based optimization strategies. Optimized linear and nonlinear models are suitable for grid connected as well as islanded modes of microgrid [47]. PSO is an intelligent computing technique that searches for the best parameter settings in real-time [48]. For the purpose of removing voltage harmonics in microgrid systems with numerous DG sources, a union of PSO based PWM and SPWM inverters was proposed in [49]. A concurrent self-tuning technique was described in [50] as the basis for an optimal control approach considering the criteria of Voltages, frequency regulation, and power-sharing in performance evaluation during microgrid operational mode changes and sudden load variations. With the intention of improving power quality in multi-bus microgrids, the authors [51] suggested an optimization technique with primary goal was to mark voltage regulation at specific buses. A controller with gains derived from system admittance and tuned via Ant-Lion Colony (ALC) algorithm was proposed in [52]. In [53], a PI controller with settings adjusted using a whale's optimization algorithm (WOA) was suggested. The apparent controller regulates voltage and frequency within an autonomous microgrid that is powered by inverters.

The authors in [54] devised a control approach that uses the Grasshopper optimization technique to govern the optimal gains in the PI controller meant for power quality enhancement in photovoltaic-based microgrids running in the autonomous mode. A Slap Swarm Optimization (SSO) based PI controller was implemented in [55] for improving power quality under conditions of dynamic loads.

5. Conclusion

- This article provides a comprehensive review on various control strategies and state-of-art-tools utilized for extenuating power quality issues in a renewable energy coordinated microgrid.
- Different controllers and their control strategies that are intended for enhancing power quality are discussed with possible challenges and solutions thoroughly.
- Also, the study deals several optimization approaches for renewable energy resources interfacing power electronic converter in terms of power quality performance.
- Further studies are recommended in the usage of adaptive control techniques and hybrid optimization algorithms which results in better performance and efficacy in improving the power quality of a microgrid.

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A Study on the Rheology of Scc with the Addition of Fly Ash in Opc, Ppc and, Psc Cements with Different Mixing Times

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Abstract: In this paper, a study was performed on the rheological properties of self-compacting concrete by the addition of Supplementary Cementitious Material (SCM) as Fly Ash with various percentages of 15%, 20%, 25%, and 30% in the different types of cement OPC, PPC, and PSC. The mix designs of self-compacting concrete were done by two methods of constants: Water-Binder Ratio Constant and Weight and Volume of Aggregates Constant for varying percentages of addition of Fly Ash with a fixed cement content of 380 kg per cubic meter. Flow ability (Flow Table and V Funnel) and Passing Ability (L-Box and U-Box) tests were carried out on fresh concrete in accordance to EFNARC with three different mixing times 5(initial), 30, and 90 minutes were done to find the self-compactibility of designed concrete mixes. Varying dosages of Super Plasticizer (Auromix 450) were added to obtain the required flow ability and passing ability of SCC without bleeding of water and segregation of aggregates. Self-compactibility of the designed SCCs was obtained for 20%, 25%, and 30% addition of SCM in Water-Binder Ratio Constant Method and 15%, 20%, and 30% addition of SCM in Weight and Volume Constant Method.

Keywords: Self-Compacting Concrete, Fresh Properties, Supplementary Cementitious Materials, Fly Ash, Constant methods, Mixing Time.

1. Introduction

With the rapid expansion of numerous structures throughout the world, the demand for self-compacting concrete (SCC) application is growing. Now a day's majority of the construction sites have issues of congestion of reinforcement in the structural members. The considerable seismic danger in the area, the facilities' susceptibility to cyclonic storms, and their massive capacity of expansion, all exacerbate the design flaws. SCC has become the only choice in such difficult site environments. Ideally, the development of concrete mix where placing and compaction have minimal dependence on the Standard of workmanship available on a particular site should improve the true quality of the concrete in the final structure, and hence its durability. This was an important driving force behind the development of self-compacting concrete (SCC). Self-compacting concrete is considered as a breakthrough in concrete technology due to its improved performance and working environment. It has wide application from thin elements to huge structures. SCC can be taken as the greatest technical advancement and most revolutionary development in concrete technology over the years. SCC is the concrete of the future, as it will be replacing normal concrete due to its distinct advantages.

The European Federation for Specialist Construction Chemicals and Concrete Systems (EFNARC) has developed guidelines for SCC, known as the "EFNARC Specification and Guidelines for Self-Compacting Concrete." These guidelines provide recommendations on mix design, fresh and hardened properties, and testing methods for SCC.

SCC can be produced using the same ingredients as that of normal concrete. A closer tolerance is required to ensure strict control of workability characteristics. The proportioning of SCC mix is much more scientific than that of conventional concrete mixes. SCC mix requires high powder content, lesser quantity of coarse aggregate, high range super plasticizer, and VMA (Viscosity Modifying Agent) to give stability and fluidity to the concrete

mix. The workability of SCC is the equilibrium of fluidity, deformability, filling ability, and resistance to segregation. This equilibrium has to be maintained for a sufficient time period to allow for its transportation, placing, and finishing. Combinations of tests are required to characterize the workability properties.

The most commonly used cement in self-compacting concrete (SCC) is Ordinary Portland Cement (OPC). OPC is widely available and has been extensively used in various concrete applications, including SCC. In self-compacting concrete, the cement content is usually adjusted based on the specific requirements of the project and the desired properties of the SCC mix. The selection of cement type may also depend on factors such as the project's location, local availability, and any specific performance requirements. The use of alternative types of cement is becoming more prevalent in the construction industry to address environmental concerns. For example, in some regions, where environmental regulations are stricter, or sustainability is a top priority, blended cements such as Portland Slag Cement (PSC) and Portland Pozzolana cement (PPC), have gained popularity due to their reduced carbon footprint and improved performance characteristics. Blended cements are already a combination of Ordinary Portland Cement (OPC) and supplementary materials, such as fly ash and slag. Adding more SCMs to these blended cements further enhances their properties and performance in SCC mixes such as Improved Workability, Reduced Permeability and Improved Durability, Reduced Heat of Hydration, Sustainable Solution, Setting Time, and Strength Development. The addition of SCMs to blended cements can also bring challenges to the mix design process. The interaction between various materials can affect the rheological behavior, setting time, and strength development of the SCC. Precise mix proportioning and testing are essential to ensure the desired performance of the concrete. The Percentage of dosage of SCMs in blended cements for SCC depends on various factors such as the type of SCM, Cementitious content, water-to-binder ratio, desired strength, and workability. Mix designs should be tested thoroughly to verify the fresh and hardened properties of the SCC to meet project specifications and requirements. In this study, the effect of fresh properties of SCC on addition of SCM to blended cement with different design mix methods was done.

Concrete, in general, loses workability over time because of the evaporation of water, the absorption of water through the aggregates, the hydration of cement, and increased mixing temperature. The properties of SCC deteriorate with prolonged mixing, casting, and finishing time. The effect of mixing time on concrete can be avoided or reduced by adding alternative cement materials or/and by increasing the dosage. Many researchers reported that the addition of high super plasticizer dosage may increase workability and decrease its negative effects that are caused by long mixing time. The increase in super plasticizer dosage may lead to wet surroundings, which increase workability, and the hydration process accelerates as water spreads between the cement granules. Thus, reducing concrete consistency increases bleeding and segregation. The effects of mixing time and suitable super plasticizer dosage still need further investigations to maintain the workability and consistency of concrete for a long time. In this study, workability was measured with 5, 30, and 60 minutes of mixing times with an optimized super plasticizer dosage for each mix.

2. Materials.

2.1. Cement:

In Production of SCC, Ordinary Portland Cement (OPC) - 53 grade, Portland Pozzolona Cement (PPC), and Portland Slag Cement (PSC) were used in this study. Some physical and chemical properties of cements which are collected from the cement manufacturer are shown in Table 1.

Table 1: Physical and Chemical Properties of Cements

Description	OPC		PPC		PSC	
	Tested Value	IS 12269:2013	Tested Value	IS 1489:2015 (Part 1)	Tested Value	IS 455: 2105
Physical Properties						

Fineness	Specific surface (sq m/kg)	308	>225	327	>300	372	>225
	Normal consistency (%)	28.3	-	31	-	-	-
Soundness	Le Chatelier Method (mm)	1.5	<10	1	<10	0.5	<10
	Autoclave (%)	0.05	0.8	0.039	<0.8	0.03	0.8
Setting time	Initial setting time (mins)	210	>30	180	>30	145	>30
	Final setting time (mins)	300	<600	280	<600	195	<600
Specific Gravity		3.15		2.9	-	2.91	-
Chemical Properties							
Lime Saturation Factor		0.93	>0.8 & <1.02	-	-	-	-
Alumina Iron Ratio		1.13	>0.66	-	-	-	-
Insoluble Residue (%)		1.98	<4.0	30.74		1.22	<4.0
Magnesia (%)		1.16	<6.0	0.79	<6.0	4	<10.0
Sulphuric Anhydride (%)		2.4	<3.5	1.82	<3.5	1.97	<3.5
Sulphide Sulphur (%)		-	-	-	-	0.16	<1.5
Loss of Ignition (%)		2.16	<4.0	1.55	<4.0	1.43	<4.0
Alkalies (%)		0.64	-	-	-	-	-
Chlorides (%)		0.02	<0.10	0.001	<0.10	0.006	<0.10
C_3A		5.82	-	-	-	-	-
Fly Ash (%)		-	-	33.5	-	-	-
GGBS (%)		-	-	-	-	45	-

2.2. Fly Ash

For this Study, Class F Fly Ash was used which is procured from Sri Damodaram Sanjeevaiah Thermal Power Station is located in Nelatur Village, near Krishnapatnam, Andhra Pradesh, India. The power plant is one of the coal-based power plants of Andhra Pradesh Power Development Company Limited (APPDCL) and is in compliant with India Standard IS 3812:2003.

Table 2: Physical and Chemical Properties of Fly Ash

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	SO_3	LOI	K_2O	Na_2O	Specific Gravity	Blaines' s Fineness
%	65.80	21.32	4.87	1.00	0.53	0.50	0.20	0.16	0.81	0.21	2.14	321

2.3. Aggregates

2.3.1. Fine Aggregate

Locally available river sand is used as fine aggregate. The sand was dried before use to avoid the problem of bulking. The fine aggregate complies with Zone 2 from the sieve analysis as per Indian Standard IS 383:2016

2.3.2 Coarse Aggregate

Locally available granite with a size ranges from 12.5 mm and down was used as coarse aggregate.

Table 3: Physical Properties of Fine Aggregate

Aggregate	Specific Gravity	Fineness Modulus	Water absorption	Bulk Density	Dry Rodded Unit Weight
Fine Aggregate	2.63	3.65	0.50%	1582.85 kg/m^3	-
Course Aggregate	2.66	6.66	0.10%	1472 kg/m^3	1495 kg/m^3

2.5 Super Plasticizer

For this study, the super plasticizer used in Auramix 450 manufactured by FOSROC Chemicals which complies with Indian Standards IS 9103: 1999. Properties of Auramix 450 which are collected from the manufacturer are shown in Table 7.

Table 4: Properties of Super Plasticizer

Specific Gravity	pH	Chloride Content	Appearance
1.07	6.1	Nil	Light yellow colour liquid

2.6 Water

Potable water is used in this study.

3. Mix Design of Self Compacted Concrete

Mix design procedure of self-compacting concrete is adopted by taking guidelines from the reference of works by Dr. Okamura and Dr. Ouchi, Japanese researchers who first developed Self Compacting concrete and the norms given in EFNARC. These guidelines are not intended to provide specific advice on mix design but give an indication of the typical range of constituents in SCC by weight and by volume. These proportions are in not restrictive and SCC mixes may fall outside this range for one or more constituents.

3.1. Self Compacting Concrete Proportions

Generally, most of the researches are conducted by simple replacement method. Replacement of cement is done in different percentages of Supplementary Cementitious Material (SCM) either by volume or Weight (Mass). In this method the quantity of Binder Material (BM) is fixed and when replacement of SCM is done in different percentages of quantities, there will be change in the cement quantity and SCM quantity. The replacement method is represented in the form of equations as

C_0 + 0% SCM = BM i.e. C_0 = BM

C_1 + 5%SCM = BM

C_2 + 10%SCM = BM

C_3 + 15%SCM = BM etc

C_0, C_1, C_2, C_3 etc of quantities of Cement and %SCM is of BM

However, in this work, the addition method is adopted which involves the direct addition of SCM without changing the quantity of cement which is fixed and SCM is added with an increase of percentages of 15%, 20%, 25%, and 30% for binder material in SCC. The percentage of SCM is of the quantity of Binder Material.

$C + 15\%SCM = BM_1$

$C + 20\%SCM = BM_2$

$C + 25\%SCM = BM_3$

$C + 30\%SCM = BM_4$

C = Cement is taken as 380kg in this work. The experiments are conducted taking OPC, PPC, and PSC Cements, and SCMs are Fly Ash (F) and GGBS (G) added separately to each individual kind of cement in percentages given above

Further, the design of concrete in this work is done by addition method by taking two methods of constants.

1. Water Binder Ratio Constant Method
2. Aggregate Weight and Volume Constant Method

3.1.1. Water Binder Ratio Constant Method.

In this method as mentioned above the binder material is varied in all the types of cement (OPC, PPC, and PSC) by adding SCM percentages. The design is done by keeping the water-binder ratio constant for all quantities of binder material. The quantities of aggregates are adjusted accordingly for the volume of 1 cum of SCC satisfying the EFNARC norms and the dosage of super plasticizer is adjusted for getting the required fresh properties of SCC.

The equation of design will be as following in this method.

$SCC_1 = BM_1 + CA_1 + FA_1 + W\% + SP$

$SCC_2 = BM_2 + CA_2 + FA_2 + W\% + SP$

$SCC_3 = BM_3 + CA_3 + FA_3 + W\% + SP$

$SCC_4 = BM_4 + CA_4 + FA_4 + W\% + SP$

$W\% = 0.4\ BM_{1\ to\ 4}$

After few trails the suitable water binder ratio for this work was fixed at 0.4

3.1.2. Aggregate Weight and Volume Constant Method

In this method similar to the earlier method the binder material is varied in all the types of cement (OPC, PPC, and PSC) by adding SCM percentages. The design is done by keeping the quantities of aggregates constant. The weight and volume of aggregates are kept constant for all mixes and the water binder ratio is changed accordingly for 1 cum of SCC satisfying the EFNARC norms and the dosage of super plasticizer is adjusted for getting the required fresh properties of SCC.

The equation of design will be as following in this method.

$SCC_5 = BM_1 + CA + FA + W_1\% + SP$

$SCC_6 = BM_2 + CA + FA + W_2\% + SP$

$SCC_7 = BM_3 + CA + FA + W_3\% + SP$

$SCC_8 = BM_4 + CA + FA + W_4\% + SP$

CA = Coarse Aggregate is constantly taken as 50% weight of Dry Rodded Unit Weight, and

FA = Fine Aggregate is constantly taken as 55% of the total aggregate weight.

These values of aggregate quantities are also constant in terms of the volume of aggregates satisfying the EFNARC norms.

SP, the super plasticizer dosage was fixed on trial and error basis with number of trials to achieve at he mix with satisfactory fresh properties in both methods.

Table 5. Mix Proportions with Water Binder Ratio Constant method

MIX	Cement	Fly Ash	Fine Aggregate	Course Aggregate	Water	Super Plasticizer		Unit Weight
	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	%	kg/m^3
OPC - SCC_1	380.00	70.00	953.00	790.00	180.00	8.10	1.80	2381.10
OPC - SCC_2	380.00	95.00	920.00	770.00	190.00	6.65	1.40	2361.65
OPC - SCC_3	380.00	126.67	877.00	747.50	202.67	3.55	0.70	2337.39
OPC - SCC_4	380.00	162.86	796.00	747.50	217.14	2.71	0.50	2306.21
PPC - SCC_1	380.00	70.00	940.00	775.00	180.00	8.10	1.80	2353.10
PPC - SCC_2	380.00	95.00	900.00	768.00	190.00	4.28	0.90	2337.28
PPC - SCC_3	380.00	126.67	877.00	747.50	202.67	3.55	0.70	2337.39
PPC - SCC_4	380.00	162.86	796.00	747.50	217.20	2.71	0.50	2306.27
PSC - SCC_1	380.00	70.00	953.00	790.00	180.00	8.10	1.80	2381.10
PSC - SCC_2	380.00	95.00	910.00	785.00	190.00	4.75	1.00	2364.75
PSC - SCC_3	380.00	126.67	878.00	747.50	202.67	3.55	0.70	2338.39
PSC - SCC_4	380.00	162.86	796.00	747.50	217.20	2.71	0.50	2306.27

Table 6. Mix Proportion with Aggregate Weight and Volume Constant Method

MIX	Cement	Fly Ash	Fine Aggregate	Course Aggregate	Water	Super Plasticizer		Unit Weight
	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	%	kg/m^3
OPC - SCC_5	380.00	70.00	913.50	747.50	214.94	3.60	0.80	2329.54
OPC - SCC_6	380.00	95.00	913.50	747.50	202.62	4.28	0.90	2342.90
OPC - SCC_7	380.00	126.67	913.50	747.50	186.14	6.08	1.20	2359.89
OPC - SCC_8	380.00	162.86	913.50	747.50	167.30	8.14	1.50	2379.30
PPC - SCC_5	380.00	70.00	913.50	747.50	214.94	3.60	0.80	2329.54
PPC - SCC_6	380.00	95.00	913.50	747.50	202.62	4.28	0.90	2342.90
PPC - SCC_7	380.00	126.67	913.50	747.50	186.14	6.08	1.20	2359.89

PPC - SCC_8	380.00	162.86	913.50	747.50	167.30	8.14	1.50	2379.30
PSC - SCC_5	380.00	70.00	913.50	747.50	212.41	6.30	1.40	2329.71
PSC - SCC_6	380.00	95.00	913.50	747.50	199.52	7.60	1.60	2343.12
PSC - SCC_7	380.00	126.67	913.50	747.50	182.35	10.13	2.00	2360.15
PSC - SCC_8	380.00	162.86	913.50	747.50	161.21	14.66	2.70	2379.73

4. Results

4.1. Fresh Properties of Self Compacted Concrete

The fresh properties of Self Compacting Concrete designed and mixed with different cements and addition SCMs as per the tables given above are tested for Flow Ability and Passing Ability. The flow ability is tested by Slum Flow, T_{500} Slump Flow and V Funnel methods and passing ability is tested by L-Box and U-Box methods.

4.1.1. Slump Flow

The slump flow of fresh Self Compacting Concrete is measured on flow table using Abraham Cone. Unit of measurement of slump flow is millimeters. The acceptance levels as per EFNARC are 650 mm to 800 mm. In this work the acceptance levels of slump flow are taken from 600 mm and above.

Table 7. Slump Flow (mm)
(Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	600	580	550
OPC - SCC_2	600	610	630
OPC - SCC_3	660	670	680
OPC - SCC_4	650	680	640
PPC - SCC_1	600	560	540
PPC - SCC_2	600	660	650
PPC - SCC_3	650	680	660
PPC - SCC_4	700	680	640
PSC - SCC_1	590	610	580
PSC - SCC_2	630	660	620
PSC - SCC_3	650	680	640
PSC - SCC_4	660	680	640

Table 8. Slump Flow (mm)
(Aggregate Weight and Volume Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	630	630	610
OPC - SCC_6	610	660	670
OPC - SCC_7	600	650	690
OPC - SCC_8	570	600	590
PPC - SCC_5	570	630	630
PPC - SCC_6	600	660	650
PPC - SCC_7	660	640	640
PPC - SCC_8	600	580	580
PSC - SCC_5	640	620	600
PSC - SCC_6	660	600	580
PSC - SCC_7	650	610	590
PSC - SCC_8	630	590	570

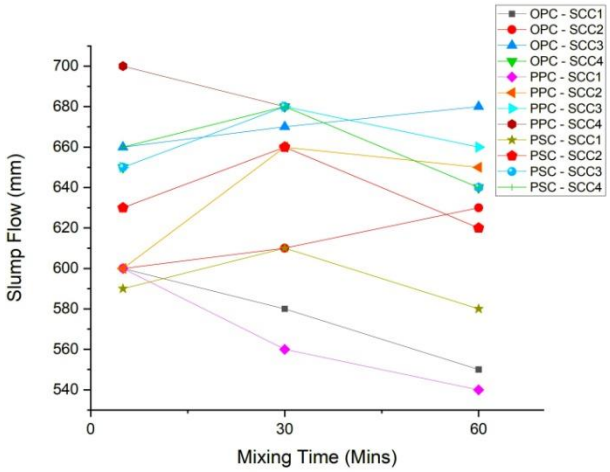


Fig. 1. Slump Flow (Water Binder Constant)

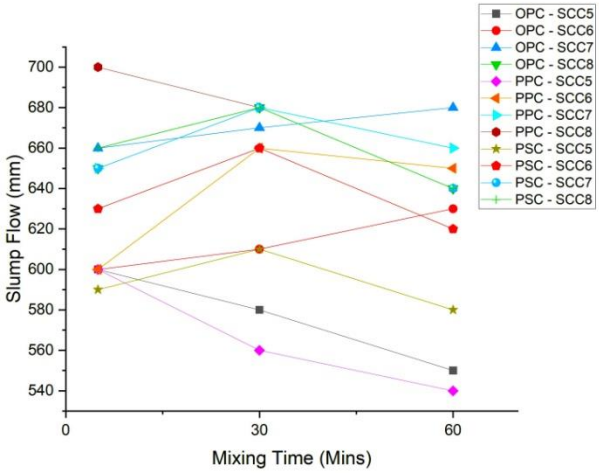


Fig.2. Slump Flow (Aggregate Weight and Volume Constant)

4.1.2. Slump Flow – T_{500}

Viscosity of the Self Compacting Concrete can be assessed by T_{500} time during slump flow test. The time value obtained does not measure the viscosity of SCC but is related to it by describing the rate of flow. Concrete with a low viscosity will have a very quick initial flow and the stop. Concrete with high viscosity may continue to creep forward over an extended time. The acceptance levels as per EFNARC are 2 sec to 5 sec. In this work the acceptance levels of slump flow are taken from 2 sec and 7 sec.

Table 9. Slump Flow – T500 (sec) (Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	7.8	7.9	8
OPC - SCC_2	5.0	4.5	2.3
OPC - SCC_3	3.2	2.8	2.8
OPC - SCC_4	3.0	2.0	0.4
PPC - SCC_1	4.0	7.2	7.6
PPC - SCC_2	4.0	2.8	3.0
PPC - SCC_3	2.4	2.2	2.1
PPC - SCC_4	2.0	2.0	3.2
PSC - SCC_1	4.0	3.5	4.3
PSC - SCC_2	3.0	2.0	3.6
PSC - SCC_3	2.0	2.0	3.0
PSC - SCC_4	2.0	2.0	3.2

Table 10. Slump Flow – T500 (Sec) (Aggregate Weight and Volume Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	2.5	2.5	2.6
OPC - SCC_6	2.7	2.0	2.0
OPC - SCC_7	5.0	4.0	2.0
OPC - SCC_8	6.2	5.8	6.1
PPC - SCC_5	3.5	2.4	2.7
PPC - SCC_6	4.0	2.8	3.0
PPC - SCC_7	4.2	4.9	2.9
PPC - SCC_8	4.0	5.0	5.3
PSC - SCC_5	3.1	3.4	4.1
PSC - SCC_6	2.0	3.6	4.4
PSC - SCC_7	2.0	3.2	4.0
PSC - SCC_8	4.0	6.0	-

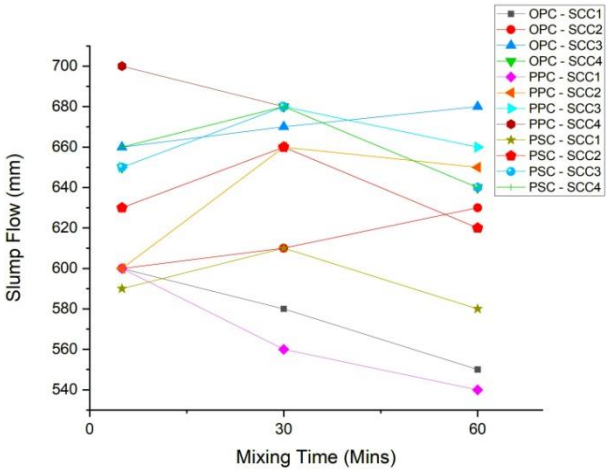


Fig. 3. Slump Flow – T500 (Water Binder Constant)

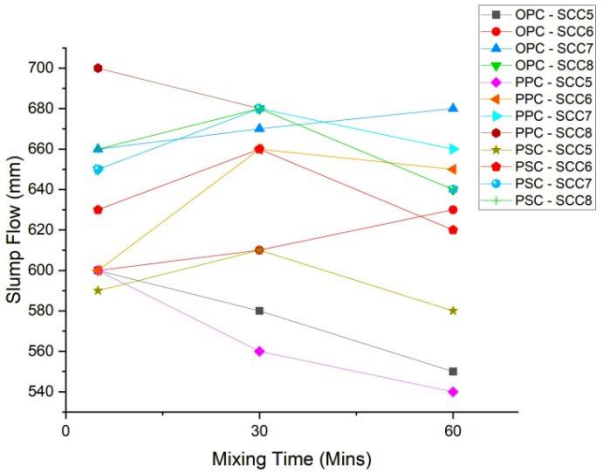


Fig.4. Slump Flow-T_{500} (Aggregate Weight and Volume Constant)

4.1.3. V-Funnel Test

Flowing ability and viscosity of the Self Compacting Concrete can be assessed by V-Funnel flowing time. The acceptance levels as per EFNARC are 6 sec to 12 sec.

Table 11. V Funnel Flow (Sec) (Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	6.4	6	6.3
OPC - SCC_2	5.2	5.4	5.7
OPC - SCC_3	5	5.2	5.1
OPC - SCC_4	5.4	5	5
PPC - SCC_1	7.3	9.4	14.7
PPC - SCC_2	7	4.1	4.4
PPC - SCC_3	6.5	4.3	4.7
PPC - SCC_4	4	4.1	5.3
PSC - SCC_1	11	9.3	14
PSC - SCC_2	7.1	5.2	6.9
PSC - SCC_3	5.3	5	5.6
PSC - SCC_4	6	4.8	5

Table 12. V Funnel Flow (Sec) (Aggregate Weight and Volume Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	4.7	6	6.4
OPC - SCC_6	5.3	4.9	5.2
OPC - SCC_7	8	6	5.6
OPC - SCC_8	11.3	9	11.1
PPC - SCC_5	11	5.7	6.2
PPC - SCC_6	7	4.1	4.4
PPC - SCC_7	5.2	6.1	7.3
PPC - SCC_8	7.2	6.7	7.2
PSC - SCC_5	6.1	9	13
PSC - SCC_6	6.1	13	16
PSC - SCC_7	6.2	12	14
PSC - SCC_8	7.4	14	18

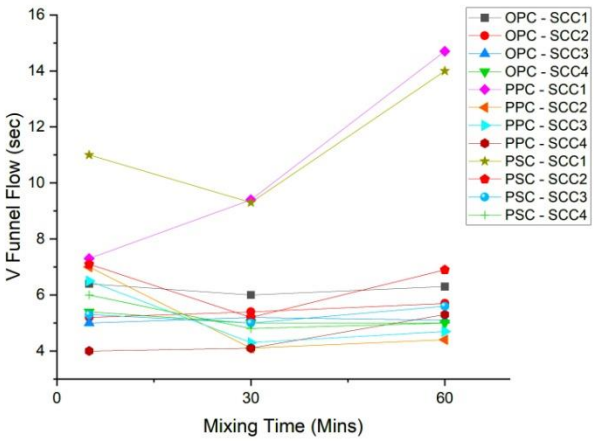


Fig.5. V Funnel Flow (Water Binder Constant)

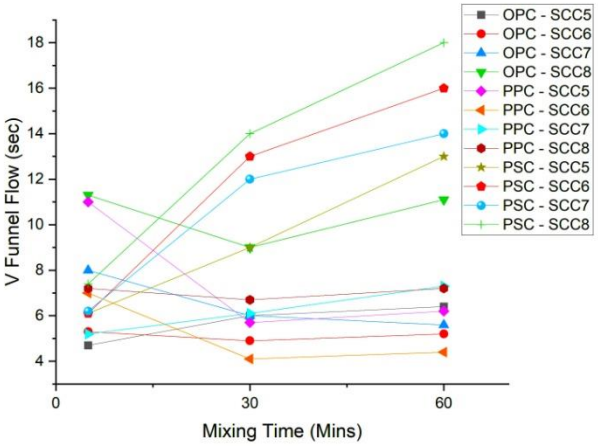


Fig.6. V Funnel Flow (Aggregate Weight and Volume Constant)

4.1.4. L-Box Test

Aggregate blocking must be avoided as Self Compacting Concrete flows through the reinforcement and the L-Box Test is indicative for passing ability of Self Compacting Concrete mix. The acceptance levels as per EFNARC are 0.8 to 1.0 (Ratio of h_2/h_1, h_1 is interior height and h_2 exterior height in L-Box base line after concrete stops flowing).

Table 13. L-Box (Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	0.75	0.79	0.80
OPC - SCC_2	0.78	0.79	0.83
OPC - SCC_3	0.84	0.89	0.93
OPC - SCC_4	0.88	0.94	1.00
PPC - SCC_1	0.83	0.84	0.77
PPC - SCC_2	0.72	0.97	0.96
PPC - SCC_3	0.89	0.93	0.98
PPC - SCC_4	1.00	1.00	1.00
PSC - SCC_1	-	0.68	-
PSC - SCC_2	0.74	0.88	0.82
PSC - SCC_3	0.89	1.00	0.95
PSC - SCC_4	1.00	1.00	1.00

Table 14. L-Box (Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	0.82	0.83	0.83
OPC - SCC_6	0.79	0.87	0.90
OPC - SCC_7	0.77	0.89	0.96
OPC - SCC_8	0.68	0.71	0.70
PPC - SCC_5	0.72	0.79	0.91
PPC - SCC_6	0.72	0.97	0.96
PPC - SCC_7	0.86	0.82	0.84
PPC - SCC_8	0.76	0.72	0.73
PSC - SCC_5	0.76	0.72	-
PSC - SCC_6	0.85	0.79	-
PSC - SCC_7	0.84	0.77	-
PSC - SCC_8	-	-	-

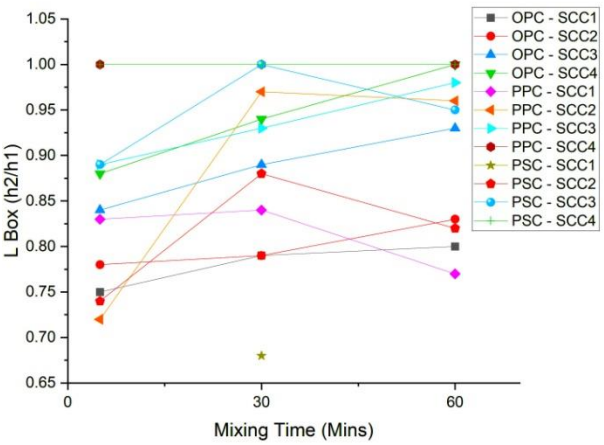


Fig.7. L-Box (Water Binder Constant)

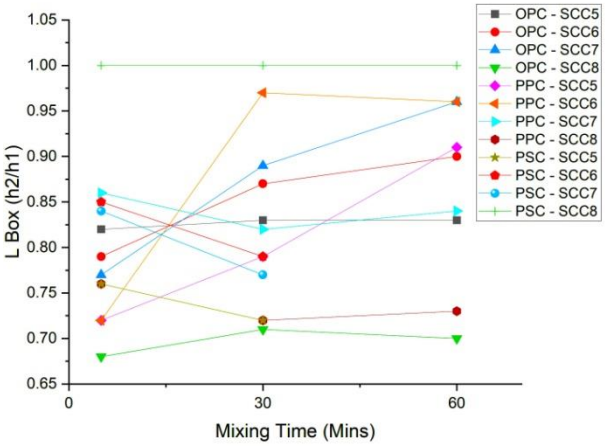


Fig.8. L-Box (Aggregate Weight and Volume Constant)

4.1.5. U-Box Test

U-Box test is also an indicative for passing ability of Self Compacting Concrete to avoid aggregate blocking during the flow. The acceptance levels as per EFNARC are 0 to 30 mm (h2-h1, the level difference of concrete in the two legs of U-box after stop of flow)

Table 16. U-Box (mm)
(Water Binder Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_1	45	34	39
OPC - SCC_2	32	15	0
OPC - SCC_3	22	0	0
OPC - SCC_4	18	0	7
PPC - SCC_1	40	25	15
PPC - SCC_2	35	0	0
PPC - SCC_3	25	0	0
PPC - SCC_4	0	0	12
PSC - SCC_1	-	-	-
PSC - SCC_2	35	10	15
PSC - SCC_3	0	0	10
PSC - SCC_4	0	0	10

Table 16. U-Box (mm)
(Aggregate Weight and Volume Constant)

Mix	5 Mins	30 Mins	60 Mins
OPC - SCC_5	35	29	21
OPC - SCC_6	29	0	0
OPC - SCC_7	25	0	0
OPC - SCC_8	-	-	-
PPC - SCC_5	35	0	0
PPC - SCC_6	35	0	0
PPC - SCC_7	0	15	20
PPC - SCC_8	45	55	60
PSC - SCC_5	40	-	-
PSC - SCC_6	25	40	-
PSC - SCC_7	25	40	-
PSC - SCC_8	-	-	-

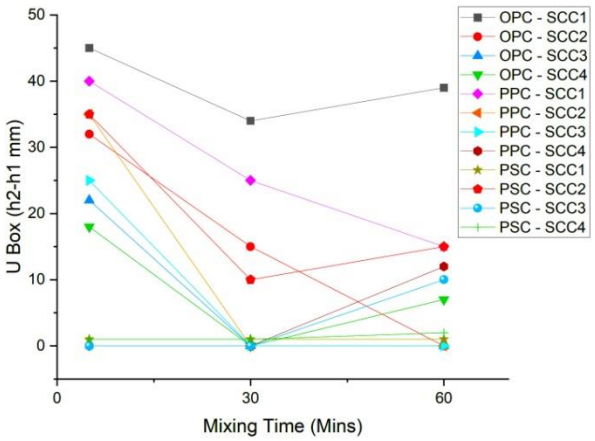


Fig.7. U-Box (Water Binder Constant)

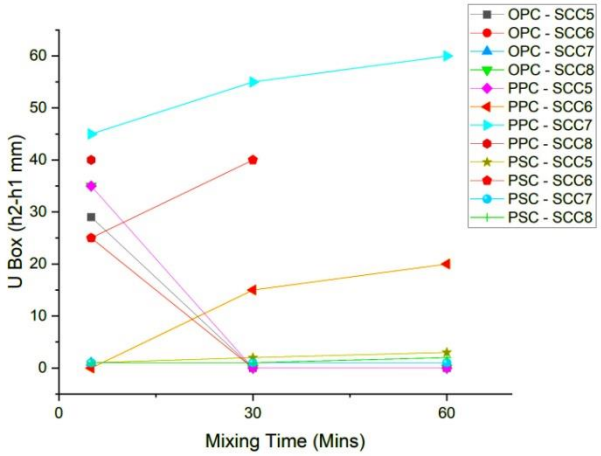


Fig.8. U-Box (Aggregate Weight and Volume Constant)

4.2. Discussion

The fresh properties of the mixes were mostly within the acceptance levels for the 20%, 25% and 30% addition with Water Binder Ratio constant method and 15%, 20% and 25% addition with Aggregate Weight and Volume Constant Method.

The slump flow in almost all mixes was observed with slight bleeding after resting of flow with initial mixing of 5 minutes. On Continuous mixing for 30 minutes the flow was good and no bleeding was observed in any of the mixes. After 60 minutes of continuous mixing the flow reduced when compared to 30 minutes with no bleeding.

The values of Slump flow $-T_{500}$ for almost all the mixes were was within the range of acceptance levels.

The V Funnel flow was good for all the mixes which had satisfactory slump flow. No blockage was found at the bottom of funnel for any of the mixes during the flow. The $T_{5Minutes}$ flow in V Funnel were also within the range of acceptance levels for all the mixes.

The values of L Box flow and U-Box Flow were observed to be good with addition of fly ash in OPC and PPC. Addition in PSC was observed with blockage and bleeding of water.

5. Conclusions

From the results and observations in this study the following conclusions may be made:

1. In Water Binder Ratio Method for 15% addition of fly ash in all types cements the quantity of aggregates was at higher side and the water was not sufficient for the binder material for getting the sufficient viscosity to get the required flow. If the super plasticizer was added more to get the flow, bleeding was observed with very low values of flow. The similar kind of observation was found in Aggregate Weight and Volume Method with addition of 30% of fly ash in all types of cements. The water content was not sufficient for the powder to get the viscosity and there were mixes with no flow. All other percentages of addition of fly ash in both the methods of mix design the results were all within the range of acceptance levels.
2. The mixing time in this study was one of the major factors. The initial mix for 5 minutes of continuous mixing in the pan mixer for all the mixes are within the acceptances levels but observed with some bleeding after the flow rested. After 30 minutes of continuous mixing almost all the mixes showed very good results with all the values within the acceptance levels. After the 60 minutes of continuous mixing almost all the flows slowed down when compared to the values 30 minutes of mixing but within the acceptance levels.
3. The mixes SCC2, SCC3, SCC4, SCC5, SCC6 and SCC7 were found to be self compactable almost satisfying the acceptance levels. All these mixes are found to be highly good with 30 minutes of continuous mixing.
4. The mixes which satisfied self compactibility can be further tested for strength properties

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PV-Based Design and Evaluation of Power Electronic Topologies for EV Applications

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Abstract: This study presents a unique concept for an electric vehicle (EV) charging system that is powered by photovoltaic (PV) technology. The core of the system is a modified single-ended primary inductance converter, chosen for its high efficiency, reduced switch voltage stress, and ample operating range for maximum power point tracking (MPPT). This study details the redesigned SEPIC converter architecture, including with and without the MPPT algorithm. Additionally, an optimized parameter selection, design methodology, and simulation technique are presented for analyzing converter performance in EV charging applications. Two MPPT approaches, Perturb and Observe (P&O) and incremental conductance (IC), are investigated and compared based on their impact on the converter switching time under standard solar PV panel testing conditions. To comprehensively evaluate the system's performance, a MATLAB/Simulink model is developed, simulating the charging of a 48 V, 200 Ah battery using a 2 kW solar PV input through the modified SEPIC converter and variations in the battery state of charge (SoC), battery voltage, and charging current are monitored. The simulation results demonstrate that under identical simulated conditions (10 Sec), the battery SoC increases from 50% to 50.034% without MPPT and to 50.042% with MPPT, highlighting the effectiveness of the MPPT algorithms in maximizing harvested solar energy.

Introduction

The increasing adoption of electric vehicles necessitates the development of efficient and readily available charging infrastructure. This paper presents a novel approach to EV charging by utilizing a PV-powered system with a modified SEPIC converter. Compared to traditional boost converters, the modified SEPIC offers several advantages, including nearly double the static gain, a wider operating range for the MPPT controller and reduced switch voltage stress, thereby enhancing the converter's reliability and lifespan (Eltamaly and Abdelaziz, 2019).

The adoption of renewable energy alternatives has increased dramatically due to the rising costs and depletion of nonrenewable energy sources. Among these, photovoltaic (PV) energy has drawn much interest as a potential remedy for the problems posed by increased energy demand and global warming. Fuel independence, environmental friendliness, durability, and cheap maintenance are just a few advantages of PV energy (Chilakapati and Manohar, 2023; Ramesh et al., 2023). Many processes are involved in integrating PV systems into the grid, one of which is raising the output voltage to meet grid requirements. Boost converters or high-frequency step-up transformers are used in conventional methods. Even though DC-DC converters are frequently used to boost PV system voltage, traditional topologies frequently have poor static gain, which lowers the output voltage (Suryoatmojo et al., 2018).

For instance, the maximum input voltage increase that a SEPIC converter with a duty cycle of 0.82 can achieve is a factor of 5. A tenfold increase in the input voltage is needed to fulfil grid requirements, making the use of a

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step-up transformer redundant. This study suggests a modified SEPIC converter architecture to overcome these drawbacks. With the addition of a diode and a capacitor, the converter may increase the input voltage by up to ten times. Because of these improved capabilities, a step-up transformer is no longer necessary, simplifying the system design and perhaps increasing efficiency. By investigating modified SEPIC converter architectures that deliver higher output voltages and better efficiency, this research seeks to integrate further PV systems (Suryoatmojo et al., 2018).

Background of the Work

Mouli et al. (2015) and Bhatti et al. (2016) systematically study various topologies and system architectures of PV charging systems in the context of electric vehicles. Three primary conclusions emerge regarding PV charging systems for EVs: grid-connected systems are more preferred against off-grid systems, a topology with a DC-link is the most effective for the overall system arrangement, and standards require that EV converters be isolated.

Mouli et al. (2015) present four different architectures of integrated EV-PV systems as follows: the PV system and the EV system use either a power converter integrated or separate converters for both PV and EV, and whether the connection is through AC or DC circuitry (Yadav et al., 2023; Thota et al., 2023). At the same time, many researchers (Tulpule et al., 2013; Verma et al., 2016) consider the power exchange to be carried out through AC, suggesting a separate PV inverter and an AC EV charger and possibly integrated energy storage to perform this function). The downside to this strategy is that both PV and EV equipment are essentially DC devices. Subsequently, power exchange over AC leads to added losses and necessitates two inverters in place of one. Thus, a design featuring an integrated converter and a DC link for exchanging power between the EV and the PV is more optimal (Goli and Shireen, 2014).

Methodology & Designing

Solar PV Specifications

The design and development of a MATLAB/Simulink model for a solar photovoltaic (PV) system intended to recharge an electric vehicle's (EV) battery is described in the present article. The system was configured to deliver 48 V and 200 Ah to the battery using a modified SEPIC converter. One of its main benefits is the 48V 200Ah battery's capacity to give electric cars a longer range. Electric vehicles (EVs) can cover greater distances on a single charge due to their larger capacity and higher voltage. The 48V 200Ah battery is considered for simulation since it also provides better efficiency compared to conventional battery technologies.

Table 1. Solar PV Module Specifications at STC.

Parameter	Specification
Voltage at MPP (V_{MPP})	30.9 V
Current at MPP (I_{MPP})	8.1 A
Power at MPP (P_{MPP})	250.29 W
Open Circuit Voltage (V_{OC})	36.6 V
Short Circuit Current (I_{SC})	8.75 A

A constant irradiation of 1000 W/m^2 and a temperature of 25°C are assumed in the simulation. The PV system incorporates the maximum power point tracking (MPPT) functionality to maximize the power output. The simulated system has eight parallel modules, and each module has sixty solar cells. The specific design parameters of the PV modules are detailed in Table 1 (Datasheet, 2023).

Perturb & Observe MPPT

The prime motive of Perturb and Observe is to ensure that the solar module operates at its peak efficiency by continuously perturbing the operating point of the solar panel and observing the corresponding change in power output. This algorithm alters the operating point till it attains the maximum power point (MPP). This is a widely used technique in the field of photovoltaic systems aimed at optimizing the efficiency of solar energy conversion. P&O MPPT is renowned for its simplicity, cost-effectiveness, and adaptability to various environmental conditions. The flow chart of P&O MPPT is shown in Figure 1(Eltamaly and Abdelaziz, 2019).

Incremental Conductance MPPT

The primary intention of the Incremental Conductance Maximum Power Point Tracking (MPPT) technique is to make sure that it operates at the maximum power point (MPP) under varying environmental conditions. This is a sophisticated algorithm employed in photovoltaic systems to optimize the energy output from solar panels. Unlike conventional fixed-point methods, Incremental Conductance MPPT dynamically tracks changes in the solar array's voltage and current characteristics, making it highly responsive to fluctuations in sunlight intensity. By comparing the incremental conductance, which is the rate of change of power concerning voltage, with the instantaneous conductance, the algorithm effectively and efficiently converges toward the MPP. The flow chart of incremental conductance MPPT can be seen in Figure 2 (Eltamaly and Abdelaziz, 2019).

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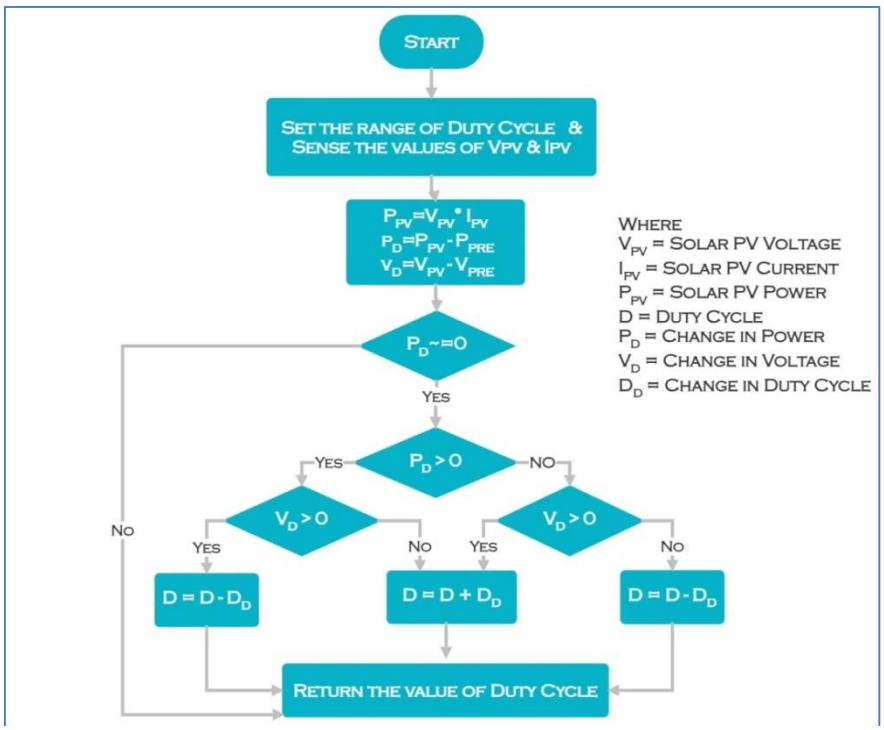


Figure 1. Flowchart for Perturb & Observe MPPT.

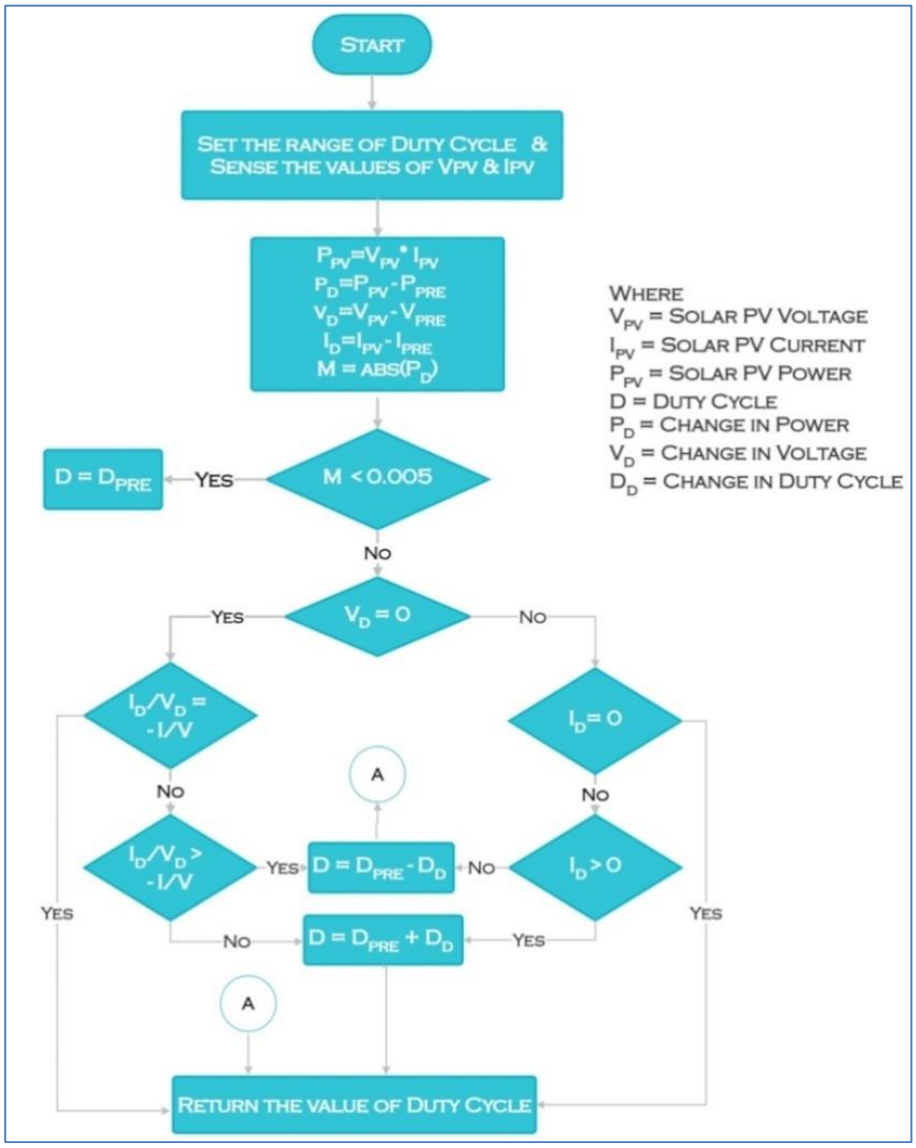


Figure 2. Flowchart for Incremental Conductance MPPT.

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Design of Modified SEPIC Converter

The power circuitry of the traditional SEPIC converter is presented in Figure 3. A key feature of the SEPIC converter is its ability to both boost (step-up) and buck (step-down) the input voltage, making it suitable for applications with a wide range of input voltages. However, the switch voltage is equal to the sum of the input and output voltages (Falin, 2023; Babaei and Mahmoodieh, 2014).

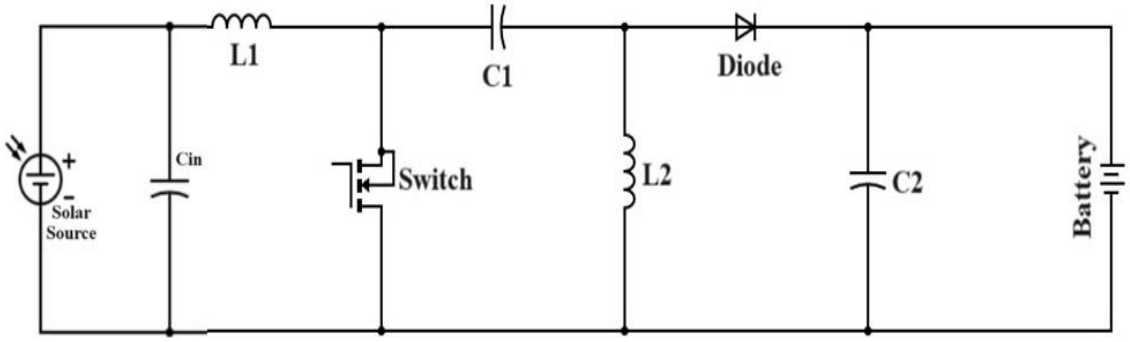


Figure 3. Schematic of the traditional SEPIC converter.

This topology is modified by incorporating additional components and rearranging the existing components. A schematic of the modified SEPIC topology is shown in Figure 4 below (Gules et al., 2011; Mishra and Singh, 2018; Maroti et al., 2019; Parthasarathy et al., 2022; Muranda et al., 2017).

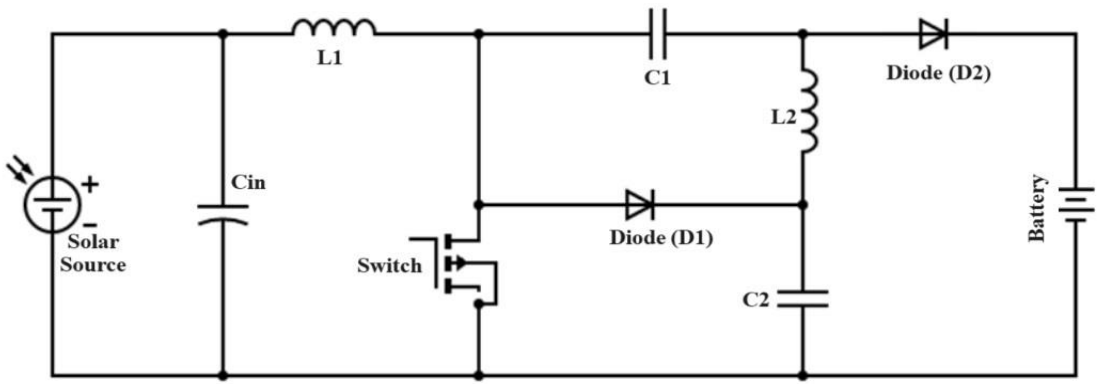


Figure 4. Schematic of the modified SEPIC converter

In continuous conduction mode, the duty cycle of the modified SEPIC converter can be determined by eq.(1).

$$Duty\ Cycle\ (D) = \frac{V_{Out} - V_{In}}{V_{Out} + V_{In}} \quad \ldots (1)$$

The input current is given by eq.(2).

$$Input\ Current\ (I_{in}) = \frac{Input\ Power}{V_{In}} \quad \ldots (2)$$

The first step in designing a PWM switching regulator is determining how much inductor ripple current (ΔI_l) to permit. The inductor ripple current of this topology can be calculated using the eq.(3).

$$Inductor\ Ripple\ Current\ (\Delta I_l) = 0.1 * I_{in} \quad \ldots (3)$$

The inductances can be calculated using eq.(4).

$$Inductances\ L_1 = L_2 = \frac{V_{In} \times D}{\Delta I_l \times F_s} \quad \ldots (4)$$

The maximum allowable output ripple is considered to be 2%. The capacitance can be determined using eq. (5).

$$Capacitances\ C_1 = C_2 = \frac{I_O}{\Delta V_C \times F_s} \quad \ldots (5)$$

The change in voltage across the capacitors is determined by eq.(6).

$$\Delta V_C = 0.02\ X\ \frac{V_{out}}{(1-D)} \quad \ldots (6)$$

For a switching frequency of 20 kHz and analogous input power and load, the various parameters of the ZETA, SEPIC and modified SEPIC converters are calculated and the values are tabulated in Table 2 (Reddy and Reddy, 2024).

Results & Discussion

This study investigated the charging performance of a 48 V, 200 Ah electric vehicle (EV) battery using a 2kW solar photovoltaic (PV) source with a modified SEPIC converter. The simulation is conducted within the MATLAB/Simulink environment.

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Table 2. Evaluated parameters of the ZETA, SEPIC and Modified SEPIC Topologies.

Sl. No	Parameter	ZETA Topology	SEPIC Topology	Modified SEPIC Topology
1	Switching Frequency	20kHz	20kHz	20kHz
2	Max. Duty Cycle (D_{Max})	64%	64%	25.6%
3	Min. Duty Cycle (D_{Min})	60.83%	60.83%	21.7%
4	Inductor (L_1)	362 mH	225 µH	7 mH
5	Inductor (L_2)	362 mH	350 µH	7 mH
6	Capacitor (C_1)	2.6 mf	410 µf	1.7 mf
7	Capacitor (C_2)	3.9 µf	264 µf	1.7 mf

Key parameters such as voltage, current, and power from the PV panel are monitored alongside the battery's state of charge (SoC), charging current, and voltage. The test conditions were kept consistent across all the scenarios. Figures 5 to 13 present the MATLAB/Simulink models, PV characteristics (voltage, current, and power), battery SoC, charging current, and voltage for the modified SEPIC converter under three configurations: without maximum power

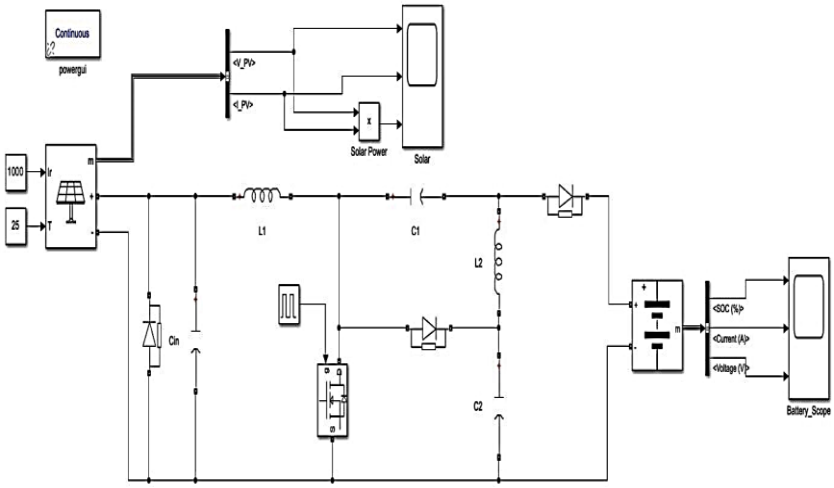


Figure 5. MATLAB/Simulink Model of the modified SEPIC converter without MPPT.

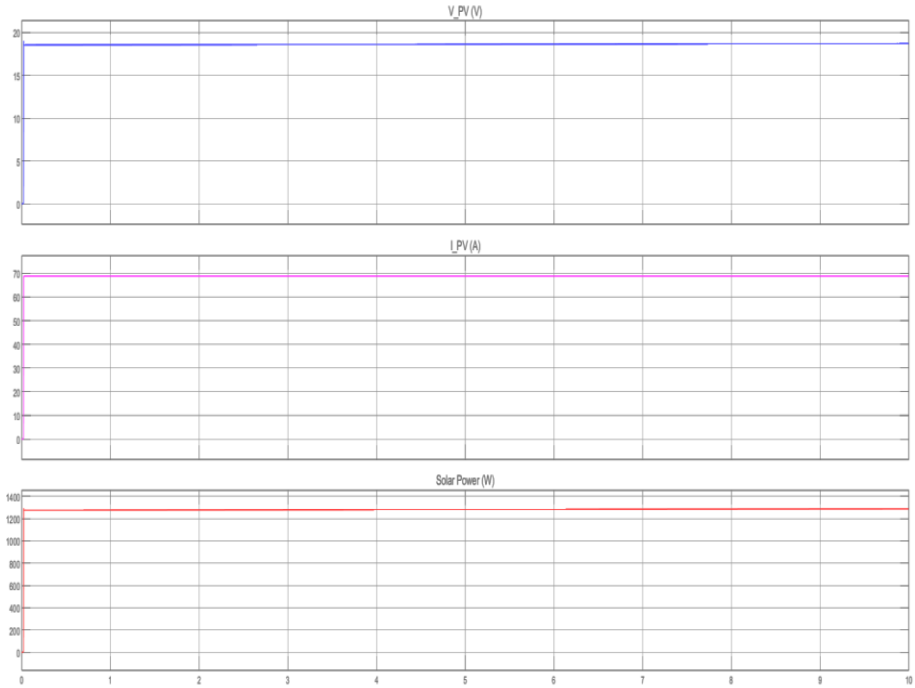


Figure 6. PV characteristics results for the modified SEPIC converter without MPPT.

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point tracking (MPPT), with Perturb and Observe (P&O) MPPT, and with incremental conductance MPPT.

Under identical test conditions, the performances of the EV charging system powered by solar PV employing ZETA, SEPIC and modified SEPIC converters with and without MPPT methodologies are presented in Table 3. Without using Maximum Power Point Tracking (MPPT), a Zeta converter takes roughly 6.94 hours to charge a battery, while a SEPIC converter completes the task in a significantly shorter 4.63 hours. This advantage persists even with MPPT techniques. For example, Incremental Conductance MPPT allows a SEPIC converter to finish charging in just 3.97 hours, whereas a Zeta converter under the same MPPT method still requires 5.5 hours (Reddy and Reddy, 2024).

Furthermore, advancements in SEPIC converter technology show even greater promise. A modified SEPIC converter can achieve the same charging level in a mere 4.09 hours without MPPT, and a remarkable 3.3 hours with MPPT. This represents a substantial improvement in charging efficiency. These results unequivocally show that utilizing solar electricity to charge the batteries of electric vehicles is a more efficient use of the modified SEPIC converter.

It is important to note that negative battery current values indicate that the battery is in charging mode.

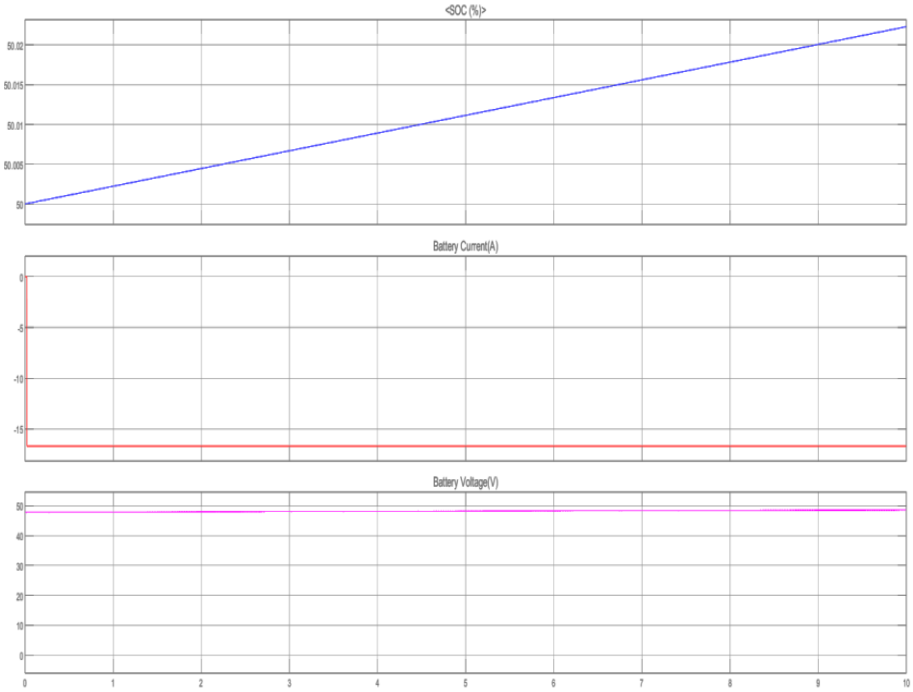


Figure 7. Battery charging results for the modified SEPIC converter without MPPT.

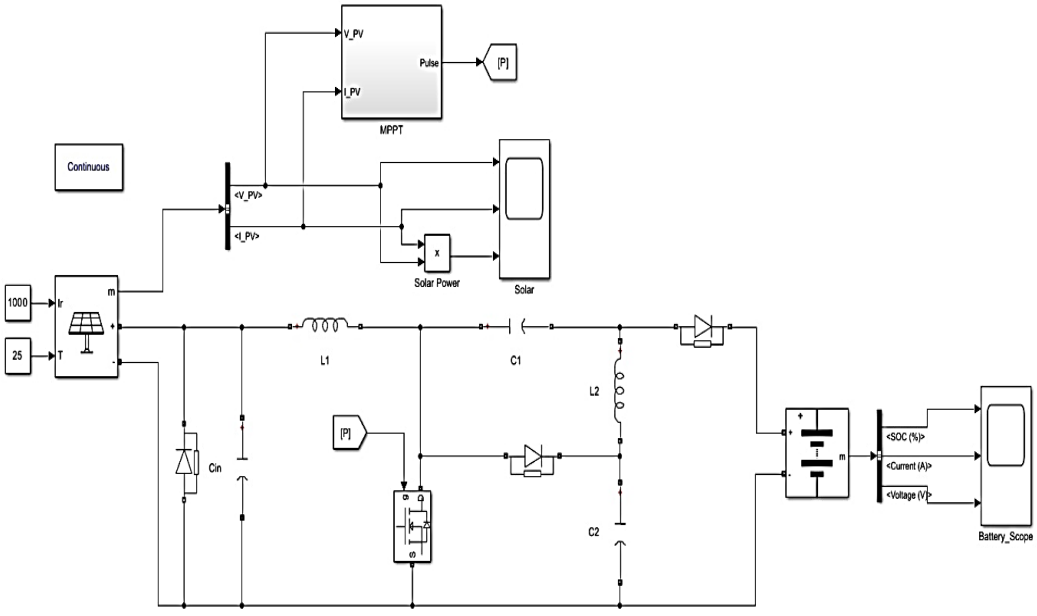


Figure 8. MATLAB/Simulink model of the modified SEPIC converter with P&O MPPT.

DOI: https://doi.org/10.52756/ijerr.2024.v39spl.009

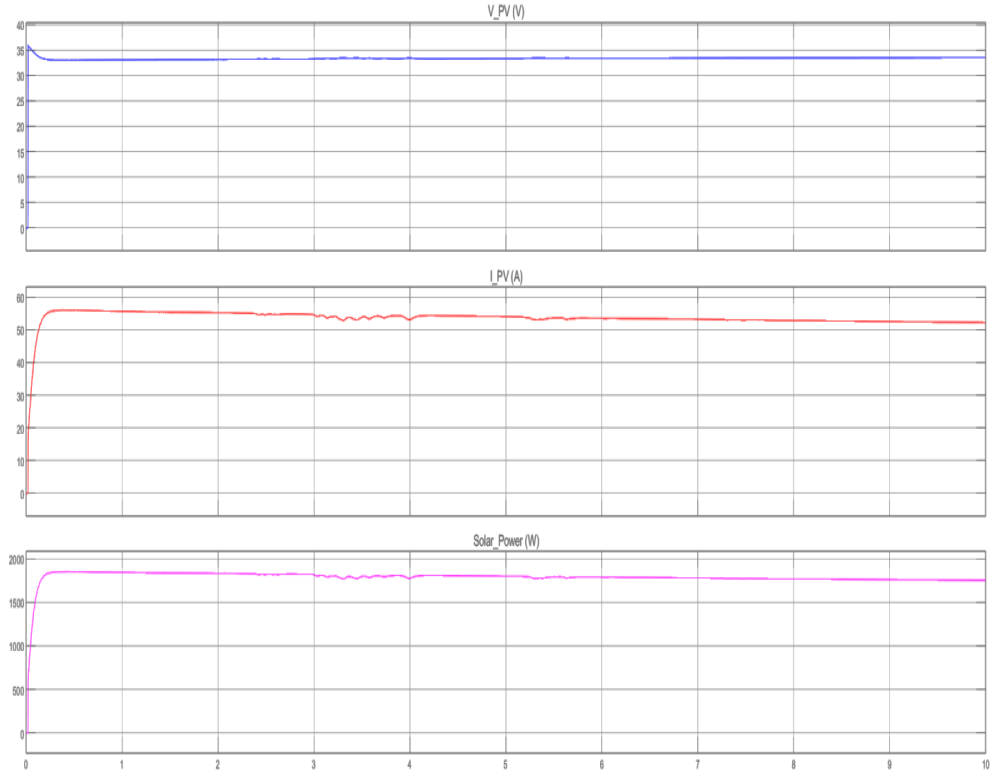


Figure 9. PV characteristics results for the modified SEPIC converter with P&O MPPT.

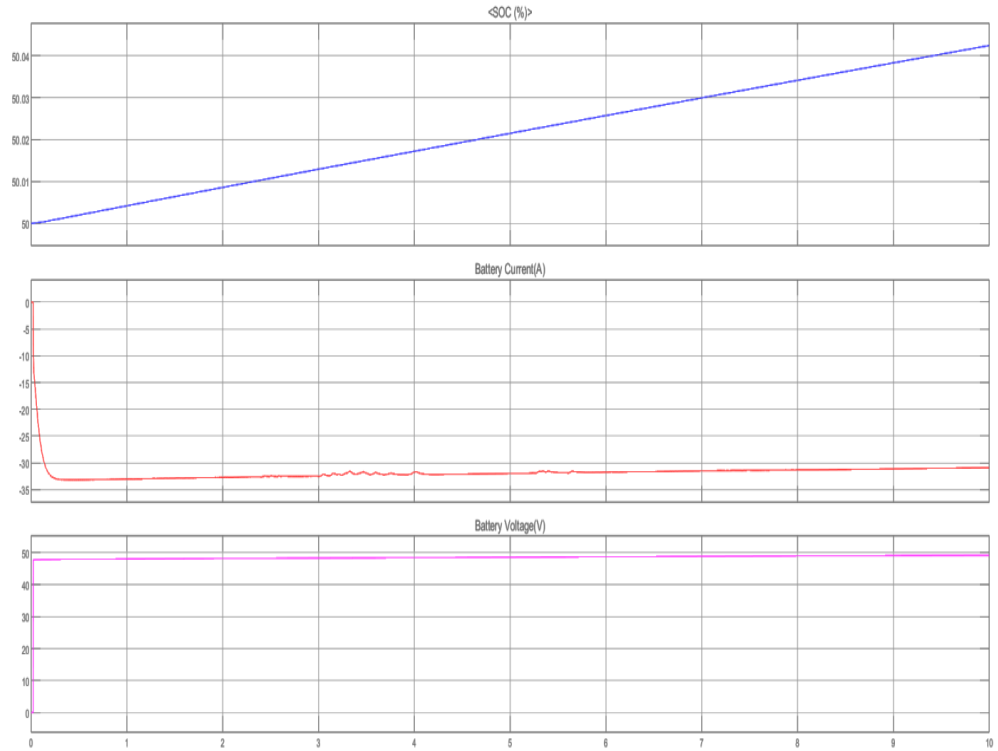


Figure 10. Battery charging results for the modified SEPIC converter with P&O MPPT.

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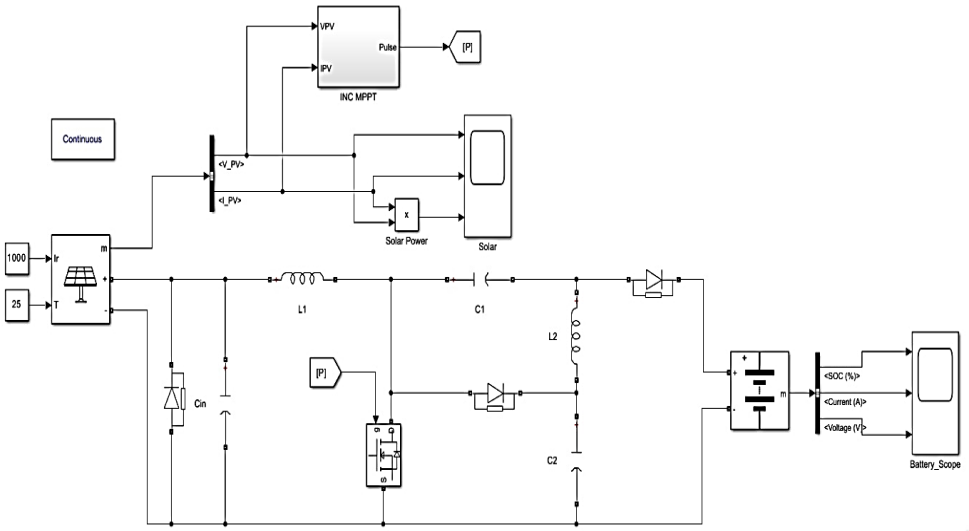


Figure 11. MATLAB/Simulink Model of the modified SEPIC converter with INC MPPT.

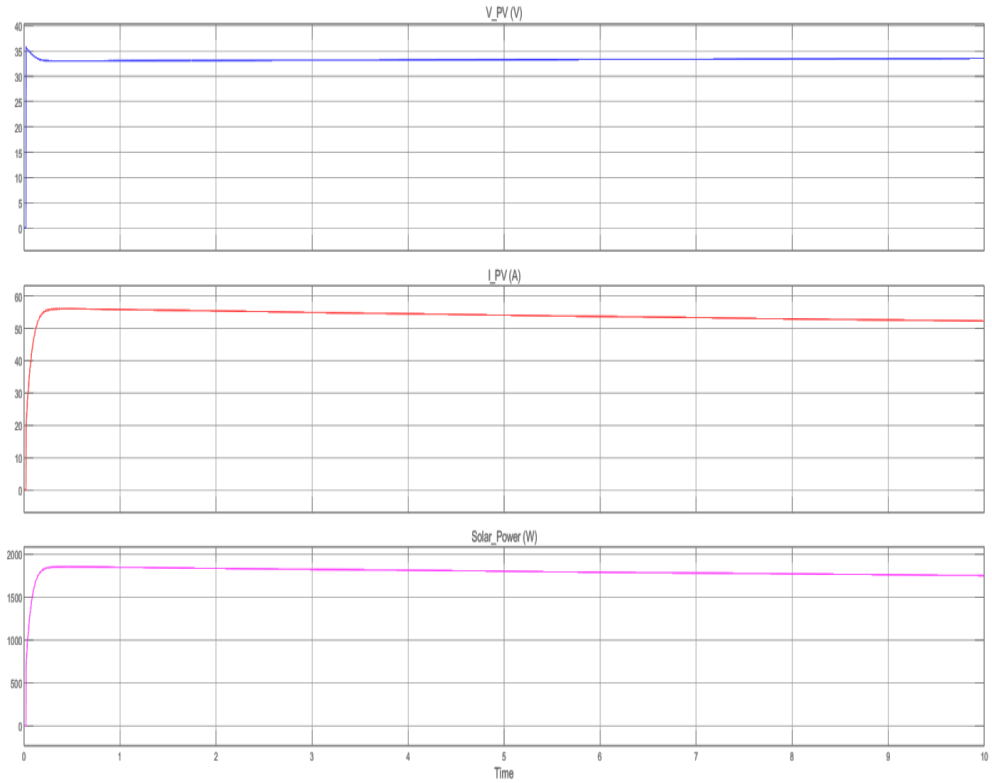


Figure 12. PV characteristics results of the modified SEPIC converter with INC MPPT.

DOI: https://doi.org/10.52756/ijerr.2024.v39spl.009

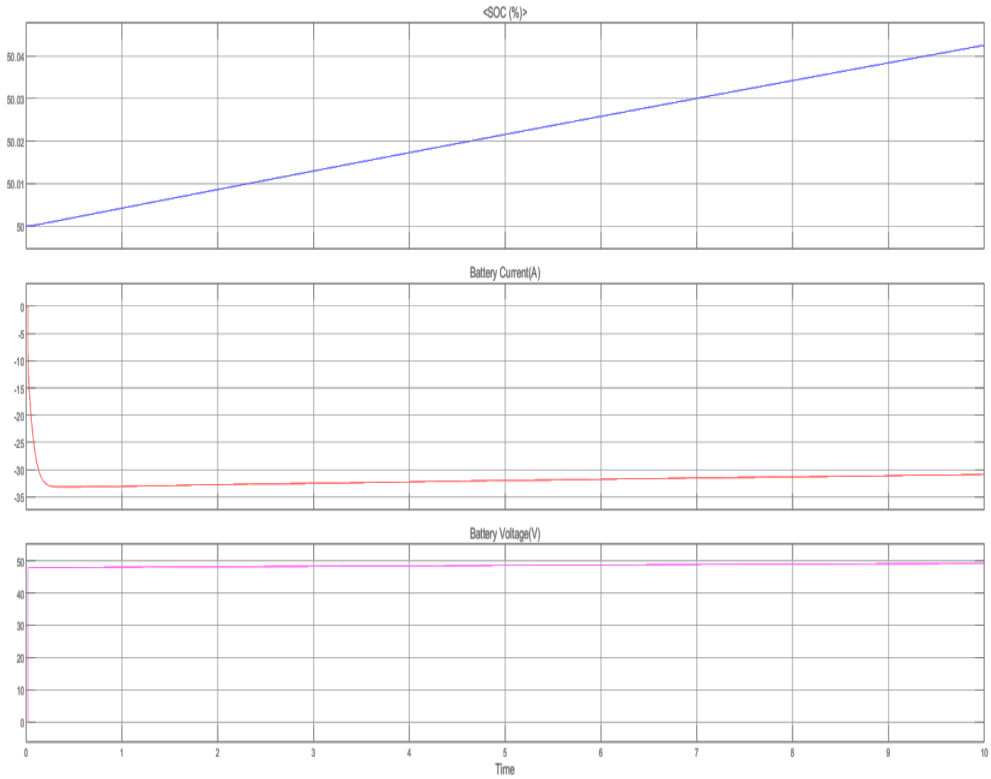


Figure 13. Battery charging results for the modified SEPIC converter with INC MPPT.

Table 3. Comparative study of Simulation results for various Power Electronic Topologies.

Parameter	ZETA Converter			SEPIC Converter			Modified SEPIC Converter		
	With out MPPT	With P&O	With IC	With out MPPT	With P&O	With IC	With out MPPT	With P&O	With IC
SoC (%)	50.017	50.025	50.025	50.02	50.03	50.035	50.034	50.042	50.042
V_b (V)	48.32	48.51	48.51	48.52	48.93	49.01	48.9	49.2	49.3
I_b (A)	-12.03	-16.56	-16.85	-14.84	-23.2	-25.1	-24.17	-30.92	-30.94
V_{pv} (V)	35.46	34.12	32.38	35.59	34.47	34.05	34.76	33.52	33.5
I_{pv} (A)	19.41	30.4	35.08	23.16	41.37	46.6	37.57	52.2	52.25
P_{pv} (W)	688.4	1035	1136	824.2	1426	1587	1306	1751	1752

DOI: https://doi.org/10.52756/ijerr.2024.v39spl.009

Conclusion

This paper presented a novel PV-fed EV charging system utilizing a modified SEPIC converter. The proposed system offers several advantages, including high efficiency, reduced switch voltage stress, and the integration of MPPT algorithms to maximize power extraction from PV panels. The simulation results demonstrated the effectiveness of the implemented MPPT techniques in enhancing the system's performance compared to the scenario without MPPT. This study paves the way for further research and development
of efficient and sustainable EV charging solutions utilizing renewable energy sources. The simulation results demonstrate that the modified SEPIC converter delivers a significantly greater current than the traditional SEPIC converter and ZETA converter, leading to a faster increase in the battery's state of charge. For instance, charging a battery without maximum power point tracking (MPPT) takes approximately 6.94 hours with a ZETA converter and 4.63 hours with a SEPIC converter, while the modified SEPIC converter achieves the same result in only 4.09 hours. The advantage persists even with MPPT techniques. Regardless of the MPPT method employed, the modified SEPIC converter consistently achieves faster charging times (3.3 hours) than the ZETA and SEPIC converter. These findings indicate that the modified SEPIC converter offers a more effective solution for charging electric vehicle batteries using solar power.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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PV-based Performance Evaluation of Zeta and Sepic Topologies for EV Applications

JES Journal of Electrical Systems

Abstract: - In this paper, a comparative performance analysis was proposed for PV fed EV charging system for ZETA and SEPIC DC-DC converter topologies. The utilization of Electric vehicles has gained significance in recent years due to societal awareness and increasing concern for environmental sustainability. EV charging time plays a vital role in modern-day vehicle commuting with energy-efficient performance. The selection of an appropriate DC-DC converter topology plays a significant role for fast charging with improved efficiency. The paper presents an optimized parameter selection, design, simulation methodology & relative performance analysis between the ZETA and SEPIC converter topologies with and without MPPT algorithm for EV charging applications. The MPPT algorithm based on P&O and IC techniques investigates for switching time of the ZETA and SEPIC converters under standard test conditions of solar PV panel i.e., at irradiance of 1000 W/m^2 and temperature of 25°C. In this article MATLAB/Simulink was developed to explore the performance of both topologies with and without MPPT approaches for battery SoC, battery voltage and charging current. The study shows that the battery charged from an SoC of 50% to 50.035% for SEPIC converter while the ZETA converter charges from 50% to 50.025% with a similar simulation time of ten seconds with Solar power input. The results demonstrate the DC-DC SEPIC converter is the best choice for EV charging applications through the PV system.

Keywords: Solar PV, EV Charging, Zeta Topology, SEPIC Topology, Perturb & Observe, Incremental Conductance.

I. INTRODUCTION

The advancement of PV energy technology is swiftly advancing. In order to maximize power and minimize loss, power electronic components were implemented into the MPPT [1]. The system can operate independently on very little self-produced electricity. In this study, to maximize the solar power extracted from photovoltaic panels, the MPPT technique is employed. The DC-DC converter's customizable switching cycle is produced using the MPPT approach. As a result, it regulates the PV Panel's output voltage [2].

The choice of capacitor, inductor, and switches affects the output accuracy of the converter and so the designing of the converters needs atmost attentiveness [3]. The Zeta converter and the single ended primary inductor converter (SEPIC) topologies operated in Boost mode are presented in this paper. The block diagram representation of the developed system is shown in Fig.1.

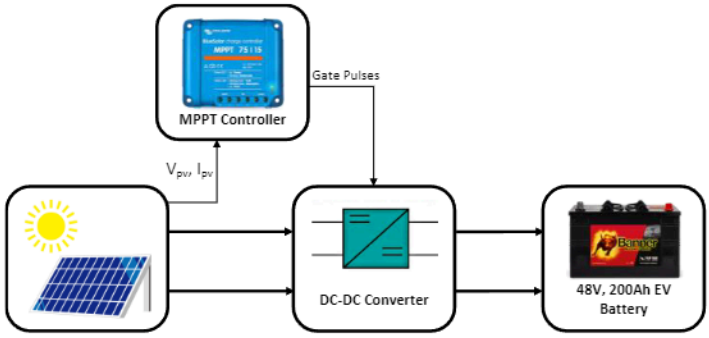


Fig 1: Block diagram of proposed system

Each DC-DC converter is driven by a gate signal, with the duty cycle of each converter being generated by the solar MPPT control. Here, P&O and incremental conductance control techniques are employed to maximise the energy from solar PV. P&O nudges the operating voltage up and down, searching for the peak value, while IC analyzes the slope to reach the summit directly. Both have their strengths, P&O is simple and cheap, while IC is faster and more accurate, especially under shifting sunlight [3].

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II. MODELLING AND DESIGNING

A. Solar PV Specifications & MPPT Techniques

The MATLAB/Simulink Solar PV system was developed to charge EV battery with specifications of 48V, 200Ah through DC-DC Converters with a constant irradiance of 1000W/m2 and temperature of 25oC and the PV system is designed with MPPT to achieve a maximum power of 2002.32W. Each module in the simulated PV system consists of 60cells. The PV system is designed to have 8 parallel modules. The PV module design parameters are represented in the Table 1 below [4].

Table 1: Solar PV Module Specifications at STC

Parameter	Specification
Voltage at MPP (V_{MPP})	30.9 V
Current at MPP (I_{MPP})	8.1 A
Power at MPP (P_{MPP})	250.29 W
Open Circuit Voltage (V_{OC})	36.6 V
Short Circuit Current (I_{SC})	8.75 A

B. Design of ZETA Converter

The ZETA converter architecture transforms an input voltage that fluctuates above and below the output value into a positive output voltage. The ZETA converter is set up to operate on a high-side P-MOSFET through a buck controller. The ZETA converter is another option for regulating an unregulated input-power supply. Using linked inductor optimizes the board space. The schematic of ZETA converter with a linked inductor operating in continuous mode (CM) is shown in Fig. 2 below [5-8].

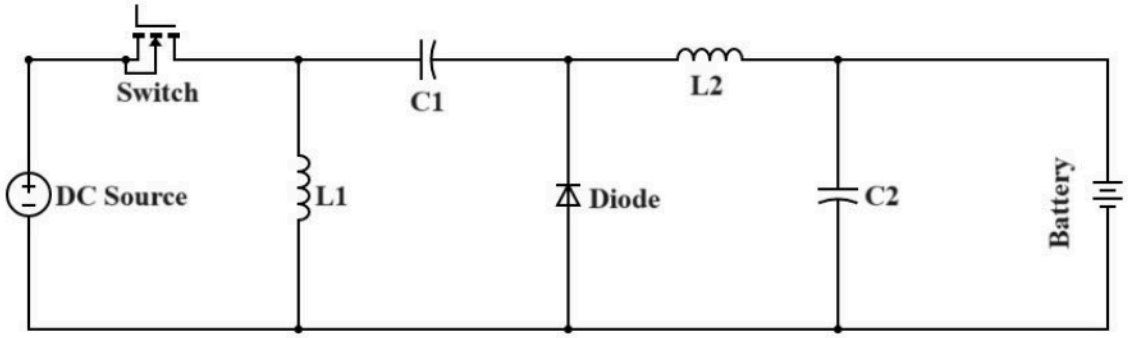


Fig.2: Schematic of Zeta Converter

When a ZETA converter runs in CM, its duty cycle (D) is given by

$$Duty\ Cycle\ (D) = \frac{V_{Out}}{V_{Out} + V_{In}}$$

The input current is given by

$$Input\ Current\ (I_{in}) = \frac{Input\ Power}{V_{in}}$$

Designing a PWM switching regulator begins with determining the amount of inductor ripple current(ΔIL) to allow. While too little can lead to unstable PWM functioning, too much increases EMI. Assigning a value around 20% to 40% of the average input current is an appropriate rule of thumb. Applying 20% as an instance, the ripple current can be computed using the formula below.

$$Inductor\ Ripple\ Current\ (\Delta I_l) = 0.2 * I_{in}$$

The value of inductances can be calculated using the formula

$$L_1 = L_2 = \frac{1}{2} \times \frac{V_{in} \times D}{\Delta I_l \times F_s}$$

Considering the maximum allowable ripple to be 1%, the coupling capacitance can be calculated using the formula.

$$C_1 = \frac{I_{Out} \times D}{0.01 \times V_{Out} \times F_s}$$

Considering the maximum allowable output ripple to be 2%, the output capacitance can be calculated using the formula.

$$C_2 = \frac{D}{8 \times 0.02 \times V_{Out} \times F_s}$$

C. Design of SEPIC Converter

In contrast to its more basic predecessors, the SEPIC converter has an exclusive architecture that combines two capacitors and two inductors, giving it unparalleled versatility. Because of its ingenious layout, it can manage a wide range of input and output voltage combinations, which makes it perfect for battery-powered systems, solar energy harvesting, and even LED drivers. Operating a SEPIC converter in continuous conduction mode (CCM) minimizes energy loss and ripple, resulting in efficient and clean power supply. The schematic of a SEPIC converter can be seen in Fig.3 below [8-10].

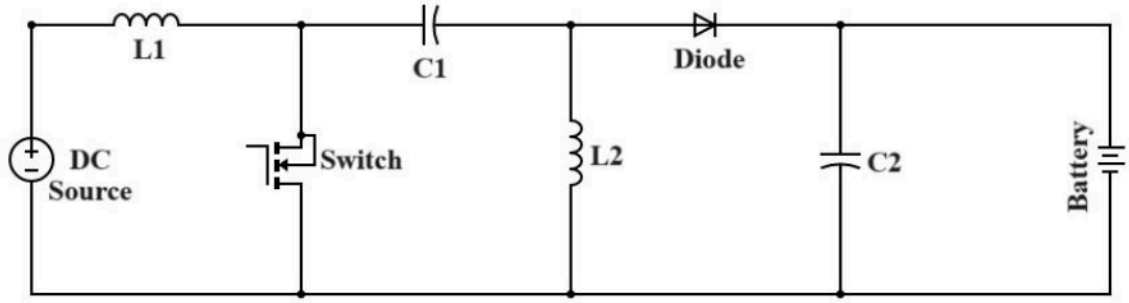


Fig. 3: Schematic of SEPIC Converter

When a SEPIC converter runs in CCM, its duty cycle (D) is given by

$$Duty\ Cycle\ (D) = \frac{V_{Out}}{V_{Out} + V_{In}}$$

The input current is given by

$$Input\ Current\ (I_{in}) = \frac{Input\ Power}{V_{In}}$$

Designing a PWM switching regulator begins with determining the amount of inductor ripple current(ΔIL) to allow. While too little can lead to unstable PWM functioning, too much increases EMI. Assigning a value around 20% to 40% of the average input current is an appropriate rule of thumb. Applying 20% as an instance, the ripple current can be computed using the formula below.

$$Inductor\ Ripple\ Current\ (\Delta I_l) = 0.2 * I_{in}$$

The value of inductances can be calculated using the formula

$$L_1 = L_2 = \frac{V_{In} \times D}{\Delta I_l \times F_s}$$

Considering the maximum allowable ripple to be 1%, the coupling capacitance can be calculated using the formula

$$C_1 = \frac{I_{Out} \times D}{0.01 \times V_{In} \times F_s}$$

Considering the maximum allowable output ripple to be 1%, the output capacitance can be calculated using the formula

$$C_2 = \frac{I_{Out} \times D}{0.01 \times V_{out} \times F_s}$$

III. SIMULATION AND RESULTS

An EV battery pack with a rating of 48V, 200Ah is charged through a 2kW PV source with ZETA & SEPIC converters are simulated in MATLAB/Simulink Environment. In simulation testing, the parameters such as voltage, current and Power from PV panel along with battery SoC, Charging current and battery voltage are observed at the same test conditions for both converters. The figures from 4 to 21 illustrates MATLAB/Simulink models, solar PV characteristics (i.e., Voltage, Current and Power), battery SoC, battery charging current and battery voltage of ZETA & SEPIC converters without MPPT, With P&O MPPT & Incremental conductance MPPT.

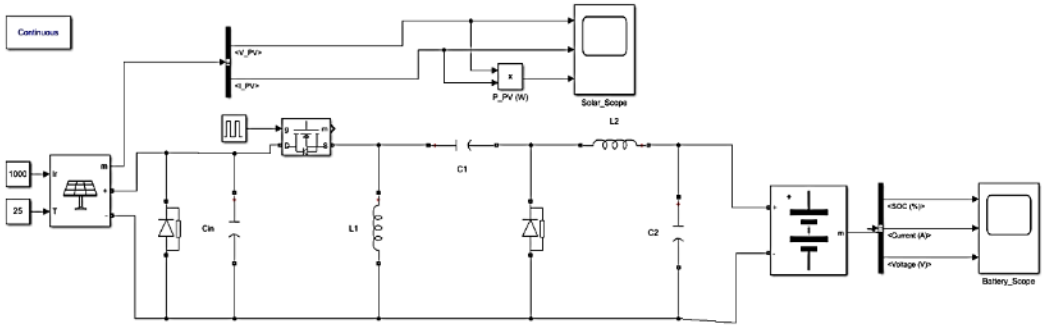


Fig.4: MATLAB/Simulink Model of ZETA converter without MPPT

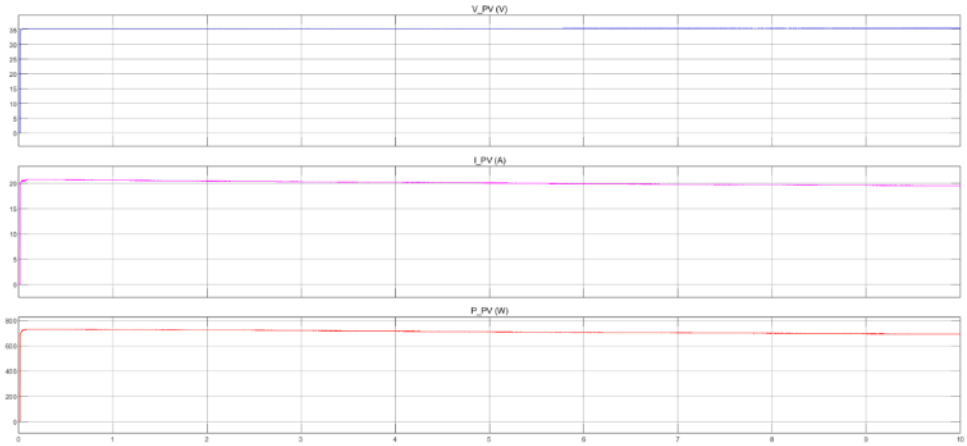


Fig. 5: PV characteristics results for zeta converter with out MPPT

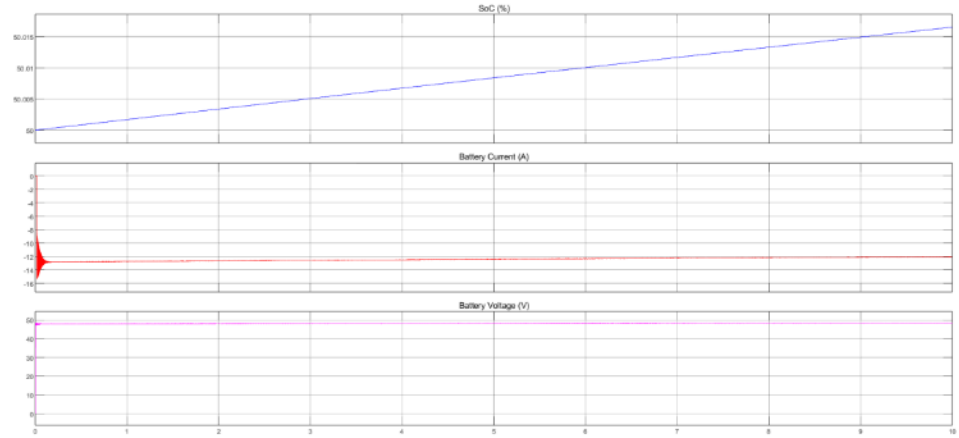


Fig. 6: Battery charging results for zeta converter with out MPPT

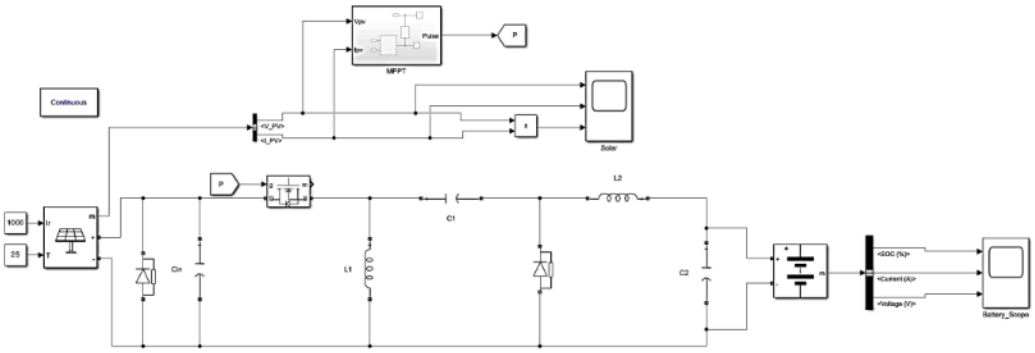


Fig 7: MATLAB/Simulink model of Zeta converter with P&O MPPT

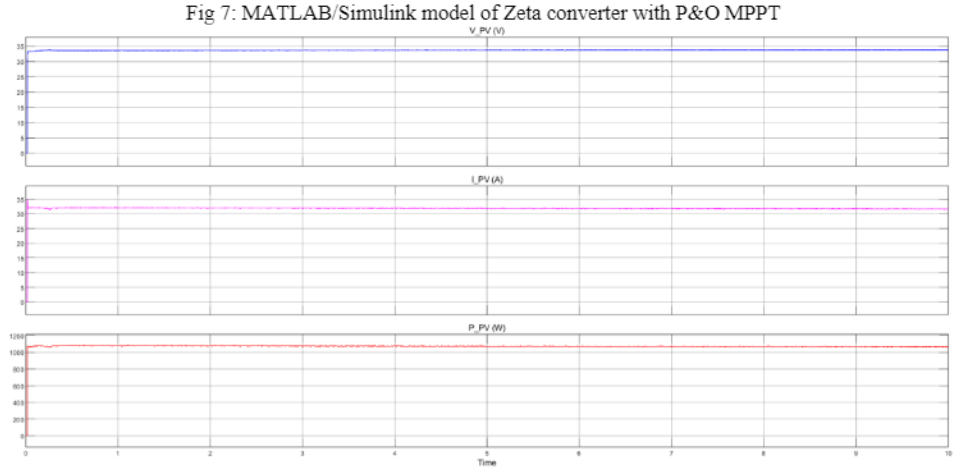


Fig. 8: PV characteristics results for Zeta converter with P&O MPPT

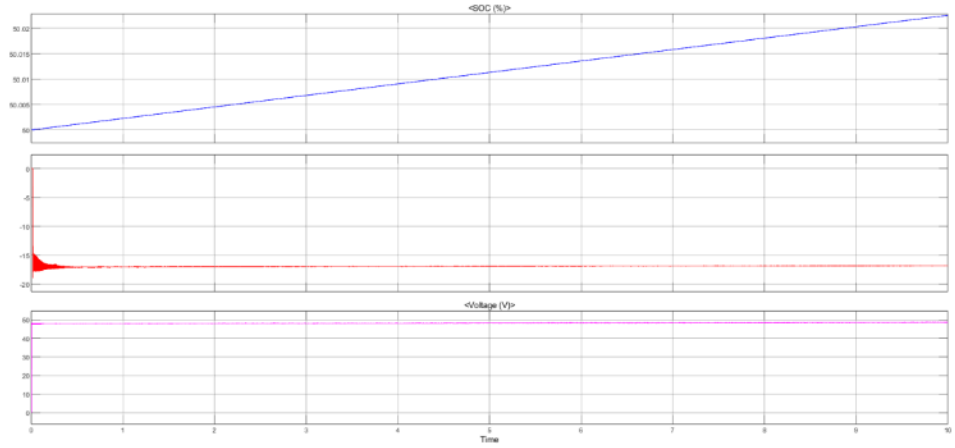


Fig. 9: Battery charging results for Zeta converter P&O MPPT

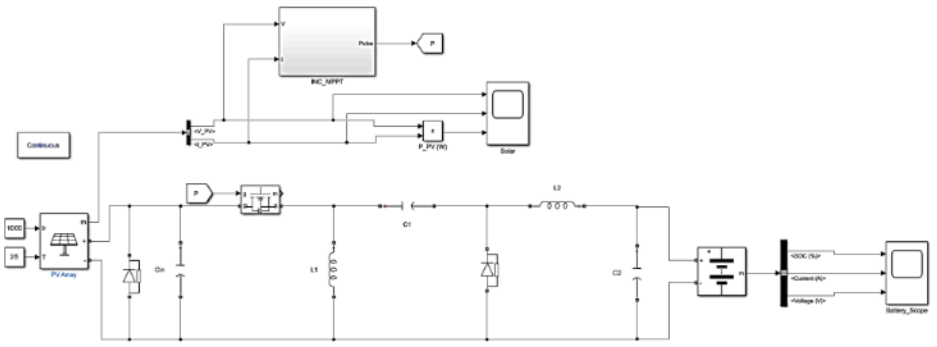


Fig. 10: MATLAB/Simulink model of Zeta converter with Incremental Conductance MPPT

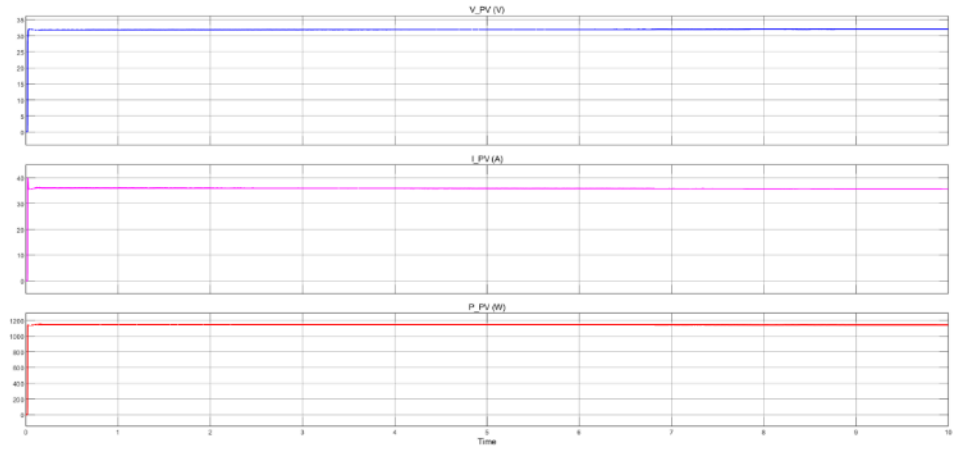


Fig. 11: PV characteristics results for Zeta converter with Incremental Conductance MPPT

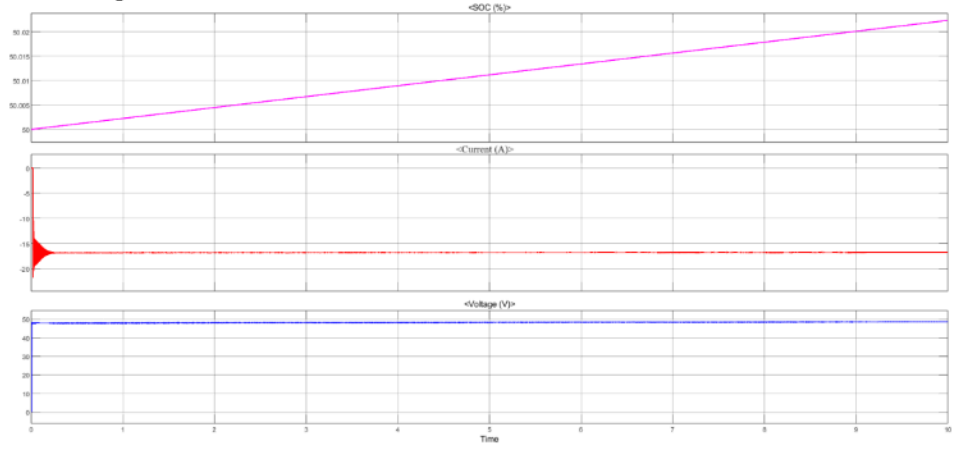


Fig. 12: Battery charging results for Zeta converter Incremental Conductance MPPT

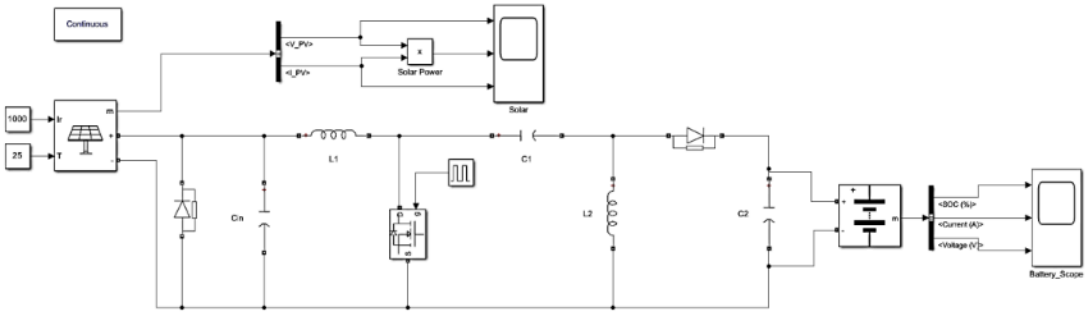


Fig. 13 : MATLAB/Simulink model of SEPIC converter without MPPT

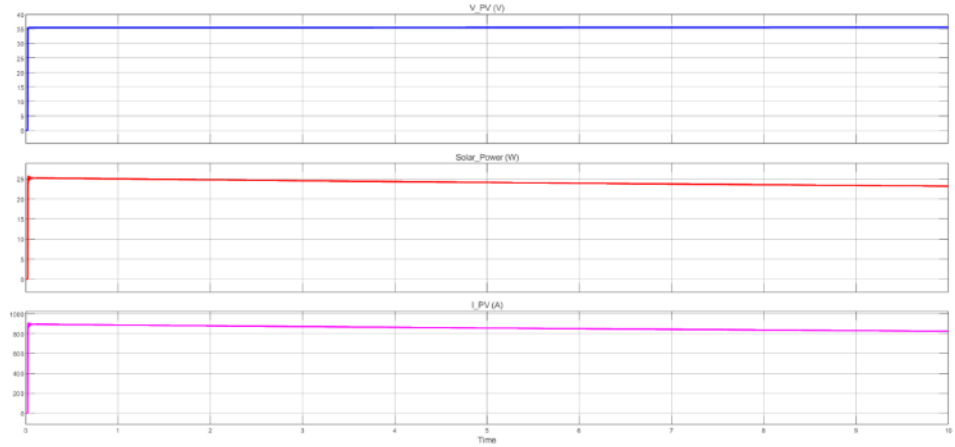


Fig. 14: PV characteristics results for SEPIC converter without MPPT

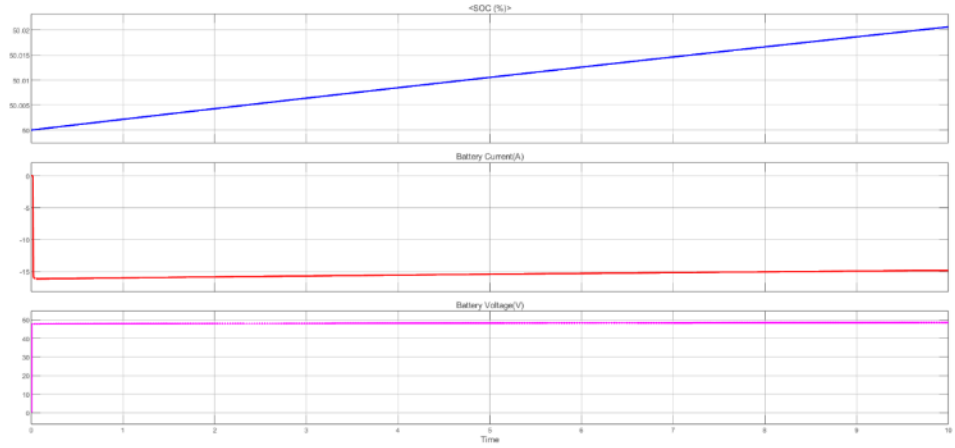


Fig. 15: Battery charging results for SEPIC converter without MPPT

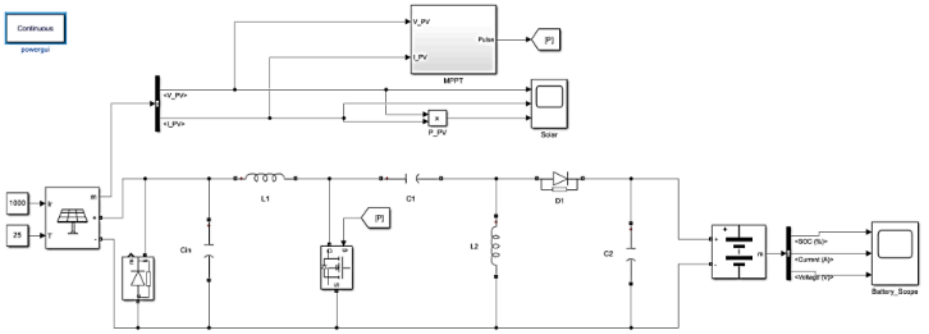


Fig. 16: MATLAB/Simulink model of SEPIC converter with P&O MPPT

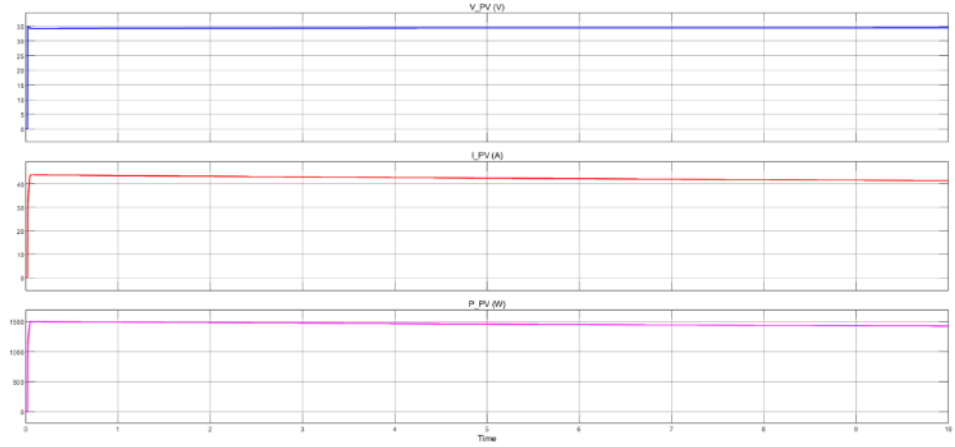


Fig. 17: PV characteristics results for SEPIC converter with P&O MPPT

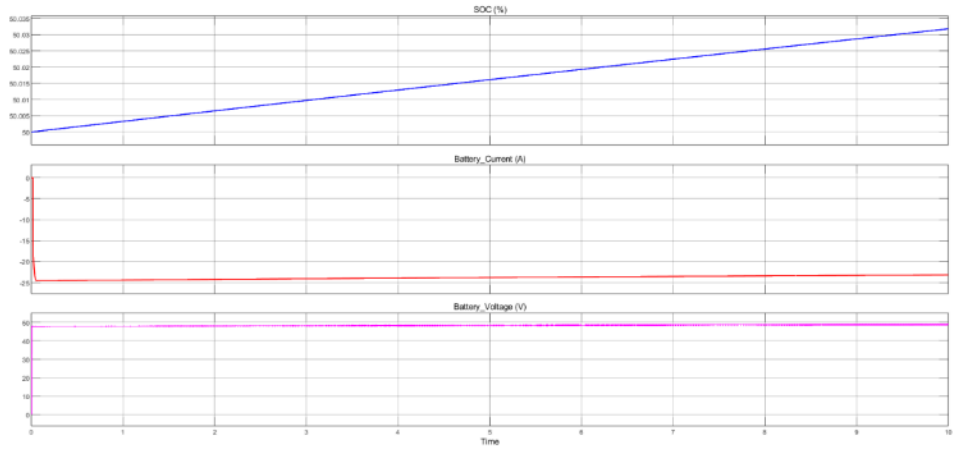


Fig. 18: Battery charging results for SEPIC converter P&O MPPT

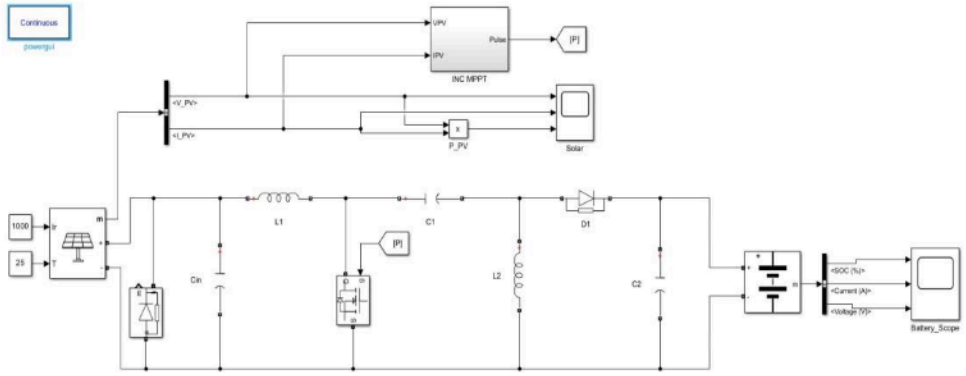


Fig.19: MATLAB/Simulink model of SEPIC converter with Incremental Conductance MPPT

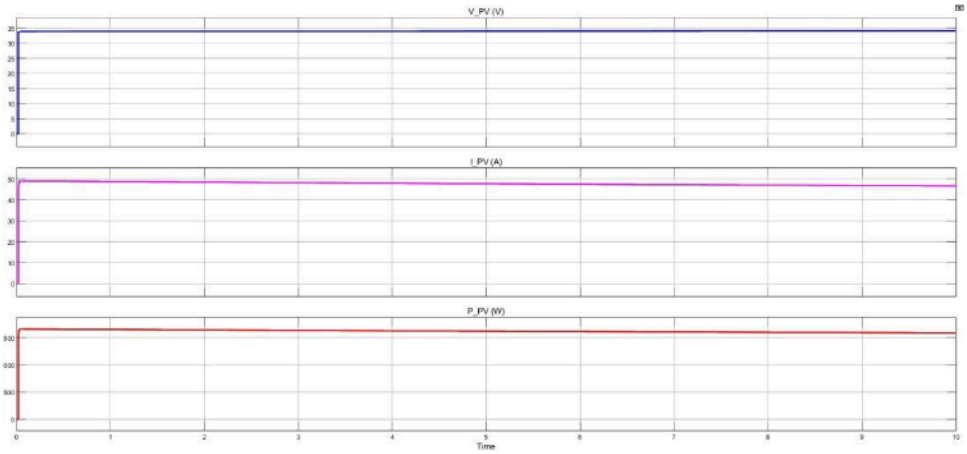


Fig. 20: PV characteristics results for SEPIC converter with Incremental Conductance MPPT

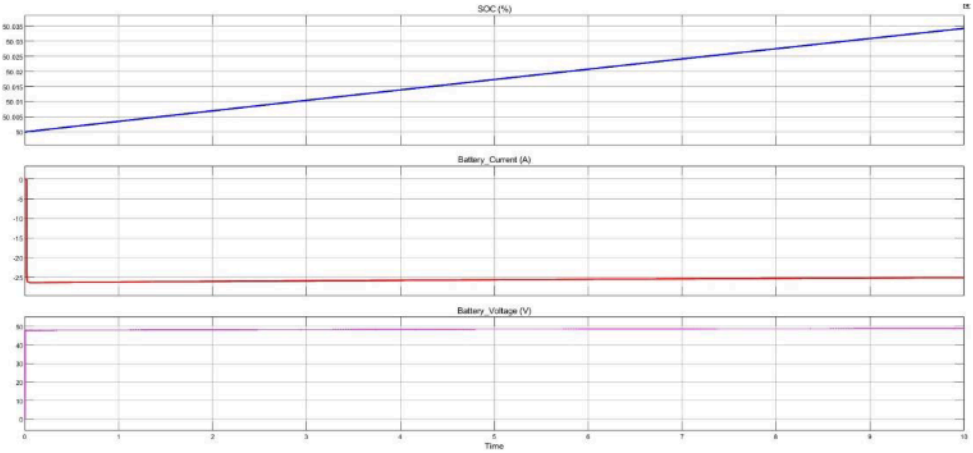


Fig. 21: Battery charging results for SEPIC converter Incremental Conductance MPPT

The results of PV fed EV charging system through Zeta and SEPIC converters under same test conditions with and without MPPT approaches are illustrated in the table 2. The value of battery current is negative which denotes that the battery is in charging state.

Table 2: Simulation results with SoC of 50% and simulation time of 10sec

Parameter	**Zeta Converter**			**SEPIC Converter**		
	Without MPPT	With P&O MPPT	With INC MPPT	Without MPPT	With P&O MPPT	With INC MPPT
SoC (%)	50.02	50.024	50.025	50.02	50.03	50.035

V_b (V)	48.32	48.51	48.51	48.52	48.93	49.01
I_b (A)	-12.03	-16.56	-16.85	-14.84	-23.2	-25.1
V_{pv} (V)	35.46	34.12	32.38	35.59	34.47	34.05
I_{pv} (A)	19.41	30.4	35.08	23.16	41.37	46.6
P_{pv} (W)	688.4	1035	1136	824.2	1426	1587

IV. CONCLUSIONS

A comparative performance analysis of PV fed EV charging system using ZETA and SEPIC converter topologies without and with MPPT techniques is simulated in MATLAB/ Simulink environment and the findings are evaluated. From the simulation findings, it is observed that the current delivered by SEPIC is more when compared to Zeta, and thereby a swift increase in the battery's state of charge. The time taken for charging a battery using the ZETA/SEPIC converter without MPPT is approximately 6.94Hrs. With P&O MPPT ZETA requires 5.78Hrs while SEPIC requires 4.63Hrs and finally with Incremental conductance MPPT Zeta still needs 5.5Hrs while SEPIC requires only 3.97Hrs. This illustrates that the charging is faster in the case of the SEPIC converter compared to the ZETA converter. Therefore with solar Power input, the SEPIC converter is more effective in charging the EV battery when compared to Zeta.

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Date 29.2.24

Appreciation Certificate

This is to appreciate Dr. S. ARUNA JYOTHY., ASSOCIATE PROFESSOR
SVUCE TIRUPATHI
NSS COORDINATOR for organizing Voluntary blood donation camp on 29-02-2024
and helping to collect 25 of precious blood to our Govt. Maternity Hospital Blood Bank. We are very much thankful to you and blood donors and we expect the same co-operation in future also.

DONATE BLOOD SAVE LIFE

29/2

Superintendent
Govt. Maternity Hospital,
TIRUPATI.

Semiconductor Optoelectronics, *Vol. 42 No. 1 (2023), 1279-1287*
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A STUDY ON MECHANICAL AND DURABILITY PROPERTIES OF CONCRETE WITH RICE STRAW ASH

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Abstract:

Concrete is a ubiquitous construction material that is used extensively for various applications. However, the manufacturing of cement, primary constituent in concrete is associated with significant environmental impacts, including carbon emissions, energy consumption, and depletion of natural resources. One such sustainable alternative to cement is Rice Straw Ash (RSA), which is a product obtained on burning of rice straw. RSA has been found to have pozzolanic properties, which means that it can react with calcium hydroxide to form additional binding compounds in concrete. This property makes RSA a potential replacement for cement in concrete production. The study will focus on evaluating the compressive strength of concretewhen RSA used for partial replacement of cement. The study will also investigate the influence of RSA on the workability, durability (water absorption and RCPT). Finally In our experimental study we got the following variation of percentage when compare to control concrete. The chloride permeability is very low at replacement of 10%, 15% when compare to normal (control concrete) and 5% replacement. So, finally from the present observation we can conclude that 10% replacement of cement by RSA can be suggested as the best replacement based on mechanical, workability and durability aspects.

Keywords: Chloride Permeability, Concrete, Rice Straw Ash, Strength, Water absorption

1. Introduction

The Concrete is a manmadesubstance used in construction extensively for various applications. The cement production is causing lot of environmental hazards. Therefore, sustainable alternatives to cement in concrete production are sought. One such alternative is RSA, which is a material resulting after burning of rice straw. RSA has been found to have pozzolanic properties, which means that it can react with calcium hydroxide to form additional binding compounds in concrete. This project aims to investigate the use of RSA as an alternatematerial to cement in concrete. The study will focus on evaluating the mechanical, water absorptionand chloride penetrationproperties of concrete containing different proportions of RSA. The results of this study providedprecious intuitions into the possibility of using RSA in concrete. The findings of this study may provide a magnificent insight for the entire construction industry,

Experimental Investigation on Self-Compacting Concrete Reinforced with Fibers

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Abstract

Maintenance and life enhancement of buildings are crucial for infrastructure development. Concrete, composed of cement, aggregate, and water, is a composite material. However, plain concrete has limitations such as low elasticity, limited ductility, and susceptibility to cracking. Steel reinforcement is used to overcome these deficiencies and improve tensile strength. Micro cracks at the mortar-aggregate interface weaken plain concrete, leading to brittle fracture. The introduction of Self Compacting Concrete (SCC) has revolutionized the construction industry, offering improved properties. This study investigates the properties of fresh SCC and incorporates different fibers (glass, carbon, and basalt) at varying volume fractions. Remarkable improvements are observed in all properties of self-compacting concrete by adding fibers, with carbon FRSCC exhibiting the best performance in the hardened state. Basalt FRSCC follows, while glass FRSCC performs best in the fresh state. Basalt fiber is found to offer the best balance in terms of performance, dosage, and cost, enhancing the overall quality of self-compacting concrete.

Keywords: Fibrereinforcedconcrete,Self-compactingconcrete,Choppedglassfiber,Carbonfiber,Basaltfiber

1. Introduction

Self-compacting concrete (SCC) is a highly fluid and cohesive concrete mix that can flow and compact under its own weight without the need for external vibration. It is designed to improve workability, eliminate segregation, and ensure complete filling of formwork, even in congested reinforcement areas. SCC has gained significant attention in the construction

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A STUDY ON MECHANICAL PROPERTIES OF M40 GRADE CONCRETE WITH FOSROC ADMIXTURE

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Abstract:

The construction industry is consisting of unorganized companies working as subcontractors making significant contribution to national economy both by increased GDP as well as in providing employment. In construction sector there are three segments like real estate is combined with residential and commercial constructions.

In the construction industry, in the presence of concrete elements depending on work inherent nature of the infrastructure or capital formation industry, capital goods are used directly and indirectly with all other types of resources.This study is aimed to find whether FOSROC admixture is suitable as usage of admixture in concrete mix, and whether FOSROC admixture results in providing durability to M40 grade concrete and to compare the compressive strength of conventional concrete sample with and without FOSROC admixture.

1. Introduction

Concrete is combination of material made from sand, gravel and cement. The cement is a mix of various minerals which when mixed with water, hydrate and roughly become strong binding the sand and gravel into a solid mass.

There are three basic components in the concrete mix:

- Portland cement
- Water
- Aggregates

The water and cement forms a paste that coats the aggregate and sand in the mix. The paste hardens and binds the both aggregate and sand together. Water is used to chemically react with the cement (hydration) and to produce workability in the concrete. The amount of cement is compared with the amount of water in the mix in pounds is called the water/cement ratio.

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AN EXPERIMENTAL INVESTIGATION ON POLYPROPYLENE FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH ALCCOFINE

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ABSTRACT: *In this experimental investigation an attempt was made to study the feasibility and effectiveness of integrating Alccofine as a supplementary material in Polypropylene Fiber Reinforced Concrete of grade M25. Various concrete mixes with Alccofine substitution (5%, 10%, and 15%) were examined to determine the optimal percentage. The addition of Polypropylene fibers to concrete at 0.1%, 0.2%, 0.3%, and 0.4% by weight of concrete were prepared to determine the optimum dosage of Polypropylene fibres in concrete which is replaced with optimum Alccofine percentage. These fibers help control cracking from plastic and drying shrinkage, reduce concrete permeability, and enhance impact strength. Addition of Polypropylene fibres transforms the material from brittle to ductile. The study includes determination of compressive strength, split tensile strength, flexural strength and impact characteristics. The findings reveal that a combination of 10% Alccofine substitution along with 0.3% Polypropylene fibers leads to notable enhancement 45.3%, 35.6%, 16.67%, and 191% in compressive, split tensile, flexural, and impact strength, respectively, compared to control concrete. Based on the results it can be concluded that the combination of 10% Alccofine and 0.3% Polypropylene fibers in concrete significantly improves both the strength properties and impact strength of the concrete in comparison to control concrete.*

Keywords: Polypropylene Fiber Reinforced concrete, Alccofine, impact characteristics, impact strength

1. Introduction

The modern construction constantly evolves to meet the demands of sustainable development and enhanced performance. Conventional concrete compositions often rely heavily on Portland cement, a material associated with significant carbon emissions during its production. To address environmental concerns and improve concrete properties, innovative solutions such as Alccofine as partial replacement for cement offers multifaceted benefits. By reducing the cement content, these materials help lower carbon emissions associated with concrete production, aligning with sustainability objectives. Moreover, to enhance the mechanical properties and Impact characteristics of concrete, resulting in structures that exhibit superior performance and longevity. Polypropylene fibers, derived from a thermoplastic polymer, is increasingly recognized for its ability to enhance the impact strength of concrete. When dispersed within the concrete matrix, these fibers act as reinforcement, improving tensile strength, crack resistance, and Impact characteristics. Additionally, Polypropylene fibers mitigate plastic shrinkage cracking and improve Impact strength, making them invaluable in various construction applications. Alccofine, a supplementary cementitious material, offers a sustainable alternative to conventional cement. Produced from finely ground aluminosilicate materials, Alccofine possesses pozzolanic properties that react with calcium hydroxide forming additional calcium silicate hydrate (C-S-H) gel. This reaction not only contributes to the densification of the concrete matrix but also enhances long-term strength of the concrete. Furthermore, Alccofine reduces the heat of hydration and mitigates alkali-silica reaction, thus improving the overall sustainability and performance of concrete structures. In this investigation the effects of incorporating Polypropylene fibers and Alccofine

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An Experimental Investigation on Steel Fiber Reinforced Self-Compacting Concrete Using Alccofine and Granite Powder

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ABSTARCT: *"The requirement for self-compacting concrete(SCC) in the construction area is increasing due to its benefits, such as easy finishing, excellent flow even in dense reinforcement, and enhanced structural integrity. In this experimental study, the binding materials are Ordinary Portland Cement (OPC), Alccofine-1203, and Granite Powder (GP). The mineral admixture of Alccofine-1203 helps to avoid segregation and bleeding while increasing workability. Granite powder (GP) is chosen as a suitable cement replacement due to its high silica content. To study the fresh and hardened properties of M30 Grade self-compacting concrete, the binder content is fixed at 500 kg/m³, with 70% OPC, 12% Alccofine-1203, and 18% GP. Furthermore, crimped steel fibers (CSF) are added at 1%, 2%, 3%, 4%, and 5% by the weight of binder content to improve the flexural strength of hardened concrete. The water-to-binder ratio is 0.4 for all the SCC mixes. The workability tests on SCC are performed according to the EFNARC 2005 Guidelines by Slump flow test (Diameter and T_{500}), V-funnel, and L-Box. The mechanical properties of SCC studied include compressive, split tensile, flexural strength, and modulus of elasticity. Based on the test results, it can be observed the improved strength properties."*

Key words: Self-compacting concrete (SCC), Alccofine-1203, Granite powder, Crimped steel fibers, Mechanical properties

1. Introduction

Self-compacting concrete (SCC) is a special type of concrete that can settle into heavily reinforced, deep, and narrow sections by its own weight. It can consolidate itself without necessitating internal or external vibration while maintaining stability without leading to segregation and bleeding. SCC demands a large amount of powder content compared to conventional vibrated concrete to produce a homogeneous and cohesive mix. One of the disadvantages of SCC is its cost, which is associated with the use of chemical admixtures. One alternative to reduce the cost of SCC is the use of mineral additives such as limestone powder, Alccofine-1203, natural pozzolans, fly ash, slag, and granite powder, which are finely divided materials. Granite stone is one of the most commonly used building materials, leading to a high amount of waste, amounting to almost 50% of the volume of the final granite products, throughout its processing and extraction. Granite waste has accumulated over the years, with only negligible amounts being used, while the rest is dumped, resulting in environmental problems. As these mineral additives replace part of the Portland cement, the cost of SCC will be reduced, especially if the mineral additive is an industrial by-product or waste. Therefore, the use of these types of mineral additives in SCC will not only decrease the cost but also increase its long-term performance.

In this present experimental investigation, the self-compacting concrete achieved using Ordinary Portland cement, Alccofine-1203, Granite Powder, and a dosage of Chemical Admixture. In this study, the PCE-based superplasticizer BUILDPLAST-SP200(M) is used to achieve self-compacting concrete, with the dosage of chemical admixture set at 1.3% by weight of binder content, using a trial method in which the water-to-binder ratio is maintained constant at 0.4. Alccofine-1203 enhances the workability of concrete by acting as a micro-filler, reducing the water demand without

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An Experimental Investigation on Glass Fiber Concrete by Partial Replacement of Cement with Alccofine

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Abstract: Concrete is the most widely used construction material due to its strength, durability, and versatility. However, the production of cement, which is a key component of concrete, is a major contributor to greenhouse gas emission. The use of supplementary Cementitious materials (SCMs) can improve the properties of concrete, reduce use on natural resources and CO_2 emissions. The present study is directed to investigate the effect of Alccofine-1203 (AL) as partial replacement of cement on Glass Fibers (GF) reinforced M30 grade concrete. Different types of concrete mixes were prepared by replacing cement with Alccofine-1203 of 5%, 10% and 15%, respectively, then it is found to be the optimum percentage of replacement of cement with Alccofine-1203 is 10%. Further, the effect of Alccofine and Glass Fiber with different combinations, such as, 10%AL+0.1%GF, 10%AL+0.2%GF, and 10%AL+0.3%GF was also carried out. Based on the test results of Mechanical properties of concrete the optimum dosage is found to be 10% AL and 0.2% GF.

Keywords: Alccofine-1203, Glass fibre, Compressive strength, Split tensile strength, Flexural strength, Modulus of Elasticity .

1. INTRODUCTION

Cement is the most prevalent kind of concrete binder. At present sustainable development of the cement and concrete industry requires the utilization of industrial and agricultural by-products. At present, for a variety of reasons, the concrete construction industry is not sustainable. It consumes huge quantities of virgin materials and the principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. So, finding a solution to substitute for part of the cement seems to be desirable for sustainable development. In the present investigation applications ofAlccofine-1203 as partial replacement of Cement for the Glass fibers reinforced concrete is adopted.

OBJECTIVES

The main objective of the present experimental investigation is to obtain the influence of Alccofine-1203 and Glass fibre on various Mechanical properties of M30 grade concrete.

It consists of following:

- To find out optimum replacement percentage of Alccofine-1203 .
- To determine the mechanical properties such as Compressive Strength, Split Tensile Strength, Flexural Strength and Modulus of elasticity of concrete prepared using alccofine-1203 and Glass fibers and to compare with conventional concrete.

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BUILDING INFORMATION MODELLING OF AN EARTHQUAKE RESISTANT STRUCTURE

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ABSTRACT

Constructing a structure that minimizes earthquake damage can be challenging due to the unpredictable nature of seismic events, making it seem impractical. However, this study focuses on developing earthquake-resistant structure by incorporating Building Information Modelling (BIM) in the design and detailing process. The primary focus is on a G+5 apartment building designed to withstand seismic forces and prioritize occupant safety during earthquakes. BIM technology, using software such as Revit, ETABS, SAFE, SketchUp, AutoCAD, etc., is employed to enhance the structural design. Starting with creating a detailed architectural plan for the G+5 structure and rendered different architectural 3d views by creating models in Blender software. Then the detailed seismic analysis and design is done in ETABS & SAFE as per seismic design code (IS:1893-2016). BIM tools generate a dynamic 3D model, facilitating the visualization and simulation of seismic responses. The project encompasses comprehensive Structural, Architectural, and MEP (Mechanical-Electrical-Plumbing) BIM. The BIM model serves as a central information repository, allowing for precise quantity take-offs and cost assessments. The study's outcomes contribute significantly to the advancement of earthquake-resistant building design, highlighting the efficiency of BIM in optimizing structural performance and cost-effectiveness. These findings hold relevance for professionals in structural engineering, architecture, and construction management, underscoring the pivotal role of integrating BIM in earthquake-resistant designs. Furthermore, the detailed cost estimation for the entire G+5 building is also included.

Keywords: Building Information Modelling (BIM), seismic resilience, G+5 apartment building, earthquake-resistant structure, cost estimation, architectural, MEP BIM.

I. INTRODUCTION

1.1 General

Designing earthquake-resistant structures is crucial in civil engineering, particularly in earthquake-prone areas. Building design must consider hindrances to earthquake forces and ensure adequate support to prevent collapse. In this G+5 project, advanced BIM tools like AutoCAD, ETABS, Revit, and SAFE are employed. These tools help as digital assistants, enhance the design process, provide detailed information, and optimize the building's resilience to both routine and seismic challenges.

In India the earthquake prone area is divided into 4 zones based upon their vulnerability to earthquakes. So, for designing any type of structure in these zones, there are some design codes (see in 1.2). Following these codes will ensure that our constructions are not only safe but also capable of withstanding earthquakes.

Design Guidelines: Structural designers must adhere to key standards for earthquake-resistant design:

- IS 1893: 2016: Criteria for Earthquake Resistant Design.
- IS 13920: 1993: Ductile Detailing of Reinforced Concrete Structures subjected to seismic forces.
- IS: 456-2000: Indian Standard Plain Reinforced Concrete Code of Practice (Fourth Revision).
- IS 875 (Part 1-5): 1987: Code of Practice for Design Loads (excluding earthquake) for Buildings and Structures (Second Revision), encompassing dead loads, live loads, wind loads, snow loads, and special loads.

These streamlined guidelines ensure structures are resilient to seismic challenges in their respective zones, promoting safety and structural integrity.

3.4.6 →1

Title: Experimental study on flexural Stength of Slurry Infiltrated fibrous Concrete (SIFCON) Bduced with various percentages of waste steel fibers recovered from used tires.

Book title: E3S Web of Conferences / International / 2024 / SVU

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AN EXPERIMENTAL PERFORMANCE OF STONE COLUMNS FILLED WITH REPURPOSING MATERIALS

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ABSTARCT:

Soft soil is a worldwide issue that has caused substantial issues for Geotechnical engineers. Engineers have been endeavoring to improve the engineering characteristics of substandard soils owing to their detrimental effects on project efficacy. The utilization of stone columns for enhancing the bearing capacity and settling characteristics of soft soils has gained significant recognition and popularity due to its demonstrated effectiveness. Utilizing waste materials in civil engineering projects presents a dual advantage of promoting environmental sustainability and yielding economic benefits. Used scrap tyres and crushed bricks are two examples of waste items that have a useful purpose in civil engineering. This study describes the findings of load tests conducted in a laboratory setting on a scaled-down tank model with dimensions of 500 mm in length and 300 mm in diameter. The tank was supported by a stone column with a diameter of 50 mm. Aggregates, tyre chips, and crushed brick obtained from the local vicinity of Tirupati are utilized in our application. The load-bearing ability of the soil was seen to enhance subsequent to the introduction of these fill materials. The load carrying capacity of a clay bed has been enhanced by 40% to 110% through the construction of stone columns using aggregates, tyre chips, and crushed brick, with aspect ratios (L/D) of 5 and 8.

Key words: Stone column, Aggregates, Tyre chips, Crushed brick,

1.0. INTRODUCTION:

The global problem of soil softness has posed considerable challenges for geotechnical engineers. Engineers often encounter a prevalent challenge while constructing structures on or with soils, namely the insufficient strength of the soils to sustain the stresses exerted upon them, both during the construction phase and throughout the operational lifespan of the facility. The soils in the majority of the region exhibit low strength and possess inadequate carrying capacity. Efforts have been undertaken to improve the engineering qualities of these soils in response to their subpar performance in the field of engineering. There exist various ways that can potentially improve the efficiency of low-quality soils. The selection of an appropriate method is influenced by factors such as soil type, soil properties, and the specific objectives and scope of the desired improvement. The adoption of ground improvement techniques has the potential to increase the geotechnical qualities of soil. Numerous techniques are available for enhancing soil quality. The methods employed are contingent upon the properties of the strata and the objectives of the augmentation. Stone columns are a soil reinforcement technique that entails the installation of a network of compacted stone columns. The utilization of this technique was initially observed in France around the 1830s, and its adoption beyond Europe did not gain significant traction until the 1950s. Stone columns, similar to other techniques employed for soil improvement, function to fortify the soil, consequently augmenting its

AN EXPERIMENTAL STUDY ON BULGING BEHAVIOUR OF RAMMED STONECOLUMNS

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Abstract:

Stone columns enhance the functionality of foundations in soft clays by lowering settlements and raising load bearing capacities. After being loaded, the top of a stone column, where the overburden pressures are lowest, bulges outward. The performance of stone column is greatly influenced by partial resistance of surrounding soil to lateral bulging of stone column. There is stiffer and stronger filler material around the column than the original soil. Load transfer due to lateral bulging is reported predominantly than due to end bearing at the column base and skin friction along the column soil interface. The stability of the soil around it plays a major role in determining the extent of bulging. The maximum weight that a stone column can support is directly proportional to its height. Longer stone columns, beyond a length of around 4D to 6D, are not expected to significantly improve capacity. This study aims to learn how the Consistency Index (I_C), length to diameter ratio (L/D) of stone column, soil's liquid limit (LL), and their interaction all affect with load-carrying capacity of a stone column when penetrating soft clays. The capacity for bearing capacity and resulting bulging of stone columns used as footings in soft clay beds. The impact of LL and I_C on column length will also be investigated. Furthermore, it is planned to develop and empirical equations to predict load carrying capacity of stone columns and the extent of bulging, taking into account all of Relative effect of each of three factors, namely LL, I_C, and L/D, and their interaction effects on load carrying capacity, bulging length, and bulging width is quantified using principles of 2^3 factorial experimentation influencing factors, and validating the same with reported results.

Keywords Stone column, Liquid limit (LL), Consistency Index (I_C), length to diameter ratio (L/D), Factorial Experimentation

1.0. INTRODUCTION:

Whenever difficult sub soil conditions are encountered during the construction of a civil engineering structure, and the site cannot be changed, ground improvement becomes necessary. If weak soils are replaced with compacted vertical columns of stones, they may or may not completely penetrate the weak strata, but

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Behaviour of stone columns based on 2^4 factorial experiments with uniformly graded materials

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ABSTRACT

The Stone columns are one of the main strategies for enhancing the behavior of engineering properties of soft clays. Stone columns are well known as vertical columns or inclusions of compacted, densely crushed stone piercing delicate clays. On the one hand, it acts as a drainage surface to accelerate consolidation, and on the other, it acts as a reinforcement to improve permissible bearing pressure. In this research two set of stone column capacities were determine by simultaneously varying the Mean particle size (D_{50}), L/D ratio, Density Index (I_D) and Consistency Index (I_c) of the stone columns, laboratory tests. Over a two levels, each one follows a principle of 2^4 factorial experimentation that permits quantifying relative effects of each factor and effects of interaction between four factors. An experimental programming shows that there's a critical L/D ratio beyond which there is no encourage increment in ultimate capacity due to L/D ratio. A regression empirical model was established to predict a capacity of stone columns. It was found to be a function of I_c, I_D, and interaction between I_D and I_c, L/D ratio, D_{50}, interaction among the L/D ratio and I_c and interaction between D_{50} and I_c. The validity of all developed models is verified by using data from present study and the results of others from literature that was not utilized in the model development. These predictions are useful not only for design of stone columns but also for a research into reinforced stone columns.

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1. Introduction

The advancement of structures such as buildings, storage tanks, warehouses, earthen dams, etc., built on weak soils is prone to excessive settlement or stability problems. Soil enhancement may solve or mitigate the problems encountered. This technology was first used in France in the 1830s, and since the 1950s, it has become widely popular throughout Europe. Because of their granular nature, stone columns are preferable over sand drains, which provide additional shear strength to the enclosed soils. They stabilize soft soils such as soft clays, silt, and silty sand.

This technique has an advantage in progressing the soil properties underneath a structure (raft and depth) and reducing irregular settlement. Bulging and general shear failures are the two basic types of failure for stone columns under compressive stresses. It has been recorded that many academics have devised hypothetical ways to estimate a bearing capacity and fortified settlement with stone columns. Impact methods, such as falling weight, or Vibro methods, such as Vibro float, can compact the stone. For a stone column installation in cohesive soils, a Vibro-replacement method is broadly utilized [ ]. A comparative method is employed in soft, relatively impenetrable soils, as well borehole steadiness needs to be fixed in locales with high groundwater tables.

Munkfakh et al. studied the influence of Vibro replacement stone columns on the stability of an embankment that simulated the actual design of a wharf structure [ ]. Madhav and Thiruselvam investigated the impact of the installation method on granular pile-reinforced soil behavior [ ]. The influence of moisture content in soft clay and the effect of column slenderness ratio (L/D) on a single column was studied experimentally by Narasimha Rao et al [ ]. The work was continued (Rao et al., 1997) to study the effects on a group of columns consisting of 2, 3, and 4 columns in soft clay. Wood et al. conducted a model test to understand better the reaction mechanism of stone columns fortified clay beds

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