

Holistic Research Perspectives

Volume 11

KVJ. Prof. Dr. R. Ganesan

Holistic Research Perspectives

Vol. 11

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Clear roads will not teach you to handle hurdles only rugged road teaches you to overcome hurdles after then you will become Clear

- KW. Prof. Dr. R. Ganesan

Foreword

The development of any nation within this globe is possible only through the overall contribution of intellectual capital. The enhancement of knowledge resources is the need for the hour, and it can be achieved by focusing on potential research and periodical innovation both in academia and industry. Also, it is to be noted that only these resources are required to bring about overall socio-economic development. Moreover, advancements in globalization depend on the outcome of holistic research at different avenues viz. corporate / industry, incubation bureaus, more precisely in various domains within academia.

Therefore, the congregation of theoretical perspectives and practical inventions is indispensable to face future challenges. Also, this notion will facilitate enhancing the socio-economic sustenance and bring radical growth to society. Keeping these aspects in view, this edited book has included selective book chapters in sciences, engineering & technology, management, and arts & humanities to support integrated learning. In furtherance, 'NFED Publications' conveys to the publishing community that it is very much conscious and cautious about quality rather than quantity. The contributions made by each author are quite unique, as they adopt scientific approaches in presenting different kinds of book chapters (experimental, empirical, and conceptual) in this edited book.

I view this edited book, 'Holistic Research Perspectives – Vol.11' as one of the most significant resources in fostering impeccable information for knowledge enrichment.

I heartily appreciate the Chief Editor's conscientious efforts in organizing various authors from different states of India and compiling their research contributions in this edited book.

I am sure this edited book will enlighten the perspective of readers, researchers, academicians, and practitioners.

Sd/-

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Preface

Today, research has gained enormous significance and enhanced in all spheres to bring in a phenomenal change. Research is only recourse for continuous learning and prime cause in achieving overall development. Moreover, a country's development depends upon nurturing the potential across all sects thereby fostering the research momentum. Furthermore, such kind of research needs to focus more on societal, economic, and ergonomic aspects respectively. This is possible only through creating a strong scientific base and encouraging socio-technology innovations. In this context, intellectual capacity building becomes indispensable for promulgating the overall socio-economic development. Also, it is quite important to understand that research is an inseparable entity to bring in a holistic development of any nation across the globe.

This edited book titled 'Holistic Research Perspectives Vol.11' envisages in the mission of congregating research on sciences, engineering & technology, management, and arts & humanities for an effective socio-economic transformation in terms of upbringing the mankind. This edited book by itself is a learning platform for various fields of research, which brings in the required knowledge sharing. In furtherance, any scientific innovation is possible only through continuous research, which accounts for inclusive growth. The findings discussed in the book chapters provide research insights and exhibit new dimensions of research to address future challenges.

I sincerely thank all the chapter authors of this edited book for placing their genuine research contributions.

I am sure all the readers will benefit from this edited book.

Jai Hind!!!

Sd/-

KVJ. Prof. Dr. R. Ganesan
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Influence of Psychological Fitness on Flourishing Among Emerging Adults - An Empirical Study

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Abstract

Psychological fitness is a recent concept that involves a combination of qualities that allow individuals to progress and enhance themselves to their fullest potential. Those who are psychologically fit are believed to have the ability to grow, adjust, react, and empower themselves to achieve a successful alignment between themselves and society. Resilience, assertiveness, self-esteem, social competence, and critical thinking are essential elements of psychological fitness. Flourishing encompasses both hedonic and eudemonic well-being, which represents the most positive aspect of the mental health spectrum. The current research is a validating investigation that aims to offer an overview of psychological fitness and its key components, emphasizing their significance in fostering the flourishing among young adults. The results revealed that psychological fitness and its components have a significant relationship with Flourishing. Additionally, regression analysis indicated that approximately 32 percent of variance in the flourishing, which could be explained by resilience, assertiveness, sense of self, critical thinking, and social competence. The findings provide evidence that psychological fitness is an essential determinant of flourishing among emerging adults. Also, it has been concluded that the components of psychological fitness are important in predicting flourishing. Furthermore, these components play a crucial role in shaping individuals' overall well-being and success during the transition to adulthood.

Keywords: Flourishing, Emerging Adults, Mental Health, Psychological Fitness, Psychological Well-being.

Introduction

Psychology has traditionally been renowned for its therapeutic capabilities. Nevertheless, in recent years, psychology has demonstrated its value not only in understanding the workings of the brain and emotions, but also in fostering and sustaining personal habits that empower

individuals to manage their moods, feelings, thoughts, and actions. Seligman and Csikszentmihalyi (2000) proposed that positive psychology seeks to expand the field's emphasis from resolving life's negative aspects to highlight its positive aspects. The concept of well-being holds a central position in positive psychology, as emphasized by Marks and Shah (2004), asserts that well-being extends beyond mere happiness and in addition to experiencing satisfaction and happiness, it entails personal development, fulfillment, and making meaningful contributions to the community. The notion of psychological fitness encompasses a variety of attributes that empower individuals to enhance their personal growth and reach their utmost potential. It denotes the existence of particular factors within individuals that can be described as psychologically fit individuals. These individuals possess the capability to evolve, adjust, react, and enable themselves to achieve a harmonious alignment between their own well-being and society. Essential elements of psychological fitness include resilience, assertiveness, self-worth, social competency, and the ability to think critically.

Psychological fitness is a combination of qualities that enable individuals to grow and improve themselves to their highest potential. The key components of psychological fitness include resilience, assertiveness, sense of self, social competence, and critical thinking (Amritha Raj & Manikandan, 2024). These components play a crucial role in personal growth and well-being, enabling individuals to navigate through life's challenges, establish healthy relationships, and make informed decisions. It is important to recognize the significance of psychological fitness in fostering personal growth and well-being. According to Seligman (2011) flourishing refers to a state of mind that encompasses positive emotions, active involvement, healthy relationships, a sense of purpose, and notable achievements, leading to favorable outcomes in both personal and professional spheres. Flourishing encompasses the state of being content with one's life and possessing the capacity to embrace life's opportunities to the utmost extent (Chaves, 2021).

Literature Review

Psychological Fitness

Psychological fitness can be considered as a crucial factor in determining one's psychological well-being. Apart from its influence on mental health, psychological fitness is a remarkable personal characteristic that is shaped by the integrity of mental capacity, as suggested by Fowler and Christakis (2008). It holds immense significance in the daily lives of individuals, serving as a vital component of psychological wellness. The field of positive psychological research has devoted significant attention to the study of psychological fitness. Psychological fitness is not a fixed personality trait, but rather a dynamic process that individuals can actively develop and cultivate. It is not a matter of simply possessing or lacking this trait, but rather a journey towards achieving a state of flourishing and thriving. According to Doll (2022), whether someone is currently experiencing illness or wellness then they have the ability to enhance their psychological fitness by building internal resources that can help them better to navigate and cope with life's stressors. Also, just as physical fitness involves training our body to stay strong and healthy, psychological fitness focuses on conditioning our mind to be resilient, adaptable, and effective in dealing with various challenges that life presents.

Moreover, by adopting healthy habits and practices, individuals can develop the necessary mental strength and flexibility to navigate through life's ups and downs with greater ease and success (Doll, 2022).

Flourishing

The studies conducted by Witten et al. (2019), Uysal (2015) and Yildirim (2019) all focused on different aspects related to flourishing. The study conducted by Witten et al. highlighted a lack of empirical research on adolescent flourishing, emphasizing the need for more studies in this area. Also, Uysal's research among university students found a positive association between social competence and flourishing as well as a negative association between social competence and psychological vulnerability. The study also revealed that flourishing significantly mediated the relationship between social competence and psychological vulnerability. Moreover, Yildirim's study on Turkish adults showed that resilience fully mediated the impact of fear of happiness on flourishing and satisfaction with life. These studies collectively contribute to understanding the factors influencing flourishing in different populations and contexts. Flourishing, as a psychosocial model of well-being, encompasses various aspects of positive mental health. It involves feeling good, functioning effectively, and encompasses concepts such as high levels of psychological well-being, emotional well-being, and social well-being (Keyes, 2002). Additionally, it is considered a crucial element for positive human development (Huppert & So, 2013) as well as fulfillment and purpose in life (Seligman, 2011). Moreover, flourishing goes beyond the absence of mental health issues like anxiety and depression; it represents the opposite of such problems (Huppert & So, 2013).

Need & Significance

This study tries to substantiate the notion that the concept of psychological fitness plays a crucial role in individual flourishing. It is widely acknowledged that every individual aspires to experience a state of flourishing, which encompasses positive emotions, active engagement, healthy relationships, a sense of purpose, and noteworthy accomplishments, ultimately leading to favorable outcomes in both personal and professional domains. Therefore, to attain flourishing, individuals must prioritize their psychological well-being and ensure they are psychologically fit. The important focus of the study is to uncover the important pathways to flourishing.

Objectives

- To find out the influence of psychological fitness and its components on flourishing
- To find out the relative efficiency of assertiveness, resilience, social competence, sense of self and critical thinking (the components of psychological fitness) in predicting flourishing among emerging adults
- To develop a regression equation for predicting flourishing among emerging adults with the components of psychological fitness

Methodology

The study utilized purposive random sampling technique to draw 250 samples from the targeted group of emerging adults aged between 18 to 29 in various districts of Kerala. The participants consisted of 50 percent males and females respectively. In terms of religious affiliation, 65 percent identified as Hindus, 8 percent as Christians, and 26 percent as Muslims. Most participants were single (85.6 percent), with 14.4 percent being married. Additionally, 79 percent of the participants are students out of which 20 percent are employed. The study employed a descriptive research design to investigate the impact of psychological fitness on flourishing.

Scales Used

The study included two scales viz. Psychological Fitness Scale (PsyFit) and Flourishing Scale.

Psychological Fitness Scale (PsyFit): Psyfit scale was used to collect data on psychological fitness of the participants. PsyFit is a 22-item scale which measure five dimensions of psychological well-being, namely resilience, assertiveness, sense of self, critical thinking, and social competence. All items in the scale are positively scored, indicating that higher scores reflect higher levels of psychological fitness. The scale has been found to have good validity and reliability 0.88, indicating that it accurately measures the intended constructs (Amritha Raj & Manikandan, 2024).

Flourishing Scale: It is a ten-item scale in vernacular language (Malayalam). Each item is presented as a statement and is phrased positively. Participants are asked to rate their agreement with each statement on a 1-5 scale, with 1 representing significant disagreement and 5 representing strong agreement. The overall score on the scale ranges from 10 to 100, with higher scores indicating a more flourished. The reliability coefficient Alpha of the scale was found to be 0.84, indicating good internal consistency. The authors of the scale also claim that it has adequate face validity, suggesting that it measures what it intends to measure (Amritha Raj & Manikandan, 2024).

Personal Data Sheet: Personal data sheet is used to gather personal information such as sex, religion, family structure, marital status, and employment status of the participants.

Procedure

The investigators directly contacted the participants and requested their participation in the study. The participants were provided with information about the study's objectives and purpose and were asked to provide written consent. Once consent was obtained, the research instruments and personal data sheets were administered to the participants. Instructions to complete the research instruments were clearly given in each instrument. The doubts regarding answering the questions were clarified at the time of administration. It is after completion, the instruments were collected back and checked for omissions, incompleteness, etc. Then the

instruments have been scored as per the key given in the manual. Also, scoring the data has been entered into a spreadsheet for further statistical analysis.

Hypotheses

Null Hypothesis (H₀): Psychological fitness will not have any significant relationship with flourishing among emerging adults.

Hypothesis 1 (H₁): Psychological fitness will have any significant relationship with flourishing among emerging adults.

Null Hypothesis (H₀): Flourishing of emerging adults will not be predicted and show a significance with the components of psychological fitness.

Hypothesis 2 (H₂): Flourishing of emerging adults will be predicted and show a significance with the components of psychological fitness.

Data Analysis

Data analysis was performed by calculating Pearson’s correlation coefficient (r) and conducting regression analysis using Statistical Package for Social Sciences (SPSS).

Results & Interpretation

Results obtained through statistical analysis of the collected data are presented below. The first objective of the study is to examine whether there exists a significant correlation between psychological fitness and its components on flourishing. Thus, to achieve this, the researchers calculated the Pearson product moment correlation, and the results are presented in Table 1.

Results of Hypothesis (H₁)

Table 1: Correlation of Components of Psychological Fitness and Flourishing

Variables	Psychological Fitness	Assertiveness	Resilience	Sense of Self	Social Competence	Critical Thinking
Flourishing	.555**	.316**	.371**	.514**	.367**	.437**

** p < 0.01, Correlation is significant at the 0.01 level (2-tailed)

Table 1 indicates that all the components of psychological variables were having a positive significant correlation with flourishing. Assertiveness was found to be significant positive correlation with Flourishing scale (r = .316, p < .01), resilience (r = .371, p < .01), sense of self (r = .514, p < .01), Social competence (r = .367, p < .01) and critical thinking (r = .437, p < .01) and with overall psychological fitness (r = .555, p < .01). Hence, the alternative hypothesis (H₁) is accepted.

The current study also aims to predict the extent of psychological fitness on Flourishing. The regression analysis has been applied to measure the relationship between variables, which determine the strength of predictors, and forecast effects or trends.

Thus, by analyzing changes in the dependent variable in relation to changes in one or more explanatory variables, a regression model can provide valuable insights into the relationship between psychological fitness and Flourishing. Using the enter method to examine the impact of assertiveness, resilience, social competence, sense of self, and critical thinking on flourishing, which are the components of psychological fitness. The results of regression are presented in Table 2.

Results of Hypothesis (H₂)

Table 2: Statistical Characteristics of Regression

Index	R	R Square
Regression	.565	.320

The table presents the R Square, which serves as a measure of the regression model's ability to explain the variance in Flourishing. This value represents the percentage of variance in the Flourishing score that can be accounted for by the independent variables, namely assertiveness, resilience, social competence, sense of self, and critical thinking (the components of psychological fitness). The results revealed that the outcome, approximately 32% ($R^2 = 0.32$) of the changes in flourishing can be predicted by the psychological score.

Table 3: Summary of ANOVA

Index	Sum of Squares	df	Mean Square	F
Regression	2350.232	5	470.046	22.744**
Residual	5001.312	242	20.667	
Total	7351.544	247	-	

** $p < 0.01$

The findings from Table 3 indicate a significant association between psychological fitness and Flourishing, with a linear relationship observed at a 1% error level.

Table 4: Simultaneous Regression on Psychological Fitness Components and Flourishing

Index	B	Beta	't' value
Assertiveness	.048	.034	0.534
Resilience	.203	.121	1.889**
Sense of Self	.379	.296	4.052**
Critical Thinking	.329	.201	3.048**
Social Competence	.131	.067	1.472*

* $p < 0.05$; ** $p < 0.01$

The findings presented in table 4, it can be inferred that resilience, sense of self, critical thinking, and social competence play significant roles in predicting Flourishing. The R^2 value obtained for the regression model, which includes these predictors, is 0.32. This indicates that approximately 32 percent of the variability in Flourishing can be explained by the variables, assertiveness, resilience, sense of self, critical thinking, and social competence. Furthermore, the F-value obtained ($F= 22.75$, $p < .01$) suggests that this model is statistically significant and reliable in predicting Flourishing. Hence, the hypothesis (H_2) has been supported, and psychological fitness variable were reliable in predicting Flourishing.

Discussion

The study presented above has examined an empirical investigation: psychological fitness and its impact on Flourishing. Findings suggest a significant positive correlation between psychological fitness and flourishing as shown in Table 1. This implies that as the levels of psychological fitness and its components increase, the levels of flourishing also increase. It can be concluded that an improvement in psychological fitness and its various components will lead to an increase in the state of flourishing and vice versa. Also, the present results are consistent with findings of the studies conducted by Witten et al. (2019), Uysal (2015), and Yildirim (2019), which indicated a positive relationship between social competence, assertiveness, resilience, and flourishing.

The components of psychological fitness, including resilience, social competence, sense of self, and critical thinking, have been identified as significant predictors of flourishing among emerging adults. These factors play a vital role in shaping the overall well-being and success of individuals during this transitional phase of life. Also, by possessing a strong sense of self and the ability to think critically, emerging adults are better equipped to navigate the complexities and uncertainties they may encounter. Moreover, the development of social competence enables effective communication and positive interpersonal relationships, which in turn contribute to Flourishing.

Additionally, the presence of resilience allows emerging adults to bounce back from setbacks and challenges, fostering their ability to thrive and flourish. In conclusion, the integration of these psychological fitness components is instrumental in predicting Flourishing among emerging adults. The findings of the results are in line with the results obtained.

Huppert and So (2013) stated that flourishing is characterized by both feeling good and functioning effectively and is closely associated with a significant level of mental well-being. Moreover, based on the findings from the regression analysis, the relationship between flourishing and the various components of psychological fitness can be expressed as follows:

The flourishing score (Y_1) can be determined by the equation:

$$Y_1 = 8.476 + (0.121 X_1) + (0.296 X_2) + (0.201 X_3) + (0.067 X_4)$$

Where X_1 = Resilience, X_2 = Sense of Self, X_3 is Critical thinking X_4 is Social Competence. This equation indicated that for every unit of change in the flourishing score, 8.476 can be added to the score along with respective coefficients multiplied by the corresponding components of psychological fitness (resilience, sense of self, critical thinking, and social competence). The proposed hypotheses (H_1 & H_2) in this research study are accepted.

Limitations

There is a limited amount of research studies available on the variable psychological fitness, resulting in a scarcity of supporting articles to validate the findings. Also, this study marks a novel progression in the development of the psychological fitness concept. In furtherance, the studies with a greater number of participants are needed to generalize and make the concept clearer.

Suggestions

- The study is conducted with a limited sample size in this study. Consequently, future researchers may include larger sample sizes enabling a more comprehensive understanding and accurate data analysis.
- To align with the Indian context, future researchers may incorporate additional variables in the studies.
- The forthcoming research may prioritize the development of intervention strategies and a practical model aimed at enhancing psychological fitness with the ultimate objective of fostering mental health and overall wellness.

Conclusion

The study concludes that there is a positive correlation between the components of psychological fitness (such as assertiveness, resilience, social competence, sense of self, and critical thinking) and flourishing. Regression analysis further confirms resilience, sense of self, critical thinking, and social competence are significant predictors of Flourishing among emerging adults. The components of psychological fitness play a crucial role in shaping the overall well-being and success of individuals during this transitional phase of life. Thus, by possessing these qualities, emerging adults are better equipped to navigate challenges and uncertainties, communicate effectively, and build positive relationships, ultimately leading to Flourishing. In the current context, it is crucial to develop habits that promote well-being and prevent burnout. This is particularly important for emerging adults who are embarking on their careers and relationships, as this stage of life involves the development of one's sense of self and can be accompanied by increasing levels of stress. It is much easier to maintain habits that support well-being if we incorporate them into our daily routines early on rather than having to unlearn and establish new habits later in our professional lives. Moreover, one such habit is practicing psychological fitness, which can greatly enhance our well-being and contribute to a higher level of flourishing in both our personal and professional spheres.

References

- Amritha Raj, K., & Manikandan, K. (2024). Exploring the predictors of psychological fitness. *Unpublished Thesis*. University of Calicut: Kerala
- Chaves, C. (2021). Wellbeing and Flourishing. In: Kern, M. L., & Wehmeyer, M. L. (eds.) *The Palgrave Handbook of Positive Education*. Palgrave Macmillan, Cham, 273-295.
- Csikszentmihalyi, M. (2000). Happiness, flow, and economic equality. *American Psychologist*, 55(10), 1163-1164.
- Doll, K. (2022). *Building psychological fitness: How high performers achieve with ease*, Doll Consulting Services, LLC, India.
- Fowler, J. H., & Christakis, N. A. (2008) Dynamic spread of happiness in a large social network: Longitudinal analysis over 20 years in the Framingham heart study. *British Medical Journal*, 337, 1-9.
- Huppert, F. A., & So, T. T. C. (2013). Flourishing across Europe: Application of a new conceptual framework for defining well-being. *Social Indicators Research*, 110(3), 837–861.
- Keyes, C. (2002). The mental health continuum: From languishing to flourishing. *Journal of Health and Social Research*, 43(2), 207-222.
- Marks, N., & Shah, H. (2004). A well-being manifesto for a flourishing society. *Journal of Public Mental Health*, 3(4), 9-15.
- Seligman, M. E. P. (2011). *Flourish: A visionary new understanding of happiness and well-being*. New York: Free Press.
- Seligman, M. E. P., & Csikszentmihalyi, M., (2000). Positive psychology: An introduction. *American Psychologist*, 55(1), 5-14.
- Uysal, R. (2015). Social competence and psychological vulnerability: The mediating role of flourishing. *Psychological Reports*, 117(2), 554-565.
- Witten, H., Savahl, S., & Adams, S. (2019). Adolescent flourishing: A systematic review. *Cogent Psychology*, 6(1), 1640341.
- Yildirim, M. (2019). Mediating role of resilience in the relationships between fear of happiness and affect balance, satisfaction with life, and flourishing. *European Journal of Psychology*, 15(2), 183-198.

Webliography

<https://hbr.org/2023/02/use-the-science-of-flourishing-to-increase-your-well-being>
<https://nextbigideaclub.com/magazine/building-psychological-fitness-high-performers-achieve-ease-bookbite/40787/>
<https://positivepsychology.com/flourishing/>
<https://www.adam-eason.com/10-ways-to-build-psychological-fitness/>
<https://www.linkedin.com/pulse/psychological-fitness-unpacked-voula-tsoflias>
<https://www.psychreg.org/psychological-fitness-how-improve/>
<https://www.thepositivepsychologypeople.com/flourishing>

Revealing the Enterprise-Specific Characteristics Affecting Labour Productivity of the Unorganized Manufacturing Sector in India

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Abstract

The Unorganized Manufacturing Sector (UMS) in India is a significant constituent of the manufacturing sector in terms of employment generation and the number of enterprises. However, its low productivity level has dragged down the productivity of overall manufacturing sector. Moreover, by utilizing secondary data from the 67th and 73rd Round National Statistical Survey Organization, this study aims to examine the characteristics of an enterprise that are likely to affect Labour Productivity during 2010-11 and 2015-16. Accordingly, quantile regression analysis has been applied to determine the association between enterprise's characteristics, namely size, sector, registration status, social group of owners, ownership of enterprises, presence/absence of government assistance and problems, and labour productivity. Our results reveal that larger-size enterprises (NDMEs & DMEs) have a higher tendency to increase labour productivity, especially at lower quantiles. Enterprises located in the rural sector tend to have declining labour productivity. This can be due to the lower competency of workers, wherein the registration could enhance labour productivity. The units owned by SCs, OBCs, others and unknown have generally shown an increase in labour productivity than those owned by STs. Female-owned enterprises need more attention if they are to improve labour productivity. The labour productivity could not increase in the presence of government assistance. Generally, problems are likely to cause a reduction in labour productivity of unorganized manufacturing enterprises.

Keywords: Unorganized Manufacturing Sector (UMS), Labour Productivity, National Statistical Survey Organization, Quantile Regression Analysis, JEL Classification: J24; L00; L29; L60.

Introduction

A major proportion of the manufacturing sector in India is unorganized. Its contribution towards employment generation and number of units has been duly recognized in academics and realms of policy making. It is to be noted that between the periods 2004-05 and 2011-12 5.9 million employment have been created in the manufacturing sector out of which only 0.9 million belong to the formal sector (Uppal, 2016). Also, from 2010-11 to 2015-16 the total employment increased from about 3 crores 49 lakhs to 3 crores 60 lakhs in UMS (Dandapat et al. 2021). The number of enterprises in the UMS also grew from approximately 1 crore 70 lakhs to 2 crores during that same period. However, the rising population accompanied by a saturated organized sector has caused the Unorganized Manufacturing Sector (UMS) to grow at an unprecedented rate, a phenomenon witnessed in developing and emerging economies. Generally, the enterprises in the UMS operate with the use of simple tools/machinery along with low-skill labourers. The enterprises and workers operating in the unorganized sector face numerous challenges and issues (Apra, 2014a; Gupta, 2012; Singh & Jain, 2006). As such, there is every likelihood that the unorganized manufacturing enterprises would have lower productivity levels compared to the organized ones. Djinodou & McGregor (2022) noted that the informal segment has been dragging the productivity growth of the manufacturing sector in India. This resulted in the poor performance of the manufacturing sector in contrast to the service sector. This matter is a concern as its lower productivity is a huge drawback and loss not only for the UMS but also for the entire economy.

The available literature on the productivity of UMS has shed light on various aspects. Few observed the effect of liberalization on productivity in both informal and formal sectors (Nataraj, 2010; Mariappan, 2011). Some dealt with productivity across states (Gupta, 2012) while some focused on a particular state (Gupta, 2012; Saikia, 2015). Certain characteristics/features of enterprises have also been found to affect productivity. Smaller enterprises, especially the OAMEs, and enterprises located in the rural sector tend to have lower productivity (Gupta, 2012; Apra, 2014a; Uppal, 2016; Baruah, 2014; Saikia & Barman, 2017). Female-owned firms are being less productive in the unorganized sector (Ghani et al. 2013). Nevertheless, female-owned enterprises in the informal sector were growing faster than male-owned enterprises (Sasidharan & Raj, 2014). There has been a positive impact on labour productivity by registering with any act/authority except the Factory Act, of 1948 (Dandapat et al. 2021). Similarly, the absence of problems is effective in increasing labour productivity in the UMS. However, it can be noted that very few studies have taken up the task of examining productivity using both partial and total productivity (Apra, 2014b; Mariappan, 2011) and they are mostly confined at the state level (Apra, 2014b; Saikia, 2015; Baruah, 2014).

Clearly, our country with its huge labour force, which is mostly low and unskilled, would end up depending on the informal sector, be it manufacturing, construction or services. One approach to observing the performance of an enterprise is through its labour productivity. This study attempts to investigate the enterprise-specific characteristics which create an impact on the labour productivity in the UMS. The heterogeneity of enterprises in the UMS compels us to employ quantile regression instead of Ordinary Least Square (OLS) regression. An enterprise's labour productivity is considered as a dependent variable and its characteristics,

i.e., size, registration status, sector, social group of owners, ownership, presence/absence of government assistance and problems as the independent variables. The analysis has been carried out at five quantiles (10th, 25th, 50th, 75th and 90th), whereas higher quantiles represent higher levels of labour productivity. Furthermore, the analysis has been carried out at the national level with the help of disaggregated data. By understanding the significance of an enterprise's characteristics at various labour productivity levels, using quantile regression, it would become easier to identify approaches to enhance it.

Literature Review

The term 'informal' originated from the work of Hart (1973) who studied the migration of Frafas from Northern to the Southern part of Ghana searching for greater income opportunities in urban areas. In the Indian context, the 55th National Sample Survey Organization (NSSO) round has included 'all unincorporated enterprises operating as proprietary or partnerships in the informal sector' (NSSO, 2000). It has also come up with the term the unorganized sector inclusive of trusts, cooperative societies, and private and public limited companies. On the other hand, the National Commission for Enterprises in the Unorganized Sector (NCEUS, 2008), have used the terms organized/unorganized interchangeably with formal/informal. It defines the unorganized sector as '.... consisting of all unincorporated private enterprises owned by households or individuals, engaged in the sale and production of goods and services, and operated on a proprietary or partnership basis but up to nine total workers...'

Available literature suggests that the labour productivity of an enterprise is affected by its size i.e., the number of workers. According to Gupta (2012), the growth of labour productivity had declined for the smaller enterprises, i.e., Own Account Manufacturing Enterprises (OAMEs) and Non-Directory Manufacturing Establishments (NDMEs), during India's post-liberalization period. The opposite was for the Directory Manufacturing Establishments (DMEs) where the growth had been tremendous. It was also the smaller enterprises, i.e., OAMEs and NDMEs which had a declining growth rate of labour productivity. The small-scale rural enterprises of UMS in India have been a huge contributor towards employment generation though their average level of productivity (GVA per unit) was quite low from 1994-95 to 2011-12 (Uppal, 2016). In Punjab, the fall in total productivity and labour productivity was highest in OAMEs (Apra, 2014a). In terms of productivity, while DMEs were the fastest-growing enterprises, the OAMEs were the least. There is a positive relationship between the productivity of unorganized manufacturing enterprises and the size of the enterprise (Baruah, 2014).

Gupta (2012) noted a decline in the per annum labour productivity growth rate in the UMS of India which was mainly because of the rural enterprises from 1994-95 to 2000-01 to 2000-01 to 2005-06. In Assam, Majumdar (2012) observed that productivity per enterprise as well as labour productivity of the urban informal manufacturing sector was higher than the national level. However, the positive total factor productivity growth rate of the UIMS in Assam and the whole country has been an encouraging sign. In Assam, the GVA per enterprise had increased during the period 2000-01 up to 2010-11 and this was found to be more among urban enterprises (Baruah, 2014). Later, Saikia and Barman (2017) also found labour productivity in

Assam's rural UMS to be less than that in the urban sector. Moreover, growth of labour productivity was found to vary when comparing the rural and urban sectors and also considering only rural sector. Moreover, Deshpande and Sharma (2013) on examining the growth of firms from the perspective of social status, found that firms owned by SC, ST and OBC registered lower growth in the MSMEs sector when compared to firms owned by "others". Coad and Tamvada (2012) had earlier related the growth performance of enterprises to their productivity level such that high-productivity entrepreneurial firms grow faster whereas low-productivity survival ones grow slower. Hence, Deshpande and Sharma (2013) concluded in their study that the SC, ST, and OBC-owned units were more likely to be survivalist (with low productivity) than entrepreneurial (with high productivity). Moreover, the study is based on registered units which leaves the unregistered units, smaller units, and those of the informal in nature, outside the purview of their study.

In India, Gupta (2012) observed that the proportion of female workers has grown in own account enterprises and part-time jobs during the post-liberalization period in India. Ghani et al. (2013) in their study noted that women-owned businesses are typically smaller and less productive in contrast to male-owned ones in the unorganized sector. However, Deshpande and Sharma (2014) noted there is a strong and positive association between enterprises being owned and managed by females and their growth. Similarly, a study by Sasidharan and Raj (2014) noted that enterprises owned by women encountered smaller chances of falling growth than the ones owned by men in the informal sector in India. Also, they observed that enterprises with government assistance in the form of training and marketing were likely to have quicker growth than otherwise. Moreover, faster growth indicates higher productivity and vice versa among firms (Coad & Tamvada, 2012). Also, Dandapat et al. (2021) in their study on the UMEs in India observed that the average labour productivity has grown from the period 2010-11 to 2015-16. The marginal productivity of labour was also found to be higher than that of capital. Labour productivity has been positively related to enterprises which did not encounter any problems and registration of enterprises besides male ownership, own account enterprises, expanding status, and government assistance. However, linear regression has been used in the study without testing for heteroskedasticity and normality of the data.

Significance

It is very common to come across studies that have addressed the effects of liberalization and the size and sector of an enterprise on its productivity. But very few which have dealt with the impact of other characteristics of an enterprise such as registration status, social group of owners, ownership, existence of government assistance and problems on the same. The importance of size on productivity has been highlighted in numerous research, worldwide. Yet the other enterprise-specific characteristics do not find importance in the discussion of productivity, especially productivity in labour. This study is an attempt to investigate in detail how certain characteristics of an enterprise of the UMS, namely size, registration status, sector, social group of owners, ownership, presence/absence of government assistance and existence of problems in an enterprise can influence its labour productivity. To this end, the quantile regression technique on labour productivity has been used on disaggregated data across all States/UTs in India. Quantile regression would enable the detection of the effects of the

characteristics mentioned above (independent variables) at various levels of labour productivity (dependent variable). This would be a significant contribution to filling in the gap to recognize the plausible measures to improve productivity by considering the enterprises' characteristics.

Objective

To investigate the characteristics of enterprises in UMS, which are more or less likely to enhance their labour productivity

Methodology

This entire study is based on secondary data sources and adopted descriptive research design to explain the data. The research on Unorganized Manufacturing Sector (UMS) begins with categorizing the various types of enterprises, which usually differ in terms of size. According to the National Statistical Survey Organization (GOI, 2001), there are two categories of enterprises based on their sizes, i.e., Establishments and Own Account Enterprises (OAEs). An establishment is termed as an enterprise hiring at least one worker on a regular basis while as OAE is an enterprise without the help of any hired worker employed on a regular basis. In furtherance, establishments can be categorized into Non-Directory Establishments (NDEs) and Directory Establishments (DEs). A NDE employs less than six workers- hired and household - taken together, and a DE employs six or more workers -hired and household - taken together. For this study, only data on UMS i.e., Establishments like Directory Manufacturing Establishments (DMEs), Non-Directory Manufacturing Establishments (NDMEs) and OAMEs have been used. Moreover, the definition given by the NCEUS has been followed where only proprietary and partnership-owned enterprises, each with a total number of workers of an enterprise up to 9 have been taken into consideration.

Data

This study is based on data obtained from the National Sample Survey Organization (NSSO) surveys on the Unorganized Manufacturing Sector (UMS) in India. Unit-level data for two rounds i.e., 67th (July 2010 - June 2011) and 73rd (July 2015 - June 2016) has been used. In this context, in both rounds of the survey, the NSSO collected data on the 'Unincorporated Non-agricultural Enterprises (Except Construction)'. Moreover, by following the National Industrial Classification of 2008, wherein the researchers separated the data for manufacturing sector (which covered the production sectors with NIC codes 01632 and 10 – 33) from 'other unincorporated non-agricultural enterprises' data as available from unit-level data files of both rounds. Hence, the period of our study has been the years 2010-11 and 2015-16, which aligns with the data available from the survey.

Procedure for Analysing Productivity in UMS

In this study, labour productivity has been estimated for both the years 2010-11 and 2015-16. Labour productivity has been defined as a ratio of Gross Value Added to the total number

of workers. Appropriate deflation of the Gross Value Added (GVA) of the period 2015-16 had been applied using the Consumer Price Index (CPI) with 2010-11 as the base year.

Quantile Regression

To examine the effect of certain characteristics on a firm’s labour productivity, the Quantile Regression technique has been adopted. The quantile regression method, which was introduced by Koenker and Bassett (1978), is more robust to non-normal dependent variables with asymmetrical distributions and outliers. Accordingly, this method has been chosen for the study because of the nature of the data whereby the dependent variable, i.e. labour productivity is not normally distributed as seen in Figure 1, the distribution is skewed to the right. To enable us to apply Ordinary Least Square (OLS) regression it must be ensured that there is homoscedasticity. The Breusch - Pagan/Cook - Weisberg test has been carried out for this purpose. The result of the test is given in Table 1, where the null hypothesis of constant variance cannot be accepted, confirming the presence of heteroscedasticity.

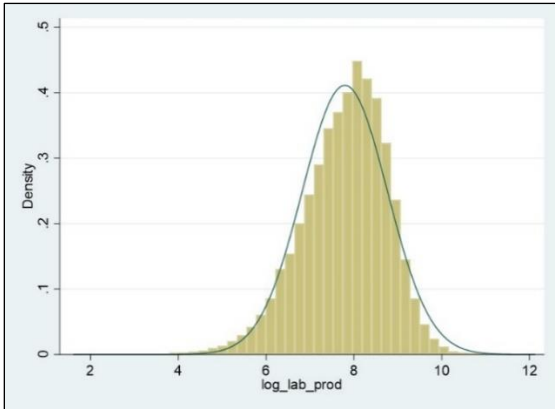


Fig 1. Normality Test of Labour Productivity Variable

Table 1. Breusch–Pagan/Cook–Weisberg Test for Heteroskedasticity
Assumption: Normal error terms
H ₀ : Constant Variance
chi2(1) = 37918.37
Variable: Fitted values of log_lab_prod
Prob > chi2 = 0.0000

Following Mundakkad (2018) where the quantile regression model was used to determine ‘the relationship between leverage and productivity across the distribution of labour productivity’, our quantile regression model has been defined as follows:

$$Q_{\theta}(y_{it} / x_{it}) = \beta_0 + \beta'_{\theta} x_{it} + z$$

Where y_{it} indicates the dependent variable (labour productivity) and x_{it} = a vector of explanatory variables, each for enterprise i at time t , $Q_{\theta}(y_{it} / x_{it})$ represents the quantile of the conditional distribution of y_{it} given x_{it} , β_0 is the intercept term, β'_{θ} is the vector of regression coefficients for the quantile θ and z = error term. The explanatory variables considered in the study are size, registration status, sector, social group of owners, ownership, presence/absence of government assistance and problems, which are characteristics of an enterprise.

Explanatory Variables:

Enterprise Type: A categorical variable for the type of enterprises, measured by their size, has been considered where OAMEs are coded as 1, NDMEs as 2, and DMEs as 3.

Registration: Registered enterprises are coded as 1 and unregistered as 0.

Location: Rural sector enterprises are coded as 1 while urban sector ones as 0.

Social Group: The social group variable, representing the social group of the owner, is considered categorical where STs, SCs, OBCs, Others and Unknown takes up values 1, 2, 3, 4 and 5 respectively.

Ownership: Our study has been based on the definition of NCEUS. Thus, only proprietary, and partnership-run enterprises are included. Accordingly, the ownership variable is also categorical with three values, i.e., 1 for male-owned, 2 for female-owned and 3 for partnerships.

Government Assistance: There are two possibilities for the variable representing government assistance, i.e., with and without government assistance. Therefore, the government assistance variable is coded 1 if an enterprise receives assistance otherwise it is coded 0.

Problem: Enterprises encountering problems are coded as 1, while those which do not encounter them are coded as 0.

The quantile regression has been estimated at the 10th, 25th, 50th, 75th and 90th quantiles. The results are in terms of coefficients of the independent variables at each quantile. When a coefficient is positive, there exists a direct relationship between the variables and vice versa. The findings of our analyses are given in the following section.

Results & Discussions

The outcomes of quantile regression analyses on the impact of mentioned characteristics of an enterprise upon its labour productivity levels are given in this section. Table 2 and Table 3 show the outcomes of the analyses during 2010-11 and 2015-16 respectively. It may be mentioned that log-linear quantile regression models have been used with the dependent variable being the log of labour productivity.

Table 2. Quantile Regression on Labour Productivity in India During 2010-11						
Explanatory Variables		10th Q	25th Q	50th Q	75th Q	90th Q
Enterprise Type (by size)	2	.7955956	.6412897	.4621916	.3518405	.2424903
	3	.8300736	.7210011	.4798026	.3841891	.3224254
	1*	-	-	-	-	-
Sector		-.2926693	-.3343287	-.3776379	-.4144506	-.4804187
Registration Status		.6057301	.5035844	.4419641	.402709	.40382
Social Status	SC	.1608107	.1787791	.1785574	.1599412	.0113254
	OBCs	.4103794	.4097848	.4102683	.3744178	.2250886
	Others	.2859738	.35812	.3389339	.2852726	.1267786
	Unknown	.513552	.5160069	.186161	.288312	.1377835
	ST*	-	-	-	-	-
Ownership	Female	-.8116877	-.8070917	-.8146329	-.8256841	-.7266693
	Partnership	-.4750235	-.4474401	-.3924179	-.2530251	-.0941758
	Male*	-	-	-	-	-
Government Assistance		.058269	-.1488075	-.0947824	-.1783338	-.0870113
Problem		-.175699	-.1384144	-.1345706	-.1299672	-.1228089
Source: Calculation done by authors using the NSSO 67 th Round data.						
Note: * The base group; **statistically insignificant						

On the type of enterprise by size, both tables (Table 1 and Table 2) showed positive coefficients indicating that labour productivity increased for Establishments (NDMEs and DMEs) more than the OAMEs more so at lower quantiles. This upholds that the size of an enterprise matters such that bigger size enterprises have more chances of higher labour productivity as has been noted earlier (Gupta, 2012; Apra, 2014b; Baruah, 2014). This could be because the methods of operations adopted by the Establishments are better and updated than the OAMEs. Possibly, the OAMEs of higher productivity become more competitive and as a result, the increase in labour productivity among the Establishments becomes lesser at higher quantiles. It has been observed that in years 2010 and 2011, the rural sector enterprises are likely to have a declining

labour productivity than urban sector enterprises at all quantiles. The informal enterprises are in a disadvantageous situation on account of a lack of education and vocational skills among the workers (Sanghi & Sensarma, 2014). Moreover, a research study reported that such a marginalized section of workers has been found mostly in rural areas (Sanghi & Srija, 2015). This could result in a decline in labour productivity in the rural sector enterprises (negative coefficients in tables) across all quantiles.

Table 3. Quantile Regression on Labour Productivity in India During 2015-16						
Explanatory Variables		10th Q	25th Q	50th Q	75th Q	90th Q
Enterprise Type (by size)	2	.8451576	.6006341	.4339976	.2631378	.1877785
	3	.8478975	.6386547	.4770589	.2933898	.1980619
	1*	-	-	-	-	-
Sector		-.3264675	-.2904296	-.3439922	-.3797665	-.398458
Registration Status		.4811997	.416925	.3289852	.2645864	.2834859
Social Status	SC	.1761346	.3232412	.1724405	.0856452	-.0253115
	OBCs	.4824462	.5125661	.3592849	.201108	.0877247
	Others	.5041981	.5224757	.340775	.2614007	.2079725
	Unknown	.3683028	.4479756	.3554754	.1934719	-.0165162
	ST*	-	-	-	-	-
Ownership	Female	-.6838331	-.7840662	-.9046941	-.8933764	- .7840524
	Partnership	-.2962379	-.2545786	-.24225	-.1390381	-.1545491
	Male*	-	-	-	-	-
Government Assistance		.072278	-.1511102	-.0875015	-.0609136	-.0385628
Problem		-.192286	-.1758575	-.1957488	-.2260613	-.1549802
Source: Calculation done by authors using the NSSO 73 rd Round data.						
Note: * The base group; **statistically insignificant						

As observed by Dandapat et al. (2021) registering can enhance labour productivity. Our coefficients have further indicated that this occurs especially among lower-productivity enterprises at lower quantiles. Social groups of owners of enterprises can have an impact on their labour productivity. The units owned by SCs, OBCs, others and unknown had generally shown an increase in labour productivity than those owned by STs. The exception was in the case of the highest productivity level enterprises owned by SCs and unknown groups (at the 90th quantile) in 2015-16.

The tables also showed that both female-owned and partnership enterprises had a decrease in labour productivity than male-run enterprises at all quantiles and throughout the period. The decline is more intense in female-owned enterprises. Perhaps, labourers in such enterprises, particularly the female-owned ones (with higher coefficients at all quantiles) are required to improve their skills to increase their productivity. Furthermore, the presence of government assistance has been benefiting only enterprises at the lowest level of productivity. It has almost

not been enough to make a positive impact on labour productivity from the 25th quantile onwards in both the years. Ghani et al. (2013) noted a huge increase in businesses owned by women as one factor in the persistence of India's UMS. As expected, enterprises reporting having problems are likely to adversely affect the labour productivity of enterprises in the UMS at all quantiles. This could be one of the reasons for decline in labour productivity in the UMS as noted by Kathuria et al. (2010).

Comparing Estimates based on Quantile Regression and OLS

This section highlights the use of OLS and quantile regression on the same data. It justifies the preference of quantile regression over OLS regression for the study. The graphical representations of above quantile regressions have been depicted in the Figure 2 and Figure 3 indicated below. The quantile of dependent variable i.e., labour productivity is given on the horizontal axis and magnitude of coefficients on the vertical axis. The coefficient of OLS analysis is plotted as a straight horizontal line with the confidence interval as two dashed lines around the coefficient line.

The OLS coefficients remain stable at all quantiles. However, the quantile regression coefficients and their confidence intervals vary across the quantiles. This is a clear indication that there have been significant differences between the quantiles and OLS coefficients.

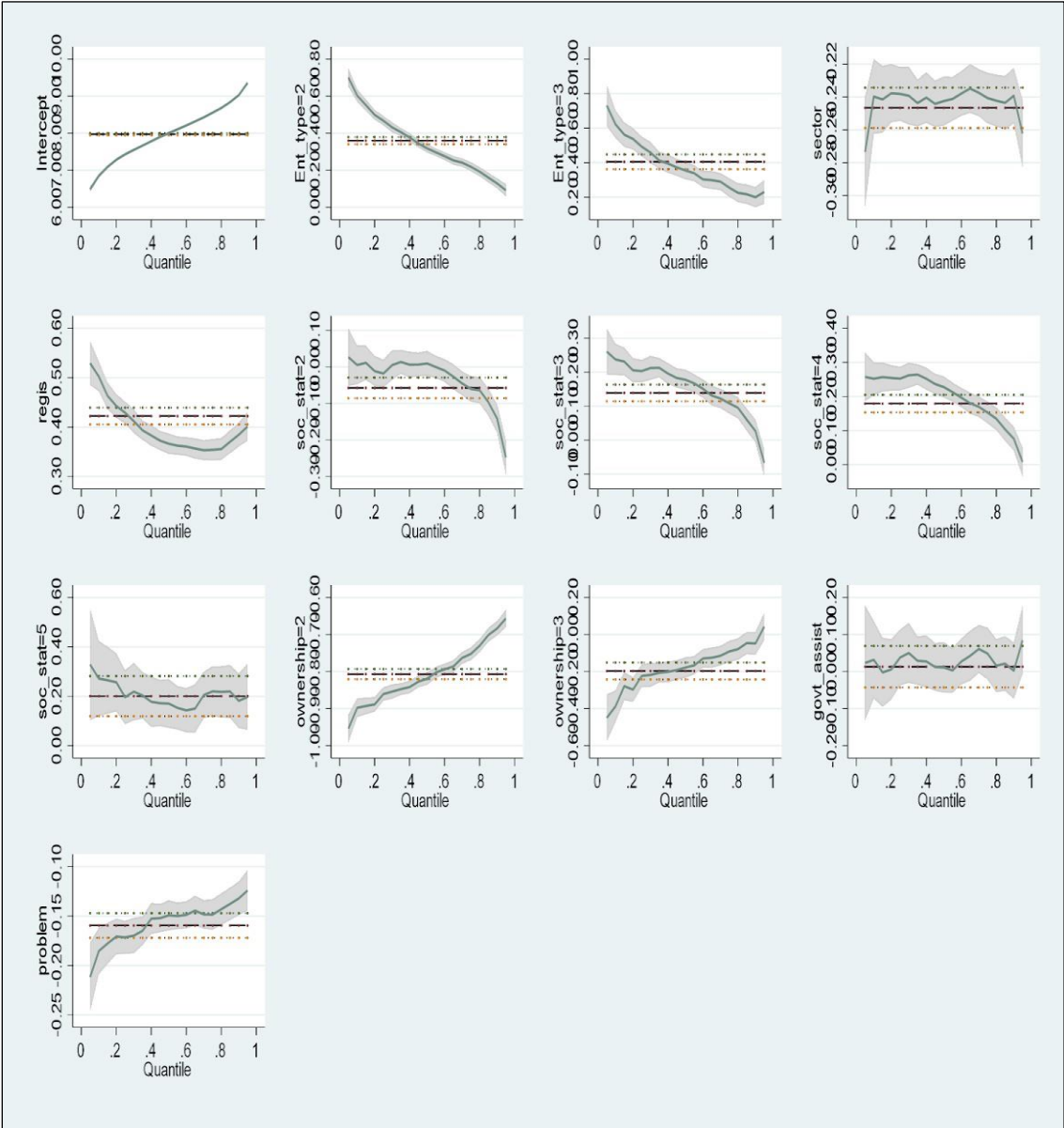


Fig 2. Representation of Coefficients of the Quantile Regression on Labour Productivity in India during 2010-11

While some coefficients based on enterprise type, registration status, and social group (SCs, OBCs and Others) can be seen to decline at higher quantiles, coefficients of ownership and the problem variables rise at higher levels of quantiles. Moreover, their confidence intervals (shaded regions around the quantile coefficients) also diverge away from OLS.

Only a few coefficients (sector, unknown social group, and government assistance) and their confidence intervals seem to be hovering around those of the OLS. The application of quantile regression in the present study brings out a detailed and clearer picture than OLS estimates on the influence of independent variables at different quantiles of the dependent variable.

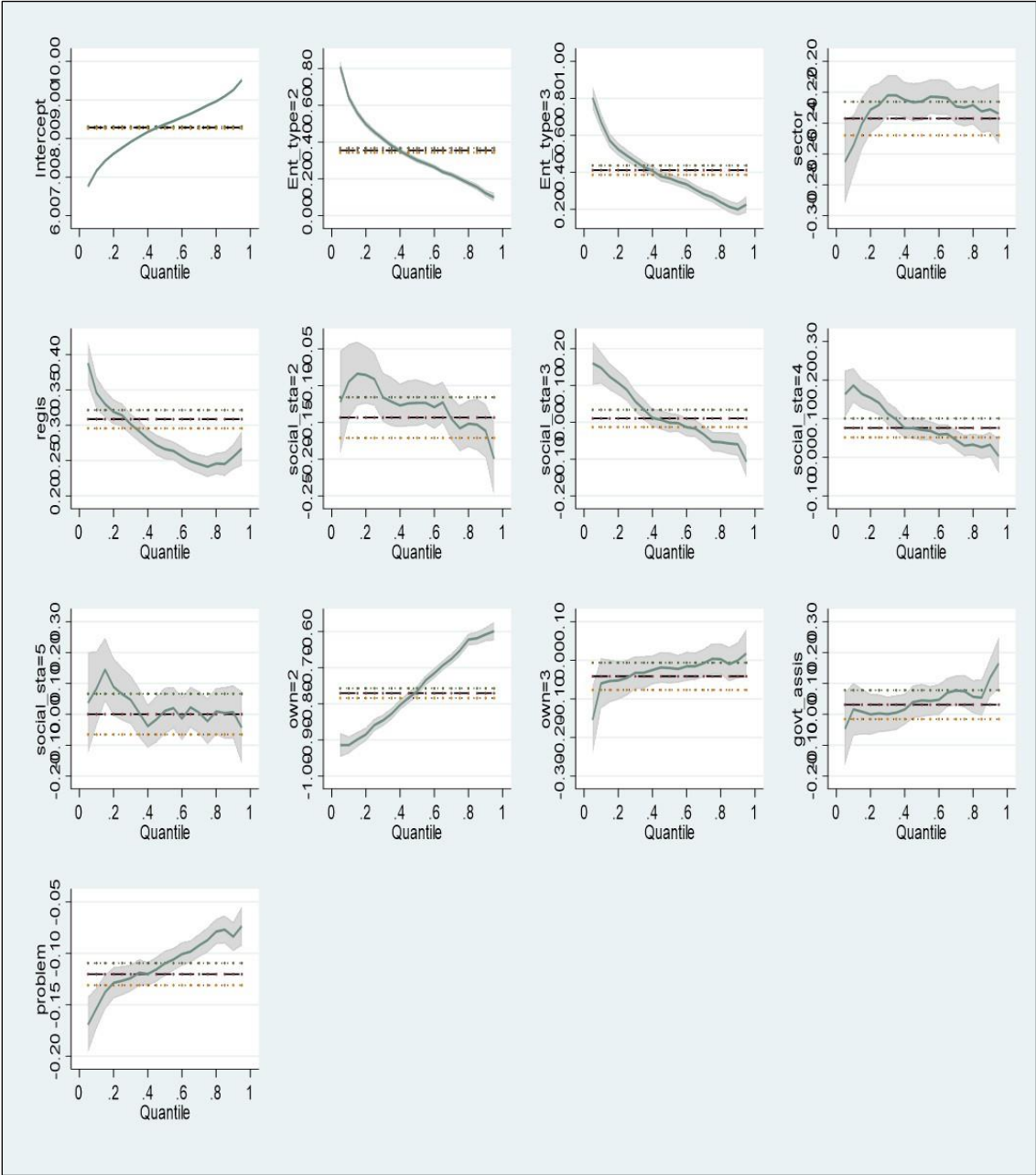


Fig 3. Representation of Coefficients of the Quantile Regression on Labour Productivity in India during 2015-16

Suggestions

The study has showed that an enterprise’s labour productivity is closely associated with the mentioned characteristics. Also, it indicated that size does matter and smaller enterprises (OAMEs), which comprise the bulk of entire UMS and need more support to uplift their productivity. The rural sector enterprises tend to have lower labour productivity which also

suggests that workers in such enterprises could be of lesser competency of labour. Moreover, the registration with any government agency has a positive impact on labour productivity though the intensity of it declines at higher quantiles. The present study has revealed that their labour productivity is not remarkable enough. Also, the productivity differences have been observed when the social group of owners is considered. In most cases, ST-owned enterprises are likely to have lower labour productivity than enterprises run by SCs, OBCs and Others. There is possibly a need to revamp government assistance as it has failed to make any significant improvement in labour productivity. Time and again, problems in the UMS have caused a hindrance to the labour productivity of UMS. Perhaps, resolving the problems requires a further examination on different categories of problems that could affect labour productivity. Each of the characteristics considered in the study can influence an enterprise's labour productivity, wherein their effects have by and large not changed during the two points of the study period. Perhaps, it is time to take into consideration the features of enterprises when policies are framed, and interventions are undertaken. The umbrella actions and interventions have not yielded satisfactory results in raising the labour productivity of the UMS. A more concerted effort and approach is the need of the hour to bring in a significant improvement in labour productivity in the UMS.

Conclusion

Studies have identified how productivity levels of enterprises in the UMS of India vary based on their characteristics such as size and sector. Moreover, other characteristics namely registration status, social group of owners, ownership, presence of government assistance and problems have also in some way linked with an enterprise's productivity. The present study is an attempt to determine how certain characteristics of an enterprise in the UMS, namely size, registration status, sector, social group of owners, ownership, presence/absence of government assistance and problems that affected the labour productivity during 2010-11 and 2015-16. This study has been carried out by performing quantile regression analysis with the labour productivity of an enterprise as a dependent variable and its characteristics as a set of explanatory variables. The findings presented in the study have indicated a significant role that each characteristic has played in influencing the labour productivity of the UMS. Furthermore, smaller-size enterprises and female-owned enterprises need additional support to ensure increasing labour productivity. Also, it is noted from the study that the importance of education and skill development in the rural sector and registration are quite important aspects in the context of labour productivity. Besides, these aforesaid aspects government assistance is required to be relooked and revisited for relevance and effectiveness. In furtherance, addressing the issues faced by enterprises can go a long way in improving the productivity of labour at the aggregate level, as there is compelling evidence that this is a major hindrance to productivity.

References

- Apra. (2014a). Growth and performance of unorganized manufacturing sector in Punjab. *Doctoral Thesis*, Punjab University.
- Apra. (2014b). Growth and determinants of employment in unorganized manufacturing sector of urban Punjab. *Envision-International Journal of Commerce & Management Journal*, 94-105.
- Baruah, P. B. (2014). Financial access of unorganized manufacturing enterprises in Assam. *Space and Culture*, India, 2(2), 4-16.
- Coad, A., & Tamvada, J. P. (2012). Firm growth and barriers to growth among small firms in India. *Small Business Economics*, 39(2), 383-400.
- Dandapat, A., Dasgupta, S. & Das, P. (2021). Productivity of unorganized manufacturing enterprises in India. *Economic Affairs*, 66(1), pp 9-16.
- Deshpande, A., & Sharma, S. (2013). Entrepreneurship or Survival? Caste and gender of small business in India. *Economic & Political Weekly*, 48(28), 38-49.
- Djidonou, G. R., & Foster-McGregor, N. (2022). Stagnant manufacturing growth in India: The role of the informal economy. *Structural Change and Economic Dynamics*, 63, 528-543.
- Ghani, S. E., Kerr, W., & O'Connell, S. D. (2013). Female business ownership and informal sector persistence. *World Bank Policy Research*, Working Paper No.6612.
- Gupta, N. (2012). Unorganized manufacturing sector in India during post-liberalization. *Period. Doctoral Thesis*, Punjab University.
- GOI (Government of India). (2001). *Concepts and definitions used in the NSS*. Golden Jubilee Publication.
- Hart, K. (1973). Informal income opportunities and urban employment in Ghana. *The Journal of Modern African Studies*, 11(1), 61-89.
- Kathuria, V., Raj, S. N., & Sen, K. (2010). Organized versus unorganized manufacturing performance in the post-reform period. *Economic & Political Weekly*, 45(24), 55-64.
- Koenker, R., & Bassett Jr. G. (1978). Regression Quantiles. *Econometrica*, 46(1), 33-50.
- Majumdar, A. (2012). Productivity growth in the urban informal manufacturing sector in Assam: A comparison to India. *International Journal of Management and Social Sciences*, 1(2), 41-48.

Mariappan, R. (2011). Growth & productivity of the Unorganized Manufacturing Sector in India. *Indian Journal of Industrial Relations*, 47(1), 20-35.

Mundakkad, P. (2018). Firms' leverage and labour productivity: A quantile regression approach. *Economics Bulletin*, 38(4), 2331-2344.

Nataraj, S. (2010). Productivity and firm size distribution: Evidence from India's organized and unorganized manufacturing sectors. *Doctoral Dissertation*, UC Berkeley.

NCEUS. (2008). *Report on conditions of work and promotion of livelihoods in the unorganized sector*. National Commission for Enterprises in the Unorganized Sector (NCEUS), Academic Foundation New Delhi, India.

NSSO. (2000). *Non-agricultural enterprises in the informal sector in India 1999 – 2000. Key Results*. National Sample Survey Organization (NSSO), Report No.456.

Saikia, D. (2015). Employment pattern in the unorganized manufacturing sector in Assam. *Journal of Rural Development*, 34(1), 1-16.

Saikia, D., & Barman, H. (2017). Urban informal manufacturing sector in Assam in the post-reforms period. *Urban India*, 37(2), 20-36.

Sanghi, M. S., & Sensarma, M. K. (2014). *Skill challenges of informal sector in India*. Confederation of Indian Industry, New Delhi, 33-41

Sanghi, S., & Srija, A. (2015). Skill development and productivity of the workforce. *Economy Matters*, 20(10), 36-51.

Sasidharan, S., & Raj, S. N. R. (2014). The growth barriers of informal sector enterprises: Evidence from India. *The Developing Economies*, 52(4), 351-375.

Singh, L., & Jain, V. (2006). Unorganized Manufacturing Industry in the Era of Globalization: A Study of Punjab. https://mpra.ub.uni-muenchen.de/197/1/MPRA_paper_197.pdf

Uppal, A. (2016). Trends and structure of employment and productivity in unorganized manufacturing sector of India in post-reform period. In *34th IARIW General Conference, Dresden, Germany* (Vol. 182).

Webliography

<http://hdl.handle.net/10603/54463>

<https://doi.org/10.1016/j.strueco.2022.07.007>

<http://hdl.handle.net/10603/3534>

<http://old.iariw.org/dresden/uppal2>

<https://www.mycii.in/KmResourceApplication/11440.EMNovemberDecember15R.pdf>

Influence of Psychological Factors in Investment Decisions: A Study on Female Educators of Selective Higher Educational Institutions of Guwahati City, Assam

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Guwahati, Assam, India

Abstract

Investment decisions are crucial for any individual as they help the person to build wealth. As per traditional philosophy, all investors are assumed to be rational in making investment decisions. However, with the advent of behavioural finance, it cannot be overruled that psychological biases can affect investors in making investment decisions. There are various psychological factors that may have impact on investment choices of individuals. In recent years, the financial system has witnessed a notable increase in the participation of women in investment activities in India. As women contribute to half of the total Indian population, understanding the psychological factors shaping the investment behaviour of female educators is of enormous importance. In this regard, this present study seeks to identify the various psychological factors that influence female educators in selection of various investment alternatives that are available for investment. The study included female educators from selective higher educational institutions of Guwahati city of Assam for meeting the purpose. The study found that psychological factors influence investment decisions of investors.

Keywords: Investment, Female, Educators, Decisions, Institutions.

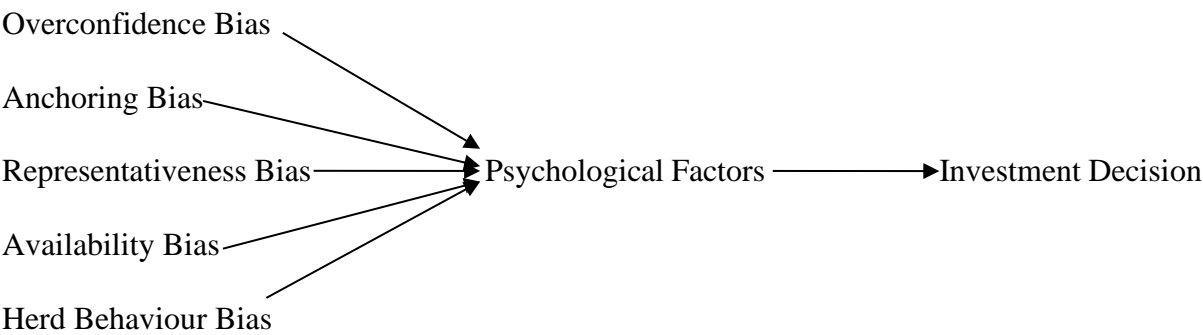
Introduction

Investment is defined as a financial asset bought with the idea that it will provide return or will later be sold at a higher price for a profit. Investment decisions are crucial for any individual as they help the person to build wealth. However, it is a complex task as there are numerous alternative options for investment available in the financial market and every type of investment has its own advantages and disadvantages depending on return, safety, tax exemption, etc. it offers. Thus, investment decision is a vital task as it involves analyzing various alternatives and the factors affecting selection amongst the alternatives. It is a topic of

concern for every new and existing retail investor. Various studies in the field of behavioural finance have revealed that some investors may act irrationally due to the differences in psychological and cognitive skills applied for investment analysis. Psychological factors have strong effects on the decision-making process as they have the tendency to make us like and dislike something. Nowadays, to study the trend and pattern of investment decisions, investors' behaviour is also taken under consideration as it plays an important role in their decision-making process. With the pace of time and reforms in the societal perspectives, the participation of women in taking financial decisions has increased many folds. The position of women is considered as important in every sphere of society. Surprisingly, investing is one such area which still proves gender gap between men and women because, still there are women who have low confidence and believe that they have less knowledge about finance than men when it comes to investing (Veena, 2020). Furthermore, women are not equally involved in every financial decision making with their spouse. There are differences in psychological factors considered by women and men in respect of making investment decisions.

According to the survey conducted by DBS Bank India and CRISIL (Credit Rating Information Service of India Ltd.), women earners in Indian metros are risk averse when it comes to investing. Investment in market linked securities is characterized by a high degree of risk and flexibility. The process of investment in market linked securities demands the risk bearing capacity of investors and their abilities to analyze securities through fundamental, technical, and psychological techniques. The irrational behaviour of investors and their investment decision has grabbed the attention of various researchers to study various psychological factors and their influence in investment decision. In recent years, the financial system has witnessed a notable increase in the participation of women in investment activities in India. As women contribute to half of the total Indian population, understanding of the psychological factors shaping the investment behaviour of female educators is of importance. Against this backdrop, the present study seeks to identify the various psychological factors that influence female educators in their investment decision making process. The study shall consider female educators of select higher educational institutions of Guwahati city of Assam for the purpose.

Conceptual Framework of the Study



Literature Review

Behavioural Finance defines the reasons for the irrationality of the investors. It is commonly defined as the application of psychology to understand human behaviour in finance and investment (Singh, 2019). The psychological factors-loss aversion, regret aversion, herding and anchoring influenced male and female investors differently. The herding bias was exhibited by both the groups in an equal manner. Furthermore, experienced investors were found to be more prone to loss aversion bias, regret aversion bias and anchoring bias as compared to that of less experienced investors (Gupta & Ahmed, 2016). The male investors are more analytical while female is risk averse due to lack of financial literacy (Singh & Yadav, 2016). Also, both heuristic and prospect theory has influence on women investors.

Psychological biases positively and significantly impact women investors' decision-making. There is a significant relation between demographic and psychological biases and correlation exists between psychological biases (Kappal & Rastogi, 2020). Moreover, significant relationship between psychological factors and economic factors in respect of an individual investor's decision-making process. Psychological factors as compared to economic factors have more effect on decision making behaviour. There is no relationship between monthly income level and investment decision making (Sarwar & Afaf, 2016). Safety of principal, return on investment, social status, and family members influence women investors while taking investment decision. Savings bank account, Investment in Gold and silver and Investment in Real estate are preferred by salaried women (Yadav, 2022). The factors influencing investment decision of working women and found that demographic factors such as age, marital status, level of education, occupation, income, and family size has impact on investment behaviour. Social factors that influence investment decision are influence of family, family member opinion, recommendation of broker, investment professional, friends and peer group while the psychological factors are Confidence level, Investor optimism, conservatism and belief (Veena, 2020). There are two types of investors-active and passive investors. The behavioural traits of active investors are termed as accumulators and independent and / or passive investors are referred to as preserver and followers.

The psychological biases affect active investors are status quo, endowment, loss aversion, mental accounting and anchoring while those of passive investors are regret, outcome, cognitive and dissonance (Tupe, 2021) After going through the above reviews, it can be asserted that various studies have been carried out on the role of behavioural finance in investment decisions. There are several studies that have explored the differences in investment decision making process of men and women, considering different factors such as social, demographic, psychological etc. There is a significant difference between male and female respondents in psychological factors, economic factors, and decision-making process (Chavali & Rosario, 2019). Moreover, there are a few studies that are solely based on women investors that revealed their preferred investments avenues considering different modes of investments such as debt and equity securities, physical assets, real estates, etc.

The Psychological biases positively and significantly affect women investors' decision making (Kappal & Rastogi, 2020). However, the researchers could not find any study which is

exclusively focused on studying the influence of psychological factors in market linked investments. Also, female educators are the prominent facilitators of knowledge to the society. The level of literacy and psychology is related to each other. Financial literacy is known to have a significant influence on investment decisions (Baihaqqy et al. 2020). The decision-making ability of educator is most likely to be different as compared to other women engaged in various field. In this regard, the present study tries to highlight the influence of psychology on investment decision with special reference to female educator of select higher educational institutions of Guwahati city.

Significance

The traditional theory of finance considered investors as rational while the initiation of behavioural finance proves investors as irrational. There are different types of investors and different psychological factors which influence their investment decision. Moreover, there is a significant difference between investment decision of male and female investors. In the aging investment market, there are various options of investment among which market-linked investment options have the highest prospects of return for investors. The level of literacy and psychology are related to each other. The decision-making ability of educator is most likely to be different as compared to other women engaged in various field. In this regard, the present study tries to highlight the influence of psychology on investment decision with special reference to female educator of select higher educational institutions of Guwahati city.

Objective

To identify the various psychological factors that influence female educators in selection of various market linked investment alternatives

Methodology

The present study has provided an insight on influence of psychological factors on investment decision of women educators of selected higher educational institutions. The study adopted descriptive research design and mainly based on primary data. The data are collected from female educators of selected higher educational institution of Guwahati city with the help of a structured questionnaire. The sample size comprises of 63 female educators who have been selected through snowball sampling technique from educational institutions such as Gauhati Commerce College, Nerim Group of Institutions, Assam Downtown University and University of Science & Technology. The distribution of respondents is indicated in Table 1. The secondary data have been taken from information available in different websites, books and various journals related to behavioural finance to form the basis of study and to identify the gap in the existing literature.

Table 1: Distribution of Respondents According to Study Area

S. No.	Name of Institutions / Varsities	No of Respondents
1	Nerim Group of Institutions	9
2	Gauhati Commerce College	21
3	Assam Downtown University	9
4	University of Science and Technology	24
Total		63

Factors

The researchers have considered five psychological factors in the present study. They are overconfidence, anchoring, representativeness, availability, and herd behaviour bias respectively.

Overconfidence Bias: Overconfidence is a psychological bias due to which people think themselves to be correct in their judgments but may not be practically correct.

Anchoring Bias: Anchoring is a kind of bias in which the mind is focused on only one simplified reference point, which works as anchor. The anchor can be facts, traits or information, past standard, idea, belief, and mental interest (Singh, 2019)

Representativeness Bias: The representativeness heuristic is one of the biases in human decision making. It involves making judgments by comparing the current situations to concepts we already have in mind (Cherry, 2023). The simplicity provided by the heuristic brings advantages but also risks arising from a lack of information, leading to cognitive errors and biases (Bilek et al. 2018)

Availability Bias: Availability can be defined as a psychological bias in which the person relies on what immediately comes to mind to take quick decisions in investment. The source of information can be recent news or any past experiences.

Herd Behaviour Bias: Herd behaviour is a cognitive bias or a tendency of the investors to behave accordingly to the fellow group without any coordination with the same.

Data Collection Tools

A questionnaire has been prepared to gather primary data from female educators. The questionnaire has three sections; the first section comprises of demographics detail like age, gender, income, etc. Second section includes investment-related questions like investment percentage, type, duration of investment. The last section contains psychology related questions, which are framed to find out the influence of different psychological biases on investment decisions by employing five-point Likert scales. The frequency distributions of collected data are presented in the tabular form along with interpretations.

Analysis & Interpretation of Data

As the study pertains to identifying the various psychological variables that have effect on investment decisions, the data gathered have been presented for each psychological variable that are considered in the present study. Moreover, demographic profiles and investment details of the respondents are presented in Table 2 and Table 3 respectively.

Table 2: Demographic Profile of Respondents

Demographic Factors	Options	No. of Respondents	Distribution Percentage
Age	< 30	12	19.00
	31-40	24	38.00
	41-50	15	24.00
	Above 50	12	19.00
Education	Post Graduation	24	38.00
	MPhil	0	0.00
	PhD	39	62.00
	Post Doctorate	0	0.00
Designation	Assistant Professor	54	86.00
	Associate Professor	9	14.00
	Professor	0	0.00
Level of Income	< 3 Lakhs	6	10.00
	3-6 Lakhs	27	43.00
	6-9 Lakhs	15	23.00
	9 Lakhs and above	15	24.00
Investment Experience	Less than 3 years	18	28.00
	3-6 years	15	24.00
	More than 6 years	30	48.00
% of Investment	Below 10%	15	24.00
	10-20%	39	62.00
	20-30%	6	9.00
	Above 30%	3	5.00

Source: Field Survey; N=63

From the above table, it can be observed that majority of female educator i.e. 38 percent of the educators, having investment in market linked securities, lies between the age group of 31 to 40 years. Majority of the female investors are doctorates, as 62 percent of the total respondents hold PhD degree whereas 38 percent are postgraduates. There is no respondent in the sample who is a post doctorate or holds MPhil degree. Most of the respondents are in the rank of Assistant Professor and their level of income lies between 3-6 Lakhs i.e. 43 percent. It is to be noted that 48 percent of the respondents are existing investors having investment experience

in market linked securities for more than 6 years and the majority of respondents i.e. 62 percent invest 10-20 percent of their total income.

Table 3: Distribution of Respondents According to Investment Details

Particulars	Options	No. of Respondents	Distribution Percentage
Preferred Area of Market Linked Investment	Mutual Fund	42	67.00
	Market Linked Insurance	12	19.00
	Investment in Equities	6	9.00
	Investment in Future and Option	0	0.00
	Other	3	5.00
Objectives of Investment	Earning Return	27	43.00
	Creating Wealth	12	19.00
	Post Retirement Plan	3	5.00
	Tax Management	9	14.00
	Protect Family Future	9	14.00
	Other	3	5.00

Source: Field Survey; N=63

Table 3 revealed that the majority of the investors (67 percent) prefer Mutual Fund as mode of investment whereas second preferred investment is market linked insurance policies as 19 percent of the investors are interested in investment in such policies. However, only small percentages i.e. 9 percent of female educators prefer investment in equities. It is noticeable that there is no female educator who is interested in investing in derivative market. It is inferred from the table that primary purpose of majority of female educators i.e. 43 percent is earning return from their investment while 19 percent of them intend to create wealth. Only 5 percent of the total respondents make investment for securing post-retirement benefit.

Table 4: Distribution of Respondents' Statements According to Overconfidence Bias

Statements	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Total
I always select profitable investment alternatives	0	0	9(14.5%)	45(71%)	9(14.5%)	63(100%)
My return expectation from investment alternative is always correct	0	9(14%)	30(48%)	24(38%)	0	63(100%)
My time for making investment is always correct	0	9(14%)	39(62%)	15(24%)	0	63(100%)
My portfolio of investment is best according to my experience	0	0	27(43%)	27(43%)	9(14%)	63(100%)
Irrespective of market movement, I stick to my own investment choice	3(5%)	12(19%)	15(24%)	27(43%)	6(9%)	63(100%)

Source: Field Survey; N=63

Table 4 highlighted the statements relating to overconfidence bias of investors. It can be observed from the table that most of the female educators believe that they always select profitable investment as 71 percent of them agreed in this regard. However, they are not very confident about making correct return expectations from the investments as 48 percent of them responded neutrally in this regard. Yet, 38 percent of the respondents are of the opinion that their expectations in respect of return are somewhat correct. A similar response can be observed in respect of being correct about the timing of investment. Again, it can be found that the investors have confidence about their portfolio as 43 percent and 14 percent of them

responded “agree” and “strongly agree” to the statement. Further, it is revealed from the table that investors tend to stick to their own portfolio irrespective of market movement as 43 percent of investors agreed to it.

Table 5: Distribution of Respondents’ Statements According to Anchoring Bias

Statements	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Total
I collect information before investment	0	3(5%)	3(5%)	39(62%)	18(28%)	63(100%)
I always rely on pre-received information for investment alternative	0	3(5%)	3(5%)	48(76%)	9(14%)	63(100%)
I always stick to previously received information for choosing investment	0	9(14.5%)	15(24.5%)	33(52%)	6(9%)	63(100%)
I never react to new information available for investment	3(5%)	27(43%)	15(24%)	18(28%)	0	63(100%)
I disapprove with the new information received for investment	3(5.5%)	33(52%)	21(33%)	6(9.5%)	0	63(100%)

Source: Field Survey; N=63

The analysis of Table 5 showed that investors collect information before investment as it is agreed and strongly agreed by most of the respondents. Moreover, they also rely on pre-received information for investment, wherein majority of them stick to the previously received information for making investment decisions. Yet, they tend to respond to the new information received and consider those in the investment decision making process.

Table 6: Distribution of Respondents' Statements According to Representativeness Bias

Statements	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Total
I believe in my own speculation for choosing investment	0	15(24%)	12(19.5%)	30(47%)	6(9.5%)	63(100%)
I always compare investment alternatives as per my pre-assumed information	0	3(5%)	12(19%)	39(62%)	9(14%)	63(100%)
I rely on past performance to make investment because; I believe the same performance will continue	0	6(9%)	12(19%)	39(62%)	6(9%)	63(100%)

Source: Field Survey; N=63

Table 6 revealed that majority of the respondents agree to the fact that they believe in their own speculation while making investment decisions. However, there are still 24 percent in the total number of respondents who disagree in this regard. Moreover, 62 percent of the respondents compare investment alternatives as per pre-assumed information. Again, as far as relying on past performance to make investment decisions is concerned; it is found that 62 percent of the respondents rely on past performance assuming that the same performance will continue in future.

Table 7: Distribution of Respondents' Statements According to Availability Bias

Statements	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Total
I always pay more attention to recent information	0	0	12(19%)	39(62%)	12(19%)	63(100%)
I rely on the easily understandable information	3(5%)	3(5%)	12(19%)	30(47%)	15(24%)	63(100%)
I rarely analyze investment technically before investment	3(5%)	18(28%)	18(28%)	18(28%)	6(9%)	63(100%)

Source: Field Survey; N=63

All respondents pay attention to the recent information as there is no respondent who disagrees in this regard. Table 7 indicated that the majority of them tend to rely on easily understandable information, which indicates their low competitiveness in analyzing complex market related information.

Table 8: Distribution of Respondents' Statements According to Herd Behaviour Bias

Statements	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Total
I always consult with my family for choosing any investment	3(5%)	18(28%)	3(5%)	24(38%)	15(24%)	63(100%)
I discuss with my colleagues for selection of investment alternative	0	9(14%)	21(33%)	27(43%)	6(9%)	63(100%)

I always follow on the investment choice of my family members	6(9%)	18(28%)	15(24%)	21(33%)	3(5%)	63(100%)
I always follow on my colleagues and others for choosing investment alternatives	3(5%)	24(38%)	18(28%)	18(28%)	0	63(100%)

Source: Field Survey; N=63

It can be observed from the response provided against the statements included in Table 8 that the investment decisions of female educators are affected by herd behaviour. The reason being most of the respondents have agreed that they discuss with their colleagues and family while selecting a particular investment avenue. Yet, there are a few respondents who do not consult family or colleagues in taking investment decisions but, the number of respondents falling under this category is less.

Findings & Discussion

Investment Details of Female Educator

As the number of retail investors is increasing, the most common discussion based on gender biasness again becomes the interest of investors. There are number of studies, which have shown that the financial behaviour of men and women differ significantly (Kansal & Zaidi, 2015). This is because of the increasing woman in work force resulting in their financial independence (Chavali & Rosario, 2019). The women investors ranging from the age group of 31-40 years is more prone to market linked investment opportunities. They are being in the investment of market linked options for more than 6 years. Women investors are risk averse and mostly they prefer mostly mutual fund and market linked insurance policies as their investment avenues and their main objectives is to earn returns, creating wealth and tax management.

Psychological Biases of Female Educator

In the context of psychological biases, it is found that Herd behaviour mostly influence women educators as they involve in discussions with their families and colleagues for selection of investment alternatives and are influenced by others in investment decision making process.

Female investors give more importance to the advice given by their friends and relatives and on their advice female investors invest in the shares (Singh & Yadav, 2016). Social interaction, herding and stress negatively influence the investment decisions because the individual investors instead of analyzing their own financial spots and making judgments accordingly rely on or become victim of the social groups around them (Moueed et al. 2015).

Overconfidence can be expressed in many different forms. Apart from miscalibration, many people do not actually think that their ability and understanding are only better than average effect. In addition, the illusion of control makes people believe that they have the ability to control situations better than they can, and they are overly optimistic about everything (Ton & Dao, 2014). People rated themselves higher than the average, i.e. investors think that they can control the market and outcome of their investment (Sarwar & Afaf, 2016). Moreover, in considering the above studies, the present study found that women educators are overconfident with their existing portfolio which include mainly mutual fund and market linked insurance. This has deprived them of exploring other market linked investment avenues which can provide higher return.

The psychological biases of anchoring influence women educators. The female educators are more prone to pre-received information to analyze the securities and react loosely to new information available in the market. Women investors use mental shortcuts to ease the decision-making process instead of search information. They fear the loss and make the wrong decision (Yadav, 2022). Representative biases affect women educator as they always depend on some probable presumption and belief on past performance of investment alternatives, which sometimes affect negatively in investment decision of investors. The influence of availability biases is clear in investment decision of the women educators as majority of them pay more attention to easily and understandable investment information and very less number of female educators tends to analyze investment related information technically. Investors should as far as possibly try to make fundamental, technical, and financial analysis before investing in the shares (Singh & Yadav, 2016).

Suggestions

- Keeping their income slabs aligned with the amount of investment, women educators can increase their percentage of investment and form a better portfolio with various market linked investment alternatives which can provide them better return in future.
- The women educators should start their investment from early years of age, which can help them to be experienced in investment in market linked securities and making investment from early years of their lives will also help them to create wealth.
- Female educators should not limit themselves with readily available information or past information. As the market keeps on changing, they should try to make detailed analysis of every investment alternative of their choice.
- Female educators should pursue training sessions provided by broking firms, banks and professional institutions on stock analysis and interpretation to have a better idea to take their own investment decision by making technical analysis of the probable investments. This in turn provides them with confidence to make their own investment choice.

Conclusion

The present research study has attempted to study the influence of different psychological factors on investment decision of female educators. The study reveals that female educators in higher educational institution prefer mutual fund and market linked insurance policies as their investment avenues. As far as the study of psychological biases on investment decision is concerned, it has been observed that all psychological factors have influence on investment decisions of female educators. They involve themselves in discussions with their families and colleagues in selection of investment from the different alternatives and are influenced by others in investment decision making process. Majority of women educators are overconfident with their existing portfolio which include mainly mutual fund and market linked insurance. This has deprived them of exploring other market linked investment avenues, which can provide higher return. The female educators are prone to pre-received information to analyze the securities. They always depend on some probable presumption and belief on past performance of investment alternatives, which sometimes negatively affect the investment decision of investors. Also, the influence of biases in investment decisions of women educators is clearly expressed in this study. Therefore, they should pursue training sessions provided by broking firms, banks, and professional institutions on stock analysis so that they can take the right investment decision by making technical analysis of the probable investments.

References

- Baihaqqy, M., Disman, N., & Sari, M. (2020). The correlation between education level and understanding of financial literacy and its effect on investment decisions in capital markets. *Journal of Education and E-Learning Research*, 7(3), 306-313.
- Bilek, J., Nedoma, J., & Jirasek, M. (2018). Representativeness heuristics: A literature review of its impacts on the quality of decision-making. *Journal of Civil Engineering*, 26(2), 29-38.
- Chavali, K., & Rosario, S. (2019). Influence of gender on investment decisions of investors in Sultanate of Oman. *Global Journal of Economics and Business*, 7(2), 234-242.
- Cherry, K. (2023). How the representativeness heuristic affects decisions and bias. *Verywell Mind*, 25 September, Dotdash Meredith, Inc. New York, USA.
- Gupta, Y., & Ahmed, S. (2016). The impact of psychological factors on investment decision making of investors: An empirical analysis. *EPRA International Journal of Economic and Business Review*, 4(11), 40-52.
- Kansal, P., & Zaidi, N. (2015). Investment behaviour of women in India. *Proceedings of International conference on Business Innovation and IT*, College of Applied Education & Health Science, Uttar Pradesh, 2-3.

Kappal, M. J., & Rastogi, S. (2020). Investment behaviour of women entrepreneur. *Qualitative Research in Financial Market*, 12(4), 485-504.

Moueed, A., Raza, B., Hunjra, A., & Asghar, M. U. (2015). Role of psychological and social factors on investment decision of individual investors in Islamabad stock market. *Science International (Lahore)*, 27(5), 4697-4706.

Sarwar, A., & Afaf, G. (2016). A comparison between psychological and economic factors affecting individual investor's decision making behaviour. *Cogent Business & Management*, 3(1), 1232907-1232123.

Singh, R. (2019). *Behavioural Finance*. PHI Learning Pvt. Ltd.

Singh, J., & Yadav, P. (2016). A study on the factors influencing investors decision in investing in equity shares in Jaipur and Moradabad with special reference to gender. *Amity Journal of Finance*, 1(1), 117-130.

Ton, H., & Dao, T. (2014). The effects of psychology on individual investors' behaviours: Evidence from the Vietnam stock exchange. *Journal of Management and Sustainability*, 4(3), 125-134.

Tupe, V. A. (2021). A study of impact of psychological biases on investor's investment decision. *EPRA International Journal of Economic and Business Review*, 9(8), 1-6.

Veena, M. (2020). Determination of factors exerting influence on investment behaviour with special focus on working women. *EPRA International Journal of Multidisciplinary Research*, 6(8), 286-296.

Yadav, K. (2022). Impact of psychological factors on individual investment decisions: A study of women investors. *Doctoral Thesis*, Institute of Management Studies and Research, Maharshi Dayanand University, Rohtak, Haryana.

Webliography

https://www.dbs.com/newsroom/47_of_female_indian_earners_in_metros_make_independent_financial_decisions_dbs_bank_india_and_crisil_survey_in

<https://www.linkedin.com/pulse/understand-psychological-factors-influencing-your-investment>

<https://www.verywellmind.com/representativeness-heuristic-2795805>

Sentiment Analysis of ChatGPT Reviews Using VADER and RoBERTa

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Abstract

ChatGPT has become one of the most widely used generative AI tools in recent years due to its accessibility and convenience of use. It is used not only for content generation, but also for problem solving in many domains of study. For any product or service to be dominant in the market for a long time, it is important to obtain opinions about the product from time-to-time in the form of reviews or feedback. Understanding the true essence of the review helps the service providers to enhance the service provided by them. Sentiment Analysis is one such methodology, which helps to extract and analyze the feelings associated with reviews of the product. In this chapter Sentiment Analysis is performed on a dataset containing 2292 reviews about ChatGPT using two different techniques: VADER and RoBERTa. VADER is a lexicon-based sentiment analysis tool, whereas RoBERTa is a transformer-based Machine Language model. A comparison is carried out using both the techniques. The 23 percent variation has been observed in the results pertaining to scores calculated using both the techniques. However, RoBERTa proved to be more accurate in calculating the score as compared to VADER for the selected dataset.

Keywords: Sentiment Analysis, VADER, RoBERTa, Reviews.

Introduction

Language models have become more complex and adaptable because of the rapid development of Artificial Intelligence (AI) and Natural Language Processing (NLP). A type of Artificial Intelligence model known as 'Generative AI', which can produce new data by using patterns and structures discovered in the previously collected data. These models can produce content in a variety of media, including text, photos, music, and more [1]. One of the recent applications of NLP is ChatGPT - a chatbot, developed by OpenAI. It enables the users to enter prompts or questions and generates replies. Moreover, it is becoming very popular tool, especially amongst students and researchers, for a variety of tasks from writing essays, research papers to solving problems. Furthermore, these users of ChatGPT often express contentment and dissatisfaction over the use of product in the form of reviews over various online platforms. These reviews serve as a basis for the data analysts at major enterprises to monitor the reputation of their brands and products, gather and analyze customer feedback,

and gauge public opinion [2]. One such field of study that helps in understanding the opinions associated with a review is Sentiment Analysis. Sentiment Analysis determines whether the given text is positive, negative, or neutral based on a sentiment score, thus enabling the service providers to make appropriate updates to their products.

Literature Review

Many research studies expressed that Sentiment analysis techniques have been applied to tweets, reviews of products on various e-commerce sites to identify the relationship between different variables. For instance, a positive correlation was found between Twitter text and Bitcoin prices during COVID-19 pandemic [3], the sentiment scores of which were calculated using VADER. Moreover, research demonstrated the use of machine learning techniques for sentiment analysis of movie review tweets, and concluded that machine learning techniques, specifically the feature vector approach, are effective for sentiment analysis of tweets related to movie reviews [4]. Furthermore, in [5], the study used machine learning and deep learning techniques to analyze people's emotions and views about the Ukraine-Russia war on Twitter. The proposed hybrid model, which combines Roberta with ABSA (Aspect Based Sentiment Analysis) and Long Short-Term Memory, achieved an accuracy of 94.7 percent, outperforming state-of-the-art techniques. Additionally, the study found that people's emotions toward the Ukraine-Russia war are mostly unfavourable. Thus, Sentiment Analysis proves to be an effective technique in identifying the sentiments of users and establishing a correlation between different factors determining the choices of the customers or users.

Need & Relevance

As of March 2024, ChatGPT had over 180.5 million monthly users. Also, ChatGPT is used by more than 92 percent of Fortune 500 businesses. Such large numbers of users will have different opinions about ChatGPT. Furthermore, availability of online platforms like review sites, blogs, forums, social networking sites are enabling the users to instantly express their opinions, thus leading to the exponential growth of user-generated data on the web [6]. Analysis of such reviews not only assist the service providers to improvise the performance of the software, but also helps various stakeholders in making policy decisions. Hence, it becomes exceedingly important to understand the sentiments associated with the reviews. However, with the volume of data generated, manual mining of the sentiments becomes a tedious task. Thus, a tool like Sentiment Analysis can automate this process of identifying the sentiments of a statement as being positive, negative, or neutral. Such form of categorization will assist the service providers and vendors to investigate further the reason for negative sentiments of the users and thus enhance the quality of product.

Objective

To compare the sentiment scores of ChatGPT reviews using a lexicon-based Sentiment Analysis tool -VADER and RoBERTa

Materials & Methods

The present research adopted experimental research design and sentimental analysis has been performed to meet the objective. The results are observed and discussed accordingly.

Observation & Discussion

Sentiment Analysis

Opinion mining, also known as Sentiment Analysis (SA), is the study of people's attitudes, beliefs, and feelings concerning an object [7]. It is a NLP (Natural Language Processing) technique which helps to analyze and process the text. Sentiment Analysis techniques identify the opinions or feelings associated with any product or service, thus giving meaningful feedback about the product or service. There are different approaches to perform Sentiment Analysis, such as Lexicon-based, Machine Learning and Hybrid. In Lexicon-based Sentiment Analysis, the system uses lexicons or dictionaries that contain lists of words and phrases associated with various emotions, to categorize the words (such as positive, negative, or neutral) and identify the sentiment. One such lexicon-based sentiment analysis tool is VADER. It can handle words, abbreviations, slang, emoticons, and emojis commonly found in social media. It is typically much faster than Machine Learning algorithms, as it requires no training. Also, in VADER, each body of text produces a vector of sentiment scores with negative, neutral, positive, and compound polarities [8].

Machine Learning algorithms, use data that has been manually tagged to train the classifiers. Machine learning techniques can be further classified as: Supervised learning and Unsupervised learning [9]. Unsupervised learning techniques classify unlabelled data into similar-looking groupings, whereas Supervised learning is the most well-known Machine Learning technique. With this method, labelled source data is used to train a model. A type of supervised learning called a Transformer model is a Deep Learning model that is primarily used in the processing of sequential data such as natural languages [10]. One such transformer model is RoBERTa (Robustly optimized BERT approach) [11]. The predecessor of RoBERTa, BERT, or Bidirectional Encoder Representations from Transformers, is also a deep learning model called transformers, in which each output and each input element is connected, and the weightings between them are dynamically determined based on that relationship [12]. However, BERT was significantly undertrained and hence, improved RoBERTa model was proposed [11].

The study has been carried out on a dataset containing the reviews of ChatGPT using VADER and RoBERTa based Sentiment Analysis. The study uses a dataset obtained from Kaggle. The 'ChatGPT App Reviews' dataset is a comprehensive collection of user reviews from the ChatGPT mobile app on iOS, capturing valuable insights and sentiments about ChatGPT. The dataset enables the understanding of user satisfaction, evaluation of app performance, and identification of emerging patterns. The dataset contains 2292 records and consists of columns: date, title, review, and rating. Rating is a numerical value between 1 to 5, a higher number indicates a higher rating. Figure 1 shows the frequency distribution of the ratings given by the

users. Title is a short description of the review. In this chapter, Sentiment Analysis of review column is carried out using VADER and RoBERTA. Sentiment Analysis was done initially with Python’s NLTK (Natural Language ToolKit) and then with Hugging Face’s transformer model RoBERTa. A comparative analysis was done of the results obtained by both the methods.

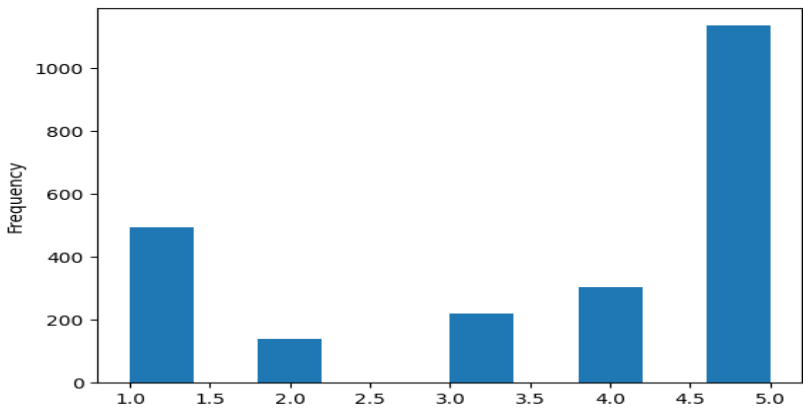


Fig 1: Frequency Distribution of Ratings

VADER Sentiment Analysis

VADER uses ‘bag of words’ approach, it assigns a positive or a negative score to each of the words and adds up the score to tell how positive or negative the statement is. VADER gives the polarity (positive, negative, or neutral) as well as intensity of the text.

Four types of scores are generated for each review:

- neg: the negative sentiment score (between 0 and 1)
- neu: the neutral sentiment score (between 0 and 1)
- pos: the positive sentiment score (between 0 and 1)
- compound: the overall sentiment score (between -1 and 1)

Polarity score is run on the entire dataset and graphs are plotted for different scores obtained. Fig. 2 to Fig. 5 shows the relation between ratings and the negative, neutral, positive, and compound scores respectively. All four show a positive correlation with the ratings provided by the user.

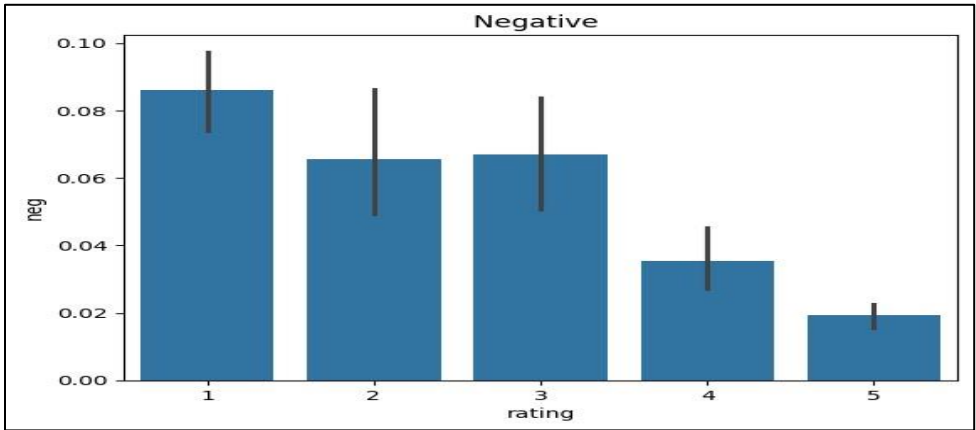


Fig 2: Vader Negative Score vs User Ratings

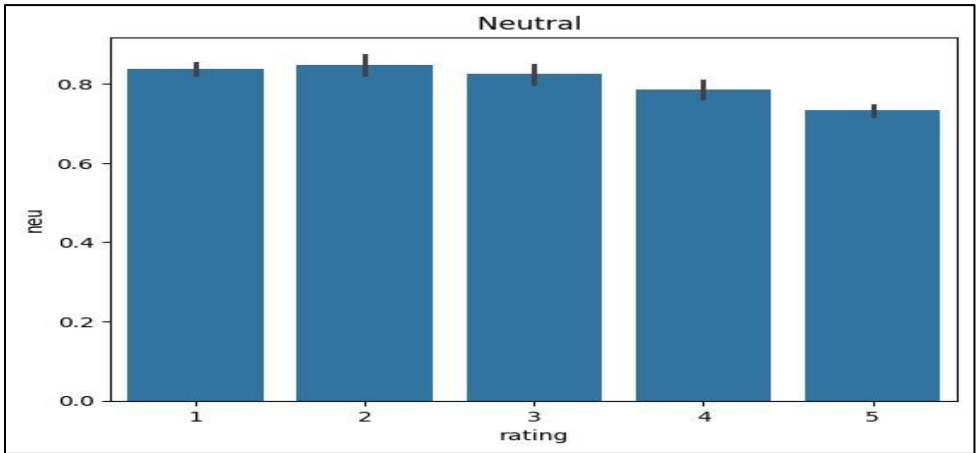


Fig 3: Vader Neutral Score vs User Ratings

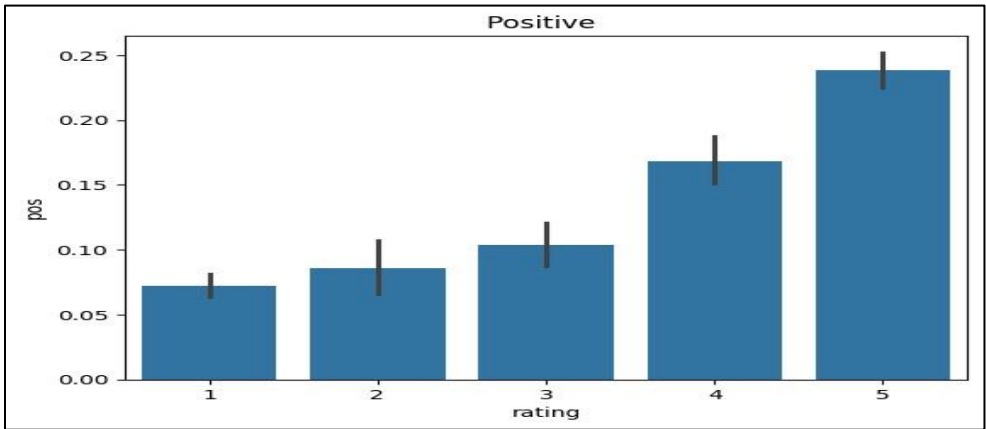


Fig 4: Vader Positive Score vs User Ratings

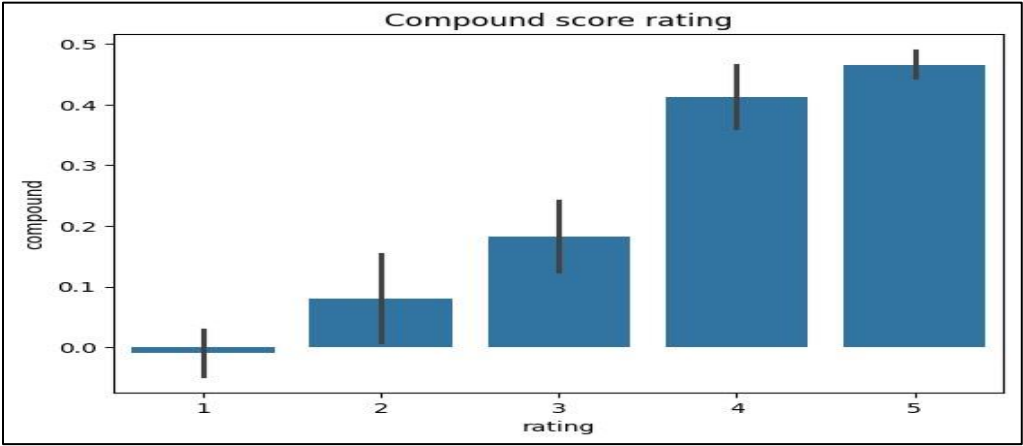


Fig 5: Vader Compound Score vs User

RoBERTa Sentiment Analysis

Sentiment Analysis is performed on the same dataset using RoBERTa transformer. The negative, neutral positive and compound score calculated, using both the techniques are compared. Scatter graph plotted (Fig. 6 to Fig. 8) shows the co-relation between the different scores. From the graphs, it can be deduced that most of the scores calculated by both the techniques, which showed a positive co-relation with each other. Data points overlap for most of the rows indicating proximity of the scores. However, for few points there was a variation in scores observed, which is further discussed in the Result section.

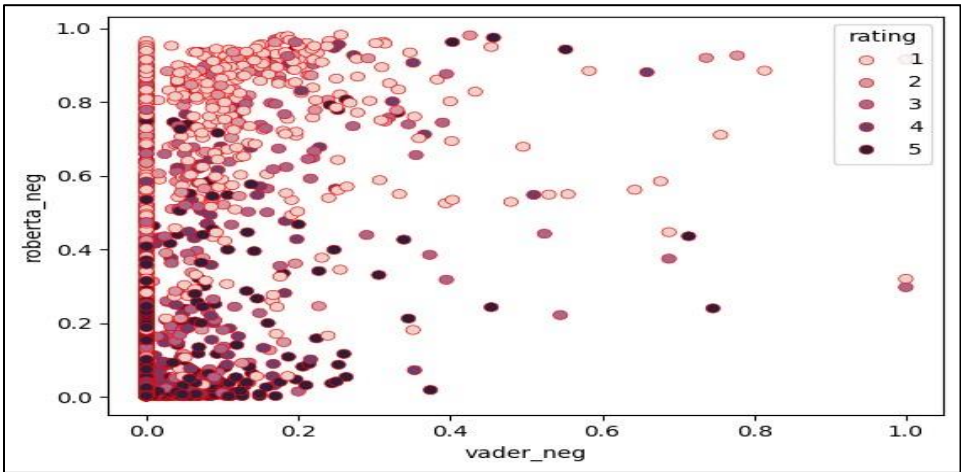


Fig 6: Scatter Graph of Vader Negative Score vs RoBERTa Negative Score

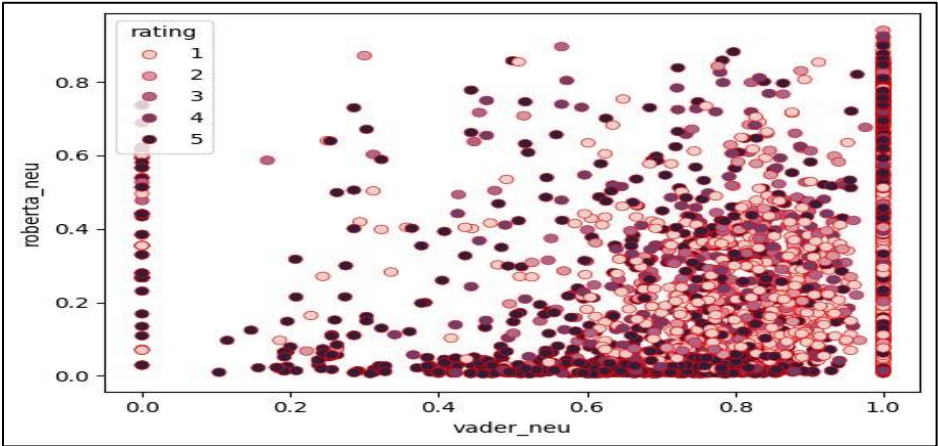


Fig 7: Scatter Graph of Vader Neutral Score vs RoBERTa Neutral Score

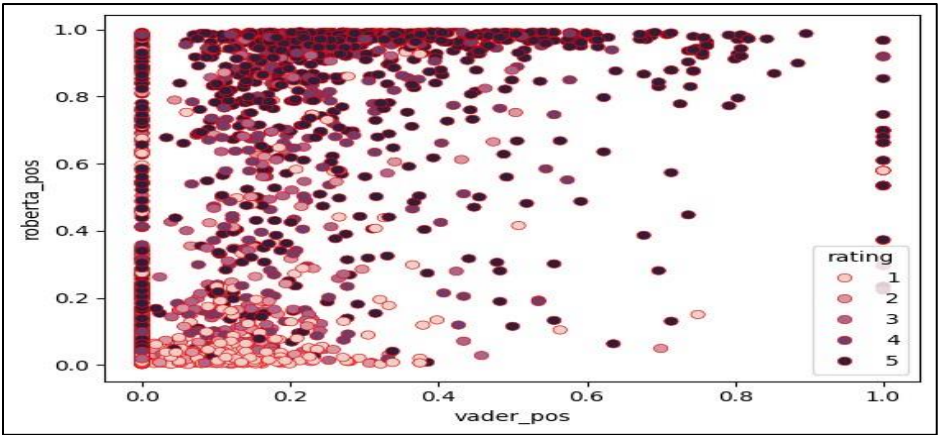


Fig 8: Scatter Graph of Vader Positive Score vs RoBERTa Positive Score

Out of 2292 reviews, positive or negative scores calculated using VADER and RoBERTa, wherein 539 scores did not match. As a result, 23 percent variation has been observed in the scores calculation after comparing both techniques. The following are some of the observations regarding reviews:

VADER did not show accurate results in some cases. Some of the reviews are miscalculated as positive results. In one of the reviews a user used the work “clunky”, which means heavy. Scores generated by VADER and RoBERTA are:

vader_neg = 0.016 vader_pos=0.082

Roberta_neg = 0.43221128 Roberta_pos = 0.161074847

VADER has not detected the meaning of slang ‘clunky and thus indicates that the comment is more positive than negative, whereas RoBERTa correctly calculates the score to be more positive than negative.

In another review, a user has given a suggestion to provide a collapsible history and has commented that on desktop browser the app pauses too often. The scores generated by VADER and RoBERTa for the review are as follows:

Vader_neg = 0.044 vader_pos= 0.089
RoBERTa_neg = 0.279949456 Roberta_pos = 0.24092561

The above review depicts a suggestion given by the user and VADER shows it as more positive as against RoBERTa, which indicates the comment to be more negative than positive.

In another review, “While the app is functional, I highly recommend using the web-based version for a superior overall experience”, VADER has calculated negative score as 0 whereas Roberta calculates it as 0.001733431, which shows more accuracy, though user is trying to give feedback regarding improvement in the app. On the other hand, for a fully positive review of the sort “This is fantastic! I used to need to bookmark the ChatGPT website on my phones Home Screen, but having an app made directly from OpenAI is absolutely amazing”, VADER calculates it correctly by giving a negative score = 0 while Roberta gives a negative score of 0.001618016.

Thus, it can be observed that VADER for a fully positive comments, gives an accurate score, but for suggestions and slight negative comments mis-calculates the score. RoBERTa, on the other hand works well with the negative comments and handles suggestions well, but for fully positive reviews miscalculates the negative score. This is because, RoBERTa takes into account the context of words. VADER, on the other hand being simple lexicon-based tool will work faster in larger datasets as against RoBERTa. As the dataset, in this study contains only 2292 reviews the difference in computation speed is not substantial, as would be for much larger datasets. Overall, RoBERTa proves to be more accurate in determining the sentiment of a review as against VADER. The study demonstrates a strong relation between the sentiment score and reviews in both the cases. Moreover, a study corroborated with the findings of which 4,00,000 Amazon reviews are analyzed and the fact that deep learning models give a better insight into sentiment analysis is established [13]. Another research study confirms that though VADER and RoBERTa show similar results, wherein latter is more accurate in analyzing the sentiments [14]. Yet another study conducted, predecessor of RoBERTa, BERT has proved to be efficient in understanding and classifying the sentiments of ChatGPT related tweets in comparison with other models [15].

Suggestions

Out of 2292 reviews, 539 review scores did not match for both the methods. Though, manually a few records out of 539 have been checked for discrepancies, it was not possible to do a manual check for all 539 records. Hence, the future research study could be conducted by

applying other Machine Language algorithms to these 539 unmatched records and confirming, which of the methods i.e. VADER or RoBERTa calculates a better score. Also, emoticons and emojis are not interpreted by either of the models in this study, which could be an enhancement in future work that can be performed on the same dataset.

Conclusion

The comparative research has been conducted to see the accuracy of results by performing Sentiment Analysis on the same dataset by 2 different techniques (VADER & RoBERTa). The present study has compared Negative, neutral, and positive scores. Interestingly, only 23 percent of the data showed a slight variation in the scores. Moreover, VADER performed well while complying with the ratings given by users. It has been an observation that while RoBERTa showed accuracy in calculating the score for negative comments, but for a fully positive review, it indicated a slight error while calculating the negative score. Overall, RoBERTa showed more accuracy in calculating the score and depicting the sentiment of reviews correctly.

References

- [1] Ray, P. P. (2023). ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope. *Internet of Things and Cyber-Physical Systems*, 3(1), 121-154.
- [2] Chadha, R., & Chaudhary, A. (2023). A Study analyzing an innovative approach to sentiment analysis with VADER. *Journal of Engineering Design and Analysis*, 6(1), 23-27.
- [3] Pano, T., & Kashef, R. (2020). A complete VADER-Based sentiment analysis of bitcoin (BTC) tweets during the era of covid-19. *Big Data and Cognitive Computing*, 4(4), 1- 17.
- [4] Amolik, A., Jivane, N., Bhandari, M., & Venkatesan, M. (2016). Twitter sentiment analysis of movie reviews using machine learning techniques. *International Journal of Engineering and Technology*, 7(6), 2038- 2043.
- [5] Sirisha, U., & Chandana, B. S. (2022). Aspect based sentiment and emotion analysis with RoBERTa, LSTM. *International Journal of Advanced Computer Science and Applications*, 13(11), 766-774.
- [6] Agarwal, B., Mittal, N., Bansal, P., & Garg, S. (2015). Sentiment analysis using common-sense and context information. *Computational Intelligence and Neuroscience*, 2015,1-9.
- [7] Medhat, W., Hassan, A., & Korashy, K. (2014). Sentiment analysis algorithms and applications: A survey. *Ain Shams Engineering Journal*, 5(4), 1093-1113.

- [8] Hutto, C. J., & Gilbert, E. (2014). VADER: A parsimonious rule-based model for sentiment analysis of social media text. *Proceedings of the International AAAI Conference on Web and Social Media*, 8(1), 216-225.
- [9] Ligthart, A., Catal, C., & Tekinerdogan, B. (2021). Systematic reviews in sentiment Analysis: A tertiary study. *Artificial Intelligence Review*, 54(7), 4997-5053.
- [10] Thoyyibah, T., Haryono, W., Zailani, A. U., Djaksana, Y. M., Rosmawarni, N., & Arianti, N. D. (2023). Transformers in machine learning: Literature review. *Jurnal Penelitian Pendidikan IPA*, 9(9), 604-610.
- [11] Liu, Y., Ott, M., Goyal, N., Du, J., Joshi, M., Chen, D., Levy, O., Lewis, M., Zettlemoyer, L., & Stoyanov, V. (2019). RoBERTa: A robustly optimized BERT pretraining approach, *arXiv:1907.11692v1 [cs.CL]*.
- [12] Devlin, J., Chang, M. W., Lee, K., & Toutanova, K. (2019). BERT: Pre-training of deep bidirectional transformers for language understanding. *Proceedings of 2019 Conference of North American Chapter of the Association for Computational Linguistics: Human Language Technologies*, 1, 4171-4186.
- [13] Gupta, A., Arhatia, I., Gautam D., Verma, R., & Sathianesan, G. W. (2024). Mobile review sentiments: An in-depth analysis. *Proceedings of 7th International Conference on Intelligent Computing (ICONIC 2K24)*, Panimalar Engineering College, Chennai.
- [14] Sandoval, E. L., Zareei, M., Barbosa-Santillan, L. I., & Morales L. E. F. (2022). Measuring the impact of language models in sentiment analysis for Mexico's covid-19 pandemic. *Electronics*, 11(16), 2483.
- [15] Sudheesh, R., Mujahid, M., Rustam, F., Shafique, R., Chunduri, V., Villar, M. G., Ballester, J. B., Diez, I. T., & Ashraf, I. (2023). Analyzing sentiments regarding ChatGPT using novel BERT: A machine learning approach. *Information*, 14(9), 474.

Webliography

<https://www.demandsage.com/chatgpt-statistics/>
<https://www.kaggle.com/datasets/saloni1712/chatgpt-app-reviews>

Edge Computing and IoT in Smart Cities - An Overview

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Abstract

In an era of growing urbanization and rising sustainability expectations, the confluence of edge computing and IoT technologies has emerged as a critical enabler for creating smarter, more efficient, and resilient urban settings. IoT and edge computing work together as complementary technologies to build smart cities. This chapter delves into the various aspects of edge computing and IoT, highlighting their critical role in enhancing urban living. It looks at the underlying ideas, architectural models, and methods of implementation that facilitate the fusion of different technologies in the context of the smart city environment. The study also discusses a range of use cases and scenarios in which edge computing and IoT are transforming smart cities in profound ways. Applications that come under this category include energy management, public safety, healthcare, environmental monitoring, and intelligent transportation systems. The present research also explores the challenges and considerations that must be made when integrating edge computing and IoT in smart cities, including infrastructure needs, security, privacy, and scalability. By bringing computation and data storage closer to the edge, these technologies can improve the performance, reliability, and security of smart city applications.

Keyword: Edge Computing, Smart Cities, IoT, Fog Computing.

Introduction

The modern world is experiencing enormous urbanisation, with cities now hosting more than half of the global population. In furtherance, rapid urbanisation has brought with it, number of

new difficulties such as increased demand for energy, transportation, healthcare, and public safety. Simultaneously, there is a stronger emphasis on sustainability, robustness, and efficiency. As a result of these difficulties, the concept of “smart cities” has gained steam, with a focus on harnessing technology to improve urban living. One of the key technologies driving the emergence of smart cities is the Internet of Things. The Internet of Things (IoT) refers to the networking of a wide range of physical devices and sensors that collect and share data. These technologies may be found throughout the city, ranging from traffic lights to trash collection systems to wearable health trackers. The sheer volume of data generated by IoT devices on the other hand, creates significant challenges for processing, evaluating, and making real-time decisions. Edge computing boosts the efficiency, dependability, and security of IoT applications by bringing processing and data storage closer to the network’s ‘edge’. This chapter intends to explore how edge computing and IoT technologies may be incorporated in the context of smart cities [1].

Edge Computing and IoT collaboration is the core of smart city development, ushering in a new era of unmatched connectivity and efficiency. Edge Computing is emerging as a critical player in the complex network of urban infrastructure, where data flows from sensors, cameras, and a plethora of IoT devices. Edge Computing decreases latency and enables real-time decision-making by processing data closer to the source of creation at the network’s edge. This dynamic synergy between Edge Computing and IoT is particularly crucial in smart cities, where split-second responses may enhance traffic flow, public safety, and overall city performance. The edge acts as a data processing hub, relieving the burden on centralised data centres, and resulting in a more dispersed, robust system. This interaction is critical to the agility and responsiveness needed in smart cities, where data-driven insights enable administrators to make educated decisions quickly [2]. Furthermore, the convergence of Edge Computing and IoT goes beyond simple data processing. It speeds up the deployment of machine learning models at the edge, allowing devices to make intelligent decisions in real-time [3].

Literature Review

The integration of edge computing and IoT technologies in smart cities has garnered substantial attention in recent years due to its potentiality to revolutionize municipality infrastructure, services, and sustainability. This study aims to provide an overview of the stream research landscape painting in this domain, focusing on key studies that explore various aspects of edge computing and IoT undefined in smart city environments. A research study delves into the acceptance of IoT edge-computing-based sensors in smart cities for universal design purposes. Also, the study highlights the importance of user acceptance in deploying IoT devices at the edge of networks, particularly in ensuring accessibility and inclusivity in urban environments [4]. Another research study proposed an efficient edge computing management mechanism tailored for sustainable smart cities, emphasizing the need for optimized resource allocation and energy efficiency in edge computing infrastructures [5]. A comprehensive survey provided insights into the diverse technologies, practices, and challenges associated with IoT implementation in smart cities. The study offers a holistic view of the current landscape, covering topics ranging from sensor networks and data analytics to privacy and security

concerns [6]. Few research studies have contributed to the understanding of IoT technologies in smart cities, focusing on applications, architectures, and edge-computing-enabled infrastructures, respectively [7, 8].

A research study discussed an efficient machine learning-based resource allocation scheme tailored for software-defined networking (SDN)-enabled fog computing environments, addressing the need for intelligent resource management in edge computing systems [9]. The research studies conducted by researchers have explored the deployment of Internet of Vehicles (IoV) and hierarchical distributed fog computing architectures for big data analysis in smart cities, highlighting the potential applications and architectural considerations in urban environments [10, 11]. Another research study proposed a novel approach for solving critical events through mobile edge computing, showcasing the role of edge computing in enhancing public safety and emergency response systems in smart cities [12]. Yet another study contributed to the literature by surveying load balancing techniques in fog computing environments, addressing the challenges associated with workload distribution and resource optimization at the network edge [13]. Lastly, studies conducted by few researchers have explored the design and application of municipal service platforms based on cloud-edge collaboration and metaverse applications in smart cities, respectively [14, 15]. The aforesaid research studies shed light on emerging trends and future directions in leveraging edge computing and IoT technologies to create innovative and urban ecosystems.

Need & Relevance

In recent years, the convergence of edge computing and Internet of Things (IoT) technologies has emerged as a game-changer in the realm of smart cities. As urban populations continue to grow, cities face mounting challenges related to infrastructure management, resource optimization, and sustainability. Edge computing and IoT offer promising solutions to address these challenges by enabling real-time data processing, decentralized decision-making, and efficient resource allocation at the network edge. Understanding the need and relevance of these technologies in the context of smart cities is crucial for policymakers, urban planners, researchers, and industry professionals seeking to harness the potential of digital transformation in urban environments. This book chapter aims to provide an overview of edge computing and IoT in smart cities, highlighting their significance, applications, and implications for urban development. The relevance of exploring edge computing and IoT in the context of smart cities extends beyond technological innovation. It intersects with broader societal goals, such as sustainability, inclusivity, and economic development. By leveraging edge computing and IoT technologies, smart cities can reduce energy consumption, minimize environmental impact, and enhance accessibility to essential services for all citizens. Moreover, these technologies have the potential to foster economic growth, spur innovation, and create new opportunities for businesses and entrepreneurs in urban areas.

Objectives

To provide a theoretical concept for understanding edge computing and IoT concepts and their relevance to smart city development

To explore the applications and use cases of edge computing and IoT in various domains of smart city infrastructure including transportation, energy, healthcare, public safety, and environmental monitoring

To discuss the challenges and opportunities, future trends, emerging technologies, and research directions in the field of edge computing and IoT for smart cities

Method of Study

The study adopted descriptive research design. The entire research chapter is based on secondary data sources, wherein the observations and challenges are discussed accordingly.

Observations

In this section the researcher discusses about the intricate intersection of edge computing and IoT within the context of smart cities, providing an in-depth overview of key concepts, technologies, challenges, and opportunities. The overall, the main content of this research chapter provides a comprehensive overview of the pivotal role of edge computing and IoT in shaping the future of smart cities.

Edge Computing in Smart Cities

In the context of smart cities, edge computing is a computing paradigm that includes processing data close to its source of origin, at the network’s perimeter, rather than depending entirely on centralised cloud servers. This method reduces data latency by executing calculations near the IoT devices and sensors that create the data. Edge Computing in smart cities enables real-time analysis, decision-making, and automation, resulting in more responsive, efficient, and intelligent urban processes. This closeness to the data source is especially important in applications like intelligent traffic management, where split-second choices can have a big influence on congestion and overall mobility. Edge Computing also intends to relieve the load on centralised cloud infrastructure by providing scalability and stability in the face of expanding volume of data generated by IoT devices in smart cities. Table 1 summarizes the key information about Edge computing and IoT in smart cities.

Table 1 Summarize Key Information about Edge Computing and IoT

Aspect	Edge Computing in Smart Cities	IoT in Smart Cities
Definition	A decentralized computing paradigm processing data closer to the source, enhancing real-time decision-making.	A network of interconnected devices, sensors, and actuators that collect and share data to improve urban efficiency.
Purpose	Improve speed, efficiency, and responsiveness of data processing and decision-making.	Create a more interconnected and intelligent urban ecosystem, optimizing various city services.

Benefits	<ul style="list-style-type: none">- Reduction of data latency.- Increased reliability and scalability.- Efficient use of bandwidth.- Enhanced privacy and security.- Deployment of machine learning at the edge.	<ul style="list-style-type: none">- Operational efficiency improvement.- Resource optimization.- Enhanced public services.- Support for evidence-based decision-making.
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The edge computing also contributes to increased reliability. Local processing at the edge ensures that critical services can continue to operate independently in the event of network disruptions or connectivity issues. Another significant advantage is the effective use of bandwidth. Moreover, Edge Computing eliminates the need to send massive amounts of raw data to centralised servers by processing data locally, maximising network capacity, and minimising operational costs. Furthermore, Edge Computing increases privacy and security by putting sensitive data closer to its source, decreasing the risks associated with network data transfer [5].

IoT in Smart Cities

In the context of smart cities, the IoT refers to a vast network of interconnected devices, sensors, and actuators that gather and share data to improve the efficiency, sustainability, and general usefulness of urban settings. IoT devices are integrated in different infrastructure components such as transportation systems, utility grids, and public areas in a smart city scenario, forming a network where data is continually created, transferred, and analysed. This network allows city officials to make more informed choices, automate procedures, and improve the quality of services given to people. The major goal of incorporating IoT into smart cities is to create a more connected and intelligent urban ecology. IoT devices act as data sources, providing real-time information about municipal operations, environmental conditions, and infrastructure usage. IoT helps to the building of cities that are not just technologically sophisticated, but also more sustainable, resilient, and responsive to the demands of their residents by supporting a data-driven approach [6]. The use of IoT in smart cities has several advantages. One key advantage is increased operating efficiency. IoT devices provide for real-time monitoring and administration of many municipal functions, allowing for quick reactions to changing conditions. For example, intelligent transportation systems may use IoT data to optimise traffic flow and alleviate congestion.

Architectural Frameworks for Edge Computing and IoT Integration

Architectural frameworks are critical in influencing the integration of Edge Computing and the IoT, across several domains, including smart cities. These frameworks provide the structure and rules required for creating and deploying systems that integrate Edge Computing and IoT technologies. Integration of these two paradigms is critical for developing resilient and efficient systems capable of handling the diverse and dynamic nature of smart city data. Figure 1 represents an overview of smart cities enabled by IoT and Edge Computing [8].

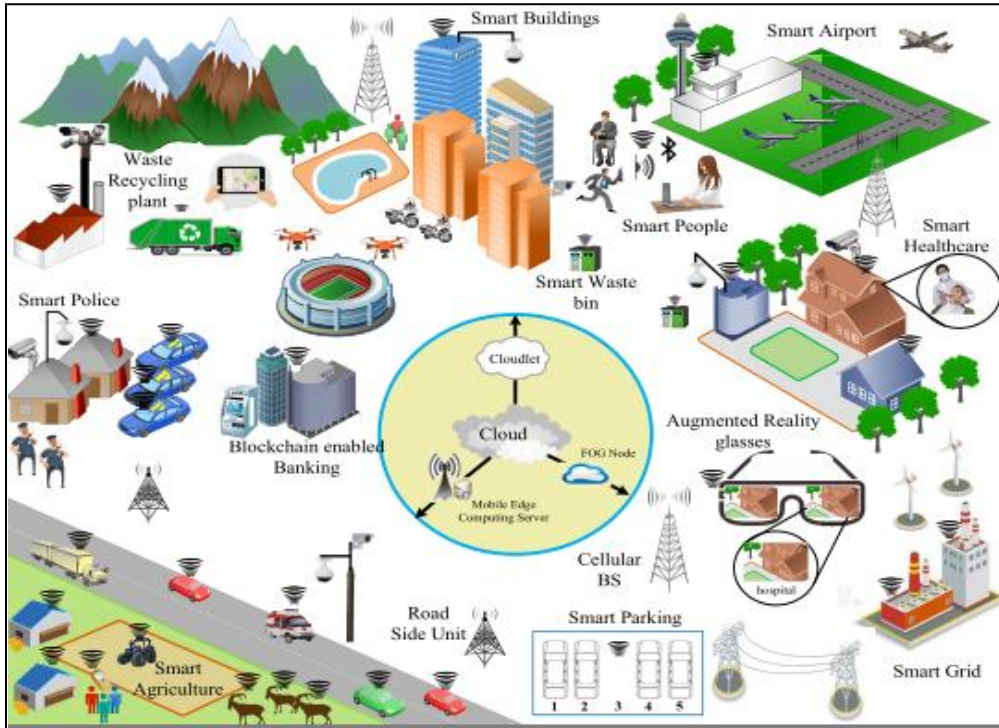


Fig 1: Overview of Smart Cities Enabled by IoT and Edge Computing

The architectural frameworks for Edge Computing and IoT integration in smart cities are focused on providing a flexible and scalable structure. The distribution of computing resources across the network is a crucial notion, with edge nodes deliberately positioned to process data locally. Architectures must allow for the training and deployment of these models at the edge, guaranteeing that real-time choices may be made based on locally processed data. Some of the most common architectural frameworks for edge computing and IoT integration are as follows:

EdgeX Foundry: It is an open-source platform that provides a standardized collection of APIs and services for developing edge computing applications.

Eclipse Kura: Kura is a Java/OSGi-based open-source edge computing framework that provides a lightweight platform for developing and maintaining IoT applications on edge devices.

FIWARE: FIWARE is also an open-source platform that contains components for developing and maintaining IoT applications.

Amazon Greengrass: Greengrass is a service from Amazon Web Services (AWS) that allows you to run AWS Lambda functions on edge devices.

Microsoft Azure IoT Edge: Azure IoT Edge is a service from Microsoft Azure that allows you to deploy and manage IoT applications on edge devices.

IBM Watson IoT Edge: It is IoT Edge service that lets you set up and maintain edge device cognitive IoT apps.

These are only a handful of architectural frameworks that are accessible for the integration of edge computing and IoT. The ideal structure for you will rely on your unique demands and specifications. Lastly, architectural frameworks for Edge Computing and IoT integration in smart cities serve as the foundation for developing intelligent, responsive, and scalable systems. These frameworks provide the rules for allocating computer resources, assuring device compatibility, and deploying machine learning at the edge. As smart cities expand, these architectural underpinnings will play an important role in creating the future of urban living by improving efficiency, sustainability, and overall quality of life for citizens [9].

Deployment Techniques in Smart Cities

In order to fully use the revolutionary power of IoT and Edge Computing, smart city deployments require the application of complex deployment strategies. The deployment of edge nodes strategically throughout the urban environment is one such tactic. Cities may guarantee that data is handled as close to its source as feasible, minimizing latency and facilitating real-time decision-making, by carefully placing sensors, gateways, and edge servers. For applications like intelligent transport systems, where split-second reactions are critical to maximizing traffic flow and guaranteeing effective mobility, this strategy is especially important. The adaptability required to adjust to the dynamic nature of smart cities is provided by this hybrid approach, which enables effective resource allocation and scalability while satisfying the various needs of various applications within the urban environment [10].

Distributed and Mobile Edge Computing

In the context of developing technologies like the Internet of Things and smart cities, distributed edge computing represents a paradigm change in the distribution and use of computing resources. Distributed edge computing, in contrast to conventional centralized computing models, moves computation closer to the data source, lowering latency and improving real-time processing capabilities. By distributing computing resources—such as servers and edge nodes—across several network locations, this method makes it possible to create an architecture that is more decentralized and flexible. Distributed edge computing minimizes the need for data to travel long distances and the possibility of network bottlenecks by guaranteeing that this data is handled closer to its source [11]. The idea of distributed edge computing is becoming a vital component of smart city applications, fostering metropolitan areas' flexibility, efficiency, and reactivity. Data processing and service delivery are being completely transformed by Mobile Edge Computing (MEC); a revolutionary technology that brings computing capacity closer to the edge of mobile networks. In essence, MEC increases the responsiveness and efficiency of mobile apps by utilizing edge computing capabilities. This technique lowers latency and allows real-time processing by putting computer equipment at the edge of cellular networks. MEC is particularly significant for mobile networks, where the exponential growth of data and low-latency applications such as autonomous vehicles and augmented reality necessitate a more distributed computing architecture. Mobile Edge

Computing is at the vanguard of mobile network evolution, ushering in a new era of mobile computing that is more responsive, scalable, and suited to the dynamic demands of modern mobile consumers [12].

Fog Computing

Within the complex environment of smart cities, Fog Computing, an extension of Edge Computing, plays a critical role in the synergy between Edge Computing and the IoT. Fog Computing, as a decentralized computing paradigm, includes the dispersal of computing resources closer to the network's edge, bringing intelligence and processing capabilities to the devices and sensors that generate data. Fog Computing serves as an intermediary layer between edge devices and centralized cloud servers in the setting of smart cities, where a plethora of IoT devices continually provide data across multiple applications. This intermediary layer enables more effective data processing, lowering latency and improving overall responsiveness of smart city systems. The integration of fog computing in smart cities is especially advantageous in scenarios requiring real-time decision-making, such as intelligent transportation systems and public safety applications. Fog Computing reduces the need for data to travel great distances to centralized data centres by processing it closer to the point of origin [13]. This not only improves reaction times, but also optimizes bandwidth utilization and relieves load on cloud infrastructure. In smart cities, fog computing illustrates a dispersed and adaptable strategy to solving the particular problems of urban settings while also contributing to the seamless integration of Edge Computing and IoT technologies for more efficient, intelligent, and responsive urban systems [14].

Applications and Use Cases

Edge Computing and IoT integration in smart cities has ushered in a plethora of applications and use cases that considerably improve urban living. Edge Computing and IoT work together to optimize traffic flow, decrease congestion, and increase overall mobility in intelligent transportation systems. Smart traffic signals with sensors and cameras, along with edge computing capabilities, offer real-time traffic pattern analysis. Edge Computing in this context provides quick decision-making for load balancing, decreasing energy waste, and boosting the integration of renewable energy sources into urban power infrastructure [15]. These applications are only a taste of the disruptive influence that Edge Computing and IoT are having in smart cities with larger ramifications extending to environmental monitoring, healthcare, public safety, and beyond [16].

Intelligent Transportation Systems

A prime example of the ground-breaking cooperation of Edge Computing and IoT in smart cities is Intelligent Transport Systems (ITS). By using Edge Computing's processing power and IoT sensors embedded in infrastructure, vehicles, and roadways, smart cities transform their transportation ecosystems. Dynamic traffic control and optimization are made possible by these systems' real-time collection and analysis of enormous amounts of data. In order to facilitate real-time decision-making for adaptive traffic signal control, route planning, and

congestion management, edge computing brings processing closer to the source. This reduces fuel consumption and emissions, which not only shortens travel times and eases traffic, but also contributes to the development of a more sustainable urban environment. Additionally, the growth of intelligent vehicle-to-everything communication is made possible by edge computing and the internet of things [17].

Traffic Management

Edge computing and IoT are driving a substantial revolution in smart city traffic management. Edge computing provides real-time analysis of information gathered by IoT devices such as sensors and cameras embedded in urban infrastructure by processing data at the edge, closer to the source of generation. This decentralized strategy minimizes latency, allowing for quick decisions in reaction to changing traffic circumstances. Edge devices, for example, can optimize traffic signal timing based on real-time data, resulting in enhanced traffic flow and reduced congestion. Edge computing and IoT device collaboration also enables predictive analytics in traffic control. Machine learning algorithms at the edge can estimate traffic patterns and potential disruptions by analyzing historical and real-time data from IoT devices. This proactive strategy enables the deployment of preventative actions such as signal timing adjustments or traffic rerouting, which contributes to the overall efficiency of transportation system. In furtherance, the integration of edge computing with IoT improves safety by allowing for the rapid identification of risks such as accidents or barriers, as well as providing prompt reaction mechanisms such as notifying emergency services or dynamically rerouting traffic.

Energy Management

With the integration of edge computing and the IoT, energy management in smart cities is experiencing a transformational transition. Edge computing brings processing capacity closer to energy infrastructure, enabling real-time data analysis from IoT devices such as smart metres, sensors, and linked appliances. This localized processing decreases latency and enables faster and more informed decisions about energy usage, distribution, and efficiency. IoT devices are critical in smart cities for gathering granular data on energy use trends, building characteristics, and grid performance. The convergence of edge computing and IoT in energy management not only improves the dependability and resilience of urban energy networks, but also adds to sustainability goals by enabling more efficient resource usage and lowering overall energy consumption [13].

Smart Grids

IoT devices are critical in smart cities for gathering granular data on energy use trends, building characteristics, and grid performance. These gadgets continually provide data to edge computing platforms, which may analyze it on the spot. This enables intelligent energy management solutions such as dynamic load balancing, predictive repair of energy infrastructure, and optimizing energy distribution based on real-time demand to be implemented. The convergence of edge computing and IoT in energy management not only improves the dependability and resilience of urban energy networks, but also adds to

sustainability goals by enabling more efficient resource usage and lowering overall energy consumption.

Environmental Monitoring

The combination of edge computing and the IoT improves environmental monitoring in smart cities dramatically. Edge computing brings processing capabilities closer to IoT devices like sensors and drones, which are widely used to collect environmental data. This enables real-time analysis of environmental data at the edge, allowing for rapid and informed decisions on air quality, pollution levels, temperature, and other critical environmental factors. When it comes to environmental monitoring, edge computing's smooth integration with IoT enables early change detection and proactive responses to environmental issues. Combined with IoT and edge computing, environmental monitoring becomes a dynamic and responsive system. Effective data filtering is made possible by localized data processing at the edge, guaranteeing that only pertinent data is forwarded to centralized systems. This lowers latency as well as network burden, enabling quicker reactions to escalating environmental problems.

Air Quality & Environmental Sensors

The IoT and edge computing have improved the efficacy of air quality monitoring in smart cities. In cities, environmental sensors are commonly utilized, such as air quality monitoring systems. In real time, these sensors record information on particles, contaminants, and other markers of air quality. This data is processed locally by edge computing, enabling real-time analysis at the edge of the network. This reduces latency and facilitates prompt decision-making in response to variations in air quality. The fast processing of information at the edge enables quick responses such as changing traffic flow or warning inhabitants of potential health hazards all of which contribute to enhanced air quality management in smart cities. In air quality monitoring, coordination between edge computing and IoT offers more effective data handling. Edge devices, rather than sending all raw data to centralized servers, can filter and analyze information locally, delivering only relevant and condensed insights to the cloud. This not only optimizes network bandwidth but also improves the air quality monitoring system's overall scalability.

Healthcare

The integration of edge computing and the IoT in healthcare is revolutionizing patient care, diagnostics, and overall healthcare delivery inside smart cities. IoT device integration, such as wearable health trackers and medical sensors, enables continuous real-time monitoring of patients' vital signs and health parameters. Edge computing enables fast processing of this massive stream of health data at the moment of collection. Furthermore, the integration of edge computing with IoT improves healthcare service efficiency by enabling remote patient monitoring and telemedicine. Wearable devices with sensors may send health data to edge devices, which can then analyze the data locally. The seamless integration of edge computing and IoT in healthcare not only improves patient outcomes, but also helps to the development

of more responsive and patient-centric healthcare systems within the context of smart cities [18].

Patient Monitoring & Telemedicine

With the integration of edge computing and the IoT in smart cities, patient monitoring and telemedicine are experiencing dramatic transformations. Wearable health monitors and in-home medical sensors, for example, capture real-time data on patients' vital signs and health indicators. This data is analyzed locally using edge computing, reducing latency, and providing quick insights at the moment of collection. In the context of patient monitoring, this implies that healthcare practitioners will be able to obtain timely and reliable information about their patients' status, allowing for proactive interventions and personalized treatment plans [19].

Video Surveillance & Crime Prevention

The combination of edge computing and IoT is causing a paradigm change in smart city video monitoring and crime prevention. IoT-enabled security cameras are positioned strategically to keep an eye on high-crime areas, public places, and vital infrastructure in metropolitan settings. By granting these cameras local processing capability, edge computing makes it possible to analyze video streams in real time at the network's edge. By reducing latency and enabling prompt identification of suspicious activity or security risks, this decentralized technique improves the efficacy of video surveillance systems. With the use of these predictive capabilities, law enforcement may more effectively allocate resources, proactively address security concerns, and put preventative measures in place to dissuade criminal activity [20]. Smart cities are becoming safer and more secure as a result of the integration of video surveillance with edge computing and IoT, which turns conventional security systems into dynamic and proactive instruments for preventing crime.

Emergency Response

The combination of edge computing with the IoT dramatically improves public safety and emergency response capabilities in smart cities. Every second matters in an emergency, and edge computing provides real-time processing of important data acquired by IoT devices such as sensors and security cameras at the network's edge. It is because of the reduced latency; emergency response teams obtain rapid and actionable information. Whether it is a natural catastrophe, a traffic accident, or a public safety danger, the combination of edge computing and IoT enables quick and informed decision-making in emergency scenarios. Edge computing and IoT collaboration not only enhances the efficiency of emergency response systems, but also plays an important role in making smart cities more resilient and better equipped to deal with unanticipated events.

Challenges

In order to ensure the success and sustainability of these game-changing technologies, the integration of edge computing and IoT in smart cities presents a number of issues and concerns

that need to be carefully considered. The interoperability of various systems and devices inside the smart city ecosystem is a major problem. Distinct communication protocols and standards may be used by various devices such as edge computing and Internet of Things applications spread. For these technologies to function together, they must achieve seamless interoperability, which calls for standardized frameworks and protocols to make integration easier and guarantee effective cooperation between systems and devices. Establishing public confidence in the security and privacy of smart city infrastructure requires the use of robust encryption techniques, safe access restrictions, and compliance with privacy laws. One of the most important aspects of tackling infrastructure difficulties in the context of edge computing and IoT in smart cities is striking a balance between the necessity of cutting-edge technology and the viability of its deployment financially. The following are some of the key challenges:

Security and Privacy: When using edge computing and the Internet of Things in smart cities, security and privacy are top priorities. Strict privacy laws and data security protocols are needed to safeguard private information that is gathered from people and different devices. It might be difficult to find the ideal balance between protecting people's privacy and using data to improve city services.

Privacy Regulations and Data Security: A complicated web of data security guidelines and privacy laws must be negotiated by smart cities. Strict compliance requirements, like GDPR or regional data protection regulations, must be followed in order to guarantee that citizen data is treated morally and lawfully. Safeguarding against possible cyber dangers requires frequent security audits, secure authentication methods, and encryption.

Scalability: Scalability becomes a crucial factor as smart cities expand and integrate additional IoT devices. Edge computing and Internet of Things applications require infrastructure that can handle increased data volumes and an expanding number of connected devices.

Infrastructure Requirements: The network infrastructure in particular requires careful planning to handle the substantial data flow that numerous IoT devices generate. It is also important to take into account the cost implications of establishing and sustaining this kind of infrastructure.

Network Infrastructure & Cost Implications: It is expensive to build the network infrastructure needed for edge computing and the Internet of Things in smart cities. Large financial expenditures are needed to build high-speed, low-latency networks that can handle the vast amounts of data produced by IoT devices. Cities must evaluate these initiatives' long-term economic feasibility and investigate creative funding options.

Discussion

In discussing the aforesaid observations and challenges associated with integrating edge computing and IoT in smart cities, several critical points emerge. Firstly, interoperability among various systems and devices within the smart city ecosystem presents a significant challenge. A research study highlighted the disparate communication protocols and standards

used by different devices hinder seamless integration, necessitating standardized frameworks and protocols to ensure effective cooperation and interoperability [4]. Similarly, the need to establish public confidence in the security and privacy of smart city infrastructure cannot be overstated. Security and privacy concerns require robust encryption techniques, secure access restrictions, and compliance with privacy laws to safeguard sensitive data [8]. Furthermore, scalability emerges as a crucial consideration as smart cities expand and integrate additional IoT devices. The edge computing and IoT applications demand infrastructure capable of handling increased data volumes and a growing number of connected devices. This scalability requirement extends to network infrastructure, which necessitates careful planning to accommodate substantial data flow generated by numerous IoT devices [5]. Additionally, the cost implications of building and maintaining such infrastructure must be carefully evaluated, and highlighted [2]. Large financial investments are required to establish high-speed, low-latency networks capable of handling vast amounts of IoT-generated data, prompting the need for innovative funding options and long-term economic feasibility assessments. The potential for efficiency, sustainability, and responsiveness to citizens' needs through the integration of edge computing, artificial intelligence, and IoT is evident. Also, the real-time data analysis facilitated by connected sensors and equipment enables better decision-making in areas such as public safety, energy efficiency, and traffic management [12]. Moreover, sustainability and resilience are paramount considerations for future smart cities has been emphasized in a research study [1]. Urban areas are increasingly prioritizing environmentally conscious projects, leveraging technology to minimize carbon emissions, maximize resource utilization, and mitigate the effects of global warming. Additionally, advancements in technology are expected to foster more transparent and participatory governance models, promoting citizen engagement and inclusion in smart city development efforts. Through multidisciplinary collaboration and strategic innovation, smart cities have the potential to evolve into vibrant centers of innovation, offering improved living standards and addressing the challenges of urbanization in a sustainable and inclusive manner.

Suggestions & Future Directions

Smart cities have a bright future ahead of them, as technology continues to change urban environments all around the world. Moreover, they have the potential to improve in efficiency, sustainability, and responsiveness to the needs of their citizens via growing integration of edge computing, artificial intelligence, and IoT. Also, smooth transition between digital and physical infrastructures in the upcoming years is expected, when real-time data analysis for better decision-making in areas like public safety, energy efficiency, and traffic management is made possible by linked sensors and equipment. The implementation of intelligent power networks, self-driving cars, and cutting-edge medical technology will all lead to improved living standards and a more integrated urban environment. Furthermore, sustainability and resilience will be given a lot of weight in the future of smart cities. The urban areas will give precedence to environmentally conscious projects, use technology to minimize carbon emissions, maximize resource utilization, and alleviate the consequences of global warming. Smart city planning will include developing green areas, integrating renewable energy sources, and putting in place sophisticated waste management systems. Moreover, technology will promote more transparent and participatory government models, making citizen participation

and inclusion crucial. Smart cities will develop into vibrant centres of innovation as the urban landscape changes, providing a higher standard of living while resolving the problems associated with urbanization and promoting a more sustainable and inclusive future.

Conclusion

The integration of edge computing and IoT offers a paradigm shift in smart city development that tackles urbanization's problems while promoting resilience, efficiency, and sustainability. In the context of smart cities, this chapter delves the basic ideas, architectural frameworks, deployment strategies, and many applications of edge computing and IoT. It emphasizes how essential these technologies are useful in transforming urban life, from energy management and sophisticated transportation systems to public safety, healthcare, and environmental monitoring. Although the study observed many advantages it needs to take into account the difficulties and factors that come alongside in deploying edge computing and IoT in smart cities. The infrastructure needs, scalability challenges, and security and privacy concerns are important factors that call for considerable thought and strategic design. Understanding the flexibility of these technologies may be gained by investigating deployment strategies like mobile edge computing and distributed edge computing, as well as architectural frameworks like edge clouds and fog computing. The future prospects for Edge Computing and IoT in Smart Cities will involve multidisciplinary endeavours that span policy formation, social sciences, and technical innovation. Thus, to overcome obstacles, improve the capabilities of smart city technologies, and contribute to building inclusive, resilient, and sustainable urban environments, researchers will collaborate.

References

- [1] Pandey, C., Tiwari, V., Imoize, A. L., Li, C. T., Lee, C. C., & Roy, D. S. (2023). 5GT-GAN: Enhancing Data Augmentation for 5G-Enabled Mobile Edge Computing in Smart Cities. *IEEE Access*, 11, 120983-120996.
- [2] Jaber, M. M., Ali, M. H., Abd, S. K., Alkhayyat, A., & Malik, R. Q. (2023). Application of edge computing-based information-centric networking in smart cities. *Computer Communications*, 211, 46-58.
- [3] Khang, A., Gupta, S. K., Rani, S., & Karras, D. A. (Eds.). (2023). *Smart Cities: IoT Technologies, big data solutions, cloud platforms, and cybersecurity techniques*. CRC Press.
- [4] Walczak, R., Koszewski, K., Olszewski, R., Ejsmont, K., & Kálmán, A. (2023). Acceptance of IoT edge-computing-based sensors in smart cities for universal design purposes. *Energies*, 16(3), 1024.
- [5] Khanh, Q. V., Nguyen, V. H., Minh, Q. N., Van, A. D., Le Anh, N., & Chehri, A. (2023). An efficient edge computing management mechanism for sustainable smart cities. *Sustainable Computing: Informatics and Systems*, 38, 100867.

- [6] Syed, A. S., Sierra-Sosa, D., Kumar, A., & Elmaghraby, A. (2021). IoT in smart cities: A survey of technologies, practices and challenges. *Smart Cities*, 4(2), 429-475.
- [7] Qian, Y., Wu, D., Bao, W., & Lorenz, P. (2019). The internet of things for smart cities: Technologies and applications. *IEEE Network*, 33(2), 4-5.
- [8] Khan, L. U., Yaqoob, I., Tran, N. H., Kazmi, S. A., Dang, T. N., & Hong, C. S. (2020). Edge-computing-enabled smart cities: A comprehensive survey. *IEEE Internet of Things Journal*, 7(10), 10200-10232.
- [9] Singh, J., Singh, P., Hedabou, M., & Kumar, N. (2023). An efficient machine learning-based resource allocation scheme for sdn-enabled fog computing environment. *IEEE Transactions on Vehicular Technology*. 72(6), 8004-8017.
- [10] Ang, L. M., Seng, K. P., Ijamaru, G. K., & Zungeru, A. M. (2018). Deployment of IoV for smart cities: Applications, architecture, and challenges. *IEEE Access*, 7, 6473-6492.
- [11] Tang, B., Chen, Z., Hefferman, G., Wei, T., He, H., & Yang, Q. (2015). A hierarchical distributed fog computing architecture for big data analysis in smart cities. In *Proceedings of the ASE BigData & SocialInformatics*, 1-6.
- [12] Sapienza, M., Guardo, E., Cavallo, M., La Torre, G., Leombruno, G., & Tomarchio, O. (2016). Solving critical events through mobile edge computing: An approach for smart cities. In *2016 IEEE International Conference on Smart Computing (SMARTCOMP)*, 1-5.
- [13] Singh, J., Singh, P., Amhoud, E. M., & Hedabou, M. (2022). Energy-efficient and secure load balancing technique for SDN-enabled fog computing. *Sustainability*, 14(19), 12951.
- [14] Singh, J., Jatinder W., & Singh P. (2021). A survey on load balancing techniques in fog computing. In *2021 International Conference on Computing Sciences (ICCS)*, IEEE, 47-52.
- [15] Yang, J., Trong-Yen L., Wen-Ta L., & Li X. (2022). A design and application of municipal service platform based on cloud-edge collaboration for smart cities. *Sensors*, 22(22), 87-84.
- [16] Yaqoob, I., Salah, K., Jayaraman, R., & Omar, M. (2023). Metaverse applications in smart cities: Enabling technologies, opportunities, challenges, and future directions. *Internet of Things*, 100884.
- [17] Rosayyan, P., Paul, J., Subramaniam, S., & Ganesan, S. I. (2023). An optimal control strategy for emergency vehicle priority system in smart cities using edge computing and IoT sensors. *Measurement: Sensors*, 26, 100697.

- [18] Ahmad, K. A. B., Khujamatov, H., Akhmedov, N., Bajuri, M. Y., Ahmad, M. N., & Ahmadian, A. (2022). Emerging trends and evolutions for smart city healthcare systems. *Sustainable Cities and Society*, 80, 103695.
- [19] Singh, G., & Singh, J. (2013). Prevention of blackhole attack in wireless sensor network using IPSec protocol. *International Journal of Advanced Research in Computer Science*, 4(11), 45-49.
- [20] Javed, A. R., Shahzad, F., ur Rehman, S., Zikria, Y. B., Razzak, I., Jalil, Z., & Xu, G. (2022). Future smart cities: Requirements, emerging technologies, applications, challenges, and future aspects. *Cities*, 129, 103794.

Prehension Using Low Cost Two Fingers with Interpretation of Contact Geometries Using Force Sensors

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Abstract

The object grasped by low cost two finger gripper features area contact and used to handle and grab a broad range of objects. The current design consists of two fingers, three links, and one actuator and offers quantifiable weight, size, complexity, and cost benefits because it uses fewer actuators. With the 3D printing technology and an intrinsic actuation technique, the prototype mechanical parts were created. Servo-assisted fingers offered benefits in measurement compelling precise motion. The fingertips can move swiftly and precisely because they are light and small. Fine-resolution location and velocity measurements are possible because the total overall range of motion is small. The fingers, when fitted with force-sensitive resistor (FSR), hence can sense and control force accurately. The grasp is balanced as the fingers are applying equal and opposing forces. The stability of grasping is enhanced by manipulation and the use of fingertips with FSR because of the large contact area and high friction involved. The FSR used is low cost, good accuracy, small dimension and lightweight is interfaced with buffered voltage divider circuitry for converting the change in resistance to the voltage output which gives a nonlinear relationship between the output voltage and the input resistance. In this chapter FSR are used to weigh things that are held and to monitor forces associated with tasks, which are used to verifying the object weights. Gripping of varying objects showed high sensitivity, repeatability, and linearity.

Keywords: Motion Control, Grasping, Manipulation, FSR.

Introduction

When considering the existing developed prosthetic hand with gripper in the market, there is very limited capabilities to grip object with different shapes and sizes in comparison with the

human hand ability to grip and manipulate objects. Hand grippers are classified depending on their design, gripping technology, and their application. Moreover, for smooth surface objects like glass to be gripped, it needs special gripper design. The commonly used hand gripper is having several other design types include two finger grippers, three finger and multi finger gripper respectively. Hand grippers can be pure mechanical, or electromechanical, depending on the user requirements. However, in spite of the number of hand grippers currently available in the market and had been developed over the years, but still prosthetic hand cannot fulfil the requirement to perform daily routine and complex tasks. Thus, limitation of prosthetic hand grippers occurs when handling fragile objects with the correct force. For example, a hand gripper handling fruit like grapes must grasp the fruit firmly enough so that it will not slip out but be gentle so the fruit will not get damaged. While natural human fingers are soft and flexible to grip objects, this is not inherent in a prosthetic hand gripper, typically made of metal or other materials with a hard surface. The tips of human fingers are soft, fleshy, and malleable. Also, because of their viscoelastic characteristics, they can locally adapt to the shape of a touched or grabbed object, making them capable of incredibly dexterous manipulation tasks. Viscoelastic materials are a captivating blend of elasticity and viscous behaviour, that instantly extends and promptly returns to its initial state when a load is removed.

Literature Review

The human hand is used for specific functions like explore, manipulate, and restrain objects [1]. In this context, ‘explore’ function deals with the area of “Sense of Touch’ becomes an important research area [2]. The task of manipulating objects with fingers also known as dexterous manipulation while the task of restraining objects is fixturing it. Also, in envelop grasping the inner parts of hand (palm and proximal phalanges) are used for restraint [3]. In artificial hand grippers many designers developed grippers with softer materials, allowing hand grippers to handle fragile objects. Even though they can do basic task of pick and place tasks effectively, but they are not suited to perform complex movements and precise gripping. FSR is an optimal sensor in the prosthetic application, which provides a reliable measurement of force over the existing state of sensor technologies. A force-sensitive resistor (FSR) used is low-cost, good accuracy, small dimension, and lightweight piezoresistive-based element is used whose resistance decreases with applied force. Many studies have utilized force sensitive resistors (FSR) to measure applied force due to their low cost and thin profile [4, 5, 6, 7, 8, 9, 10, 11]. Based on this evaluation, the FSR is only recommended for low-accuracy applications where low cost is a high priority. Consistent with the recommendations of Schofield et al., each FSR should be calibrated in conditions as close to intended use as possible [13]. There are large number of simple robotic grippers used throughout the manufacturing industry, to carry out their duties efficiently and without high incidence of breakdown, however in most cases these grippers are only good for their one specific job and are completely inflexible. The existing gap between the two categories of end effectors, i.e. complex “hands” and simple gripper [14]. Moreover, large number of other robot hands, of varying complexity, have been proposed or constructed [11]. Moreover, the number of available degrees of freedom of a gripper will generally improve the dexterity and versatility with increase in weight, complexity, and size as a result. This is normally an undesirable side effect, particularly when low power handy hands are needed for many applications.

Need & Relevance

Most gripper designs are subjected to the classical component between dexterity and simplicity. In furtherance, to possess a remarkable degree of dexterity, it can be achieved by means of intricate mechanical design and complex sensing, control, and actuation systems. There are many challenges in trade-offs between cost, size, power, flexibility, and controllability that arise in the design and operation of handy hands along with simple gripper and degrees of freedom. For instance, the need to minimize hand size while maintaining sufficient power results in the usage of cables that pass through the wrist to power the fingers. The flexibility and friction of these cables cause related control issues. Programming and controlling them is a significant undertaking, which is another reason for the delayed development in putting dexterous hands to manipulation activities.

Objective

To grasp objects of varying size and weights using developed cost-effective two finger with FSR and measure the output pertaining to sensitivity, repeatability and linearity

Materials & Methods

The experimental research design is adopted, wherein the object is grasped by two finger grippers, which typically feature area contact, since the fingers are typically designed for grasping. The results are interpreted and discussed accordingly.

Experimental Setup

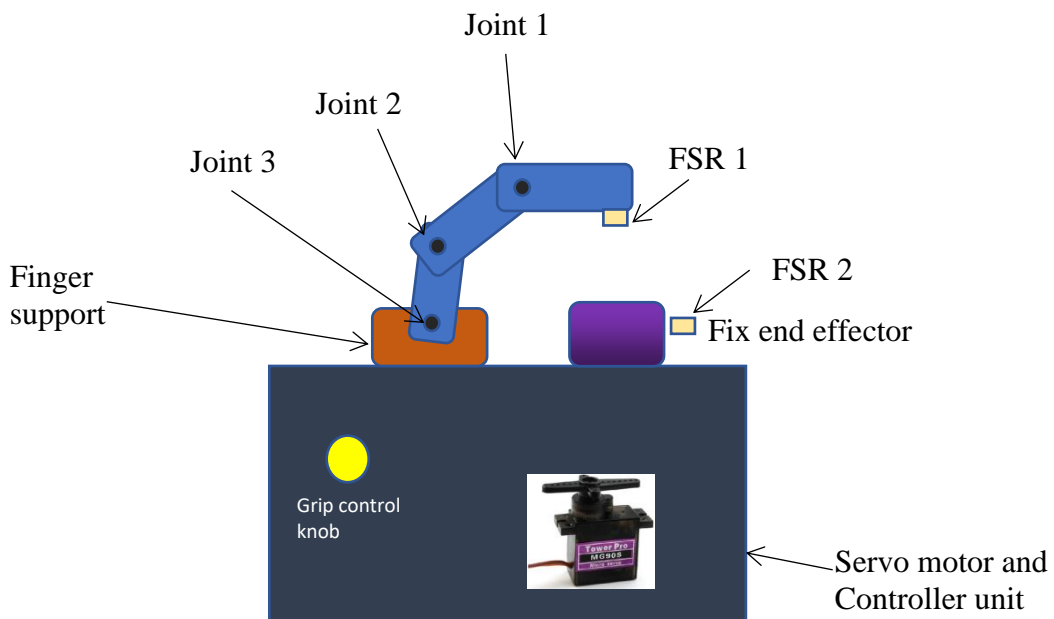


Fig. 1: Setup for Grip Force Using FSR Sensor

The Fig. 1 shows the two-finger gripping setup used to perform experiment. The setup consists of servo motor, control circuit, signal conditioning unit (SCU) to interface FSR, power supply, finger grip speed control knob, finger movement activation and deactivation switch and microcontroller board. In this experiment, two Fingers (end effectors) are used to grip objects and each Finger is having force-sensitive resistor (FSR) mounted on its tip to sense grip force applied on gripped object. A moveable finger is having three joints, wherein each joint has different angle of rotation. It is to be noted that for joints 1, 2 and 3, the angles of rotation are 55 degrees, 120 degrees and 45 degrees respectively. Furthermore, to control the movement of moveable finger precisely, a servo motor is used during grip and release of object. Operating voltage of servo motor is 4.8V and PWM input signal is used to control speed. In this experiment, maximum input signal duty cycle is 65 percent at 50Hz, and measured RMS voltage is 3.2V for maximum gripping force used for experimental study. The servo motor is capable to rotate at maximum angular speed of 1.66 m/s per degree. The gear ratio used in this servo motor is 75:1. Also, an object needs to be physically touched by a finger in order to be grasped, and the finger must also exert positive force on the object, in doing so the grasp is in balance because the fingers are applying equal and opposing forces. However, if the object is rotated just a little, the grasp becomes unstable since the fingers' force will induce the object to rotate much more.

The microcontroller is tasked with controlling all aspects of the hand's operation. It receives the grip classifications and translates those to specific finger positions. In furtherance, it determines the velocity the fingers should be moving to achieve the target position. Also, it communicates with pressure sensors in the fingers to determine when objects are being contacted and determines their velocity. The microcontroller must also detect and respond to any errors it might encounter to ensure the hand movement for grasping.

Two pressure sensors are placed in the fingertips of thumb and index fingers, which are part of the mechanical design. The pressure readings are transmitted to the microcontroller. The motor drivers are responsible for actuating the motors, which move the fingers. The servo motor actuates the fingers, allowing the fingers to perform grips specified by the microcontroller. The mechanical design includes parts that are 3D printed as Thumb mount, Thumb motor mount, Link, Distal finger bone, and Distal finger motor mount. The system operation starts when the toggle switch is ON, and the object is placed in between the two fingers for gripping. The gripper servo motor has been preset to a fixed gripping angle for each cycle of the test, so that measured force is observed and recorded. However, the system is carried out in an open loop system and programmed to grip different objects.

The experiment for the gripping system consists of FSR sensors, a servo motor with analog position feedback given to microcontroller, wherein the motor shaft is attached to an extension rod. The FSR are then placed on tip of the fingers facing each other. The system is switched ON by using the toggle switch manually. Furthermore, to detect the pressure, finger force is exerted on the object. The performance of gripping for objects of different size and shape are observed. The position of servo motor is set to desired (100) degrees and input data from the FSR are converted to angle.

Results & Discussion

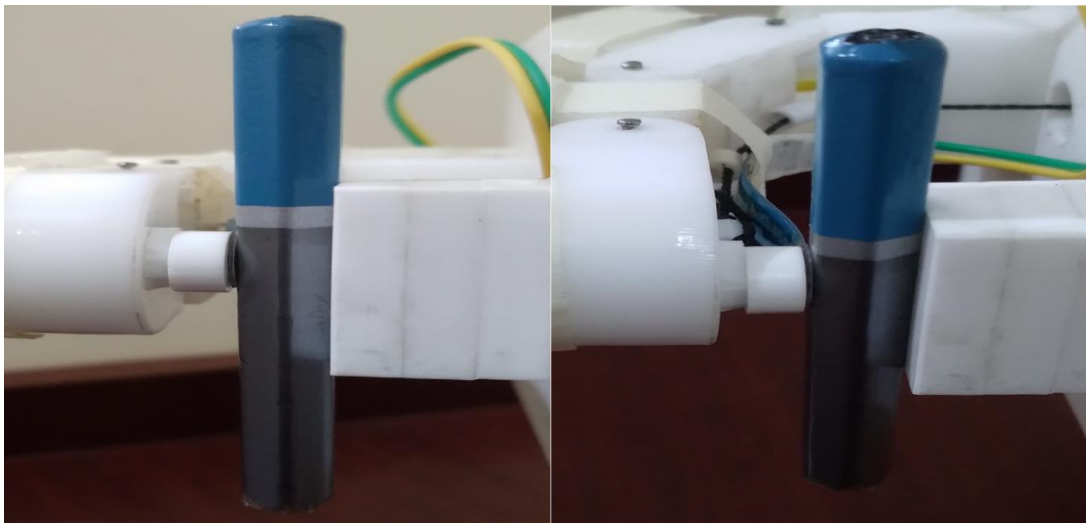


Fig. 2: Mechanical Arrangement of Finger Type Gripper

The object is grasped by two finger grippers solely using two fingers as indicated in Fig 2. This gripper type features the area of contact, since the fingers are naturally designed and typically do not allow for two points of contact, which is insufficient to firmly hold the object and limit its degrees of freedom. An object needs to be physically touched by a finger that needs to be grasped, and the finger must also exert positive force on the object [2]. However, there should be no displacement of object by the fingers, and their combined forces should be zero, meaning they should not be applying any torque to the object. Once the requirements are met, then state that a grip i.e. the arrangement of fingers is in equilibrium. Moreover, simply maintaining equilibrium in a grip is insufficient; the object must also be stable enough to remain in the fingers even if they are slightly shifted.

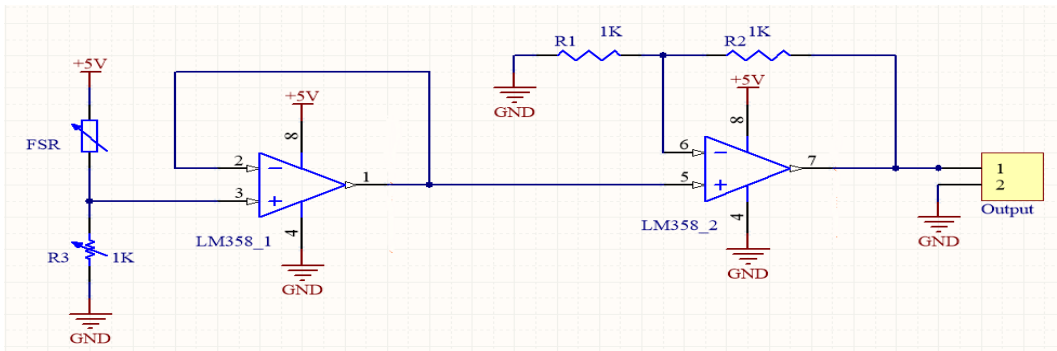


Fig 3: FSR Interface Signal Conditioning Circuit

As shown in Fig 3 signal conditioning circuit is used to interface FSR. The circuit is configured as a combination of unity gain amplifier and non-inverter amplifier. The FSR signal is applied at the non-inverting terminal of unity gain amplifier. The output terminal of unity gain

amplifier is fed to non-inverter amplifier. The unity gain amplifier is used to avoid FSR loading due to circuit interface, wherein the Output will be as follows:

$$V_{out} = (1 + R_2 / R_1) V_{in}$$

Where, $R_1 = R_2 = 1K$, Gain = 2

$$V_{out} = 2 * V_{in} \quad (1)$$

The FSR sensor's static parameters, such as sensitivity, repeatability, and hysteresis get affected. Hence, a simple buffered non-inverting amplifier has been incorporated as a translating circuitry for the sensor [6]. The equation (1) gives the output (V_{out}) for the circuit where +5V is the input voltage to FSR, 1M to 2.5K is the resistance of FSR and 1K is the feedback resistance. Normally, the resistance decreased from 1 M Ω to 10 K Ω for the applied load of 100g to 10,000g i.e. approximately 1N to 10N. The R_3 value has been set to 820 Ω to achieve the required sensitivity for this application. FSR sensing portion is active for the appropriate distribution of grip force over the contact surface area. The sensor output measured is a 0–2 V linear envelope. Moreover, FSR at the fingertip serves as a feedback element for providing contact force data during gripping of object. The sensor output is applied through signal conditioning circuit at the analog input channel of microcontroller for acquiring an estimated value of prehension force during interaction of finger with the object is indicated in Fig 4. The stability of grasping is enhanced by manipulation and use of fingertips with FSR because of the large contact area and high friction involved [6]. The ability to maintain stable and dynamic control over an object gripped between two fingertips using a sensor (FSR) interface between the manipulating fingers and object being controlled.

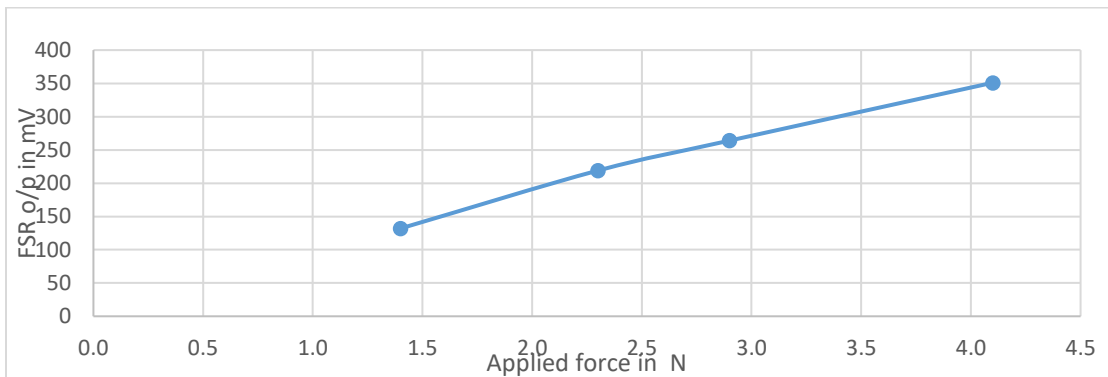


Fig. 4: Applied Grip Force-Output Voltage Curve

Sensitivity

Experiments are performed on various weights and sizes of objects when gripped vertically in between two fingers. The output voltages are recorded by applying controlled grip force as shown in Fig 5, which represents a straight line, the linear regression [12]. Thus, for the regression value $r=0.985343$, there is a linear correlation, which shows that relationship

between the X and Y variables are stronger and hence there exists a linear relationship. The ‘r’ value is an indication showing how appropriate the data fits in the linear relationship. It also shows that the sensitivity, which is output divided by input, and observed as nearly constant for all ranges of applied grip force. Thus, to ensure stability in the gripping process, two finger contacts are pressed against each other on opposite sides of the object being grabbed [2]. This creates friction between the finger contact surfaces and the object.

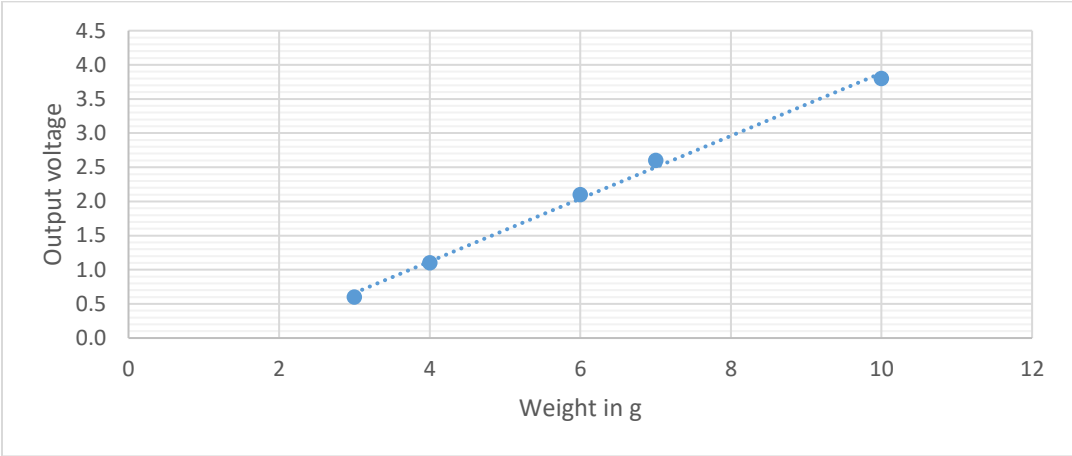


Fig. 5: Linearity Graph for Gripping of Different Weights

Repeatability

The present study tested the repeatability for 8mm object size and different weights of 3g, 4g, 6g, 7g and 10g on the sensor tip. The repeatability has been found to be very encouraging with about 4.3 percent uncertainties from cycle-to-cycle, which is indicated in Fig 6. Moreover, the observations indicated that for 5 cycles all the readings are exactly overlapping.

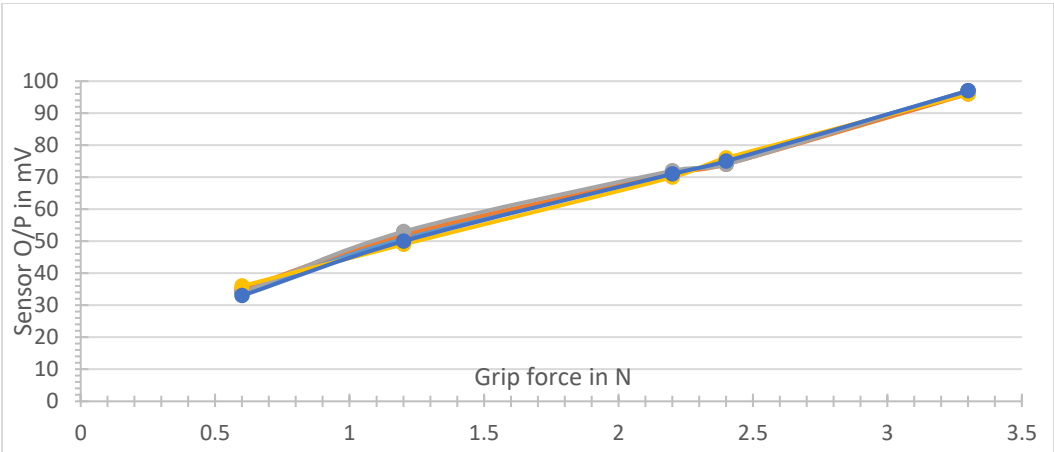


Fig. 6: Repeatability Error Curve for The Sensor

Hysteresis

A hysteresis curve has been obtained, which represents a change in voltage output with gripping and release of object. The average hysteresis error for sensor is around 2 percent.

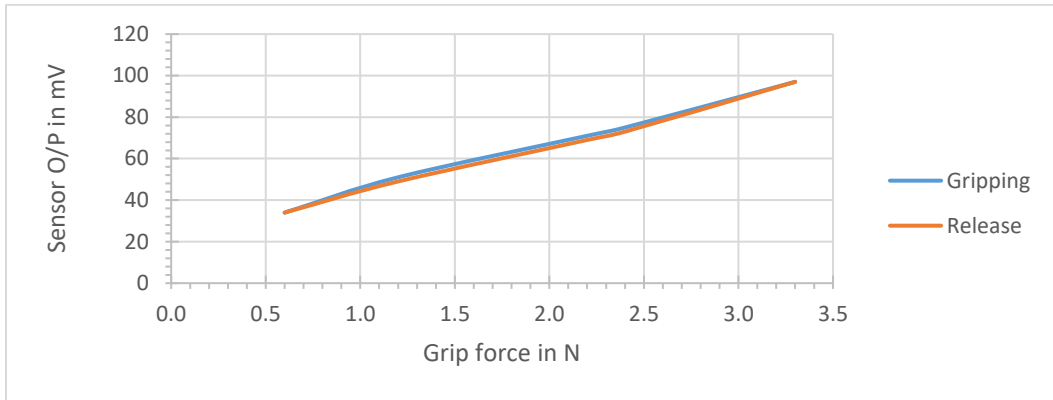


Fig. 7: Hysteresis Curve for the Sensor

As shown in Fig 7, work representation is by area, which is below force-path curve. Hysteresis or energy dissipated by finger during gripping is difference between work done on finger and during release is elastic energy returned by finger. Due to friction in the finger joints during deflection of finger parts will lead to small joint rotations. Also, because of the high activation force there are high joint loads. Thus, the rotational friction in the joint will be high resulting in sizable energy dissipation although at small joint rotations. The energy dissipation caused by friction occurs during the gripping and release motions. The motor must deliver this dissipated energy depending on the number of fingers, joints, and degrees of freedom for each finger [10]. The results indicated that calibration process is necessary before executing the experiment so that the performance of both FSR is improved. The FSR output must be measured and tested to record a consistent and repeatable reading. Hence, it is recommended that with area contact it can grip different shape objects such as a pencil as shown in Fig 2 and other objects such as square, rectangle, circle, and triangle (not shown).

Suggestions

The present study focused on two-finger gripper device, which is capable of conforming to a variety of shapes or types of objects is described. The impact of design is that the gripper, while retaining the gripping versatility, its ability to conform to different objects to be carried out in a most economical way and efficient manner. The future researchers focus on added advantages by including low power consumption, simpler control, and higher reliability. Also, better tactile sensing capability can be added to the links to provide more information about the object being gripped and to detect or even predict slip. The extension of present prototype is to develop three fingers with more links (degrees-of-freedom) per actuator can be investigated.

Conclusion

The present chapter has discussed the developed finger prototype, which is cost-effective, light weight with the effect of varying the gripper parameters such as motor speeds, force thresholds and link torque, angular positions in the gripping process for a variety of objects. The parameters indicating whether a grasp have successful or not have been identified and their values optimized. The gripper parameters and effect of varying the object parameters like shape, weight, size is being experimented, and reading regarding the same obtained indicated the versatility of grasp. Moreover, successful realisation of this two-finger gripper with FSR has greatly enhanced the capability of gripper to conform to more complex objects. It has also increased the possibility of achieving gripping with wide sensing capability. The two pressure sensors are placed on the fingertips of thumb and index finger and pressure readings are transmitted to the microcontroller so that actual configuration of the gripper gets monitored. The experimental results of this study have indicated higher sensitivity and repeatability.

References

- [1] Shimoga, K. B., & Goldenberg, A. A. (1996). Soft robotic fingers: Part II: Modeling and impedance regulation. *The International Journal of Robotics Research*, 15(4), 335-350.
- [2] Ohwovoriole, E. N. (1987). Kinematics and friction in grasping by robotic hands. *IEEE/ASME Transactions*, 398/109.
- [3] Ha, X. V., Ha, C., & Nguyen, D. K. (2017). A general contact force analysis of an under actuated finger in robot hand grasping. *International Journal of Advance Robotic Systems*, 13(1), 1-17.
- [4] Clemente, F., D'Alonzo, M., Controzzi, M., Edin, B. B., & Cipriani, C. (2016). Non-invasive, temporally discrete feedback of object contact and release improves grasp control of closed-loop myoelectric transradial prostheses. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 24 (12), 1314-1322.
- [5] Chou, T. G., Daly, W. K., Austin, R., Chaubey, P., & Boone, D. A. (2016). Development and real world use of a vibratory haptic feedback system for upper-limb prosthetic users. *Journal of Prosthetics and Orthotics*, 28 (4), 136-144.
- [6] Pylatiuk, C., Kargov, A., & Schulz, S. (2006). Design and evaluation of a low-cost force feedback system for myoelectric prosthetic hands. *Journal of Prosthetics and Orthotics*, 18(2), 57-61.
- [7] Fallahian, N., Saeedi, H., Mokhtarinia, H., & Tabatabai, F. (2017). Sensory feedback add-on for upper-limb prostheses. *Prosthetics and Orthotics International*, 41(3), 314-317.
- [8] Saunders, I., & Vijayakumar, S. (2011). The role of feed-forward and feedback processes for closed-loop prosthesis control. *Journal of NeuroEngineering and Rehabilitation*, 8, 60-60.

- [9] Antfolk, C., Balkenius, C., Lundborg, G., Rosén, B., & Sebelius, F. (2010). A tactile display system for hand prostheses to discriminate pressure and individual finger localization. *Journal of Medical and Biological Engineering*, 30(6), 355-360.
- [10] Hebert, J. S., Olson, J. L., Morhart, M. J., Dawson, M. R., Marasco, P. D., Kuiken, T. A., & Chan, K. M. (2014). Novel targeted sensory reinnervation technique to restore functional hand sensation after transhumeral amputation. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 22(4), 765-773.
- [11] Liu, C. H., Chung, F. M., Chen, Y., Chiu, C. H., & Chen, T. L. (2020). Optimal design of a motor-driven three-finger soft robotic gripper. *IEEE/ASME Transactions on Mechatronics*, 25, 1830-1840.
- [12] Birglen, L., & Schlicht, T. A. (2018). A statistical review of industrial robotic grippers. *Robotics and Computer-Integrated Manufacturing*, 49, 88-97.
- [13] Chen, F., Xu, W., Zhang, H., Wang, Y., Cao, J., Wang, M. Y., Ren, H., Zhu, J., & Zhang, Y. F. (2018). Topology optimized design, fabrication, and characterization of a soft cable-driven gripper. *IEEE Robotics and Automation Letters*, 3(3), 2463-2470.
- [14] Yoon, D., & Choi, Y. (2021). Analysis of fingertip force vector for pinch-lifting gripper with robust adaptation to environments. *IEEE Transactions on Robotics*, 37(4), 1127-1143.

Emerging Perspectives of Localising SDGs in Northeast India – A Conceptual Overview

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Abstract

The sustainable development has gained prominence in a country like India after ratification of 17 Sustainable Development Goals (SDGs) with a 2030 deadline. Addressing sub-national contexts and concerns during 2030 agenda's implementation is part of the process of localizing the SDGs. The 120 districts of Northeast India are assessed for their progress towards the goals by adopting the NER District SDG Index (2021–2022). This researcher chapter revisits the institutionalized approach towards achieving the SDGs in Northeast India by highlighting the salient features and anomalies of sustainable development scenario in the region as well as the perspectives surrounding the localization of SDGs. The present study has found that there are substantial variations and anomalies in the level of sustainable development across the districts. Moreover, several interlinked perspectives of localizing SDGs in the Northeast region indicated that the initiative is driven by either development issues or opportunities.

Keywords: Northeast India, Sustainable Development, SDGs, NITI Aayog, Localization.

Introduction

Sustainable development has been a topic of considerable discussion for many decades. In fact, it has largely replaced the conventional development terminology since the turn of millennium. India is among the member nations that have ratified the 17 Sustainable Development Goals (SDGs) with a target date of 2030. These objectives are centred on the collective aspiration for a sustainable, tranquil, and prosperous planet earth that benefits the present and future generations. India, being the second most populated country and one of the most rapidly expanding economies, which possesses the ability to significantly contribute to the global pursuit of the SDGs. Using the SDG India Index, NITI Aayog as an agency of the Government of India has endeavoured to monitor the progress towards these goals. The process of localising the SDGs is an example of these institutional initiatives. The sub-national contexts and issues

are acknowledged and tackled throughout the entirety of the process of implementing the 2030 Agenda, including the establishment of objectives and targets, identification of implementation strategies, and utilisation of indicators to track and evaluate advancements (NITI Aayog, 2021a). The final product of SDG localisation is a progress report on the SDGs in subnational and local contexts, such as Indian States, Union Territories (UTs) and Districts. As of now, three annual reports (2018-19, 2019-20 & 2020-21) have been published detailing the SDG India Index at the State/UT and national levels. Furthermore, the NER District SDG Index report (2021-22) has been developed in partnership between the NITI Aayog and Ministry of Development of North-Eastern Region (MoDoNER), which is an entity under the Government of India. This report represents an unprecedented effort to evaluate the progress and accomplishments of the objectives and targets with a specific focus on 120 districts comprising of Northeast region of India. This research chapter is a revisit to the localised approach of concerned institutions in realisation of SDGs in India, especially in accordance with the case of Northeast India.

Literature Review

As part of governmental efforts towards the agenda 2030, the NITI Aayog has undertaken the task of measuring the performance score of SDGs and also incorporating localization of goals in the process (NITI Aayog, 2018, 2019, 2021a & 2021b). This performance score is basically a composite score of selected indicators under various goals. It ranges from 0 to 100, where 0 means lowest performance while 100 means fullest achievement of the goals. The NITI Aayog categorises the SDG Index score into four groups i.e. Aspirant (0-49), Performer (50-64), Front Runner (65-99) and Achiever (100). As far as SDGs in the Northeast India is concerned, the following 15 goals are consideration i.e. No poverty (SDG-1), Zero hunger (SDG-2), Good health & well-being (SDG-3), Quality education (SDG-4), Gender equality (SDG-5), Clean water & sanitation (SDG-6), Affordable & clean energy (SDG-7), Decent work & economic growth (SDG-8), Industry Innovation Infrastructure (SDG-9), Reduced inequalities (SDG-10), Sustainable cities & communities (SDG-11), Responsible consumption & production (SDG-12), Climate action (SDG-13), Life on land (SDG-15), Peace Justice Institutions (SDG-16). SDG-14 (life below water) and SDG-17 (Global partnerships) are excluded since as they are not relevant for Northeast India.

The research studies conducted by Sadashivam & Tabassum (2022) and Bhattacharyya (2023) has explored the evolution of SDG localization in the Northeast India and achievements of individual goals by the states and their districts. Also, Singh (2022) highlighted the road map adopted by Northeast states to bring about SDG targets under the initiative of government agencies. The localization initiative taken up in this region is pure reflection of special thrust given by the government in its plans and policies. There are critical studies on the strategy and progress of SDGs in India. Mishra and Padhi (2021) critique the framework adopted in assessing the progress of SDGs and insist for more scientific rigour. Chatterjee (2022) argues that while focusing on localization of the SDGs at state level the national progress on specific goals is being neglected.

Need & Relevance

India has the potential to make a substantial contribution to the global effort to achieve the SDGs, as it is the second most populous nation and has one of the fastest growing economies. In order to achieve the set goals in time, the main strategy was localization of the SDGs. SDG Localization at state (sub-national) level has been initiated quite early and already completed in India as per the international trend of going '*Global to National to Local*' (NITI Aayog, 2019). As far as the localization of SDG at local (district) level is concerned, it could be completed only in the Northeast India so far. Also, with less than a decade's time remaining till 2030, it is high time to reconsider the success story of the Northeast region in the field of SDG localization and its underlying perspectives. This practice shall be relevant to other states of India.

Objectives

- To explore the key aspects and anomalies in sustainable development scenario in the Northeast India
- To find out the perspectives associated with the institutional localisation of SDGs in the region

Methodology

This study follows a descriptive research design to work out a conceptual overview of the localisation of SDGs in Northeast India. Its findings are based on secondary sources of quantitative and qualitative data collected from concerned government sources. The previous research works in this field are also consulted as secondary literatures. The anomaly detection analysis is performed on District SDG Index to find out outlier districts in Northeast India. This study uses Z-score and Inter-Quartile Range (IQR) to detect anomalies in district SDG index values. In this study, Z-score shall measure how many standard deviations a district value is away from the mean in the distribution of 103 districts for specific SDGs. Z-score is given by: $Z = (X_i - M) / SD$, where X_i is district values, M is mean and SD is standard deviation. Z-scores of ± 3 or more are considered as anomalies (Andrade, 2021). The Inter-Quartile Range (IQR) method of anomaly detection uses two measures of dispersion i.e. 1st Quartile (Q1) and 3rd Quartile (Q3) from the distribution. Outliers are detected by setting a standard range which is defined as: from $[Q1 - 1.5 \times IQR]$ to $[Q3 + 1.5 \times IQR]$, where Q1 is the 1st quartile; Q3 is the 3rd quartile $[IQR = Q3 - Q1]$ in the same distribution (Dash, 2023). Those districts whose SDG index values fall outside this range are considered as anomalies.

Observations & Discussions

The observations are discussed under various aspects for wider understanding.

Overview of Sustainable Development in the Northeast India

The Northeast India is a contiguous region encompassing the states of Sikkim, Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, and Tripura respectively. The region shares extensive international boundaries with Nepal, Bhutan, China, Myanmar, and Bangladesh. It constitutes 7.98 percent of entire land area of the nation and is home to 3.78 percent of its total people. The population density of this region ranges from 17 persons per sq. km. in Arunachal Pradesh to 398 persons per sq. km. in Assam. Despite the abundance of valuable natural resources in this area, it remains one of the least developed regions in the country. The region encounters numerous development obstacles, including inadequate infrastructure, isolation, rugged and challenging topography, exorbitant operational expenses, limited job prospects, reliance on subsistence agriculture, and resource limitations (Singh, 2022). Since gaining independence, Northeast India has experienced a significant degree of isolation from the rest of the country. This isolation has resulted in the alienation of the populace, lack of development, emergence of socio-political turmoil, insurgency, and ethnic conflicts (Bhattacharyya, 2023).

The Northeast states fall below the national average on various crucial indicators such as health, education, infrastructure, and more. The Northeast region not only exhibits lower levels of development compared to other states and union territories, but also experiences significant differences in development both across states and within individual states. Nevertheless, the region exhibits significant capacity for growth and progress. As far as the level of sustainable development is concerned, India's aggregate performance score, as reported by the SDG India Index (2020-21), is 66. According to the NITI Aayog (2021b), 22 States/UTs have advanced to the frontrunner category, while the remaining 14 states/UTs are falling behind in the performer category. In case of the Northeast states, three of them are in front runner category i.e. Sikkim (SDG Index score=71), Mizoram (68), Tripura (65); whereas remaining states are put in the performer category i.e. Manipur (64), Nagaland (61), Meghalaya (60), Arunachal Pradesh (60), and Assam (57) (Aayog NITI, 2021a). In comparison to the national average level, only Sikkim and Mizoram perform better while other NE states are falling behind.

Inter-District Variations & Anomalies

The inter-governmental venture on localising SDGs as far as district levels has truly facilitated inter-district comparison of the scenario of sustainable development in the Northeast India. It involves a prolonged process of adoption, planning, implementation, and monitoring of the goals (NITI Aayog, 2019). It is worthwhile to mention that district-wise performance scores on the fulfilment of SDGs are derived from a year-long technical processes of sensitization and conceptualisation of stakeholders, mapping of 103 districts (out of 120 districts based on data availability), statistical exercises on 84 selected indicators covering 50 targets and 15 SDGs (NITI Aayog, 2021a). For every district under consideration, the District SDG Index provides two types of scores i.e. an index score for a specific SDG and a composite score for all SDGs combined. The significant variations of the composite scores across the districts of the Northeast region are noticed. The five districts of the region that register highest in the overall score are as follows: East Sikkim (75.77), Gomati (75.73) in Tripura, North Tripura

(75.73), West Tripura (75.67), and Serchhip (74.87) in Mizoram. A total of 64 districts out of the 103 are classified as front runners. On the other hand, the worst performing districts are Kiphire (53) in Nagaland, Zunheboto (54.5) in Nagaland, Kra Daadi (55.6) in Arunachal Pradesh, Tuensang (55.9) in Nagaland, Mon (55.9) in Nagaland, North Garo Hills (56.9) in Meghalaya and so on (NITI Aayog, 2021a). These districts which are falling behind, are yet to fulfil nearly half of the goals.

Furthermore, the study of goal-wise index scores reveals that some districts score 100 on certain goals, which means that they have fully achieved their targets, whereas some others performed so terribly that they have scored close to zero on certain goals. Most districts outperform the national level (score of 66) in the case of SDG-5 (gender equality), SDG-6 (clean water and sanitation), SDG-7 (affordable and renewable energy), and SDG-15 (life on land). There is positive news regarding the complete accomplishment (score of 100) of specific goals by certain districts. SDG-7, which pertains to affordable and sustainable energy, has been entirely accomplished in seven districts of Arunachal Pradesh i.e. Changlang, Dibang Valley, East Siang, Longding, Namsai, Tirap and West Kameng. Seven additional districts, namely Chandel, Churachandpur, Senapati, Ukhrul, South West Garo Hills, South West Khasi Hills, and West Khasi Hills have entirely attained SDG-11 (Sustainable Cities & Communities). Once more, a total of twelve districts (9 districts from Arunachal Pradesh, 2 from Assam and 1 from Sikkim) have attained a perfect score of one hundred on SDG-15 (life on land). However, regarding goals such as SDG-13 (climate action), SDG-1 (zero poverty), SDG-3 (excellent health and well-being), and SDG-4 (quality education), most of the districts are performing comparatively poorly. Moreover, regarding the SDG-13 (climate action), 57 districts in the NER received an index score below 50, indicating that they are only halfway to attaining the targets for climate action. The states primarily prevailed by these subpar performances are Arunachal Pradesh, Manipur, and Sikkim.

The substantial variations have been found in district SDG index scores are indications of the possible occurrence of anomalies too. In Z-score analysis, 9 districts are found to be anomalies in different distributions. They are SW Khasi Hills (31) in SDG-3 distribution; East Kameng (0), Kra Daadi (13), Pakke Kessang (16) in SDG-7 distribution; Leparada (19) in SDG-10 distribution; Shi Yomi (15) in SDG-12 distribution; Barpeta (34), Thoubal (39) in SDG-15 distribution; Lohit (36) in SDG-16 distribution. As per IQR analysis, 14 districts are found to be anomalies including the 9 districts mentioned above. The other 5 districts are Leparaka (24), Kamle (31), Kiphire (33), East Sikkim (84) in SDG-1 distribution; and East Jantia Hills (32) in SDG-3 distribution. East Sikkim is highly scoring district and included among anomalies since its score has been considerably far from the mean. Otherwise, all the remaining anomalous districts are poorly performing in sustainable development. Interestingly, one limitation encountered in the anomaly detection analyses is that the attributes of districts are already standardised into scores whose minimum and maximum possible values are 0 and 100 respectively (NITI Aayog, 2021a). In the process, some of the anomalies would have been normalised. Keeping this in view, it can be deduced that the anomalous districts mentioned above do not necessarily constitute the lowest SDG scoring districts. For instance, in SDG-13 distribution, Kra Daadi (3) and North Sikkim (3) are the worst performing districts although they are not found to be anomalies in the analyses.

Emerging Perspectives of Localizing SDGs in Northeast India

A Test Pilot's Experience

The localisation of SDGs at subnational level in India was initiated since 2018 by adopting the SDG India Index for the states/UTs (NITI Aayog, 2018). However, the 'localisation' initiative in its true sense has been realised with the release of NER SDG Index, which not only confines to the Northeast region but also considers the districts as individual entities under study. This is the first of its kind example of localisation of sustainable development in the country initiated by the NITI Aayog (2021a). While setting aside other states of India, special emphasis has been given to the Northeast region on pilot basis. It is made feasible by certain existing situations in the region like lesser physical and socio-economic dimensions, relative isolation, ease of programme implementation under one single ministry, need for special attention due to relative backwardness and so on. In pursuit of the SDGs, the pre-existing Ministry of DoNER expedites the formulation and implementation of regional policies. In its development planning, the Indian government has accorded the Northeast region special consideration. As an illustration, the Northeastern states receive central assistance in the proportion of 90:10, which is facilitated by the MoDoNER (Singh, 2022).

Regional Disparity & Backwardness

The Northeast region is among the backward regions in India. Moreover, backwardness in the region is apparent from several development challenges including inadequate infrastructure, high unemployment, limited resource mobilisation, subsistence cultivation, etc. In this region, interstate and intrastate development disparities are also substantial as a result of prolonged political violence, insurgencies, ethnic conflict, migration pressure and inter-state disputes (NITI Aayog, 2021a). Concurrently, the region possesses sufficient capacity and potential for sustainable development. The area is brimming with natural resources and rich biodiversity including forests, minerals, hydroelectric power, and agricultural products. In order to localise the SDGs, NE states must bolster their institutions and capabilities through the implementation of a holistic strategy. It will foster an environment that motivates states and districts to advance into a sustainable competition by learning from one another. The Government of India's endeavour to promote sustainable development in the Northeast India and monitor district-level progress towards the SDGs serves as a prominent illustration of its '*Sabka Saath Sabka Vikas*' development policy. Thus, localising SDGs in the region is considered as need of the hour to overcome development disparities and backwardness. The localising of SDGs in the districts of Northeast India may be viewed from various perspectives. Setting as a primary example, it can be considered as a test pilot's experience, after which the NITI Aayog has plans to go for the remaining States/UTs (NITI Aayog, 2018 & 2021a).

Act East Policy in Northeast India

The renovation of India's *Look East Policy* into *Act East Policy* has the potential to motivate the government to promote sustainable development in the Northeast India. With more than 5,300 kilometres of international borders shared by each of the eight states, the region's

geographical location designates it as the primary strategic entry point to ASEAN countries. This policy aims to focus on the development of connectivity infrastructure in the trans-border region, which can change the region into a strategic nodal trade hub (NITI Aayog, 2021a). Also, to realise the economic and strategic benefits of engagements with South-East Asian nations, Indian government deems the development of the region as a transit corridor essential. Therefore, in accordance with this long-term multi-lateral policy, the government is localising the sustainable development in the Northeast region so that states can reap the fruits of *Act East Policy*.

Rich Biodiversity

Geographically, Northeast region is situated in the Himalaya and Indo-Burma Biodiversity Hotspots (NITI Aayog, 2021a). The government considers rich biodiversity, rare wildlife, and distinctive cultural heritage of the region as favourable conditions for sustainable development initiatives. This is because various SDGs necessitate the restoration of ecological equilibrium and biodiversity. The regional biodiversity has already been threatened by unplanned development. Increasing soil erosion caused by jhum cultivation, rapid deforestation, and drying up of wetlands are all imminent dangers that require an immediate intervention to bring about sustainable approach. While rich biodiversity in the region is boon for sustainable development, environmental degradation and loss of biodiversity has called for sustainable approach. This is how localisation of sustainable development is more and more important for the scenario of biodiversity in the Northeast India.

Suggestions

It is suggested that localization of SDGs at district level needs to be adopted in other remaining States/UTs of India as a policy implication. Also, from the Northeast India's experience it has been realized that sustainable development initiative at local level can only show the true picture of progress and shortcomings in attaining the SDGs. It is also suggested that a strategy of SDG localization should be adopted, which suits to local conditions in terms of resources availability, ecological balance, level of industrialization and urbanization for better implementation in Northeast States within India.

Conclusion

Out of the eight northeast states, only Sikkim and Mizoram perform better in sustainable development as compared to the national average. Now, localization of SDGs at district level in the Northeast India has make it clear that 64 out of 103 selected districts from these regions are in frontline of the race to 2030. Some of the districts from different states of the region have already reached the 2030 target in the areas of affordable and clean energy (SDG-7), sustainable cities and communities (SDG-11) and life-on-land (SDG-15). On the other hand, sustainable development in areas of climate action, poverty, health, and education is not very progressive. Moreover, from SDG index scores of these districts 14 cases of anomalies could be detected. This indicates the prevalence of disparities in sustainable development across the districts of the region. In addition to this, regional disparities and backwardness prevailing the

region in tandem with ‘*Sabka Saath Sabka Vikas*’ policy of the government perhaps brings in the priority of sustainable development to the Northeast region. At the same time, the concerned stakeholders do not want to lose the developmental opportunities given by implementation of the ‘*Act East Policy*’ and occurrence of biodiversity hotspot in this region. This initiative shall not only benefit the pursuit of bringing about sustainable development in the Northeast States in India but also its success story shall be learned somewhere else.

References

- Andrade, C. (2021). Z scores, standard scores and composite test scores explained. *Indian Journal of Psychology Medicine*, 43 (6), 555-557.
- Bhattacharyya, R., Anand, S., & Das, M. (2023). Sustainable Development Goals in Northeast India - Challenges and Achievements, In: Anand, S. Das., M., Bhattacharyya & Singh, R. B. (Eds.). *Sustainable Development Goals in Northeast India. Advances in Geographical and Environmental Sciences*, Springer, 1-17.
- Chatterjee, S. (2022). The sustainable development goals: A future within or beyond reach? *Economic & Political Weekly*, 57(18),17-22.
- Dash, C. S. K., Behera, A. K., Dehuri, S., & Ghosh, A. (2023). An outliers detection and elimination framework in classification task of data mining. *Decision Analytics Journal*, 6, 100164.
- Mishra, U. S., & Padhi, B. (2021). Sustaining the Sustainable Development Goals. *Economic & Political Weekly*, 5 (18), 30-31.
- NITI Aayog. (2018). *SDG India Index Baseline Report*, New Delhi.
- NITI Aayog. (2019). *Localizing SDGs: Early Lessons from India 2019*. New Delhi.
- NITI Aayog. (2021a). *North Eastern Region District SDG Index Report & Dashboard 2021-22*, New Delhi.
- NITI Aayog. (2021b). *SDG India Index & Dashboard 2020-21*, New Delhi.
- Sadashivam, T., & Tabassum, S. (2022). Sustainable Development Goals in Districts of India’s North-Eastern States: A Study towards Localization. *Bihar Journal of Public Administration*, 19(2), 35-47.
- Singh, I. J. (2022). Sustainable Development Goals: A Road Map for the North-eastern States. *Economic & Political Weekly*, 57(1), 22-28.

Webliography

https://sdgindiaindex.niti.gov.in/assets/Files/SDG3.0_Final_04.03.2021_Web_Spreads.pdf
https://www.niti.gov.in/sites/default/files/2020-07/LSDGs_July_8_Web.pdf
https://www.niti.gov.in/sites/default/files/2021-08/NER_SDG_Index_NITI_26082021.pdf
https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf

Conceptual Understanding of the Oil Spill Dynamics in the Coastal Regions of Goa and its Environmental Implications

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Abstract

Liquid petroleum hydrocarbons released into aquatic ecosystems as a result of oil spills undergoes weathering over a period of time leading to formation of toxic compounds. Over the past decade, numerous oil spill incidents have occurred globally with significant quantities of oil being lost. Along the Indian coastline, including Goa the oil spills have been a recurrent concern, which is driven by various anthropogenic activities and topography. Goan region falls within the medium-high sensitivity index to oil spills concerns and have witnessed several incidences of oil spills previously. Tarballs, a common consequence of oil spills has hindered with the scenic beauty of Goan beaches, thus affecting the economy and ecology in the state. The environmental impacts of oil spills are wide-ranging and severe, affecting marine ecosystems, biodiversity, coastal tourism, and human health. Furthermore, oil contamination of sand beaches, freshwater system and coastal ecosystems can have long-lasting ecological and socio-economic consequences, affecting habitat stability, nutrient cycling, and livelihoods. This chapter provides an in-depth understanding of oil spills, occurrence of tarballs, and environmental implications, focusing particularly on the Indian coastline and state of Goa.

Keywords: Oil, Spills, Tarballs, Goa, ESI.

Introduction

Oil is a naturally occurring viscous liquid mixture composed primarily of hydrocarbons found in geological formations beneath the earth's surface. Crude oil, also termed as petroleum is a fossil fuel consisting mainly of alkanes, cycloalkanes, and aromatic hydrocarbons, along with smaller amounts of sulphur, nitrogen, and oxygen-containing compounds. The oil spills, whether accidental or deliberate, lead to release of oil of any kind or in any form crude or

refined, including but not limited to petroleum hydrocarbons and their by-products into the environment, primarily affecting aquatic ecosystems such as oceans, seas, rivers, or lakes [1]. This can occur due to various human activities, including transportation (ex: tanker accidents), extraction and production (e.g., offshore drilling accidents), storage and handling (ex: pipeline ruptures), or natural disasters (ex: hurricanes or earthquakes). Over the past ten years globally, there have been 62 oil spills of varying magnitudes, resulting in the loss of 164,000 tons of oil. In majority of cases, small scale oil spills (< 7 tonnes) constitute approximately 72 percent of the incidents and contribute less than 1 percent to overall volume of oil spilled. Conversely, spills exceeding 30 tonnes occurs in only 0.1 percent of cases, yet they account for nearly 60 percent of the total volume of oil spilled [2]. Due to the ever-increasing number of oil spill incidents, the present research aimed at developing effective prevention and response strategies is always at the focal point. Moreover, studying the records of oil spills is crucial, as it provides valuable insights into the patterns, trends, and drivers of oil spill incidents over time, enabling the identification of potential risk factors and vulnerabilities.

Literature Review

Along the Indian coastline which is about 7,500 km with addition of Andaman and Nicobar Islands and Lakshadweep Island, the occurrence of oil spills has been a recurrent concern, stemming from various anthropogenic activities [3]. Indian coastal route is a trading route for many countries including transport of around 75 percent of world oil demand. Besides that, the most important mineral found in Indian ocean is petroleum that comprises for 28.5 percent of total world oil production. In addition to this, ocean also has the Asia's largest ship breaking yard. Furthermore, India has 0.4 percent of world's proven reserves of hydrocarbons and there is indication for more in future explorations [4]. All these reasons contribute heavily to increased incidences of on-shore and off-shore oil spills in the country. Marine oil pollution along the west coast of India including the 105 km long coast of Goa, is evident by seasonal episodes of tarballs. From 1970s till now, Goa has witnessed several accounts of oil spills and surfacing of tarballs on and offshore, which has emerged as a significant concern for authorities, necessitating strategic and systematic approaches for effective management.

A pilot study was carried out in 2009 following the National Oceanic and Atmospheric Administration guidelines to map the environmental sensitivity index (ESI) of various places in Goa. ESI mapping involves the compilation and analysis of data related to coastal shoreline sensitivity, biological resources, and human resources in a particular area. These maps are created to assess the vulnerability of coastal environments to oil spills and other potential hazards occurring thereafter. The parameters considered for vulnerability study are landforms, oil sensitive organisms, tidal interference, mangroves, creeks, estuary, grain size of beach sand, geomorphology, and factors like exposure to wave action, substrate type like mud, sand, biological productivity, slope of shore and ability to clean the area. The study categorized the sensitivity of Goan coast as medium-high to oil spill concerns, which extends across various ecological, economic, and social dimensions, posing significant challenges to the region's coastal ecosystems and communities [5]. All these findings have underscored the need to study the incidences of oil spills and process of tarball formation for developing comprehensive strategies for oil spill or tarball prevention, preparedness, response, and recovery.

Need & Relevance

Studying the occurrence of oil spills along the Indian coast, particularly in the state of Goa is crucial due to the region's unique ecological significance, economic dependence on coastal resources, and susceptibility to environmental risks. Goa, with its 105 km coastline and strategic location alongside major shipping routes, faces heightened vulnerability to oil pollution resulting from maritime transportation, offshore activities, nearby oil field, and coastal development. Also, given the state's reliance on marine-based industries such as fishing and tourism, oil spills pose significant threats to local livelihoods, ecosystems, and public health. Hence, understanding the patterns, impacts, and drivers of oil spill and tarball occurrences in Goa is essential for informing targeted mitigation efforts, enhancing emergency response capabilities, and fostering sustainable coastal development practices that prioritize environmental conservation and community resilience. Furthermore, comprehensive research is very much needed on oil spill incidents in Goa to support the formulation of evidence-based policies, regulatory frameworks, and risk management strategies. Also, the research study must aim at safeguarding the state's coastal environment and promoting long-term socio-economic sustainability.

Objective

To comprehensively elucidate the oil spill dynamics on the coast of Goa and their consequential environmental impacts

Methodology

The dynamics of oil spills in the coastal regions of Goa was studied through spillage incidences and tarball occurrences in this region. Firstly, a systematic literature review has been conducted to gather the existing knowledge on fate of oil after spillage in the waters and reason of oil spillages along the Indian coastline with special emphasis on state of Goa. Moreover, to address the issues databases such as PubMed, Scopus, Web of Science, and Google Scholar are searched along with numerous peer-reviewed articles, reports, books, dissertations, and other scholarly sources have been referred for a thorough review. Secondly, historical data and records related to oil spill and tarball incidences in Goa are collected and analyzed, including archival research, government documents, and newspaper articles. The aim of the present study is to trace the history of oil spills and tarball occurrence, identify key incidents, and understand their formation process and impact over time. The data collected from literature studies and historical analysis have been synthesized to develop a conceptual framework for understanding the complex interactions between oil spills, sensitivity of the places and environmental consequences.

Fate of Oil After Spills and Genesis of Tarballs

Oil, when spilled at sea will normally break up and be dissipated or scattered into the marine environment over time due to a number of physical, chemical, and biological degradation processes collectively known as weathering [6]. The fate of the oil depends on various factors,

including the type of oil spilled, environmental conditions, and response efforts. The primary pathways through which oil can be weathered include:

Evaporation: Lighter fractions of crude oil, such as volatile hydrocarbons, can evaporate rapidly when exposed to air and sunlight. This process can lead to the loss of oil from water surface into the atmosphere, reducing the volume of oil present in marine environment over time.

Dispersion: Mechanical or chemical dispersants like wind, waves and currents may be applied to oil spills to break up the oil into smaller droplets, enhancing its dispersion in the water column. Dispersed oil can be transported by ocean currents and distributed over a wider area, reducing its concentration at surface or may also result in the creation of a secondary slick or thin film (sheen) on the surface of the water potentially increasing its impact on marine life throughout the water column.

Emulsification: Oil and seawater can mix to form emulsions, where oil droplets become suspended in the water as a stable mixture. This process increases spilled area 2 to 5 times and increases viscosity of oil by 1000 times. Emulsified oil can persist in the marine environment for extended periods, making it challenging to remove through conventional cleanup methods.

Biodegradation: Naturally occurring microorganisms, such as bacteria and fungi, can metabolize hydrocarbons present in oil, breaking them down into simpler compounds through biodegradation. This process occurs more rapidly for lighter fractions of oil but can also occur over time for heavier components, albeit at a slower rate.

Sedimentation: Heavier components of oil, along with sediment particles may sink to the seafloor, where they can accumulate in marine sediments. This process can result in long-term contamination of benthic habitats and potential impacts on bottom-dwelling organisms.

Bioaccumulation & Biomagnification: Oil components can enter the food chain through ingestion by marine organisms, especially marine filter feeders. Once absorbed, these contaminants can accumulate in tissues and organs, leading to biomagnification, where concentrations of contaminants increase at higher trophic levels. This process can result in toxic effects on marine organisms and ecosystem health. Furthermore, consumption by humans can also lead to human health adversities.

Oxidation: Poly-aromatic hydrocarbons and aromatic N- S- and O- heterocycles of oils usually undergo oxidation in presence of light to form compounds that are more water soluble and resistant to biodegradation. The chemical reaction of oil with oxygen can also lead to the formation of persistent compounds called tars, which are difficult to remediate.

Spreading: Once oil is released into the water, it swiftly disperses across the sea's surface, initially forming a single slick. The rate of dispersion largely hinges on the oil's viscosity, with thinner, less viscous oils spreading more rapidly compared to thicker ones. Within a few hours, the slick starts to fragment forming elongated bands or windrows aligned with the direction of

wind. The severity of these environmental conditions directly influences the speed at which the oil spreads and breaks apart.

Dissolution: Soluble constituents within oil can dissolve into the adjacent water. Among the oil constituents, the lighter aromatic hydrocarbon compounds like benzene and toluene exhibit higher solubility in seawater. Nonetheless, these compounds are also prone to rapid evaporation, a phenomenon occurring at a rate 10-100 times faster than dissolution. Given that oil typically contains minimal quantities of these compounds, dissolution ranks among the less significant processes compared to other mechanisms.

Weathering of crude oil from spills due to evaporation, dispersion, and degradation form small, sticky masses that wash up on shorelines following an oil spill. These tarballs often appear as dark-coloured, viscous blobs ranging in size from a few millimetres to several centimetres in diameter with varying weight. The substances that tarballs pick up during the weathering process determine their density, and when their density is lower than that of seawater the tarballs can move large distances. Deep sea currents have the potential to distribute tarballs further over great distances. The concentration and characteristics of tarballs have been used to gauge the size of oil spills, and their makeup can be utilized to pinpoint the sources of spills [7].

History of Oil Spills & Tarball Occurrences in Goa

Tarballs has been first seen in 1970s, which have hindered with the scenic beauty of Goan beaches, thus affecting the ecology and also the tourism industry. In 1994, a cyclonic storm hit the Goan coast and consequently, an ore carrier merchant vessel (MV) ‘Sea Transporter’ carrying about 1000 ton of fuel oil. This caused drifting of vessel from the outer anchorage area of Marmugao harbour and grounding on a rock a few meters away from the beach at Sinquerim. Slowly, a crack is developed and widened on the starboard side of ship due to rough weather leading to the spillage and spreading of fuel oil from the ship. Due to this spillage tarballs got formed and drifted from the site of the incident to the beach shore. In 2000, MV ‘River Princess’ was grounded off the beach of Candolim-Siquerim-Calangute for almost three years. During this period the state witnessed release of almost 40 tonnes of oil in the water by this vessel [8]. After this, in the upcoming years heavy tarball deposits are seen on tourist beaches of Goa and from there on it has become an annual seasonal event occurring in Goa. Another oil spill occurred off Goa, in 2005 from the vessel MV ‘Maritime Wisdom Bulk Carrier’, due to contact damage by the barge MV ‘Prapti’ spilling around 85 tons of heavy fuel oil in water. In May 2006, a bulk carrier MV ‘Ocean Seraya’ grounded off the Karwar coast split into two, spilling gallons of oil in water, which got carried up to Benaullim beach in Goa [9].

Another incident took place in 2011, wherein the MV ‘Lucky Star’, a large cargo ship, drifted ashore near Dona Paula during rough weather and leaked fuel oil into the sea leading to pollution and environmental damage along the coastline. This year also marked the hitting of Velsao beach in South Goa by tarball avalanche. In 2015 and 2016 oil spills from passing ships and spill at Mumbai high field resulted in tarball occurrences along the coast of Palolem and

the coast of Varca and Colva beaches respectively [10]. In the following years, beautiful beaches are once again terrorized by the occurrences of tarballs. Moreover, in 2021 these ugly blobs took over the popular beaches of Anjuna, Miramar, Mandrem, Morjim and Colva leaving fishermen and travel stakeholders worried. Tarballs resurfaced back in 2022 to sully Goa's beaches proving a major headache for beach goers who are left with oil sticking to their feet and covering those bathing in the sea with an acidic stench. Thus, it can be concluded that the Goan coast is highly prone to the incidences of tarballs, which has been a reason of worry for the authorities.

Factors Behind Tarball Occurrences

Exploring the multifaceted factors contributing to the occurrence of tarballs reveals a complex interplay of environmental, anthropogenic, and geological influences. Marmugao Port Trust is the primary port in Goa, which has significantly contributed to the expansion of maritime trade in India. Additionally, Goa boasts nine minor ports with a total of 19 commercial jetties in the North and 13 in South. The coastline of Goa falls within major traffic and transit zones for offshore oil transport, accounting for approximately 80 percent of global oil transportation. This significant volume of oil transport poses a considerable risk of oil spills along the Goan coast, leading to various environmental concerns [11]. Major factors contributing to oil spills along the Goan coastline include oil tankers accidents such as fires, groundings and sinkings, and discharge from offshore installations such as hotels, shacks, casinos, and cruise ships anchored at jetties. Furthermore, activities such as loading and unloading of petroleum products, blowouts, accidental leakages from cargo and marine terminals at harbours, unintended breakups of tankers and barges, deliberate washings of oil tankers, shipbreaking yards, collisions, water sports, and tourism activities on beaches, as well as surface runoffs due to storms, all contribute to the vulnerability of Goa's coastline to oil pollution. According to the data of Goa fisheries department, leakages from Canoe, Trawlers, Purse-Seiner, Sports and Fishing Vessels using petrol and diesel can also to some extent contributes to oil concentrations in the waters in Goa. Moreover, India's largest oil producing Mumbai High field also cause oil pollution along Goan coast due to operational mismanagement, leaks and pipeline ruptures [12]. Till date Goa's coast has faced a lot of oil spill incidences, ultimately leading to occurrences of tarballs along the coastline. In South and North Goa, places most affected by tarball occurrences includes 15 km long stretch from Benaulim Beach to Velsao in Salcete and 6 kms long stretch from Siquerim to Baga in Bardez respectively [13].

The reason for these aforesaid occurrences varies mostly because of the location of beach and human activities going on there. Preliminary research carried out by our group points out that apart from anthropogenic activities, tarball deposition on the seashore is also influenced by the width of shoreline. In North Goa, Dona Paula, Miramar, Siquerim, Calangute, Candolim, Vagator and Baga have reduced foreshore and backshore width, where there is frequent occurrence of tarballs. Heavy deposits are also seen along Keri, Arambol, Mandrem, and Morjim beach line. Miramar beach is major tourist destination and has casinos, hotels, restaurants nearby and fishing activity is also prominent, which might be the foremost reason for oil spills. Fishing boats anchored in Baga and Calangute beach in Bardez taluka makes these beaches vulnerable to oil leakages. In South Goa, beaches like Velsao, Mobor and

Cavelossim have now become hotspots of tarballs. The stretch from Beanulim to Velsao is worst affected while Talpona beach has very minute concentrations of oil. South Goa forms a major shipping hub and the activities like loading, transportation, unloading, and fishing adds on to the oil leaks in the waters. Mobor beach in South Goa also sees lot of oil spills due to its proximity to a jetty, wherein there are oil leaks from the anchored ships or during ship repairs. During the monsoon and prior to its arrival, rough sea and winds blowing towards the Goan coast also brings a lot of tarballs during June to October.

Environmental Implications of Oil Spills

Oil spill is one of the major issue and environmental threat in the world as it affects ecology, biodiversity, livelihood and tourism in the coastal areas and countries world-wide. Seawater and sand contaminated with oil have detrimental impact not only on environment but also on humans. Moreover, studies have reported threat to marine life and species in Goa by the activities like overfishing, toxic pollutants like oil spills, and climate change, putting stress on natural and local marine life. Oil spill of 1970 has been the major reason for tarball occurrence on different beaches of Goa, resulting in the decline of marine biodiversity health and water quality because of its carcinogenic and toxic nature [14].

Oil film on sea surface prevent exchange of gases, heat and energy by preventing interaction of seawater and atmosphere and reduce refractive index of ocean surface. This affects the photosynthetic ability of phytoplanktons and thus decrease the primary productivity of ecosystem. Oil spills also affects zooplanktons as the toxicity caused by hydrocarbons affects their brain, liver, kidney, and cardiac performance. It can also cause increase in death rate, decrease in survival chances of eggs, and cause deformity among young ones. Overall, it can affect growth and reproductive ability of both zoo- and phytoplankton. Many bottom-dwellers are also affected severely by oil contamination, and they transmit these toxins to their predators, leading to increased concentration of the toxins in higher species.

The Polycyclic Aromatic Hydrocarbons (PAHs) found in tarballs contain pollutants like fluorine, naphthalene, acenaphthene and thirteen others, which are carcinogenic even at very low concentrations. As tarballs float in the water over a period, there is a chance of leaching of these PAHs into the marine environment and this can produce harmful impacts on marine life [15]. After the 1994 incident of MV ‘Sea Transporter’, catastrophic destruction of bacteria, marine algae, phytoplanktons, zooplanktons and benthic meiofauna due to oil-slicks, tar residues, petroleum hydrocarbons (PHC) in water and beach sand were reported. Also, soon after the ‘River Princess’ incidence, benthic organisms of Candolim and Sinkerim showed 60 percent decrease in species abundance and richness. In furtherance, persistent oil spills reduced the macrobenthos community and biomass of benthic organisms and imposed harm to oil sensitive organisms.

Marine fauna is also adversely affected because of oil spills and impacts are also seen on kelp, coral, and mangrove ecosystem. Seabirds faces dangers of oil ingestion during attempted feeding and inhalation of volatile organic components above oil surface. Oil contamination is also known to inhibit flight and cause severe deaths of avifauna increasing mortality rates.

Mammals in ocean waters are also unable to detect the floating oils resulting in adherence of oil to their skin, eyes, and sensitive body parts. In furtherance, problems like lung congestion, pneumonia and inflammation of membrane are also faced by them. It is because of its harmful nature, oil spills are responsible for causing major concerns related to availability of fresh waters as these oils enter fresh water sources like lakes, reservoir and affects fish, birds, and wildlife. Volatile organic components present in polluted water gets evaporated and affects the quality of atmosphere which in turn cause harm to nearby residential areas. Mangrove ecosystems are also highly sensitive to oil spills. Oil coats the breathing surfaces of roots, stems, and their seedlings in these ecosystems causing death of these plants.

Mostly the effects of oil spills are seen in intertidal zones where sessile species are affected. Turtles that rely seasonally on these grounds as nesting areas are widely affected and sometimes consume the tarballs seen on the nesting habitat leading to several health issues [16]. Studies have been conducted to show the correlation between that faunal density and PHC. The coast of Palolem, Agonda and Benaulim in Goa were investigated, which showed negative correlation between macrofaunal density and PHC, depicting negative impact of oil spills on species diversity. The 1994 incident also impacted the terrestrial flora-fauna, and amphibians in Goa and declined the density of meiofauna at Siquerim beach within first few weeks of oil spill as a short-term effect. Post ‘River Princess’ oil spill decrease in the population of Copepods and Amphipoda at Sequerim beach, which are sensitive to PHC has been observed. Further as the port on which MV ocean Seraya has been docked is located at the mouth of river Zuari, wherein the oil spillage of 2006 posed serious threats to around 186 aquatic species. It affected many dominant species in turn affecting overall faunal composition of the oil spill site.

Another environmentally important factor for biological, cultural, physical, and recreational activities is beach sand as it has complex biodiversity of primary producers, secondary producers and decomposers. The oil spill contamination in sand affects its quality and changes its physical and chemical properties such as compaction, compression, strength, and permeability. Hydrocarbon pollution affects erodibility and water infiltration properties of sand and may also lead to ground fires. Due to fusing of minerals, aggregation of sand particles and destabilisation of sand organic matter is observed in the presence of hydrocarbons [17]. Tarballs percolation in the sand have shown change in the chemical and physical properties of Goan beaches. Apart from these, impacts on human health due to consumption of seafood bioaccumulated with toxins formed due to oil spills is also a major concern. The carcinogenic effects, nausea and central nervous system inhibition and disruption are detected among individuals consuming such food. There are also economic stressors due to loss of fisheries and scenic beauty on beaches since Goa’s economic growth is based on tourism and fisheries [18].

Suggestions

This study points at the urgent need for enhanced preventive measures, robust response strategies, and effective policy frameworks to mitigate the environmental impacts of oil pollution. Firstly, proactive measures such as regular monitoring of shipping activities,

stringent enforcement of safety regulations for offshore operations, and implementation of advanced technologies for oil spill detection and surveillance are imperative to prevent accidents and minimize the risk of spills. Moreover, development of oil spill models simulating weathering processes and forecasting the fate of oil once spilled can also prove beneficial. Additionally, investing in research and development initiatives aimed at improving spill response capabilities, including the development of innovative cleanup technologies and establishment of dedicated response teams, can significantly enhance the effectiveness of emergency interventions.

The future research can be focused on bioremediation of oil spills via oil degrading bacteria, which can be isolated from tarballs itself. There is also a need for updated environmental sensitivity indexing of various places to oil spills, which will provide a concise summary of coastal resources that could be at risk in the event of an oil spill. Moreover, fostering collaboration between government agencies, industry stakeholders, and local communities is essential for fostering a coordinated approach to oil spill preparedness, response, and recovery efforts. Thus, by integrating scientific expertise, community engagement, and stakeholder collaboration, Goa can develop a comprehensive framework for addressing the complex challenges posed by oil pollution, safeguarding its coastal ecosystems, and promoting sustainable development practices for the benefit of present and future generations.

Conclusion

Overall, the fate of oil from spills in the ocean or sea involves a complex interplay of physical, chemical, and biological processes, with long-term implications for marine ecosystems and human health. The history of oil spills on the Goan coastline underscores the importance of proactive measures to enhance maritime safety, strengthen environmental protection measures, and build resilience against future incidents. Also, collaboration among government agencies, industry stakeholders, and local communities is essential to effectively address the risks and mitigate the impacts of oil spills on Goa's coastal environment and economy. Furthermore, efforts to mitigate the impacts of oil spills typically involve containment, recovery, and cleanup operations as well as the implementation of preventive measures and environmental monitoring to minimize future incidents and assess the extent of damage caused. Thus, mitigating exposure to sensitive habitats and organisms and facilitating the natural breakdown are also equally important. Overall, studying the occurrence of oil spills is essential for effective environmental management, sustainable development, and safeguarding the health and well-being of ecosystems and communities.

References

- [1] Ye, X., Chen, B., Li, P., Jing, L., & Zeng, G. (2019). A simulation-based multi-agent particle swarm optimization approach for supporting dynamic decision making in marine oil spill responses. *Ocean & Coastal Management*, 172, 128-136.
- [2] Zhang, B., Matchinski, E. J., Chen, B., Ye, X., Jing, L., & Lee, K. (2019). Marine oil spills - oil pollution, sources and effects, In *World seas: an environmental evaluation Second*

Edition, Volume III: Ecological Issues and Environmental Impacts, Sheppard, C. (Ed.), Cambridge: Academic Press, 391-406.

- [3] Yadav, D. S., Rani, A., Dubey, S., & Bast, F. (2022). Status, issues, and challenges of biodiversity: Marine biota, In *Biodiversity in India: Status, Issues and Challenges*, Kaur, S., Batish, D., Singh, H., & Kohli, R. (Eds.), Singapore: Springer, 363-383.
- [4] Fatima, D. Q., & Jamshed, A. (2020). The political and economic significance of Indian ocean: An analysis. *South Asian Studies*, 30(2), 73-89.
- [5] ManiMurali, R., Kumar, R., & Vethamony, P. (2010). Taluka level environmental sensitivity index (ESI) and vulnerability mapping for oil spills: A pilot study from Goa state, India, In *Second International Conference on Coastal Zone Engineering and Management (Arabian Coast 2010)*, Muscat, Oman, 1-4.
- [6] Rout, C., & Sharma, A. (2013). Oil spill in marine environment: Fate and effects, In *Proceedings of 2nd international conference on evolution in science & technology & eye on educational methodologies ESTEEM*, Hisar, India, 326-329.
- [7] Zhang, Z., Wang, C., Chen, L., & Luan, C. (2022). Source identification and weathering processes of tar ball deposited Qinhuangdao coast along the Bohai Sea, China. *Marine Pollution Bulletin*, 184, 114106.
- [8] Ansari, Z. A., & Ingole, B. (2002). Effect of an oil spill from MV sea transporter on intertidal meiofauna at Goa, India. *Marine Pollution Bulletin*, 44(5), 396-402.
- [9] Sivadas, S. K. (2008). Impact of anthropogenic activities on macrobenthic communities of west coast of India. *Doctoral Dissertation*, Department of Marine Science, Goa University, Taleigoa, Goa.
- [10] Suneel, V., Vethamony, P., Naik, B. G., Krishna, M. S., & Jadhav, L. (2015). Identifying the source of tar balls deposited along the beaches of Goa in 2013 and comparing with historical data collected along the west coast of India. *Science of the Total Environment*, 527, 313-321.
- [11] Gregory, A. (2007). Response of macrobenthic communities to oil spills along Goa coast. *M.Sc. Dissertation*, Environmental Science Department, Institute of Science, Mumbai University, Goa, India.
- [12] Suneel, V., Vethamony, P., Zakaria, M. P., Naik, B. G., & Prasad, K. V. S. R. (2013). Identification of sources of tar balls deposited along the Goa coast, India, using fingerprinting techniques. *Marine pollution bulletin*, 70(1-2), 81-89.

- [13] Shinde, V. L. (2023). Studies on diversity of bacteria associated with tarballs in Goa and ability of selected species to degrade tarballs. *Doctoral Dissertation*, School of Biological Sciences and Biotechnology, Goa University, Taleigao, Goa.
- [14] Saadoun, I. M. (2015). Impact of oil spills on marine life, In: *Emerging pollutants in the environment-current and further implications*, Larramendy, M. & Soloneski, S. (Eds.), Croatia: InTechOpen, 77-106.
- [15] Warnock, A. M., Hagen, S. C., & Passeri, D. L. (2015). Marine tar residues: A review. *Water, Air, & Soil Pollution*, 226, 1-24.
- [16] Green, J., & Trett, M. W. (Eds.). (2012). *The fate and effects of oil in freshwater*. England: Elsevier Science Publishers Ltd.
- [17] Puri, V. K. (2000). Geotechnical aspects of oil-contaminated sands. *Soil and Sediment Contamination*, 9(4), 359-374.
- [18] Laffon, B., Pásaro, E., & Valdiglesias, V. (2016). Effects of exposure to oil spills on human health: Updated review. *Journal of Toxicology and Environmental Health, Part B*, 19 (3-4), 105-128.

Webliography

https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/Company_Lit/Oil_Spill_Stats_brochure_2020_for_web.pdf
<https://www.researchsquare.com/article/rs-3066291/v5>

Social Media: A Stimulator for Women Entrepreneurs

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Abstract

Social media acts as a stimulator for entrepreneurs enabling businesses to reach a new horizon in the era of digitalization. The advent of social media has simplified the journey of women entrepreneurs. The authors have attempted to examine keyword coincidence and recent research work through the co-word analysis technique. Moreover, the data has been retrieved from the Scopus database platform and analyzed through VOSviewer software. Also, the co-word analysis resulted in four clusters namely, Female entrepreneur's operations in digital space, empowerment of women through innovation, gender and digital divide, and entrepreneurial challenges. The result corroborates that undoubtedly, social media changed the way women entrepreneurs for strategy formulation and carry out daily business and marketing activities.

Keywords: Social Media, Women, Entrepreneurs, Bibliometric Analysis, Co-Word.

Introduction

Social Media acts as a stimulator for entrepreneurs enabling businesses to reach a new horizon in the era of digitalization. In furtherance, to leverage the brand reputation, organizations across the sphere embark on exploring the techniques for rapid market penetration, customer reach, and client service. Earlier, women are more dependent on their counterparts for financial support, to identify and mitigate unexpected business complexities, business networking, peripheral sponsoring, etc. Today, the advent of social media has simplified the journey of women entrepreneurs by empowering them in many ways. Social Media sites including Facebook, Twitter, WhatsApp, Instagram, TikTok, WeChat, Telegram, SnapChat, Pinterest,

etc. not only help businesses to excel their business but also make customers aware about latest market updates. According to the Statista 2024 report worldwide 5.17 billion people are active social media users (Dixon, 2024). The report supports the notion that people devote an increasing amount of time and effort to social media. Consequently, marketers also responded positively to the changing consumer demand and recognized social media as an integral component of their business.

Review of Literature

Social media is a collection of multiple internet-centered applications permitting the construction and conversation of operator-created content and has been nearly a decade since it started using and accessing social media and today, it has been a part of almost everyone's life. An increasing number of scholarly articles published demonstrates the usefulness of the platform. The social media platform is used by entrepreneurs for several reasons as a primary tool for daily business activities. Free transmission of data, easy access to information, and connectivity empower entrepreneurs to find solutions to difficulties within a fraction of a second (Kuhn et al. 2017).

Women entrepreneurs are not an exception to this and are also habituated to social media platforms. Chakraborty and Biswal (2023) have concluded that social media not only leads women towards digital entrepreneurship but also furnishes psychological empowerment. Emmanuel et al. (2022) noted that tremendous opportunities for young women entrepreneurs to enrich business performance in emerging countries. Moreover, the platform is mainly used to mitigate business challenges (Chaker & Zouaoui, 2023), and communicate business-related information publicly as marketing tools and promotional activities (Alhakimi & Albashiri, 2023). Also, during the COVID-19 pandemic situation women entrepreneurs marketed their products and sustained their businesses through WhatsApp, Facebook, and Instagram platforms (Rahayu et al. 2023).

Need & Relevance

Through the review of literature, it can be postulated that in the 21st century, social media is considered pivotal for entrepreneurial activity. In line to this, this study offers the following contributions to the nascent literature on social media influence women entrepreneurs. Identification of co-occurrence of selected keywords and gauging the relationship between frequently searched topics and thereby identifying emerging research trends in social media and women entrepreneurship is required. Hence, there is a need to understand the research work related to social media usage among women entrepreneurs.

Objective

To examine keyword coincidence and recent research work related to social media usage among women entrepreneurs through the co-word analysis technique

Methodology

The study adopted descriptive research design to interpret the observations and discussions in the present study. The following procedures have been administered to meet the objective of the research study:

Search Strategy

Elsevier – the Scopus developer claims it to be the leading database with 7+ thousand publishers, 23.4 million open access items, and 2.4 billion cited references mentioned in their official website. A search strategy applied in Scopus database consists of keywords namely: women OR female AND entrepreneur OR entrepreneurship AND technology OR digital OR communication OR social AND media.

Sampling Procedure

The application of article title, abstract, keywords search in Scopus initially enabled 509 documents. Later, the exclusion criteria including time horizon 2000-2023; document type – articles, conference papers and review; documents published in English language facilitated a total of 381 results.

Data Analysis

Bibliometric analysis is used to measure the cutting-edge research of various authors, identification of prominent journals, research collaborations among universities and countries. Also, it is to be noted that along with identification of latest research work, this method also helps to identify the current gaps in a certain research discipline, both content-wise as well as geographically (Gall et al. 2015).

Techniques Used

VOSviewer software tool is used for constructing and visualizing bibliometric networks. The authors have attempted to examine keyword coincidence and recent research work through co-word analysis technique.

Results & Discussion

The results are explained in the light of Co-Word analysis process, wherein the keywords are discussed under various clusters (Cluster 1 Blue, Cluster 2 Red, Cluster 3 Yellow and Cluster 4 Green).

Co-Word Analysis Process

Co-Word analysis is performed through the steps shown in Fig.1. As discussed in the search strategy and study design, initially keyword search was performed in Scopus database and CSV

file of selected articles are uploaded in VOSviewer software version 1.6.20 to conduct Co-occurrence of all keywords.

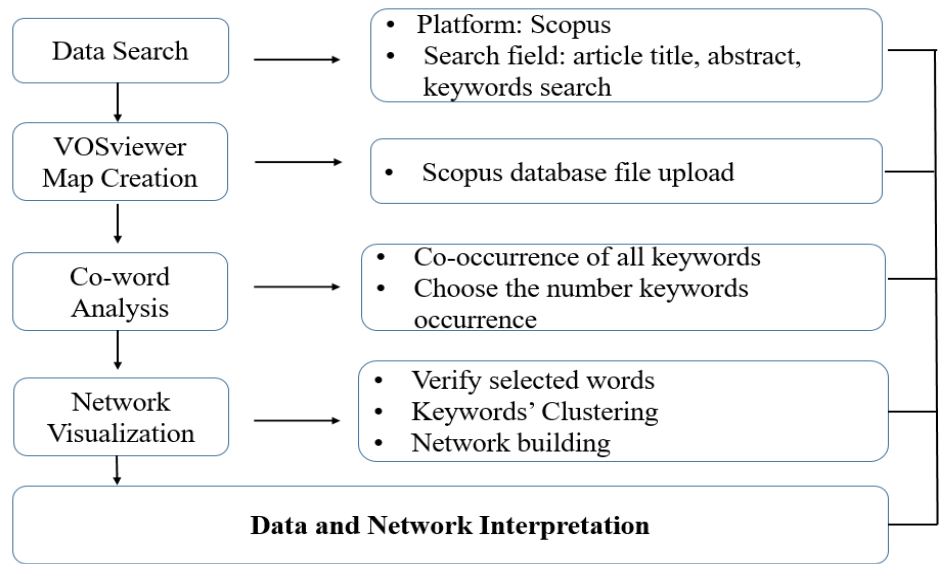


Fig. 1 Co-Word Analysis Steps

Source: Author’s Elaboration

As mentioned in Fig. 1, to carry out ‘Co-Word Analysis’, the authors have selected keywords extracted from chapter as basic analysis unit. The total selected keywords extracted are 1951. In furtherance, to create the co-occurrence of keywords matrix, out of total keywords i.e. 1951, the researchers selected the threshold 5. This indicated that only 89 keywords, which have fulfilled the minimum co-occurrence of 5 times have been included in the study. Accordingly, out of 89 keywords, the list of top 10 keywords with total link strength of each keyword showing derived trend is presented in Table 1.

Table 1. Top 10 Keywords in the Co-Occurrence of Keywords Analysis

Keyword	Occurrence	Total Link Strength
Social Media	81	286
Entrepreneurship	76	281
Female	37	271
Human	32	244
Adult	26	205
Male	27	201
Humans	16	121
Gender	42	120
Women Entrepreneurs	48	120
Social Networking (Online)	23	118

Source: VOSviewer

It is inferred from above table that highest co-occurrence keywords are social media (81), entrepreneurship (76), female (37) and so on. Additionally, the total link strength of keyword indicates the number of publications in which two keywords occur together. Visualizing bibliometric network is often referred to as ‘science mapping’. Network map of co-word analysis is shown in Fig. 2.

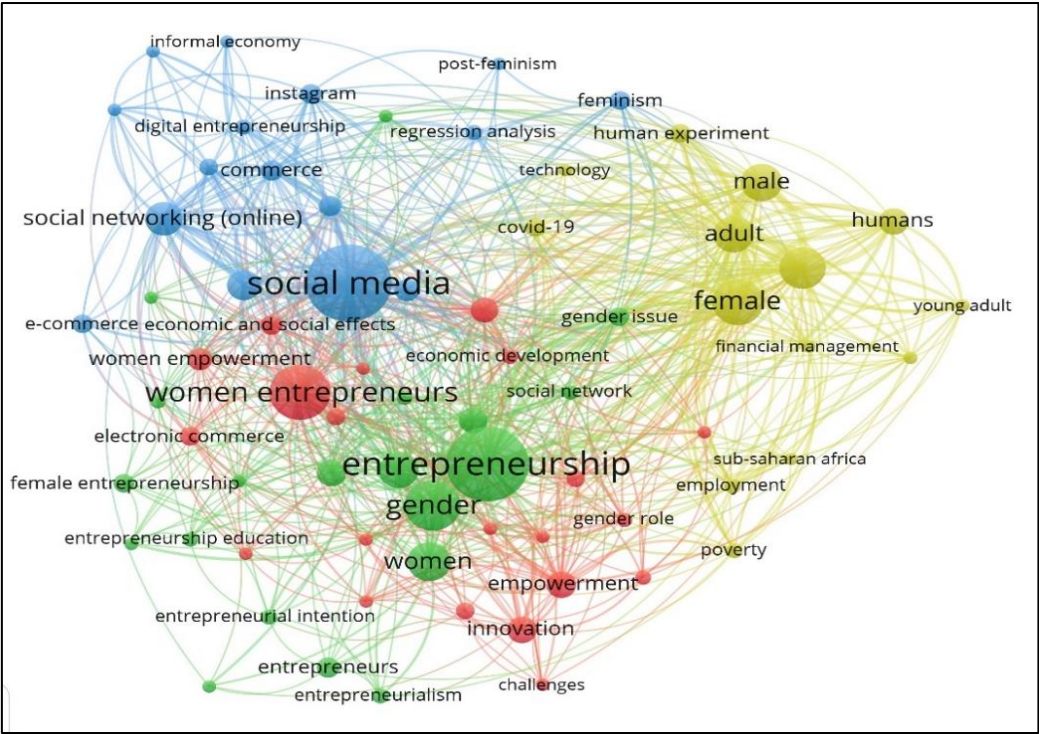


Fig. 2 Network Map of Co-occurrence Matrix

Source: Author’s Elaboration

The co-word analysis network reveals the presence of four separate clusters. These clusters have been assigned labels by the author through qualitative assessment, reflecting the interconnection of keywords within them. The attributes of each cluster are subsequently assessed and elucidated.

Cluster 1 Blue: There are 10 keywords in this cluster (social media, e-commerce, social networking, digital entrepreneurship, commerce, Instagram, informal economy, regression analysis, feminism, and post feminism) and it is labeled as ‘Female entrepreneur’s operations in digital space’. Female entrepreneurs operating in the digital space are actively leveraging technology and online platforms to establish and grow their businesses. In today’s digital age, women are increasingly recognizing the vast opportunities offered by the online realm for entrepreneurship (Brush et al. 2019). Moreover, research by Olsson and Bernhard (2020) highlights the role of digital skills and training programs in empowering women entrepreneurs to effectively navigate the digital landscape, develop innovative business models, and capitalize on emerging trends. These women demonstrate resilience, creativity, and

adaptability as they harness the power of digital technologies, contributing to economic growth and gender empowerment.

Cluster 2 Red: There are 8 keywords in this cluster (gender role, empowerment, innovation, challenges, economic development, economic and social effects, women entrepreneurs, women empowerment, and economic development) and it is labeled as ‘Empowerment of women through innovation’. The presence of entrepreneurial resources, particularly technical ones, has a notable and beneficial influence on innovation capability, consequently enhancing business performance (Taleb et al. 2023). The empowerment of women through business innovation is a multifaceted phenomenon with significant implications for gender equality and economic development. Women’s entrepreneurship has been recognized as a key driver of innovation and economic growth (Brush et al. 2019). Through innovative business practices and approaches, women entrepreneurs can challenge traditional norms and barriers, expanding opportunities for themselves and others. Innovation enables women to leverage technology, access new markets, and develop novel solutions to address societal challenges, ultimately contributing to their economic empowerment (Huyghe et al. 2016).

Cluster 3 Yellow: There are 11 keywords in this cluster (human experiment, Covid-19, technology, male, adult, female, humans, financial management, Sub-Saharan Africa, employment, and poverty) and it has been labeled as ‘Gender and Digital Divide’. The research indicates that women are often disproportionately affected by limited access to digital tools, internet connectivity, and digital literacy skills, which can hinder their participation in the digital economy (Acilar & Saebo, 2023). Furthermore, economic crisis, cultural and educational background, migrating or relocating issues may perpetuate this digital gender gap, restricting women’s opportunities for education, employment, and entrepreneurship in the digital sphere (Kalaitzi et al. 2017).

Cluster 4 Green: There are 10 keywords in this cluster (female entrepreneurship, entrepreneurship education, entrepreneurial intention, entrepreneurs, entrepreneurialism, entrepreneurship, gender, women, social issue, and social network) and it has been named as ‘Entrepreneurial Challenges’. The digital skills gap hinders women’s ability to effectively navigate the digital landscape and capitalize on emerging opportunities. Additionally, gender biases in online platforms and social networks may limit women’s visibility and access to valuable networks and resources (Fosch-Villaronga et al. 2021). Women entrepreneurs may encounter barriers to networking and collaboration in online spaces, which are crucial for accessing mentorship, partnerships, and market opportunities.

Summary

This study employed bibliometric analysis to examine the thematic relationships within literature concerning women’s entrepreneurship and use of social media. Also, through co-word analysis, this research explored the interconnected themes and further identified dominant topics and significant areas related to women entrepreneurship and use of social media to stimulate their business. The investigation identified four distinct clusters in co-word analysis, highlighting the key areas and warranting further exploration within this field that are

quite significant for supporting future research. Moreover, social media platforms serve as hubs for networking and collaboration.

Suggestions

Women entrepreneurs can connect with like-minded individuals, mentors, potential clients, and collaborators globally, thereby breaking geographical barriers. In furtherance, they can network with platforms like LinkedIn, Facebook Groups, and specialized forums that provide spaces for women entrepreneurs to share insights, seek advice, and forge mutually beneficial partnerships. Social media offers cost-effective and accessible marketing channels, wherein women entrepreneurs can leverage platforms such as Instagram and Pinterest, to showcase their products or services, build brand identity, and engage with their target audience. The reason being, influencer marketing on platforms like Instagram allows women entrepreneurs to partner with influencers who resonate with their brand values, expanding their reach and credibility.

Social media provides a wealth of real-time data that women entrepreneurs can use for market research and understanding consumer preferences. Through social listening tools and analytics, they can gather feedback, identify trends, and adapt their products or services accordingly. Moreover, direct engagement with customers on platforms like Twitter and Facebook allows entrepreneurs to address concerns, receive suggestions, and foster a loyal customer base. It is also suggested that specialized training programs and workshops focused on digital skills relevant to entrepreneurship can be organized. These programs should cover areas such as social media marketing, website development, e-commerce platforms, digital analytics, and cybersecurity. Thus, by implementing above suggestions, stakeholders can contribute to bridging the digital divide and empowering women entrepreneurs to thrive in the digital era, thereby unlocking their full potential for innovation, growth, and socio-economic empowerment.

Conclusion

The study supports the notion that usage of social media has not only propelled the business of entrepreneurs but also elevated the burden of women entrepreneurs. The landscape of female entrepreneurship in the digital space presents both opportunities and challenges. While digitalization and social networking platforms offer unprecedented avenues for women to innovate, connect, and grow their businesses. They also underscore persistent disparities, such as the gender digital divide and entrepreneurial challenges. Despite these obstacles, empowering women through innovation remains crucial in addressing these disparities and unlocking the full potential of female entrepreneurs. Thus, by bridging the gender digital divide, providing access to resources and support, and fostering an inclusive entrepreneurial ecosystem, the nation can create a more equitable and prosperous future, wherein women become an integral part of the system and thrive as dynamic contributors to the digital economy.

References

- Acilar, A., & Saebo, O. (2023). Towards understanding the gender digital divide: A systematic literature review. *Global Knowledge, Memory and Communication*, 72(3), 233-249.
- Alhakimi, W., & Albashiri, S. (2023). Social media adoption by women entrepreneurial small businesses. *Asia Pacific Journal of Innovation and Entrepreneurship*, 17(3-4), 158-175.
- Brush, C. G., de Bruin, A., & Welter, F. (2019). A gender-aware framework for women's entrepreneurship. *International Journal of Gender and Entrepreneurship*, 11(2), 125-149.
- Chaker, H., & Zouaoui, S. (2023). Meeting the challenge of entrepreneurship with social media: The case of Tunisian women entrepreneurs. *Journal of Entrepreneurship and Innovation in Emerging Economies*, 9(1), 33-61.
- Chakraborty, U., & Biswal, S. K. (2023). Impact of social media participation on female entrepreneurs towards their digital entrepreneurship intention and psychological empowerment. *Journal of Research in Marketing and Entrepreneurship*, 25(3), 374-392.
- Dixon, S. J. (2024). Global social networks ranked by number of users 2024. *Statista*, United Kingdom.
- Emmanuel, C. P., Qin, S., Hossain, S. F. A., & Hussain, K. (2022). Factors influencing social-media-based entrepreneurship prospect among female students in China. *Heliyon*, 8(12), E12041.
- Fosch-Villaronga, E., Poulsen, A., Søråa, R. A., & Custers, B. H. M. (2021). A little bird told me your gender: Gender inferences in social media. *Information Processing and Management*, 58, 102541.
- Gall, M., Nguyen, K. H., & Cutter, S. L. (2015). Integrated research on disaster risk: Is it really integrated? *International Journal of Disaster Risk Reduction*, 12, 255-267.
- Huyghe, A., Knockaert, M., & Obschonka, M. (2016). Unraveling the “passion orchestra” in academia. *Journal of Business Venturing*, 31(2), 344-364.
- Kalaitzi, S., Czabanowska, K., Fowler-Davis, S., & Brand, H. (2017). Women leadership barriers in healthcare, academia and business. *Equality, Diversity and Inclusion*, 36(5), 457-474.
- Kuhn, K. M., Galloway, T. L., & Collins-Williams, M. (2017). Simply the best: An exploration of advice that small business owners value. *Journal of Business Venturing Insights*, 8(C), 33-40.

Olsson, A. K., & Bernhard, I. (2021). Keeping up the pace of digitalization in small businesses: Women entrepreneurs' knowledge and use of social media. *International Journal of Entrepreneurial Behaviour & Research*, 27(2), 378–396.

Rahayu, N. S., Masduki., & Ellyanawati, E. R. N. (2023). Women entrepreneurs' struggles during the COVID-19 pandemic and their use of social media. *Journal of Innovation and Entrepreneurship*, 12, 51.

Taleb, T. S. T., Hashim, N., & Zakaria, N. (2023). Mediating effect of innovation capability between entrepreneurial resources and micro business performance. *The Bottom Line*, 36(1), 77-100.

Webliography

<https://www.elsevier.com/products/scopus>

<https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/>

Wavelets for Denoising 1D Signals

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Abstract

Wavelet analysis is an essential part of signal processing since it can provide enhanced time-frequency localization and high-resolution analysis. In this chapter, a wavelet-based denoising technique is suggested to recover signals that have been contaminated by Additive White Gaussian Noise (AWGN) based on the concept of thresholding. Wavelet threshold denoising plays a crucial role in quantifying the wavelet coefficients and is particularly effective for eliminating AWGN. This chapter discusses the application of wavelet denoising techniques to remove noise from seismic and power quality disturbance signals.

Keywords: Denoising, Multiresolution Analysis, Wavelet Analysis, Thresholding Value.

Introduction

Wavelet denoising is a classical and effective approach for reducing noise in 1D signals. It involves rectifying the coefficients of noisy signal in the transform domain using a set of shrinkage functions. Various methods have been recommended to exploit the advantages of wavelet transform, such as sparsity, multiresolution structure, and similarity with the human visual system. Moreover, various denoising techniques have been proposed to address these challenges and further research can continue to focus on developing more efficient and effective methods to manage denoising 1D signals.

Literature Review

A Wavelet Transform (WT) is a signal decomposition method that uses a set of basic functions to analyze the time-frequency relationship of signals. The Wavelet Transform (WT) has several advantages compared to other time-frequency representations like Short-Time Fourier Transform (STFT). These advantages include multi-resolution analysis and contrast relative bandwidth [1]. The Wavelet Transform (WT) is also used in sub-band coding for audio, video, and image compression. Furthermore, extensive research and development have been devoted to the WT leading to advancements in the field of signal processing and its wide-ranging applications in science and engineering. The efficient noise reduction from 1D signals can be achieved by denoising operators such as the bilateral filter, Gaussian range filter [17], and median filter [5]. Also, Low Pass Filter (LPF) is suitable for smoothing signals by attenuating high-frequency noise, this can lead to loss of information in the signal [6]. At the same time, the High Pass Filter (HPF) is effective in eliminating low-frequency interference [7]. Moreover, median filtering is particularly useful for removing impulse noise without blurring edges. While LPF, HPF, and median filtering offer effective denoising capabilities, they also have inherent limitations such as signal distortion, sensitivity to parameters, and computational complexity [10]. The present study has denoised 1D seismic signals and Power Quality Disturbance (PQD) signals contaminated by AWGN using the threshold Daubechies wavelet denoising method. The results are compared with Rigrsure, minimax, and sure threshold functions used for universal threshold at various decomposition levels [18]. The Rigrsure thresholding techniques offer an automatic and data-driven approach to threshold selection, which can effectively remove noise while preserving important signal features [13]. The minimax thresholding method aims to provide robust denoising performance by minimizing the worst-case MSE [14]. The universal threshold method adapts to noise level present in the signal without requiring prior knowledge of noise characteristics [2]. The Additive White Gaussian Noise (AWGN) plays a crucial role in seismic signal processing, serving multiple purposes. Primarily, it allows for the simulation and testing of algorithms under realistic noise conditions, aiding in the evaluation of their performance. Moreover, AWGN helps model background noise commonly present in seismic data, enabling researchers to study its effects and develop mitigation strategies [12]. Thus, by adding controlled levels of noise, the robustness and effectiveness of signal processing algorithms can be assessed, particularly in denoising and feature extraction. AWGN also finds application in education, providing a practical demonstration of how noise affects seismic signals and the methods used to enhance signal quality [11].

Need & Relevance

Wavelet denoising is a powerful technique used in signal processing to remove noise from 1D signals. 1D signals often contain noise from various sources such as interference, measurement errors, or environmental factors. Overall, AWGN serves as a fundamental tool in seismic signal processing for understanding, analyzing, and improving algorithms amidst noisy environments. Wavelet denoising helps in reducing this noise, thus enhancing the signal quality. However, the signal components are also removed. Several thresholds have been proposed by Donoho and Johnstone to denoising signals like Universal Threshold, Sure shrink,

or Minimax [9]. Wavelets are mathematical functions that can be used to analyze and process signals, such as seismic signals and Power Quality Disturbance (PQD). They provide a powerful tool for denoising signals by decomposing them into different frequency components.

Objective

To employ Wavelet Transform (WT) methodologies to effectively remove noise from 1D signals

Materials & Methods

This research has adopted experimental research design, wherein the results and observations are discussed accordingly. In the present study, Denoising refers to the reduction of noise while preserving the signal integrity [3]. It relies on the time-frequency amplitude matrix generated through wavelet transformation, leveraging the distinction in frequency ranges between the desired signal and undesired noise. In scientific measurements, the signal components are typically found at lower frequencies, contrasting with the higher frequency presence of noise [16]. Also, denoising process is governed by the choice of wavelet type and a parameter known as the wavelet level, where higher levels offer finer resolution in distinguishing between signal and noise frequencies. Generally, the wavelet denoising procedure follows these steps:

- Utilize wavelet transformation on the noisy signal to generate coefficients at a level that enables clear differentiation of PQD occurrence.
- Choose suitable threshold limits and methods such as hard or soft thresholding at each level for optimal noise removal.
- To obtain a denoised signal, take an inverse wavelet transform of the threshold wavelet coefficients.

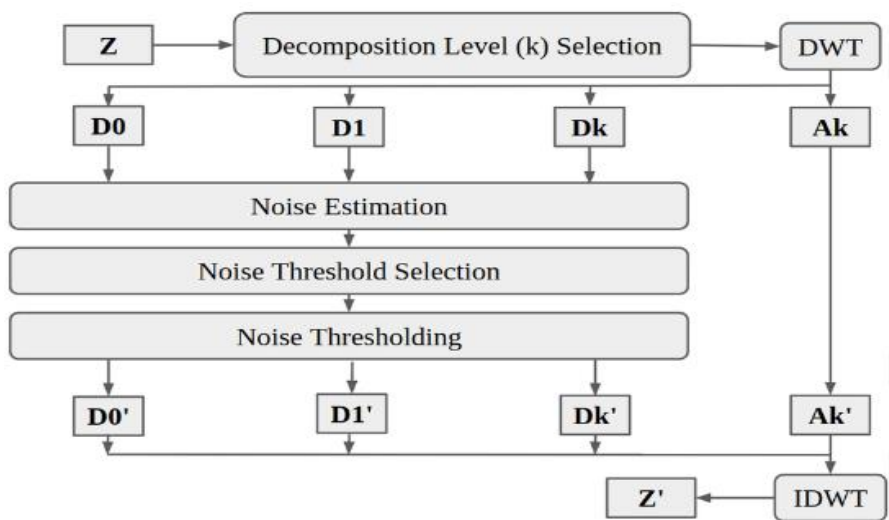


Fig.1: Flow Chart of the Proposed Methodology

Various methods exist for determining the threshold in wavelet denoising. One approach involves setting the threshold individually for each case, which can be time-intensive but allows for tailoring the threshold to achieve satisfactory noise reduction [8]. When applying an orthogonal wavelet transform to Gaussian noise, the noise is Gaussian in nature and is maintained, producing a histogram that resembles a symmetrical bell-shaped curve centered around its mean. The theory suggests that approximately 99.99 percent of noise falls within four times the standard deviation. Therefore, it is possible to effectively remove the Gaussian noise by setting a threshold at 4.5 times the standard deviation of the wavelet transform signal [4]. In general, there are two rules for threshold wavelet coefficients: soft thresholding, where coefficients are zeroed below the threshold, and hard thresholding, wherein coefficients are zeroed with absolute values below the threshold. The appropriate determination of the threshold is essential for the efficient use of wavelet thresholds to remove noise [14]. The valuable information and noise will also be removed if the chosen threshold is set too high, while some noise will remain if it is set too low. Many researchers have investigated threshold determination methods to address this issue.

Wavelet Threshold Denoising

Noise affects the original signal in 1D noisy signals through linear superposition,

$$x(u) = s(u) + n(u) \quad (1)$$

Where $s(u)$ is an original signal, $n(u)$ is an additive white Gaussian noise, and $x(u)$ is a noisy signal.

Signal denoising using the wavelet threshold method involves:

Signal Decomposition: Employing wavelets to decompose the signal into N layers.

Threshold Processing: Determine a suitable threshold and compare it with the wavelet coefficients obtained after transforming the signal and coefficients below the threshold are identified as noise.

Signal Reconstruction: Obtain the denoised signal by reconstructing the processed wavelet coefficients.

Universal Threshold

Donoho and Johnstone introduced a universal threshold, denoted as T, and established that the risk associated with both hard and soft thresholding is minimal, making it suitable for most applications [15]. If the thresholding function is,

$$\rho_T(x_i) = (x_i - \lambda_i \text{sign}(x_i)) \quad (2)$$

If soft thresholding is applied to a Gaussian random variable X with a mean of μ and a variance of 1, then the estimation risk is

$$r(\lambda_i, \mu) = E[(\rho_\lambda(x_i) - \mu)]^2 \quad (3)$$

Sure Threshold

A reduction in the threshold value is a common strategy to minimize thresholding risk. For example, Stein introduced the Sure threshold for this purpose, which involves selecting a distinct threshold for each sub-band at every level of the wavelet transform. This method is recognized as an adaptive approach to threshold selection. The Sure Shrink threshold T_{sure} is expressed as [16],

$$\tilde{T}_{sure}(d) = \text{sign}(d) \cdot \max(|d| - \lambda, 0) \quad (4)$$

Minimax Threshold

The minimax approach employs predetermined thresholds aimed at minimizing a constant component in the upper limit of the minimax risk for function estimation via a threshold estimator. While the resulting estimates from minimax thresholds might not always exhibit visually appearing characteristics, they offer the advantage of strong predictive performance [18].

$$\tilde{C}_{thresh}(d) = \text{sign}(d) \cdot \max(|d| - \lambda^2, 0) \quad (5)$$

Result & Discussion

The results of denoising experiment using wavelet decomposition and thresholding showed a significant reduction in noise levels. The noise levels are significantly reduced through the application of wavelet decomposition and thresholding in the denoising experiment. Moreover, Fig.2 showed the seismic signal with different noise levels added to the original signal.

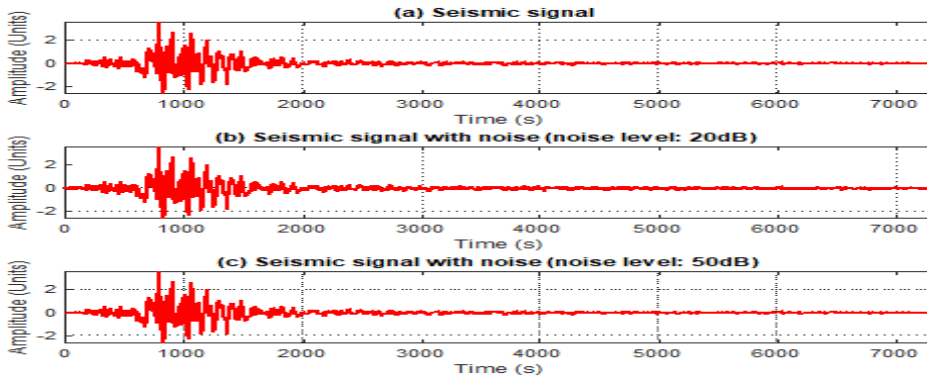


Fig.2: Seismic Signal with Different Noise Levels (a) Original Signal (b) Noise Signal with 20 dB Noise Level (c) Noise Signal with 50 dB Noise Level

Fig.2 clearly shows that a seismic signal has been added with AWGN for different levels. AWGN with an SNR of 20 dB and 50 dB was added for each signal. Additive White Gaussian Noise (AWGN) is also utilized in power quality disturbance signal analysis. In this context, AWGN serves similar purposes to its application in seismic signal processing.

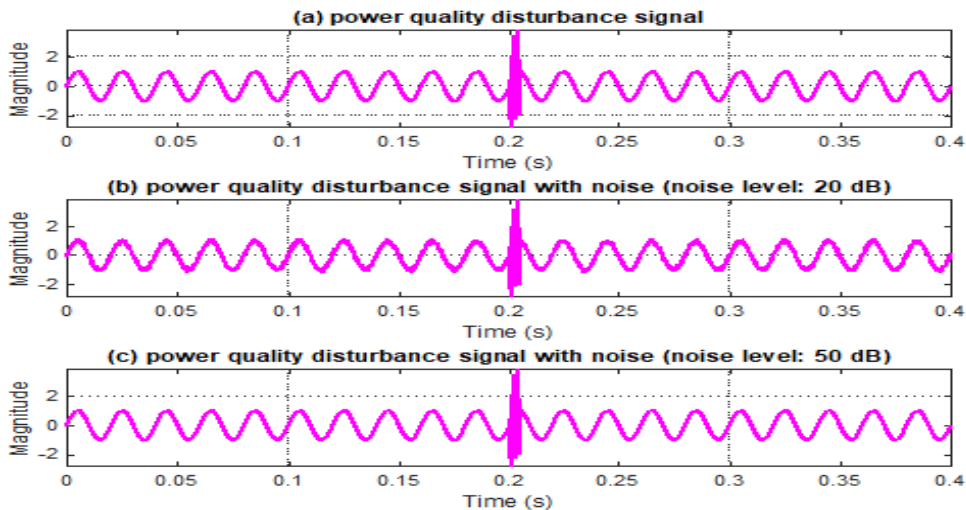


Fig.3: Power Quality Disturbance (PQD) Signal with Different Noise Levels (a) Original Signal (b) Noise Signal with 20 dB Noise Level (c) Noise Signal with 50 dB Noise Level

As illustrated in Fig.3, AWGN with SNR of 20 dB and 50 dB have been added to each signal. The dB4 wavelet proves to be the most suitable for identifying PQD and seismic signals. Wavelet-based denoising results for Gaussian noise added seismic signal, and PQD signal with different threshold methods as shown in Fig.4.

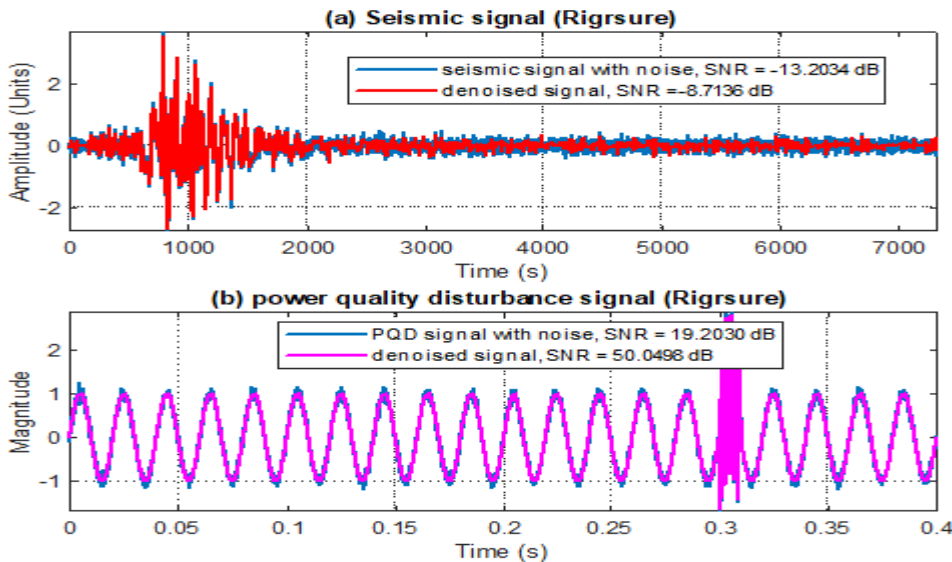


Fig.4: Results of Rigrsure Threshold Method (a) Seismic Signal, (b) Power Quality Disturbance (PQD) Signal

Fig.4 clearly shows that the SNR results are based on the decomposition level using Rigrsure thresholding as a denoising parameter. For the Rigrsure threshold method [13], the highest SNR value has been observed at a decomposition level of 4.

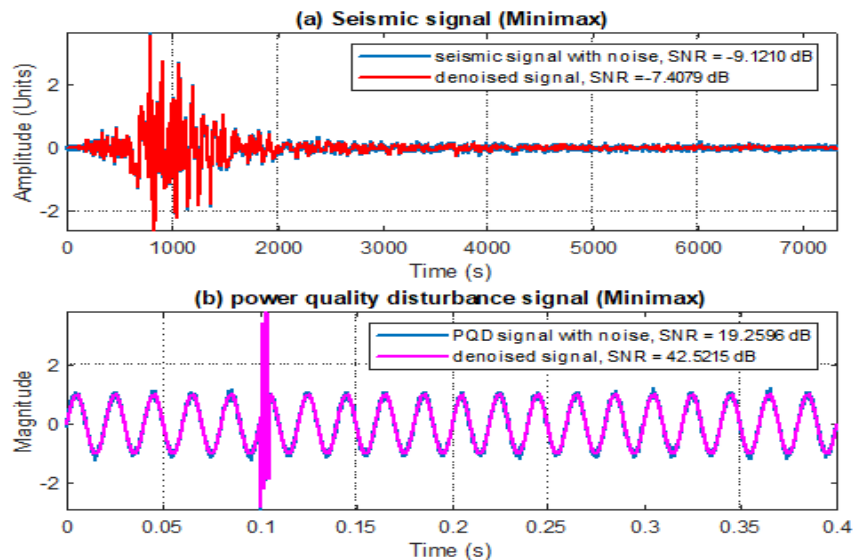


Fig.5: Results of Minimax Threshold Method (a) Seismic Signal, (b) Power Quality Disturbance (PQD) Signal

Fig.5 presented the results obtained using the Minimax threshold method. Fig.5 (a) shows that it initially exhibits noise with an SNR of -9.1210 dB, and after denoising, the SNR improves to -7.404 dB. Conversely, the PQD signal starts with a noise SNR of 19.256 dB, which significantly increases to 42.5215 dB after denoising. These results underline the efficacy of the Minimax threshold [14] method in reducing noise and enhancing signal quality, particularly evident in the substantial enhancement of SNR for the PQD signal.

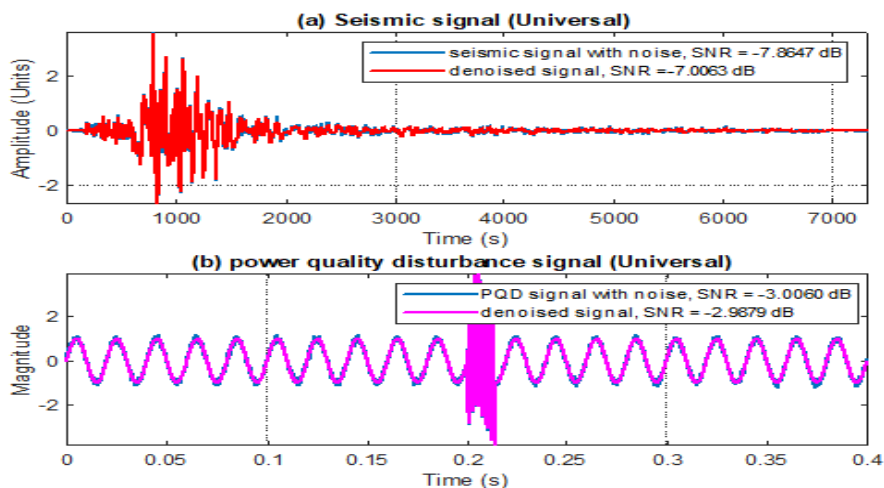


Fig.6: Results of Universal Threshold Method (a) Seismic Signal, (b) Power Quality Disturbance (PQD) Signal

Fig.6 illustrates the results obtained from applying the Universal threshold method to denoise signals. For the seismic signal, the initial SNR was -7.8647 dB, which marginally increased to -7.0063 dB after denoising. Similarly, the PQD signals an SNR of -3.0060 dB, with a marginal change to -2.9879 dB after denoising. The results suggested that while Universal threshold [2] method has a modest effect on improving SNR for both signals, its ability appears limited compared to the Minimax threshold method. The SNR represents in dB between the original and denoised signal using six levels of DWT decomposition. The Fig. 7, 8, and 9 shows the effects of different threshold methods on signal quality.

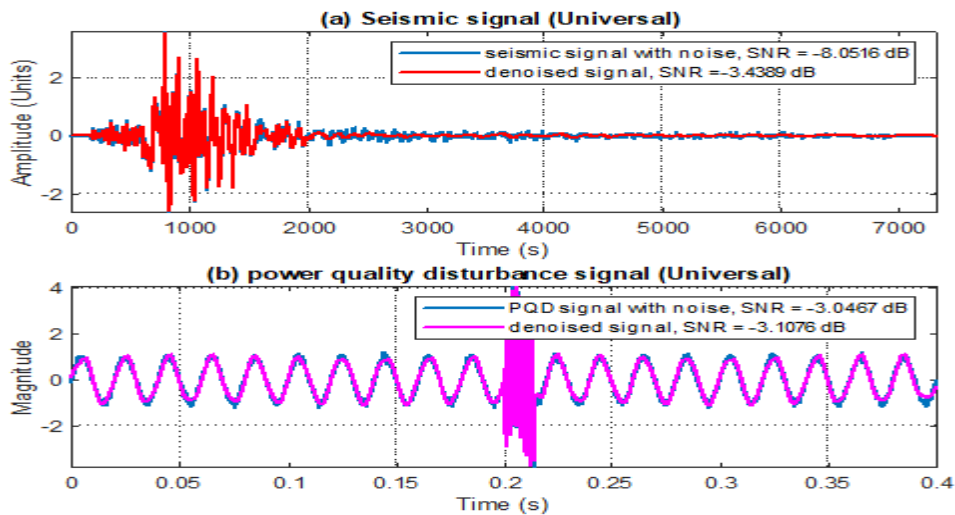


Fig.7: Results of Universal Threshold Method (a) Seismic Signal, (b) Power Quality Disturbance (PQD) Signal

As indicated in Fig 7, the results of employing the Universal threshold denoising method are depicted. In which Fig.7 (a) illustrates the seismic signal, while Fig.7 (b) shows the PQD signal analyzed using the db4 wavelet. The SNR of the noise present in the seismic signal is measured at -8.0516 dB, with the denoised signal achieving an SNR of -3.4389 dB. This analysis underscores the effectiveness of Universal threshold denoising method in reducing the noise in both seismic and PQD signals, as demonstrated by the improved SNR values [2]. Fig.8 shows the Minimax threshold denoising method.

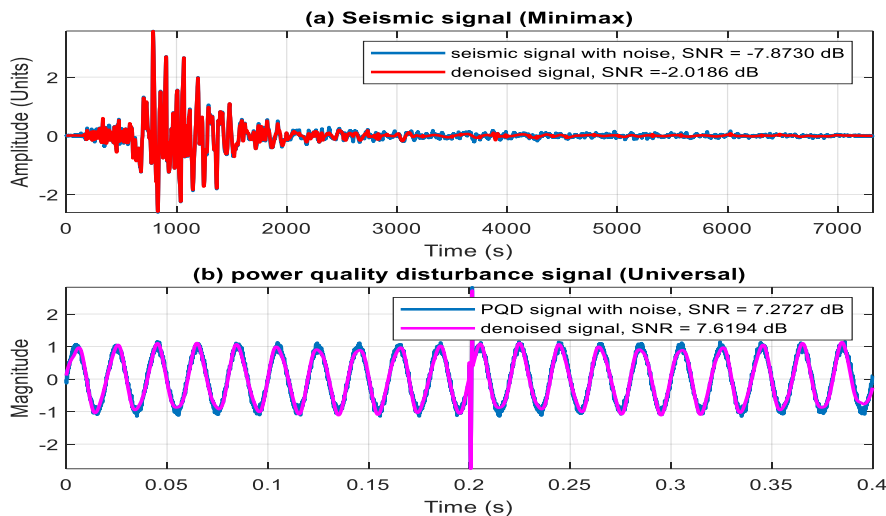


Fig.8: Results of Minimax Threshold Method (a) Seismic Signal, (b) Power Quality Disturbance (PQD) Signal

Fig.8 illustrates the results of applying the Minimax threshold denoising method. Fig.8 (a) represents the seismic signal, where the denoised signal, highlighted in red, achieves an SNR of -2.0186 dB, with noisy signal SNR measured at -7.8730 dB. The Fig.8 (b) depicts the PQD signal analyzed using the db4 wavelet, the noise SNR for the PQD signal is 7.2727 dB. After denoising, the SNR increases to 7.6194 dB, with the denoised signal highlighted in pink. These results indicated that the Minimax threshold [14] denoising method effectively reduces noise and improves signal quality for both seismic and PQD signals.

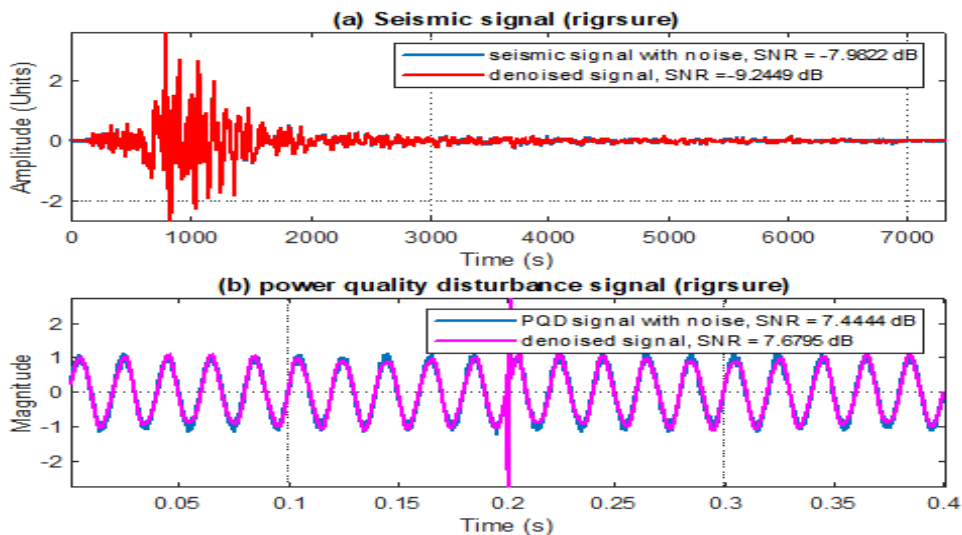


Fig.9: Results of Universal Threshold Method (a) Seismic Signal, (b) Power Quality Disturbance (PQD) Signal

Furthermore, it is noteworthy that, in comparison to the seismic signal and power quality disturbance (PQD) with noise signal, whereas SNR of denoised signal obtained using the proposed method is enhanced by 7.6795 dB, -9.2449 dB. The proposed method demonstrates a favorable impact on general denoising effects, particularly in noisy environments, as shown in Fig.7, Fig.8, and Fig.9 respectively. Additionally, it is capable of adapting to various decomposition levels while maintaining a good denoising effect in both seismic signals and PQD signals.

Table:1 Comparison of the Threshold Methods with Various Decomposition Levels

Level-6, Daubechies Wavelet				
Threshold Methods	Seismic Signal		PQD Signal	
	Noise Signal SNR (dB)	Denoised Signal SNR (dB)	Noise Signal SNR (dB)	Denoised Signal SNR (dB)
Rigrsure [13]	-13.2034	-8.7136	19.2030	50.0498
Minimax [14]	-9.1210	-7.4079	19.2596	42.5215
Universal [2]	-7.8647	-7.0063	-3.0060	-2.9679
Level-6, Daubechies Wavelet				
Rigrsure [13]	-8.0516	-3.4389	-3.0467	-3.1076
Minimax [12]	-7.8730	-2.0186	7.2727	7.6194
Universal [2]	-7.9622	-9.2449	7.444	7.6795

Table 1 shows the seismic signals, both levels exhibit improvements in SNR after denoising. However, Level 6 generally outperforms level-4 across all thresholding methods. Notably, the Rigrsure [13] and Minimax [14] methods show more substantial SNR enhancements with Level-6, indicating their superiority in preserving signal quality. Additionally, study evaluated the performance of various wavelet families and decomposition levels. Results indicated that the selection of wavelet basis and decomposition level significantly influenced denoising outcomes. The specific wavelet families demonstrated superior capability in preserving signal characteristics while effectively attenuating noise, underscoring the importance of meticulous selection in wavelet-based denoising endeavours.

Table:2 Performance Comparison of Denoising Methods for Seismic Signal and PQD Signal

Denoising Methods	Seismic Signal		PQD Signal	
	Noise Signal SNR (dB)	Denoised Signal SNR (dB)	Noise Signal SNR (dB)	Denoised Signal SNR (dB)
Bilateral filter [17]	-20.8762	-19.3456	3.4985	5.6787
Gaussian Range Filter [17]	-12.3568	-11.3976	6.7891	8.9832
Median Filter [5]	-17.3466	-17.0982	7.6782	8.9820
Low Pass Filter [6]	-15.8765	-14.9876	10.8754	12.8986
High Pass Filter [7]	-20.6541	18.9755	12.7654	15.9873
Proposed Method	-13.2034	-8.7136	19.2030	50.0498

As shown in Table 2, the proposed method outperforms the other denoising methods in terms of SNR improvement for both the seismic and PQD Signals, indicating its effectiveness in reducing noise and preserving signal quality. Conversely, the Bilateral filter [17] and Gaussian Range filter [17] exhibits the lowest SNR for noise signal, indicating comparatively inferior noise reduction capability. The Low Pass filter [6] and High Pass filter [7] also demonstrate respectable denoising performance, although slightly less effective than the proposed method.

Suggestions

To effectively denoise 1D signals using wavelets, several key considerations should be addressed. It is important to select the appropriate wavelet and decomposition level for a 1D signal. Thresholding techniques should be applied carefully to remove noise while preserving signal features. Proper evaluation metrics such as SNR, and MSE help in assessing denoising performance. Also, in future this research needs a cross-validation, which can be used to validate the effectiveness of algorithm. Optimization techniques and efficient implementation are also key to improving performance, especially for handling larger datasets or real-time applications. Also, by considering these factors, wavelet-based denoising can significantly enhance signal quality.

Conclusion

This chapter evaluated the performances of Wavelet denoising based on different thresholding methods in 1D signal processing. The investigations discussed in this chapter revealed that the proposed wavelet-based denoising techniques employing both four-level and six-level decompositions, and various threshold methods using Universal, Minimax, and Rigrsure threshold with Daubechies wavelet decomposition have provided valuable insights. The proposed method also provided substantial improvements in signal quality, particularly in terms of Signal-to-Noise Ratio (SNR) for seismic and Power Quality Disturbance (PQD) signals. Notably, the Minimax threshold method consistently outperformed other threshold methods, which exhibited superior noise reduction capabilities and signal enhancement. Moreover, utilizing a six-level decomposition generally yielded more favorable denoising outcomes compared to the four-level decomposition strategy.

References

- [1] Downie, T. R., & Silverman, B. W. (1998). The discrete multiple wavelet transform and thresholding methods. *IEEE Transactions on Signal Processing*, 46(9), 2558-2561.
- [2] Sardy, S. (2000). Minimax threshold for denoising complex signals with Waveshrink. *IEEE Transactions on Signal Processing*, 48(4), 1023-1028.
- [3] Dong, Y. S., & Yi, X. M. (2006). Wavelet denoising based on four improved function for threshold estimation. *Journal of Mathematics*, 26(5), 473-477.

- [4] Liu, C. C., Sun, T. Y., Tsai, S. J., Yu, Y. H., & Hsieh, S. T. (2011). Heuristic wavelet shrinkage for denoising. *Applied Soft Computing*, 11(1), 256-264.
- [5] Kose, K., Cevher, V., & Cetin, A. E. (2012). Filtered variation method for denoising and sparse signal processing, *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, 3329-3332.
- [6] Tulsani, H., & Gupta, R. (2014). 1-D signal denoising using wavelets-based optimization of polynomial threshold function. *Proceedings of 3rd International Conference on Reliability, Infocom Technologies and Optimization*, 1-5.
- [7] Ali, M. A., & Shemi, P. M. (2015). An improved method of audio denoising based on wavelet transform. *International Conference on Power, Instrumentation, Control and Computing (PICC)*, 1-6.
- [8] Lahmiri, S., & Boukadoum, M. (2015). Physiological signal denoising with variational mode decomposition and weighted reconstruction after DWT thresholding. *IEEE International Symposium on Circuits and Systems (ISCAS)*, 806-809.
- [9] Al-Aboosi, Y. Y., & Sha'ameri, A. Z. (2017). Improved signal de-noising in underwater acoustic noise using S-transform: A performance evaluation and comparison with the wavelet transform. *Journal of Ocean Engineering and Science*, 2(3), 172-185.
- [10] Liu, C., Song, C., & Lu, Q. (2017). Random noise de-noising and direct wave eliminating based on SVD method for ground penetrating radar signals. *Journal of Applied Geophysics*, 144, 125-133.
- [11] Singh, B., & Wagatsuma, H. (2019). Two-stage wavelet shrinkage and EEG-EOG signal contamination model to realize quantitative validations for the artifact removal from multiresource biosignals. *Biomedical Signal Processing and Control*, 47, 96-114.
- [12] Xie, B., Xiong, Z., Wang, Z., Zhang, L., Zhang, D., & Li, F. (2020). Gamma spectrum denoising method based on improved wavelet threshold. *Nuclear Engineering and Technology*, 52(8), 1771-1776.
- [13] Baldazzi, G., Solinas, G., Del Valle, J., Barbaro, M., Micera, S., Raffo, L., & Pani, D. (2020). Systematic analysis of wavelet denoising methods for neural signal processing. *Journal of Neural Engineering*, 17(6), 066016.
- [14] Tang, J., Zhou, S., & Pan, C. (2020). A denoising algorithm for partial discharge measurement based on the combination of wavelet threshold and total variation theory. *IEEE Transactions on Instrumentation and Measurement*, 69(6), 3428-3441.

- [15] Upadhay, P., Upadhyay, S. K., & Shukla, K. K. (2020). Denoising 1D signal using wavelets. *International Journal of Intelligent Systems Technologies and Applications*, 19(6), 517-525.
- [16] Li, H., Shi, J., Li, L., Tuo, X., Qu, K., & Rong, W. (2022). Novel wavelet threshold denoising method to highlight the first break of noisy microseismic recordings. *IEEE Transactions on Geoscience and Remote Sensing*, 60, 1-10.
- [17] Li, F., Sun, F., Liu, N., & Xie, R. (2021). Denoising seismic signal via resampling local applicability functions. *IEEE Geoscience and Remote Sensing Letters*, 19, 1-5.
- [18] Zhao, S., Iqbal, I., Yin, X., Zhang, T., Jia, M., & Chen, M. (2024). Seismic data denoising using curvelet transforms and fast non-local means. *Petroleum Science and Technology*, 42(5), 581-596.

Trend of Educational Infrastructures in Karbi Anglong District of Assam, India – An Overview

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Abstract

Education is playing an important role in shaping an active citizen; improve knowledge, way of life as well as social and economic status throughout life. Therefore, to promote good quality education and adequate educational infrastructure are utmost necessary for smooth functioning of teaching-learning processes at the institution. However, there are efforts taken by both central as well as state governments to chalk out unequal distribution of education in the country by enacting acts and launching various schemes. The present study focuses on educational infrastructures at Karbi Anglong District of Assam, wherein a tremendous effort has been put on by both central and state governments towards ensuring equality and quality education opportunities. Despite of these efforts, a section of people in this district is still lagging i.e. 31 per cent of the total population are still illiterate due to unequal opportunities. This chapter focuses on the trend of educational infrastructures. The study is based on secondary sources of data from various books, journals, reports, etc. Thus, to comprehend the trend of education infrastructures available in the district the data obtained have been analyzed and discussed. The observation is that unequal distribution of educational infrastructures has a strong implication on the people in this district, which influences the overall growth and development in the sphere of education.

Keywords: Education, Infrastructure, Karbi Anglong, Society.

Introduction

The development of quality educational infrastructure is the need of the hour for development to the downtrodden and weaker section of society in any region. After post-independence period in India, the government at central and state as well as the council have been working

effortlessly for development of education system for the welfare of society. Through various schemes and programmes the central government has been trying to expand the facilities for the people towards achieving compulsory elementary education, reforming the secondary and university education system, enhancing vocational and technical education, encouraging women education, etc. The government has been endeavouring to give a concrete shape to various programmes and policies. The New Education Policy 2020, India has emphasized on universalizing access to quality education, promoting research and innovation, ensuring inclusivity, and fostering a holistic development in the sphere of education. The effort taken by the government under various mission and programmes at different levels, the education sector is in a state of completely different in some interior and remote areas in the country. In the context of Karbi Anglong, which is having a diverse geographical setting inhabiting larger tribal population is comparatively different from that of the plain districts of Assam. Thus, looking at the present scenario, education system in the district is not satisfactory with respect to modern competitive world due to certain socio-political factors. The education system with modern physical as well as social infrastructure is the urgent need in the entire district.

Social development occupies very important place in the overall process of growth and development of a society. For this educational institution is a platform where knowledge, skills, techniques can be imparted and shape the youngsters. After attaining abilities, a person can bring improvement and can maintain congenial social relationship. This will enhance to mould good behaviour and always seek adjustment and tries to maintain social harmony in the area. Education system needs to be quality with quantity and accessibility beyond geographical and social background so as to make India a successful democratic country in the world. This present research has tried to highlight the trend of educational infrastructures in Karbi Anglong district of Assam. The base year is taken from 2001 and observations are indicated till 2022 in lieu of trends on availability of educational infrastructures in the district.

Literature Review

India has tremendously enhanced the education sector. However, it lags in quality despite of given inadequate autonomy to our varsities. Banu & Rawal (2015) in their study found that literacy rate is higher in southern portion of West Bengal adjacent to Kolkata while higher for educational facilities higher educational status. The basic infrastructural facility for primary education in Sivasagar District has not developed as per the objectives laid down in the RTE Act. Also, a study conducted by Saikia & Gogoi (2022) highlighted the status of educational infrastructure in the rural areas of Jorhat District and relate infrastructure status to the level of educational attainment (enrolment & literacy) and concluded that the overall educational infrastructure is quite good in the district. Another study conducted by Devi (2022) found that Science Education in Sonitpur District of Assam needs to improve to facilitate the development of human resources as well as material aspects. She further stated that infrastructure and laboratory facilities need to be improved immediately as science cannot be taught as a theoretical subject. Moreover, the prevailing education system, especially run by the state government of Assam could not impart adequate knowledge to its students to compete with the present complex socio-economic sphere (Kro, 2015). Furthermore, the study conducted by

Das (2016) highlighted that there are certain problems and issues connected with secondary education in Karbi Anglong district that are to be solved for further development.

Significance

Quality education with sophisticated modern infrastructures at all levels is the urgent need of the hour where the seed of ideas, knowledge and wisdom sprout and enlighten towards progression without any social discrimination. The development of educational infrastructures contributes to production of quality education and has a great impact on modernization of the society, economic security and ultimately on overall development. The significance of present study relies in this context, wherein having quality education infrastructures would greatly impact the education scenario in the district. Moreover, identifying the temporal availability of educational institutions would bridge the gap and insight for proper planning and implementation of schemes and programmes in the district.

Objectives

- To conceptually understand the trend and status of educational infrastructures
- To suggest the workable measures for quality educational infrastructures for all round development

Methodology

The entire study is based on secondary data included inputs from books, journals, reports from government, and online information respectively to understand the real trend and present status of educational infrastructures to provide the workable measures for all round development. The study adopted descriptive research design, wherein the observations are interpreted and discussed accordingly.

Study Area

The undivided Karbi Anglong is the largest amongst the administrative districts of Assam (Fig.1). It lies between 25°33' to 26°36' North latitudes and 92°7' to 93°54' East longitudes and comprises an area of 10,434 square kilometres. At present the district has 956313 populations with the density of 93 persons per km² in 2011. It is bounded by Golaghat district on the east, to the west lies Meghalaya state and Morigaon districts. To the north is bounded by Nagaon and Golaghat districts and to the south is bounded by North Dima Hasao district, Meghalaya, and Nagaland state. The region at different times was ruled by different dynasties such as the Varmans, Palas, Kacharis (Dimasas), Ahoms and then the British. Apart from this, parts of it were also ruled by the Karbis and Jaintias (Phangcho, 2001). The district came into being on June 23, 1952, which was provided with some legislative, executive, financial and judicial powers in accordance with provisions laid down in the Sixth Schedule of Constitution of India. It is politically an autonomous unit consisting of three sub-divisions Diphu, Hamren and Bokajan respectively.

The district constitutes a homogeneous region in terms of physical and cultural setting. The physical isolation and lack of developmental activities have kept the district in a relatively backward stage. At present the district is divided into East and West for administrative convenient. The Autonomous Council is run by the elected members called Member of Autonomous Council (MAC). It has thirty members including four nominated members, having twelve Executive Members, a Chief Executive Member, a Chairman and Deputy Chairman. The Government of Assam has entrusted thirty departments at the disposal of Karbi Anglong Autonomous Council for all round development. The entire district is largely inhabited by Karbi Tribes. Also, the other major tribes include Dimasas, Bodos, Kukis, Zeme-Nagas, Hmars, Tiwas, Kacharis, Garos and Jaintias. People belonging to general category are inhabited in the plains and the urban areas due to their association with trade and commerce activities. They are comparatively more developed than original inhabitant tribal peoples in the district.

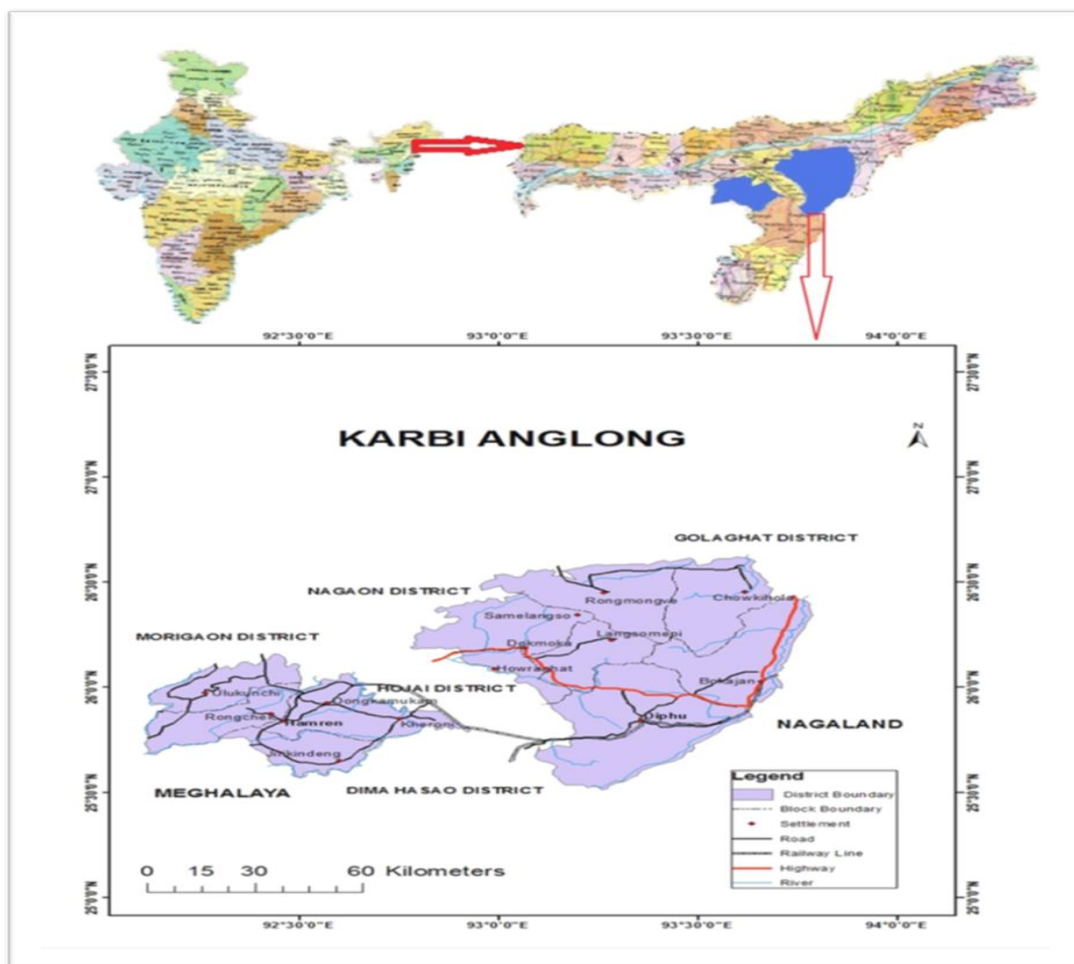


Fig 1: Map of Karbi Anglong

Source: Prepared By Researchers Using GIS technique

Observations & Discussion

The following observations are highlighted in accordance with the trends and status of educational infrastructures from 2001 till 2022:

Educational Institutions in the District

As per UDISE.Plus2019-20 data, the district has total 1748 numbers of Government Provincialized Lower Primary Schools,241 numbers of Upper Primary Schools, 123 numbers of Government Provincialized High Schools including newly provincialized, and 14 numbers of Government provincialized Higher Secondary Schools or Senior Secondary Schools in the district. At higher institutional level include a Diphu Campus under Assam University, a Medical College & Hospital, Diphu Government College, B.Ed College, Law College, District Institute for Education & Training, Basic Training Centre (BTC) all are located at the heart of Diphu town in Lumbajong Block in the eastern part of Karbi Anglong. Eastern Karbi Anglong College at Sarihajan, Thongnokbe College at Dokmoka, Rukasen College at Bakulia and Rangšina College at Donkamukam are the government provincialized colleges in the district. A Model Degree College located at Deithor is recently established in the district. In addition to this, altogether 34 numbers of colleges under government aided/venture are functioning in the district. Elementary and secondary schools are sizeable in numbers while higher institutions are lesser in numbers and mostly confined to urban centres in the district.

Trend of Educational Institutions

Very few educational institutions were found prior to before Independence India in the district. After creation of the district less than 200 primary schools were functioned at different location. In the year 2001 number of primary schools reached to 660 and has geometrically increased to 1722 in 2022. Educational institutions were mostly established after Independence. At present elementary education institutions found in larger numbers in comparison to secondary and higher institutions. Table 1 shows the trend of educational institutions from elementary to junior college levels in the district from 2001 to 2022. It includes trend of educational institutions from primary schools to junior colleges. Educational institutions from 2001 to 2022 have increased at all levels. It has 660 primary schools in 2001 and increased to1722 in 2022. There are only 205 middle schools in 2001, which has increased to 469 in 2022. Also, registering 162 high schools in 2001 and slightly decreased to 144 in 2022 whereas numbers of higher secondary schools were fluctuating from 12 in 2001 to reaching 31 in 2016 and come down to 12 in 2022.

Table 1: Trend of Educational Institutions in Karbi Anglong, Assam (2001-2022)

Year	No. of Institutions				
	Primary	Middle	High School	Higher Secondary	Junior College
2001	660	205	162	12	0
2002	660	205	163	12	0
2003	1398	273	165	12	0
2004	1398	273	165	12	0
2005	1398	273	177	12	2
2006	1416	372	197	12	2
2007	1408	396	197	12	2
2008	1408	396	197	12	2
2009	1402	324	198	11	2
2010	1402	324	198	11	2
2011	1772	413	225	11	2
2012	1776	412	229	21	2
2013	1777	432	291	20	12
2014	1787	434	291	20	12
2015	1793	438	291	20	12
2016	1802	443	292	31	14
2017	1802	445	126	13	14
2018	1802	449	114	12	NA
2019	1753	450	126	12	5
2020	1752	457	114	12	5
2021	1715	464	114	12	1
2022	1722	469	144	12	1

Source: Statistical Handbook of Assam (2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 & 2022)

Infrastructure Statistics of Assam, 2014-15

There witnessed a gradual increase in the number of Junior College from 2 in 2005 substantial increased to 12 in 2013 and continued to 14 in 2016. This increase has been due to establishment of new schools during these periods. Interestingly, the number of institutions in higher secondary and junior college levels remained limited throughout the years, with minor fluctuations. This might suggest that access to higher education and junior college remained less prominent or underwent slower growth compared to primary and middle school during these periods in the district. It is an insightful data that there is unequal distribution of educational institutions from elementary to secondary levels due various factors like disperse settlement with less households, physical constraints, and other socio-cultural issues. The educational institutions in the district of Karbi Anglong are found to be very low that proper planning for the development of educational institution is the need of the hour (Mochahari et. al. 2021). The data reflects periods of stability, growth, and occasional decline across different levels of education. These trends were influenced by factors such as government policies, demographic changes, and educational reforms. Fluctuating numbers of secondary levels

depend on students’ enrolment and choices or institutional preferences by parents as well the student’s concern.

Enrolment

Table 2 shows the enrolment numbers of students at different educational levels from 2009 to 2022 in the district covering from Lower Primary to Senior Secondary or Junior college levels. The data includes primary, middle, high school, higher secondary, and junior college levels. Between 2009-10 and 2015-16, the enrolment numbers displayed fluctuations across various levels.

Table 2: Enrolment of Students in Government / Provincialized Educational Institution in Karbi Anglong, Assam (2009-2022)

Year	No. of Students Enrolled				
	Primary	Middle	High School	Higher Secondary	Junior College
2009-10	83841	48325	33285	9245	541
2010-11	98888	62802	20481	9250	541
2011-12	136876	58758	25944	4569	474
2012-13	109461	48001	31892	5349	7442
2013-14	106250	47598	31892	5349	7442
2014-15	106326	48986	31892	5349	7442
2015-16	87699	44622	34482	6109	6847
2016-17	87499	45470	18363	2728	2739
2017-18	77571	19833	16569	5123	NA
2018-19	78687	43093	17254	2630	2503
2019-20	76661	42613	14899	4864	2026
2020-21	78707	43971	NA	NA	NA
2021-22	78557	47423	NA	NA	NA

Source: *Statistical Handbook of Assam (2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 & 2022)*; NA: Data Not Available

Primary school enrolment experienced an initial increase with 83841 in 2009 to 106326 in 2015, followed by a decline to 78557 in 2022. It has found a negative increased (-0.48) during these periods. This could be attributed to demographic shifts or educational policies impacting enrolment trends. While middle school enrolment remained relatively stable accounting 48325 in 2009 to 47423 in 2022. It has witnessed a negative increased rate of (-0.14) during these periods. High school enrolment exhibited a mixed trend, with fluctuations over the years registering 33285 in 2009 to a decline of 14899 in 2019-20. A negative increased rate of (-11.21) is witnessed during these periods. Also, the higher secondary and junior college levels saw variations in enrolment, possibly due to changing preferences for higher education options. In 2009 total 9245 students have been enrolled, which declined to 4864 in 2019-2020. It has found a negative increased rate of (-8.18) during these periods. At Junior College, the enrolment has been recorded at 541 in 2009, which has substantially increased to 7442 in 2015 and came down to 2026 in 2019-2020. It has recorded an increased rate of 6.66 during these

periods. Enrolment at the higher has been declined, which indicate changes in student aspirations or available opportunities. In conclusion during these decades the enrolment numbers displayed fluctuations across various levels. The enrolments have been fluctuating witness decreased rate at all levels except at Junior College level. The socio-economic background also largely impacts on higher studies particularly poor parents whose annual income are minimal were unable for financial supports for their children and compelled to drop at secondary level.

Availability of Teachers

Table 3 shows the number of teachers in various educational levels from 2009 to 2022 in the district. It includes from elementary to Junior College. At Primary level there were 2961 teachers in 2009, which has decreased to 2842 in 2011-12 and consistently increased to 3894 in 2021-22 increased at the rate of 1.84 during these periods.

Table 3: Status of Teachers in Government / Provincialized Educational Institutions in Karbi Anglong, Assam (2009-2022)

Year	No. of Teachers				
	Primary	Middle	High School	Higher Secondary	Junior College
2009-10	2961	1736	1392	298	34
2010-11	2992	2839	1505	308	34
2011-12	2842	1782	1914	172	27
2012-13	3679	2193	2008	367	231
2013-14	3791	2945	2008	367	231
2014-15	3776	2915	2008	367	231
2015-16	3719	2922	2517	159	268
2016-17	3571	2867	763	84	110
2017-18	3602	2704	1140	238	NA
2018-19	3495	3482	1061	257	140
2019-20	3406	3489	1466	316	175
2020-21	3298	3515	1436	307	11
2021-22	3894	3514	1480	293	10

Source: Statistical Handbook of Assam (2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 & 2022); NA: Data Not Available

The trend of middle school teachers has been increased from 1736 in 2009-10 to 3514 in 2021-22. It has witnessed and increate rate of 3.89 during these periods. There were fluctuating numbers of high school teachers recorded at 1392 in 2009 to only 763 in 2017 which has steadily increased to1480 in 2021-22. It has recorded 0.45 increased rates during these periods. Similarly, at higher secondary level availability of teachers have been fluctuated from 298 in 2009 to a decline of 84 in 2016-17 and again steadily increased to 293 in 2021-22. At this level teachers found negative increased rate of -0.13, which is a matter of concerned for accessing quality education. Availability of teachers at Junior College exhibits more fluctuating trend accounted 34 teachers in 2009 to an increase of 268 in 2015-16 and came down to only 10 in

2021-22. It has witnessed a negative increased rate of -18.46 during these periods. In conclusion, numbers of teachers in various educational levels during this period have been fluctuated due to changes in education policies particularly recruitment system of the department.

Drinking Water & Toilets Facilities

Table 4 shows the infrastructure status in various primary and upper primary schools from the years 2009 to 2022 with key factors of availability of drinking water, boys’ toilets, and girls’ toilets. From 2009-10 to 2015-16, the number of primary and upper primary schools remained relatively stable, indicating the consistent educational infrastructure. There is an increase in the number of primary schools and middle schools in the study area from 2015-16 to 2017-18. Interestingly, from 2018-19 to 2021-22 both primary as well as middle schools have relatively decline. Out of the total 1402 primary schools in 2009, total 798 schools have drinking water facility, 607 schools have boy’s toilet, and 621 schools have girl’s toilet. The number of primary schools increased to 1798 in 2017-18 and accordingly increased drinking water to 1289, accounting 1688 boys’ toilet and 1768 girls’ toilet. Also, there is a slight decrease of primary school in 2021-22 to 1718 and the numbers of drinking water facility came down to 1383, boys ‘toilet accounted for 1592 and girls’ toilet are 1649 only.

Table 4: Government and Provincialized LP and UP Schools having Various Facility in Karbi Anglong

Years	Primary School				Upper Primary School			
	No. of Schools	Numbers			No. of Schools	Numbers		
		Drinking Water	Boys Toilet	Girls Toilet		Drinking Water	Boys Toilet	Girls Toilet
2009-10	1402	798	607	621	206	148	117	146
2010-11	1405	819	763	758	205	157	127	168
2011-12	1772	1208	1165	1234	185	145	112	159
2012-13	1773	1216	1122	1745	185	160	100	176
2013-14	1783	1030	1398	1775	269	185	193	152
2014-15	1789	1108	1415	1779	268	207	201	264
2015-16	1798	1160	1789	1791	266	218	265	265
2016-17	1798	1185	1783	1789	266	220	263	264
2017-18	1798	1289	1688	1768	243	204	227	236
2018-19	1749	1444	1617	1707	241	226	222	233
2019-20	1748	1456	1654	1712	241	226	222	236
2020-21	1711	1383	1619	1671	240	215	225	233
2021-22	1718	1383	1592	1649	242	219	221	229

Source: Statistical Handbook of Assam, 2010-2022

Out of 206 middle schools in 2009, about 148 schools have drinking water, 117 schools have boys’ toilet, and 146 schools have girls’ toilet. This figure increased to 207 schools having drinking water, 201 schools have boys’ toilet, and 264 schools have girls’ toilet in 2014-15,

wherein number of middle schools are increased to 268. The number of middle schools came down to 242 in 2021-22 and drinking water facility accounted for 219 schools, 221 schools have boys' toilet, and 229 schools are having girls' toilet facility.

Overall, the data indicates an effort to improve basic amenities in both primary and upper primary schools over the years. Also, a study by Konwar (2019) stated that the progress of Right to Education (RTE) Act in different villages cannot be easy or smooth, unless there is a proper development of infrastructural facility in the primary schools. The focus on enhancing facilities such as drinking water and toilets reflects a commitment to providing a conducive learning environment for students.

Highlights of Findings

Based on the aforesaid discussions, the following observations are highlighted below:

1. The district experienced periods of stability, growth, and occasional decline across different levels of education institution. These trends are influenced by factors such as government policies, demographic changes, and educational reforms.
2. Students enrolment have been witnessing a negative rate at Lower Primary school (-0.48), Middle School (-0.14), High School (-11.21), Higher Secondary School (-8.18) respectively, whereas students' enrolment at Junior College have been found an increased rate of 6.66 from 2009 to 2020. This data indicates that decreasing enrolment at government run schools at elementary and secondary levels in the district, wherein most of the junior colleges are run by private and government aided, which found an increased enrolment rate.
3. The comparison of information have witnessed an increase of schoolteachers, whereas it is 1.84 in Lower Primary School, 3.89 in Middle School, and 0.45 in High School respectively. Also, there is a negative rate of increase in teachers, wherein it is -0.13 at Higher Secondary School and -18.46 at Junior College respectively. This implies that shortage of teachers at Higher Secondary and Junior College would affect the smooth functioning of the institutions.
4. There is a substantial increase of infrastructure facilities like drinking water, toilets for both boys and girls at Lower Primary and Upper Primary level in the district. This is a positive development for maintain health and hygienic educational environment along with boosting to health conditions among the students.

Suggestions

- The district authority particularly education department should come forward and take a strong decision for establishment of quality and need based institutions in the area so that regional imbalance will be removed, and social justice will prevail in.
- Higher Educational institutions should be established in the area to meet the 21st Century education system for young generation.

- There is unequal concentration of different levels of education institutions in the district particularly higher institutions are mainly confined to urban centres only. Therefore, government should establish such higher institutions in every nook and corner in the district to avoid imbalance development in the district.
- All necessary school infrastructures like building, desk and benches, board, toilet, drinking water, electricity, playground and other should be availed not in quantity, but in quality along with proper utilization of all funds for school development.
- The locality must come forward in support for establishment of higher educational institution with sophisticated infrastructure.

Conclusion

The social development plays a vital role to bring in a holistic progress and development of any region. Hence, to achieve this development, educational institutions with modern quality infrastructures acts as a platform to deliver the knowledge, skills, techniques, etc. to shape the younger generation. Also, the education system needs to focus on quality with quantity and accessibility beyond geographical and social background to make India a successful democratic country in the world. The seed of education have been started prior to independence, but larger numbers of institutions particularly elementary levels came into being after the creation of the district in 1952. Although, education is the inherent subjects of Autonomous Council, but still need to work harder to equally access educational opportunities to all section of societies. In comparison to other districts within the state, Karbi Anglong district of Assam is one of the most backward in the sphere social, economy as well as political. Moreover, there is an unequal distribution of educational institutions at different levels in the study area, whereas larger numbers constitute elementary levels. The non-availability of educational institutions at various levels in the areas creates socio-political unrest in the district. In furtherance, the unequal distribution of educational infrastructures has strong implication on the people for overall growth and development in the sphere of education in the district. Hence, proper planning and implementation of all government schemes and programmes is the need of hour for upliftment of education scenarios in the entire district for achieving all-round development.

References

- Banu, N., & Rawal, S. K. (2015). Regional variations of educational facilities in West Bengal. *The Deccan Geographer*. 53(2), 93-108.
- Das, K. (2016). Development of secondary education in sixth scheduled areas of Assam with special reference to Karbi Anglong District. *International Journal of Research and Analytical Reviews*. 3(1), 92-99.

Devi, A. A. (2022). Availability of infrastructure support for science education at secondary school level: A survey-based study in Sonitpur District of Assam, India. *International Journal of Science Academic Research*, 3(7), 4101-4103.

Konwar, P. (2019). Infrastructural facilities for primary education in the Sivasagar District of Assam. *Social Science Journal of Gargaon College*, 7, 45-61.

Kro, M. S. (2017). Present education system and its impact on the economically backward students in Assam. *International Journal of Research-Granthaalayah*, 5(6), 196-201.

Mochahari, B., Yaden, T. S., & Rongphar, M. (2021). Status of educational institutions in Karbi Anglong District, Assam, India. *Journal of Humanities and Social Science*, 26(6), 59-64.

Phangcho, P. C. (2001). *Karbi Anglong and North Cachar Hills – A study on Geography and Culture*, Printwell, Diphu.

Saikia, S., & Gogoi, B. (2022). Educational Infrastructure: A block level comparative assessment of Jorhat District, Assam. *Journal of Rural Development*, 41(4), 477-491.

Statistical Handbook. (2018). *Directorate of Economics and Statistics*, Guwahati, Assam.

Webliography

<https://censusindia.gov.in/nada/index.php/catalog/226>

<https://des.assam.gov.in/documents-detail/statistical-hand-book>

Study on the Behavior of Geopolymer Concrete Filled Steel Tubular Columns: Analytical Approach

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Abstract

Today, most composite construction utilizes steel tubes that have been filled with concrete. The present study intends to understand the behaviours of Geopolymer concrete, wherein it is put into use to fill steel tubes with concrete. Thus, concrete made of Geopolymer is a good alternative for conventional concrete since it emits less carbon dioxide (CO₂). In order to produce the Geopolymer concrete, industrial wastes like fly ash and GGBS are used, which are the effective substitutes for cement. Moreover, for binding alkaline activators are utilized in Geopolymer concrete. In this study, river sand has been used as a substitute for M-sand. Furthermore, the study involves the partial replacement of M-sand. The tests have been conducted to assess the mechanical and physical properties and determine the optimal percentage of steel slag for use in Geopolymer concrete. Moreover, steel tubes are available in a variety of sizes and are used in this research study. The Geopolymer concrete is mixed into the steel tubes with the recommended replacement dosage of 20 percent steel slag. It is to be noted that the compressive and split tensile strengths are higher when comparing steel slag-infused concrete to normal concrete. Analytical studies are conducted to determine the axial behaviour of GPC filled Concrete-Filled Steel Tubes. The results indicated that GPC filled Concrete-Filled Steel Tubes with a D/t ratio of 31.43 and a height of 300 mm outperformed other specimens in terms of axial load carrying capacity and displacement.

Keywords: Steel Slag, Alkaline Activators, GPC, GGBS, Geopolymer Concrete, Concrete-Filled Steel Tubes.

Introduction

Composite members known as Concrete-Filled Steel Tubes (CFSTs) are made up of a steel tube that has been filled with concrete. CFST structural members utilize both concrete and steel. Due to the integration of outer core steel tube and in filled concrete material, these steel hollow sections of circular or rectangular shape filled with plain or reinforced concrete are highly recommended for modern building structures. CFST is more resistant to seismicity and corrosion, which has a better aesthetic appearance, and is more durable. Also, when compared to conventional steel or a reinforced concrete system, concrete-filled steel tubes offer numerous advantages. The contact between steel tube and concrete slows down strength deterioration and delays local buckling of the CFST. The Postal Terminal Building of Liaoning Province, completed in 1996, exemplifies this issue, as does the Hetai Building. Cement manufacturing necessitates a substantial consumption of natural resources. CO₂ emissions are produced during the production of cement. The heating of limestone leads to the immediate emission of carbon dioxide. The creation of an inorganic polymer binder known as Geopolymer. Usually, fly ash is a residual substance derived from thermal power plants, formed through the heterogeneous byproduct of coal combustion in power plant operations. GGBS (Ground Granulated Blast Furnace Slag) is a cement-like material primarily utilized in concrete, originating as a byproduct of blast furnaces employed in iron production. Steel slag, a byproduct of the steelmaking process is generated when molten steel undergoes separation from impurities within steelmaking furnaces. The incorporation of GPC (Ground Granulated Blast Furnace Slag, Fly Ash, and Steel Slag) in CFST (Concrete-Filled Steel Tubes) enhances the steel carrying capacity, ensuring all sections operate at their limit state, minimizing the risk of local buckling even when subjected to high loads, until the initiation of concrete cracking.

Literature Review

A research study has shown that Fly ash is utilized as a cementitious ingredient for the creation of GPC by utilizing a binder of sodium silicate and sodium hydroxide with a 10M molarity, wherein 20 percent of the natural fine aggregates are replaced with granite waste. Moreover, by using 15 percent of waste granite as natural fine particles, geo polymer concrete acid resistance can be increased [1,2]. Another research study showed that Steel furnace slag serves as a partial replacement for natural coarse aggregates. Fly ash and GGBS are used to create 90 percent fly ash and 10 percent GPC. The alkaline activators made up 1:2.5 of the mixture. Steel slag is added to GPC to improve its compressive strength and binding behavior [3,4]. The durability studies have been conducted for fly ash and silica fume-based GPC [5]. GPC filled steel tubular columns also tested under fire conditions [6]. Another study highlights that the axial capacities of CFST columns made with high strength and recycled concretes exceed those made with standard control concrete [7,8]. Cost of CFSTs reduced linearly with the increase in GGBFS content in concrete [9]. The literature review yields several conclusions: Geopolymer employment reduces the dependency on Portland cement, a significant CO₂ emitter. Introducing steel slag into GPC improves compressive strength, durability, and bonding properties. Furthermore, the expense of concrete-filled steel tubes decreases with the augmentation of GGBFS content in concrete, thereby improving fire resistance.

Need & Relevance

The use of GPC improves construction efficiency, reduces pollution, and is less harmful to the environment. The steel tubular tube provided sufficient lateral support to the concrete core and increased the ultimate strength of columns. The GPC filled in CFST will enhance the steel carrying capacity so that all the section will reach its limit state and avoid the possibility of local buckling until cracking induced in concrete at high load levels.

Objectives

- To obtain GPC mix by partially replacing fine aggregate with plastic granules and using fly ash and GGBS as cementitious materials
- To assess the strength and durability properties of GPC
- To examine the behavior of GPC filled steel tubes under axial loading analytically

Materials & Methods

The present research adopted experimental research design; wherein analytical approach is used to perform the experiments to meet the objectives of the study and results are explained accordingly.

Fly Ash

Fly ash shown in Fig 1 is a byproduct of thermal power plants like NLC. It is a fine powder formed during coal combustion. It improves concrete flow and workability, reducing hydration heat and enhancing sulfate resistance. The physical properties of Fly Ash are indicated in Table 1.

Table 1: Physical Characteristics of Fly Ash

Properties	Value	Recommended Value
Specific Gravity	2.2	1.90-2.96
Bulk Density	675 kg/m ³	650 - 700 kg/m ³



Fig 1. Fly Ash

Ground Granulated Blast – Furnace Slag

GGBS (Ground Granulated Blast-furnace Slag) is a low-Carbon-di-oxide cement substitute derived from iron blast furnaces, widely used in concrete. It offers high sustainability and superior resistance to chloride attack, reducing concrete corrosion risk. It is off-white in color, GGBS-concrete sets slightly slower, but offers similar or better consistency. The physical properties of GGBS are given Table 2.

Table 2: Physical Characteristics GGBS

Properties	Value	Recommended Value
Specific Gravity	2.9	2.9
Fineness	350 m ² /Kg	350 m ² /Kg
Bulk Density	1200 kg/m ³	1000 - 1100 kg/m ³ (loose) 1200 - 1300kg/m ³ (vibrated)

Alkaline Activators

Alkaline activators like sodium hydroxide (NaOH) and sodium silicate (Na₂SiO₃) enhance GPC’s binding properties. GPC with higher NaOH concentration shows greater compressive strength. Sodium silicates, also known as liquid glass, are used as activators in the Geopolymerization process. Sodium hydroxide, also known as caustic soda, is an inorganic compound with the formula NaOH, comprising hydroxide anions (OH) and sodium cations (Na+).

Steel Slag

Steelmaking produces steel slag shown in Fig 2 as a by-product, comprising silicates and oxides that solidify after cooling. Also called tap slag, its dark grey and features strong resistance to deformation, high wet and dry strengths, and excellent resistance to impact, abrasion, and skidding. The physical properties of steel slag are given Table 3.

Table 3: Physical Properties of Steel Slag

Property	Value	Recommended Value
Specific Gravity	3.4	3.2-3.6
Absorption	3%	Up to 3%



Fig 2. Steel Slag

Coarse Aggregates

A coarse aggregate of size 10 mm is used. According to (IS: 2386 (1963), Part III) [10], these were carried out. The properties of Coarse aggregate are given Table 4.

Table 4: Properties of Coarse Aggregates

Properties	Value	Recommended values as per IS:383-1970
Specific Gravity	2.80	2.60-2.80
Bulk Density	1545 kg/m3	1525-1575 kg/m3
Water Absorption	0.38%	0.40%

Fine Aggregates

Manufacturing sand of good quality with 4.75 mm maximum size obtained from local source was used as fine aggregate. The tests conducted by (IS: 2386 (1963), Part III) [10] are used to determine the properties. The properties of Fine aggregate are given Table 5.

Table 5: Properties of Fine Aggregates

Properties	Value	Requirements as per IS:2386, Part 3 & 4
Specific Gravity	2.73	2.1-3.2
Grading Zone	Zone – II	Zone-II
Water Absorption	1%	>2%

Super Plasticizer

The properties of super plasticizer used are indicated in Table 6.

Table 6: Properties of Super Plasticizer

Properties	Values
Appearance	Deep Brown Coloured Liquid
Specific Gravity	1.08
Chloride Content	Below 0.02
Solubility	Readily Soluble in Water

Geopolymer Concrete (GPC)

As per the literature review, the mix proportions for geopolymer concrete are predetermined. The composition involves a combination of Fly ash and GGBS in a fixed ratio of 45 percent to 55 percent. Coarse aggregate with a particle size of 10 mm is employed, and high-quality manufacturing sand, sourced locally, is used as the fine aggregate with a maximum size of 4.75 mm. The binding properties of GPC are strengthened through the incorporation of alkaline activators, with Sodium Hydroxide (NaOH) and sodium silicate (Na₂SiO₃) being the commonly preferred options. Additionally, there is a partial replacement of fine aggregate with steel slag, constituting 20 percent of the mixture. The mix proportions are shown in Table 7.

Table 7: GPC Mix Design

Materials	Quantity
Fly ash	240 kg/m ³
GGBS	310 kg/m ³
Fine Aggregates	360 kg/m ³
Coarse Aggregates	431 kg/m ³
Sodium Silicate	113 kg/m ³
Sodium Hydroxide	50 kg/m ³
Water/Binder Ratio	0.2

Sieve analysis and specific gravity tests have been used as preliminary tests on the materials that are used to make GPC. The particle sizes of steel slag, coarse aggregate, and fine aggregate are determined by sieve analysis.

Casting & Curing of GPC

The conventional method used to produce GPC. Fly ash, GGBS, NaOH, M-Sand, and 10 mm aggregates are mixed for approximately three minutes in the laboratory pan mixer. The saturated surface dry condition is used to prepare the aggregates. The amount of sodium silicate added is proportional. When mixing fresh concrete, the super plasticizer is added to water. The casting specimens should dry for 24 hours in the air before setting. After that, specimens subjected to curing. The various samples prepared to find Optimal mix of GPC as shown in Table 8.

Table 8: GPC Sample Specimen Label

Specimen Label	Mix
GPC	Conventional GPC
GPC SS1	GPC with 10% Steel Slag
GPC SS2	GPC with 20% Steel Slag
GPC SS3	GPC with 30% Steel Slag
GPC SS4	GPC with 40% Steel Slag

TEST on Hardened Concrete

The compressive and split tensile strength tests on specimens were conducted to obtain the optimal percentage of steel slag, adhering to the guidelines outlined in (IS516 (2021) (Part1/sec1) [11]. Thus, to evaluate the watertightness of concrete cubes, a test was conducted to measure the extent of water infiltration when the samples are submerged. The measurement of sorptivity, a direct indicator of water penetration, involved determining the rate at which a wetting front moves through concrete under capillary suction.

GPC Filled Steel Tubular Specimens

To examine the performance of concrete-filled columns, nine specimens have been selected, each varying in dimensions and featuring distinct proportions of GPC mixtures. The dimensions of the GPCFST columns were decided by the different D/t ratio as per (EN 1994-1-1 (2004): Eurocode 4) [12] recommendations and height. The specimen details are listed in Table 9.

Table 9: Specimen Label

Specimen Label	D/t Ratio	Length of Steel Tube (mm)
CFST 1	55	300
CFST 2	55	450
CFST 3	55	600
CFST 4	44	300
CFST 5	44	450
CFST 6	44	600
GPCFST 7	31.43	300
GPCFST 8	31.43	450
GPCFST 9	31.43	600

The concrete-filled steel tubes are taken in the required dimensions. The surface grinding equipment is employed to smooth both ends of the steel tube, ensuring a uniform and polished surface. The prepared steel tubes are filled with freshly prepared GPC mix and compacted. After casting the concrete filled steel tubes are allowed to air curing for 7 days and tested in universal testing machine.

Analytical Modelling

The axial behavior of GPC-filled steel tubes is investigated using ABAQUS software. ABAQUS employs Finite Element Modeling, a three-dimensional nonlinear analysis methodology utilizing numerical techniques, to simulate and identify defects in composite structural elements.

Part Module - The first step in finite element analysis is to specify the components. For this research, the focus is on a GPC-filled column that is 300mm tall and has thicknesses that vary between 2mm, 2.5mm, and 3.5mm. The part module is illustrated in Fig 3.

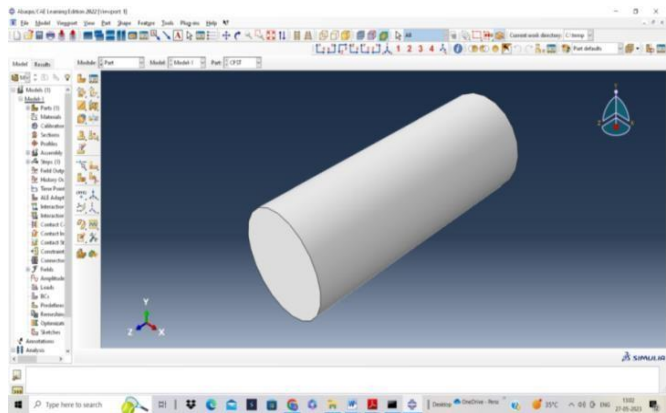


Fig 3: Part Module of CFST

Step Module - In finite element analysis, the step module serves as a simple way to record changes in load and boundary conditions, improvements in the interaction among structural elements, the addition or subtraction of components, and any other procedural changes that might take place throughout the analysis.

Mesh Module - The meshing method used is Abaqus’s simplest, requiring no preset mesh patterns. Parts are individually meshed and then assembled for analysis, using advanced tools to ensure a clean, consistent mesh for structural assessment. The meshed module for the CFST (Concrete-Filled Steel Tube) is depicted in Fig 4 and Fig 5.

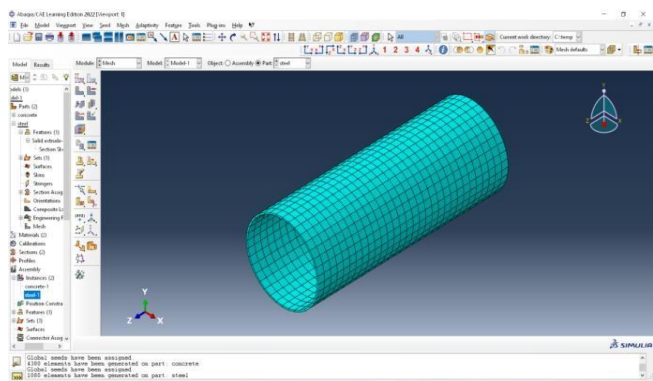


Fig 4: Mesh Module

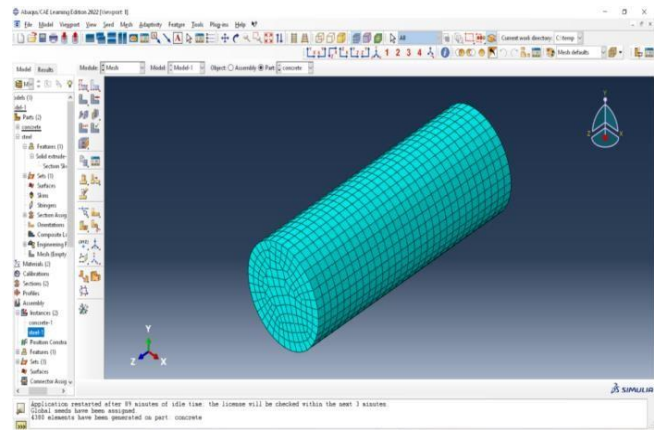


Fig 5: Mesh Module

Interaction Module - In the model, two interaction properties, shell, and concrete-steel are established. The shell interaction is applied between concrete solids or steel tubes and plates, whereas the concrete-steel interaction is used between concrete and steel. Both interactions display tangential and normal behaviors. Fig 6 shows the Interaction module.

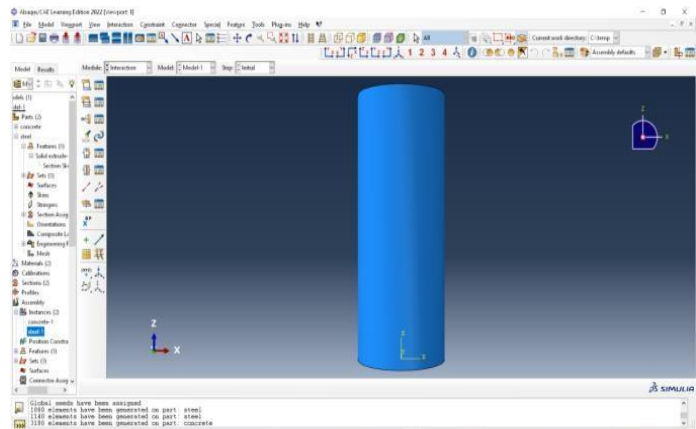


Fig 6: Interaction Module

Load Module - The step series provides an effective way to record changes in loading and boundary conditions, alterations in component interactions, component additions or removals, and any other modifications occurring throughout the analysis. Fig 7 shows the Load module.

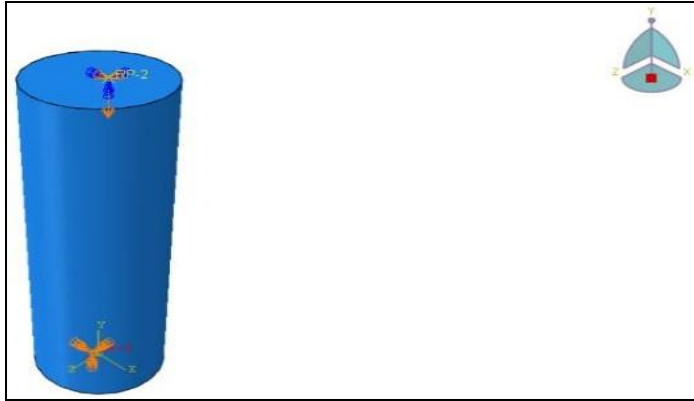


Fig 7: Load Module of CFST

Results & Discussions

Optimal GPC Mix:

This study investigated the mechanical and durability properties of geopolymer concrete (GPC) with partial replacement of fine aggregate by steel slag. The compressive strength tests conducted in this study revealed a significant increase of 21.67 percent when 20 percent of M-Sand has been replaced by steel slag compared to other specimens. Additionally, tensile strength results showed a 22.57 percent rise in GPC-SS2 (20% steel slag replacement) compared to other specimens. These findings support the identification of 20 percent steel slag as the optimum replacement for M-Sand in GPC [13].

Workability & Strength

This study examined the effect of GGBS (Ground Granulated Blast Furnace Slag) on the workability and strength of geopolymer concrete (GPC). The results indicated a slight decrease in workability with the addition of GGBS to fly ash. However, it has been observed that the compressive strength increased with the combined use of GGBS and fly ash at certain proportions (45 percent & 55 percent). This supports the claim [14] that workability may decrease slightly, but strength increases with the combined use of GGBS and fly ash.

Water Absorption & Durability

This study conducted durability studies on geopolymer concrete (GPC) incorporating GGBS and steel slag as partial replacements for cement and sand, respectively. The results revealed that GPC with steel slag exhibited lower water absorption (47.76 percent) compared to conventional concrete (52.2 percent). Additionally, the durability of GPC, as evidenced by water absorption and sorptivity results, surpassed that of conventional concrete. These findings support the claim that GPC with steel slag exhibits improved water absorption and durability compared to conventional concrete [15]. The optimal percentage of GPC (Geopolymer Concrete) has been established. The test results unequivocally indicated that substituting 20 percent steel slag for M-Sand enhances strength. The strength of geopolymer concrete has been

assessed through tests measuring hardened concrete properties and durability. The graphical representations of compressive and tensile strength are shown in Fig 8 and Fig 9. The durability test results are shown in Fig 10 and Fig 11.

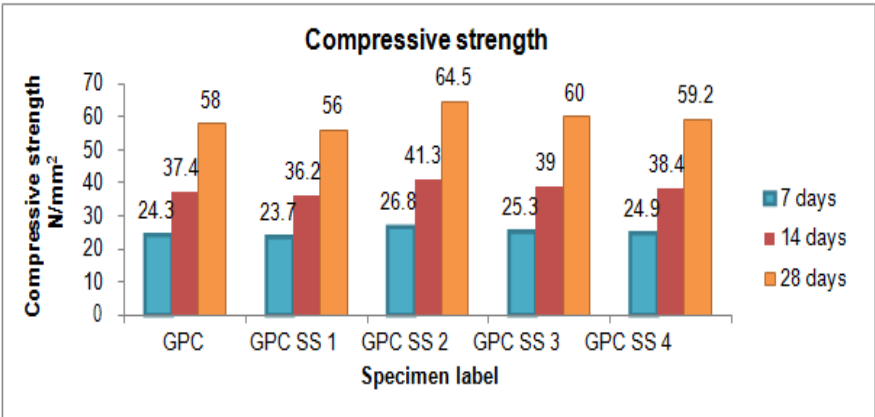


Fig 8: Compressive Strength

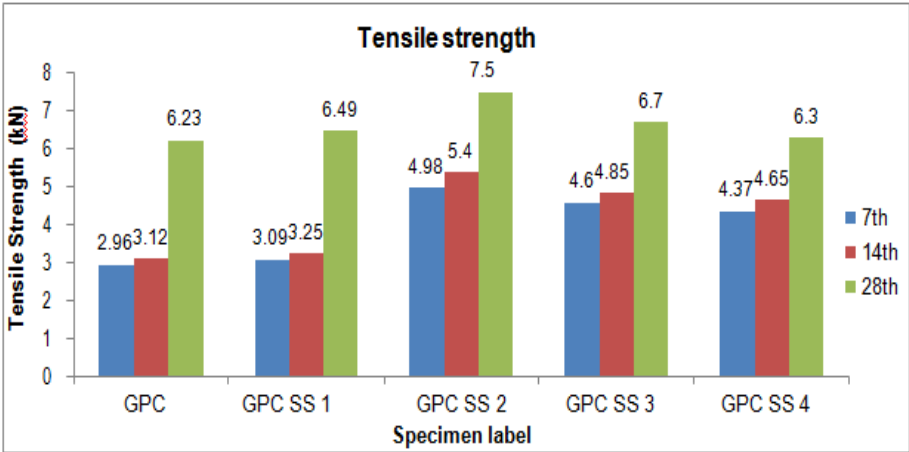


Fig 9: Tensile Strength

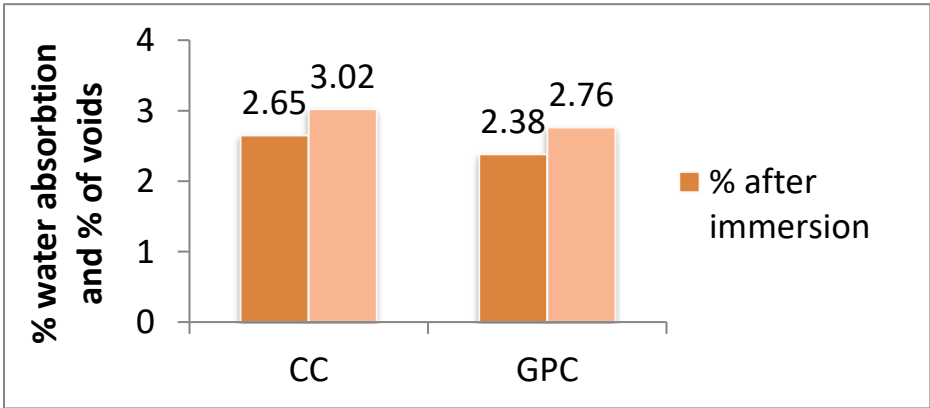


Fig 10: Water Absorption

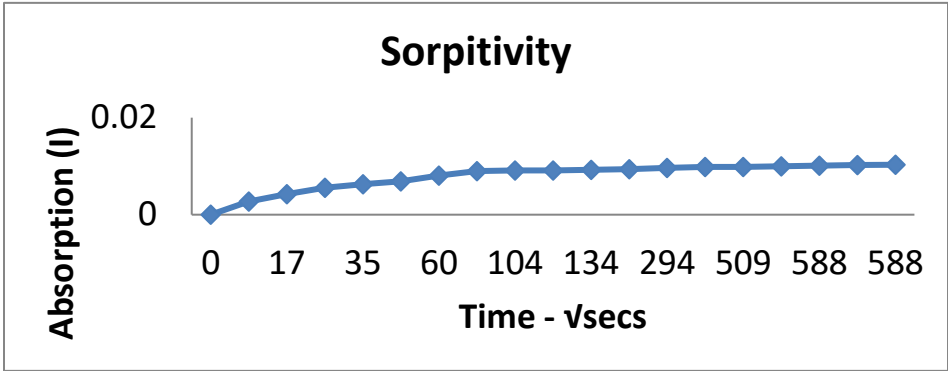


Fig 11: Sorpitivity

Load-Displacement Behaviour of CFST

The loading process to failure in CFST (Concrete-Filled Steel Tube) exhibits three distinct stages: elastic stage, plastic stage, and failure stage. Throughout the specimen, failure modes such as local buckling and elephant buckling are observed. The load applied to CFST induces axial deformation during this process. The axial deformation on CFST columns is discussed based on the Effect of D/t ratio and Effect of height.

Effect of D/t ratio

The axial deformation and load-bearing capacity of CFST Columns are significantly impacted by the depth-to-thickness ratio. As axial load deformations increase, the D/t ratio decreases. The capacity of column to bear more weight increases in proportion to CFST thickness in line with the research findings available in literature [16]. The figures 12, 13, and 14 illustrate the axial deformation behaviour of CFST with D/t ratios of 55, 44, and 31.43 respectively under axial loading. It can be concluded that depth-to-thickness ratio significantly impacts the axial deformation and load-bearing capacity of CFST columns [17, 18]. As axial load deformations increase, the D/t ratio tends to decrease, while thicker CFST columns typically have higher load-bearing capacities. These findings provide empirical evidence supporting the statements regarding the behavior of CFST columns in relation to specified parameters.

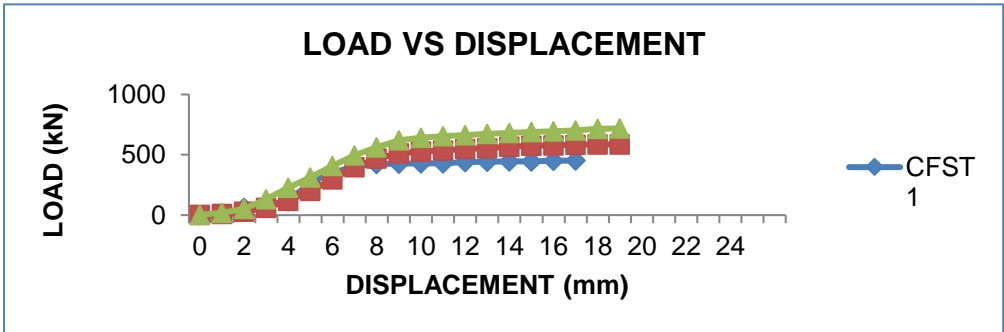


Fig 12: Load vs Displacement for Varying D/t Ratio with Constant Height of 300mm

According to the graph above, it is concluded that CFST 7 with a D/t ratio of 31.43 has been performed effectively in terms of the load-carrying capability of 40.84 percent higher than the other specimens.

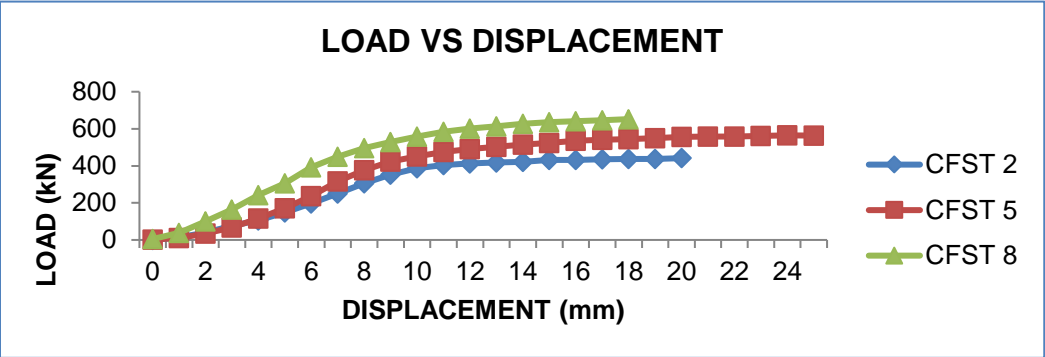


Fig 13: Load vs Displacement for Varying D/t Ratio with Constant Height of 450mm

According to the graph above, it is concluded that CFST 8 with a D/t ratio of 31.43 has been performed effectively in terms of the load-carrying capability of 39.32 percent compared with other specimens.

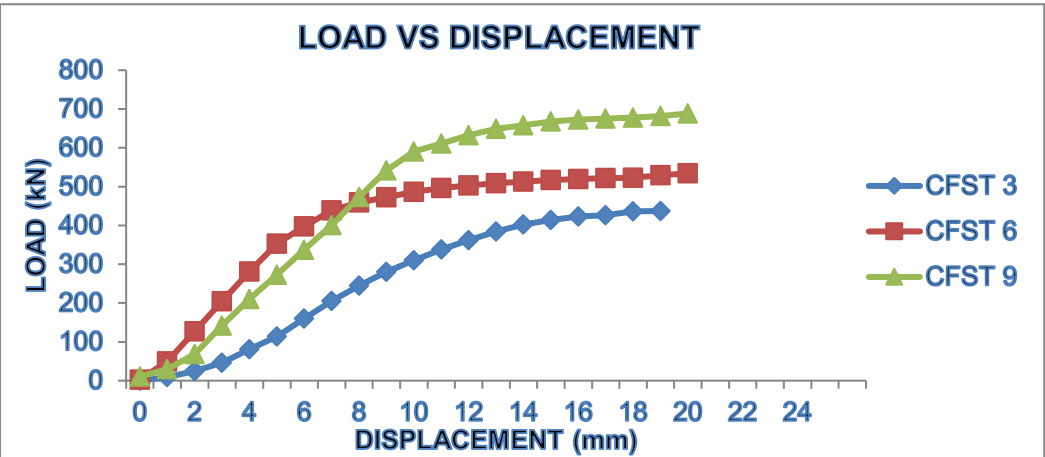


Fig 14: Load vs Displacement for Varying D/t Ratio with Constant Height of 600mm

According to the above graph, it is concluded that CFST 9 with a D/t ratio of 31.43 has been performed effectively in terms of the load-carrying capability of 41.47 percent compared with other specimens. Based on the graphs above, it is inferred that the CFST with a higher thickness has a higher load carrying capacity.

Effect of Height

Each specimen of CFST columns has a distinct height. The ability of the column to bear loads increases with a decrease in height [18]. Similarly, the displacement varies with columns that are 600 mm taller experiencing more axial deformations. Hence, to further analyze their

increased load-carrying capacity, columns with a 300 mm height underwent finite element analysis. Figures 15, 16 and 17 shows the comparison and analytical results of CFST columns. Also, it depicts the load-carrying capacity of CFST columns with the same height but varying thickness.

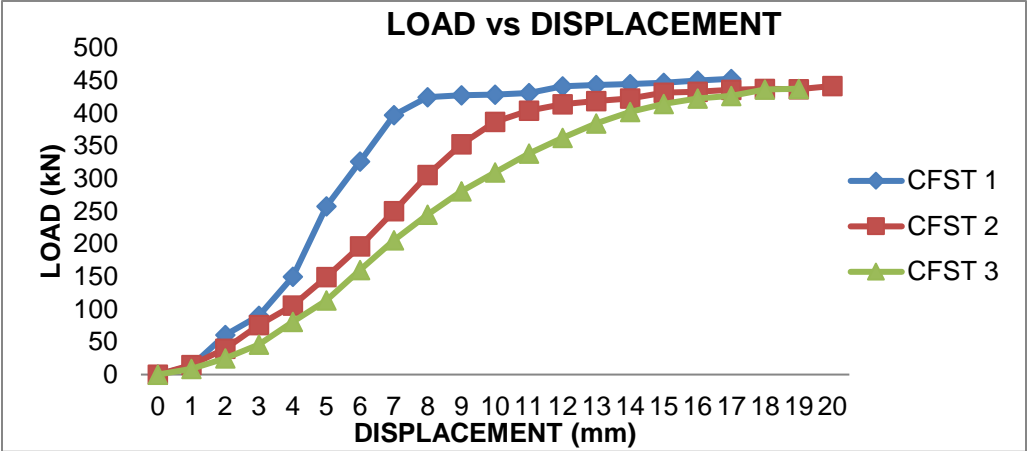


Fig 15: Load vs Displacement for Varying Height with Constant D/t Ratio

According to the graph above, it is concluded that the CFST 1 with a height 300mm has been performed effectively in terms of the load-carrying capability of 34.06 percent compared with other specimens.

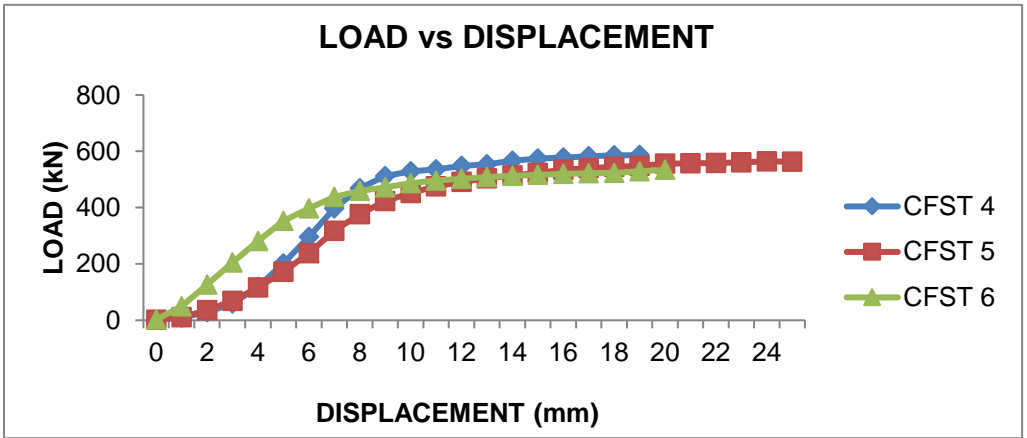


Fig 16: Load vs Displacement for Varying Height with Constant D/t Ratio

It is inferred from the above graph that the CFST 4 with a height 300mm has been performed effectively in terms of the load-carrying capability of 34.81 percent compared with other specimens.

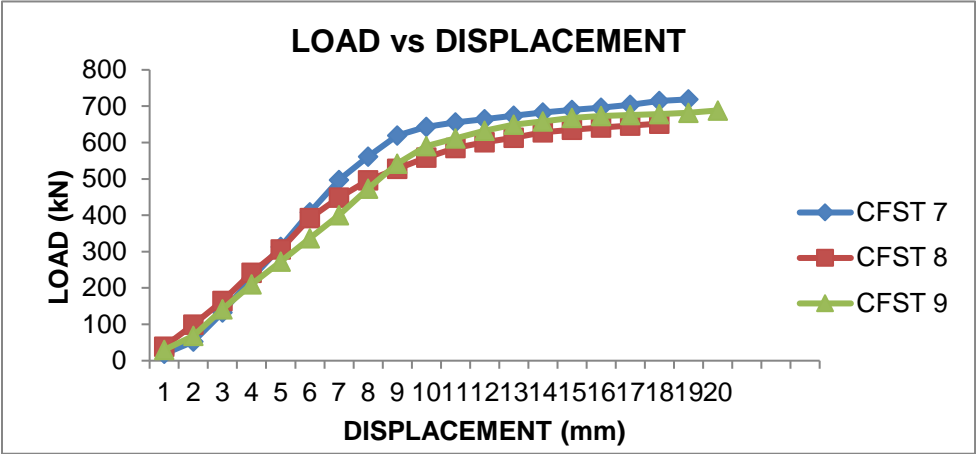


Fig 17: Load vs Displacement for Varying Height with Constant D/t Ratio

Based on the presented graph, the conclusion is drawn that CFST 7 with a height of 300mm has exhibited effective performance in terms of load-carrying capability, surpassing other specimens by 34.90 percent. This observation underscores that load-carrying capacity tends to increase as the column height decreases.

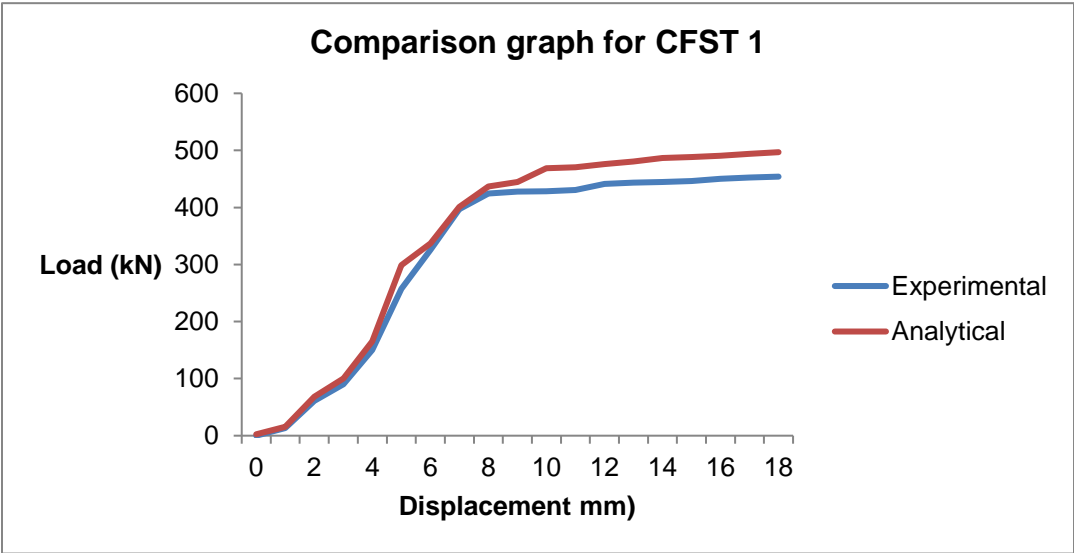


Fig 18: Comparison of Results for CFST 1

The test results represent experimental value of CFST 1 having height of 300mm and thickness 2mm is 4.50 percent, which is lesser than the analytical values as shown in Fig 18.

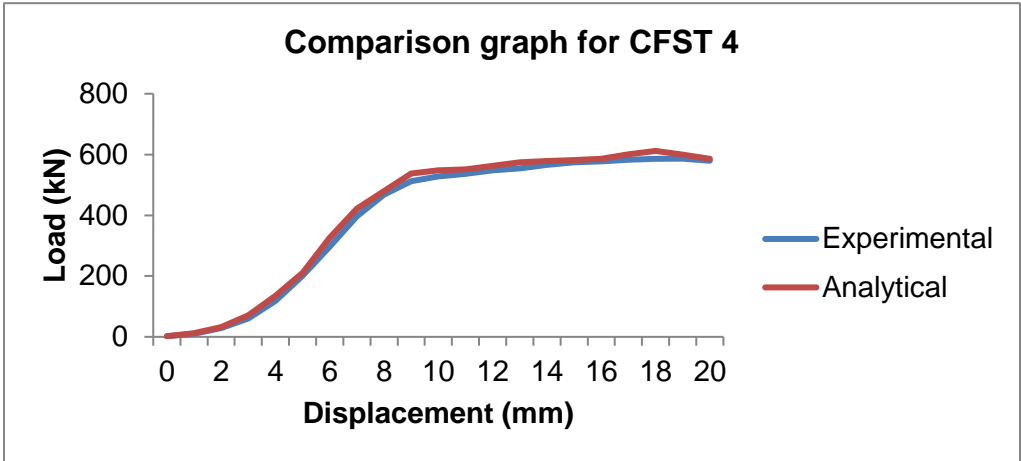


Fig 19: Comparison Results for CFST 4

The test results represent experimental value of CFST 4 having height of 300mm and thickness 2.5 mm is 2.13 percent, which is lesser than the analytical values as shown in Fig 19.

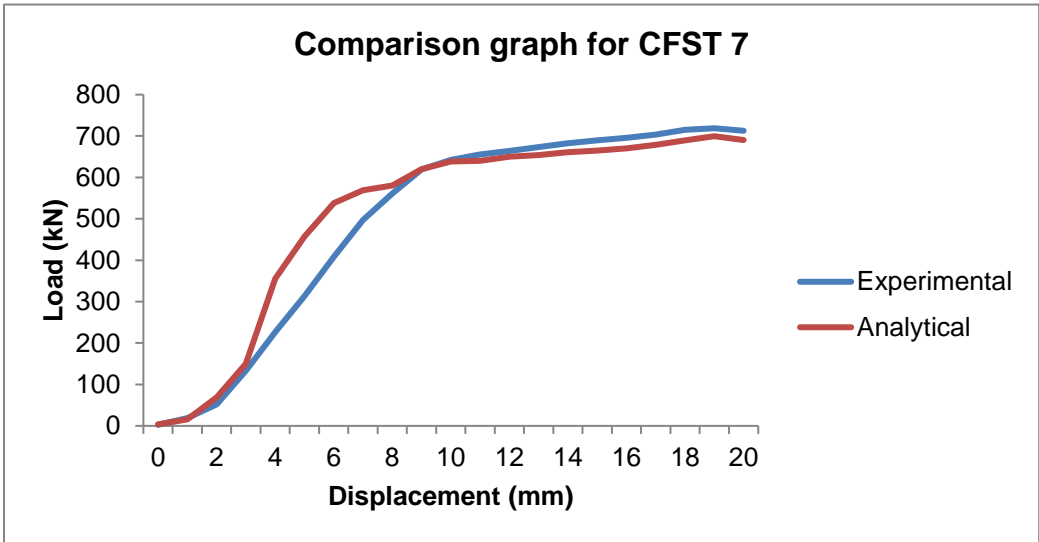


Fig 20: Comparison of Results for CFST 7

The test results represent value of CFST 7 having height of 300mm, and thickness 3.5 mm is 1.35 percent, which is higher than the analytical values as shown in Fig 20.

The outcomes of the analyses are contrasted, wherein the test findings show that CFST 1 value with a 300 mm height and 2 mm thickness is 4.50 percent, which is smaller than the analytical values. According to the test results, the value of CFST 4, which has a 300 mm height and a 2.5 mm thickness, is found to be 2.13 percent less than the analytical values. According to the

test results, the CFST 7 value, which has a 300 mm height and 3.5 mm thickness, is found to be 1.35 percent greater than the analytical values. The comparison graphs are shown in Figures 21, 22 and 23 respectively.

The load deflection behavior and failure modes of the developed model of Geopolymer Concrete filled steel tubular columns exhibited close alignment with the data [16, 17, 18]. The typical failure modes of the column specimen are shown in Fig 24.

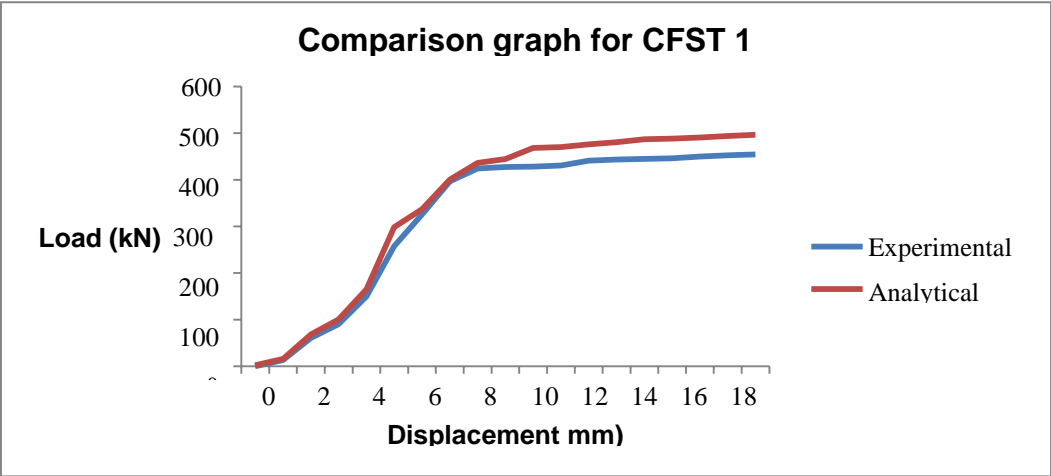


Fig 21: Comparison of Results for CFST 1

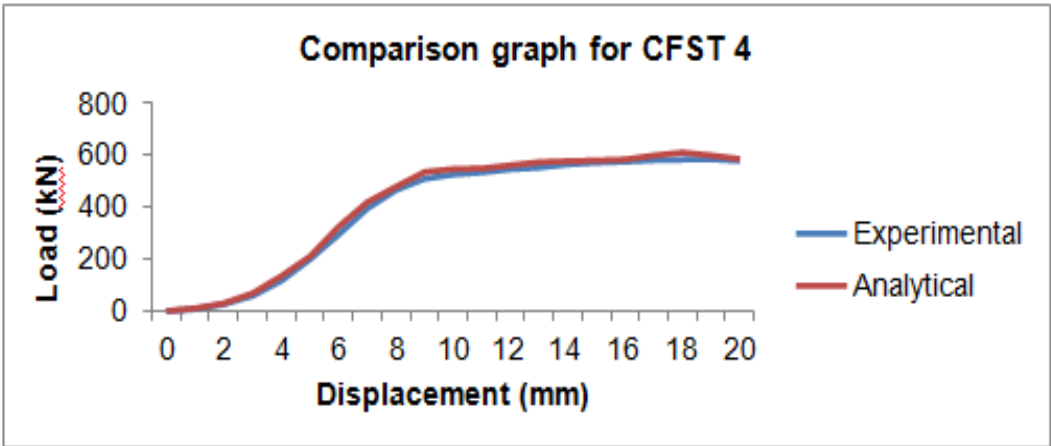


Fig 22: Comparison of Results for CFST 4

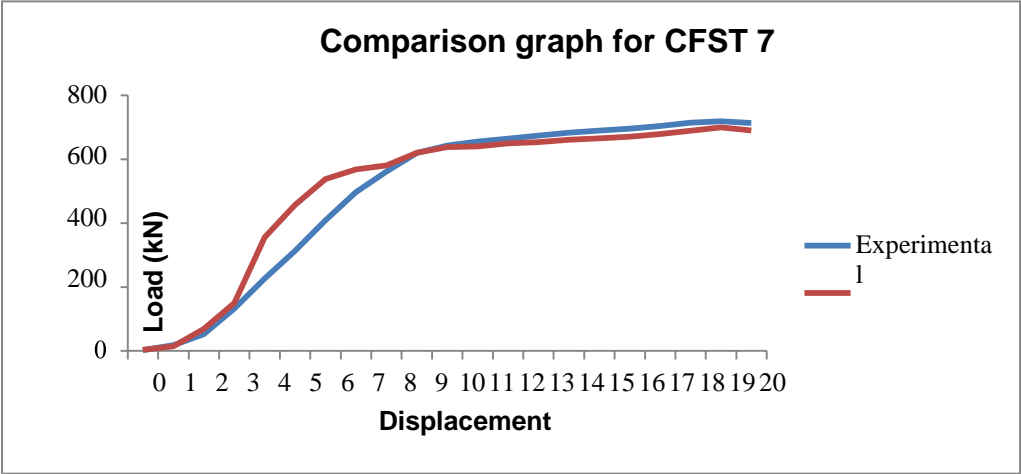


Fig 23: Comparison Results for CFST 7

Failure Modes in CFST

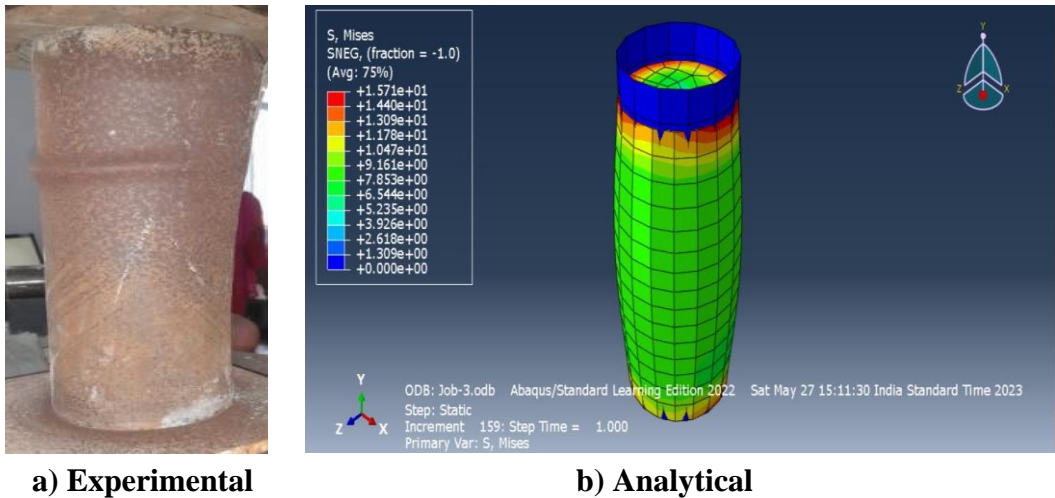


Fig. 24: Failure Modes in CFST

Suggestions

This study provided valuable insights into GPC-filled steel tube properties and its behavior, aiding structural understanding. This study can be explored further to study the effects of different curing conditions, such as temperature and humidity on the properties of GPC mixes to optimize the manufacturing process. Also, a comprehensive study to be conducted on the rheological behavior of GPC mixes with varying proportions of GGBS and fly ash to understand the factors affecting workability in detail. The behavior of GPC-filled steel tube columns under dynamic loading conditions such as seismic or impact loads, to assess their performance in real-world scenarios can be investigated by future researchers.

Conclusion

This study delves into the utilization of GPC-filled steel tubes employing industrial by-products such as fly ash, GGBS, and steel slag. Notably, a significant enhancement in compressive strength, up by 21.67 percent has been observed with a 20 percent steel slag replacement for M-Sand, marking it as an optimal mix. While a slight decrease in workability has been noted with the addition of GGBS to fly ash and there is an increase in strength when both are used in tandem. Moreover, the durability of GPC with steel slag showcased lower water absorption rates and superior performance compared to conventional concrete. The examination of axial behavior of CFST columns highlighted that those with a height of 300mm exhibited greater load-carrying capacities. Additionally, the analytical assessment conducted using ABAQUS software revealed slightly higher results, contributing valuable aspects into the structural performance of GPC-filled steel tubes. Overall, the study provides valuable insights into the mechanical properties, durability, and axial behavior of GPC-filled steel tubes, offering a comprehensive understanding of their structural performance.

References

- [1] Saxena, R., & Gupta, T. (2021). Influence of granite waste on mechanical and durability properties of fly ash-based GPC. *Environment, Development and Sustainability*, 23, 17810-17834.
- [2] Das, S. K., & Mustakim, S. M. (2020). Fresh, strength and microstructure properties of GPC incorporating lime and silica fume as replacement of fly ash. *Journal of Building Engineering*, 32, 101780.
- [3] Khan, M. S. H. & Castel, A. (2016). Performance of fly ash-based GPC with partial replacement of fine aggregate by steel mill slag. *Cement and Concrete Research*, 59(1), 496-500.
- [4] Premkumar, R., & Rajesh, S. (2022). Performance of fly ash-based GPC with partial replacement of fine aggregate by steel mill slag. *Materials Today: Proceedings*, 11(1), 473.
- [5] Prakash, S., & Singh, N. B. (2017). Durability of fly ash-based GPC in the presence of silica fume. *Journal of Cleaner Production*, 149, 1062-1067.
- [6] Katwal, U., & Aziz, T. (2022). Tests of circular GPC-filled steel columns under ambient and fire conditions. *Journal of Constructional Steel Research*, 196, 107393.
- [7] Xiong, M.-X., Xiong, J. Y., & Liew, R. (2021). Axial performance of short concrete-filled steel tubes with high- and ultra-high-strength materials. *Composite Structures*, 136, 494-510.
- [8] Song, T.-Y., Qu, X.-Y., & Pan, Z. (2021). Fire resistance tests on concrete-filled steel tubular columns with geopolymetric recycled aggregate. *Fire Technology*, 58, 2727–2754.

- [9] Ahmad, S., Kumar, A., & Kumar, K. (2021). Axial performance of GGBFS concrete-filled steel tubes. *Structures*, 23, 539-550.
- [10] Bureau of Indian Standards. (1963). IS: 2386 (1963). Part III: Indian Standard Methods of Test for Aggregates for Concrete. New Delhi: Bureau of Indian Standards.
- [11] Bureau of Indian Standards. (2021). IS 516 (2021). Part 1/Sec 1: Testing of Strength of Hardened Concrete. New Delhi: Bureau of Indian Standards.
- [12] European Committee for Standardization. (2004). EN 1994-1-1 (2004): Eurocode 4: Design of Composite Steel and Concrete Structures - Part 1-1: General Rules and Rules for Buildings. Brussels: European Committee for Standardization.
- [13] Anbazhagan, P., Suganya, M., Raghavendran, K., & Rajamanickam, G. V. (2017). Mechanical and durability properties of geopolymer concrete with partial replacement of fine aggregate by steel slag. *Materials Today: Proceedings*, 4(2), 5125-5130.
- [14] Shetty, M., Geetha, P., Rao, S., Rajashekar, M., & Prakash, A. (2017). Investigation on geopolymer concrete using fly ash and GGBS. *International Journal of Innovative Research in Science, Engineering and Technology*, 6(3), 4536-4540.
- [15] Kumar, R., Gunasekar, C. L., & Usha, K. (2016). Durability studies on geopolymer concrete with GGBS and steel slag as partial replacement for cement and sand. *International Journal of Engineering Research & Technology*, 5(2), 288-292.
- [16] Chen, S. H., Yang, H. L., Xu, J. C., Wu, S. G., & Yu, Z. Q. (2018). Experimental study on the behavior of axially loaded concrete-filled steel tubular stub columns with high strength materials. *Journal of Constructional Steel Research*, 144, 103-117.
- [17] Qu, W., Yu, R., & Liu, J. (2015). Behavior of short concrete-filled steel tubular columns with low D/t ratio. *Journal of Constructional Steel Research*, 112, 121-132.
- [18] Li, Y., Hu, F., & Shi, Y. (2016). Behavior of concrete-filled steel tube columns with various cross-sectional shapes. *Thin-Walled Structures*, 101, 179-189.

Tech Couture: Exploring Futurism with AI in Fashion

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Abstract

As technology intertwines with fashion, artificial intelligence (AI) emerges as a game-changer in the fashion industry. AI is swiftly evolving and already finds numerous applications across various sectors, including fashion. It revolutionizes fashion's production, marketing, and consumption, from designing garments to predicting consumer preferences. With its prowess in analyzing extensive data and recognizing patterns, AI introduces fresh opportunities for designers, retailers, and consumers. Moreover, by offering cutting-edge data analysis and instantaneous insights, AI facilitates forecasting trends, optimizing customer interactions, and maximizing revenue opportunities, heralding a transformative shift in the landscape of fashion retail. While case studies underscore AI's transformative impact in fashion, challenges persist, notably concerning data privacy and the need for skilled professionals to utilize AI effectively. Nevertheless, the significance of AI in fashion realm cannot be overstated. It not only enhances efficiency and sustainability but also fosters a more customer-centric approach, envisioning a future where fashion is more inclusive, ethical, and personalized.

Keywords: Artificial Intelligence, Fashion, Customer-Centric, Personalized.

Introduction

Traditionally, fashion relied heavily on designers' creativity, but now a blend of data science is enhancing the industry. Artificial Intelligence (AI) and Machine Learning (ML) analyze diverse data, from social media to runways, predicting trends and enabling brands to craft sought-after designs. This integration of AI has revolutionized all aspects of fashion, enhancing efficiency from production to marketing and sales. Also, by leveraging data analysis and fostering creativity, companies can design trendy, in-demand clothing, staying ahead in the market. Artificial Intelligence algorithms are required to analyze client data and deliver specific recommendations that promote sales and satisfaction. As AI becomes integral, fashion businesses must embrace it to remain competitive and avoid financial setbacks in an AI-driven landscape.

AI is changing how design happens in the fashion world, allowing companies to create unique and innovative products. Designers use AI to make fabrics and clothes while consulting firms leverage AI to forecast trends and provide invaluable insights to the companies they collaborate with. The key lies in generative design algorithms, which harness machine learning to analyze historical data and generate novel designs based on predefined criteria (Priya, 2023). This process is too complex to be done manually, and AI not only fosters creativity but also contributes to time efficiency. As fashion weeks commence in London, Milan, New York, and Paris, brands are preparing to transition the showcased designs from the runway to production and market, capitalizing on the latest trends and consumer preferences. Currently, a trend has emerged in the potential integration of creative directors' expertise with generative AI. In furtherance, this collaboration promises expedited time-to-market, streamlined sales processes, and an enriched consumer experience.

Artificial Intelligence (AI)

Artificial intelligence (AI) is the term used to describe how technology, mostly computer systems, can simulate human cognitive abilities. Artificial intelligence (AI) has various applications, including vision, natural language processing, specialized systems, machine learning, and speech recognition. These applications increase AI's versatility and usefulness across a range of industries. Implementing AI necessitates specialized hardware and software to develop and train machine learning algorithms effectively. Generally, AI systems function by assimilating extensive labelled training data, scrutinizing it for correlations and patterns, and utilizing these insights to forecast future conditions. For example, an image recognition tool can do very well in item identification and description by analyzing large datasets including millions of photos, while a chatbot trained on text examples can learn to have realistic conversations with humans. Furthermore, emerging generative AI techniques exhibit rapid advancements, enabling the creation of lifelike text, images, music, and other forms of media.

AI programming prioritizes the development of cognitive skills, including:

Learning: Acquiring data and crafting algorithms to process it into actionable insights.

Reasoning: Selecting suitable algorithms to achieve desired outcomes.

Self-correction: Continuously refining algorithms for optimal accuracy.

Creativity: Using various AI techniques to generate innovative content like images, text, music, and ideas.

The term AI, originating in the 1950s, describes the emulation of human intelligence by machines, encompassing a dynamic range of abilities that evolve with the advent of new technologies. Within the realm of AI, technologies such as machine learning and deep learning are prominent, contributing to its diverse landscape of capabilities. Machine learning empowers software applications to improve their accuracy in predicting outcomes without the need for explicit programming. Utilizing historical data as input, machine learning algorithms forecast new output values, with their effectiveness significantly enhanced by the availability of extensive datasets for training purposes. One branch of machine learning called deep learning takes its cues from the way the human brain is structured. Its use of artificial neural network design lays the groundwork for more current developments in AI, such as ChatGPT and self-driving cars (Laskowski & Tucci, 2023).

Literature Review

A study conducted by Nangia (2024) indicated that globally ‘AI in fashion market’ growth is noteworthy. According to a Mordor Intelligence analysis, it had a value of USD 270.4 million in 2020, and estimates show that by 2026, it will have significantly increased to USD 1,260.9 million. The projected trajectory for the years 2021–2026 shows a noteworthy annual compound growth rate (CAGR). Moreover, a case study conducted by Sajja et al. (2020) mentioned creating and deploying a comprehensible artificial intelligence (AI) platform for novel product forecasts in the fashion industry. The way system handles the integration of data, cleanliness, and export possibilities increases stakeholder adoption.

With an emphasis on pre-season preparation and interventions, this chapter aims to optimize manufacturing, design, and procurement for sustainable fashion. Subsequent investigations will focus on stock allocation, counterfactual reasoning, and development of hyper-local assortments. AI chatbots still have several limitations in the modern world. Furthermore, their best performance is hampered by issues such as a deficiency of personalization, poor contextual awareness, insufficient problem-solving skills, worries about data protection, difficulties integrating with past systems, and an excessive dependence on predetermined answers. Businesses need to concentrate on improving chatbots’ capacity to manage intricate requests, offer tailored solutions, and protect customer information. AI chatbots can help organizations and customers by providing more effective and user-centric solutions to tackling these issues.

Significance

AI is transforming the fashion industry by enhancing efficiency, promoting sustainability, and personalizing consumer experiences. Moreover, by leveraging AI, fashion businesses can optimize their production processes and reduce wastage, thereby promoting sustainability. AI can foresee future fashion trends, recognize styles that are trending, and predict customer preferences by evaluating large volumes of data. This enables fashion firms to create highly customized and in-demand products that can boost client happiness and increase revenue. It automates tasks, optimizes inventory management, and enables better control of delivery timelines.

AI sparks creativity by mining insights, simplifying design workflows, and elevating personalization. However, concerns over job loss in traditional roles in design, manufacturing, and retail have also emerged. Adapting to new roles and reskilling will be essential in mitigating the impact of automation on employment in the fashion sector. This could involve training employees in AI and data analysis or providing them with new job opportunities in areas such as customer service, creative direction, and data analysis.

Objectives

- To conceptually analyze the innovations of Artificial Intelligence (AI) in the fashion industry
- To discuss the specific applications of AI in the Indian fashion market, using case studies
- To understand the potential limitations of using AI in the fashion domain

Methodology

The entire investigation relies on secondary data, wherein the inputs are gathered from a variety of sources such as academic journals, books, websites, and other online platforms. Hence, a descriptive research design is adopted to illuminate the observations and case highlights. The relevant observations and potential constraints associated with AI implementation in the fashion industry are discussed in this conceptual study.

Observations & Discussion

Innovations of Artificial Intelligence in the Fashion Domain

With AI's bright future ahead of it, the fashion industry is set for a revolutionary ride. Below are examples of innovative technologies set to shape forthcoming advancements in AI within the fashion domain:

A. AI In Fashion Business Operations

Trend Forecasting & Buying

Artificial intelligence has transformed retail data analytics, particularly in the fashion business, by improving its ability to predict trends and sales. As a result, there is less unsold inventory every season, and fashion buyers can better anticipate customer behavior. Artificial intelligence (AI) is capable of predicting trends with amazing precision by evaluating massive amounts of data across numerous sources, such as social media, fashion blogs, internet businesses, and sales data. Programs like Stylumia employ AI to manage inventory, predict demand, and make decisions for fashion companies. Moreover, AI not only informs buyers about product performance but also provides insights into specific garment components like color, prints, and styles. With real-time data, buying teams can be more proactive, staying ahead of the competition. IBM and FIT work together to create AI solutions for the fashion sector to improve sales tactics, product creation, and consumer experiences. Heuritech uses machine learning to evaluate photos from social media, helping high-end companies like Dior and Louis Vuitton with production scheduling and trend forecasting. Furthermore, Edited and WGSN use AI to collect data from several sources—such as fashion shows and e-commerce sites—to give important insights to international brands (Loboda, 2024).

From Sketch to 3D Models

Fashion designers can easily turn basic sketches and written descriptions into intricate 3D models by integrating AI. Using modern algorithms and computer vision techniques, this approach precisely translates the designer's concept into a digital representation. Moreover, using AI tools like pattern recognition and picture identification, designers can quickly produce intricate 3D models that perfectly capture the spirit and nuances of their original conceptions. This speeds up the design process and improves communication and visualization in the fashion business, which facilitates more effective teamwork and decision-making.

Design & Product Development

Designers can use artificial intelligence (AI) to produce new product ideas by forecasting fashion trends in hues, materials, patterns, and styles and by examining past and projected performance metrics. This makes it possible for designers to provide trend-leading designs with sewing patterns for production in a timely and correct manner. After that, the designers can make any necessary changes to the designs before approving the finished product. Artificial intelligence may additionally be employed to drastically simplify a large amount of the production procedure like creating digital samples and performing fit testing. Furthermore, it can precisely automate defect detection, color matching, pattern inspections, and fabric quality control. This significantly reduces the amount of time needed to create and test things before they are manufactured. Even if artificial intelligence is now widely used in the fashion industry, technological advancements are always being made. For example, a greater focus on sustainability would make it possible to employ AI to find environmentally friendly replacement materials (Renaningtyas et al. 2023).

Styling & Visual Merchandising

For visual merchandisers and internet stylists in the fashion sector, artificial intelligence has many advantages. Artificial intelligence (AI) can improve online shoppers' shopping experiences and satisfaction levels by offering tailored recommendations and styling advice based on analysis of client data and preferences. Retailers may generate individualized recommendations more rapidly by using AI styling tools that help with maintaining and creating customer style profiles. Sales and revenue can rise when such suggestions are easily included in the process of purchasing. Additionally, Generative Adversarial Networks (GANs) are transforming the fashion industry by generating lifelike images and unique designs based on customer preferences. For example, H & M group utilizes GANs to create designs for its conscious exclusive collection, promoting sustainability and customer loyalty by aligning with popular patterns and preferences. For instance, Adidas is harnessing reinforcement learning algorithms to improve production efficiency and minimize waste by analyzing data on demand trends, production timelines, and material availability (Priya, 2023).

Merchandising & Analysis

Artificial intelligence offers significant advantages in the fashion industry by swiftly analyzing complex data and providing detailed insights. This is particularly beneficial for merchandisers managing inventory, pricing, and conducting competitor analysis. Thus, by reducing shortages and overstocking and optimizing product placement based on geography and seasonality, artificial intelligence (AI) improves stock control and management. In furtherance, by taking a proactive stance, businesses can minimize waste and excess inventory by keeping ahead of supply and demand trends. AI also gives retail stores the ability to track competitors' prices, which helps them develop competitive and ROI-maximizing pricing strategies. Retailers can deliberately modify prices to maximize earnings while maintaining margins by identifying the best pricing windows.

B. AI in Fashion E-Commerce

Product Recommendations

AI offers numerous benefits within fashion e-commerce, particularly in product recommendations. It can suggest alternatives for out-of-stock items and provide fit recommendations based on customers' shopping habits. "Complete the look" recommendations are another AI-driven strategy to boost the average order value. Thus, by recognizing items in styled images, AI includes them in the complete look section, inspiring customers to purchase additional items. Furthermore, online stores are increasingly using customized sizing recommendations. After completing a fit assistant survey, customers can receive precise sizing recommendations from AI based on their height, weight, body type, and previous garment data and retailers save money as a result of fewer returns. (Loboda, 2024)

Product Search & Discovery

AI-driven product search and discovery have become seamlessly integrated into everyday online shopping experiences. Whether through Google Lens or Pinterest, customers can effortlessly find items they are interested in based on images they encounter, a functionality widely utilized by retailers. In the fashion industry, images play a crucial role in showcasing brands and products. AI technology interprets these images, enabling retailers to offer personalized product suggestions to customers based on their interactions. This enhances the shopping experience by inspiring customers with complementary products that match their preferences. Furthermore, AI facilitates personalized product rankings, ensuring that each customer sees the most relevant products first. By analyzing customer preferences and behavior, AI optimizes product recommendations, as seen in ASOS's 'new in' section, where products are ranked based on personalized recommendations rather than their release date (FRA News, 2023).

Customer Service

AI chatbots have revolutionized customer service in the fashion industry by providing round-the-clock, personalized assistance to customers across various platforms like Facebook, Instagram, and WhatsApp. These chatbots keep customers updated on the latest offers, products, and content, making online shopping more convenient. Chatbots, tailored to identity and tone of the company, guarantee continuous customer service, and increase brand awareness. They manage returns and exchanges, reply to questions, make customized product recommendations, and offer styling guidance—all of which are integrated with CRM systems. Furthermore, chatbots intelligently interpret conversation flow and determine when to escalate to human assistants, reducing the workload for customer service teams while maintaining a human touch when needed. H & M Group, Tommy Hilfiger (with IBM and FIT), and Stitch Fix showcase AI's diverse applications in the fashion industry. The H & M group utilizes an AI-driven Chatbot for customer queries and styling recommendations. Tommy Hilfiger leverages AI to analyze fashion data for crafting new collections and targeted marketing. The Stitch Fix employs AI to personalize marketing and outfit suggestions based on customer preferences, driving customer engagement and sales.

C. AI in Fashion Retail

Shop Floor Optimization

In addition to internet platforms, AI improves in-store shopping experiences and streamlines the shop floor. When a customer's preferred product isn't available in their size or color, sales assistants can effectively suggest substitutes by utilizing artificial intelligence (AI) technology, providing exceptional customer service to a larger number of customers. This helps retail employees hit sales goals and decreases lost sales opportunities. Furthermore, AI improves the individualized service provided to consumers and raises the mean value of a basket by enabling sales assistants to offer professional outfit style suggestions for every product available. In

essence, AI empowers retail staff to deliver bespoke customer experiences and maximize sales opportunities in-store.

Omni Channel Shopping

Artificial intelligence revolutionizes retail brands with both digital and physical store presence, ensuring consistent and personalized customer experiences across all touchpoints. For instance, Zara's buy online, pick up in-store service as an example. Brands can provide individualized service to loyal consumers wherever by combining retail data, both digital and physical, into unified customer profiles. With the use of these profiles, sales assistants can quickly determine a customer's preferences, style, and past purchases, enabling them to consistently deliver a customized experience that pleases customers (FRA News, 2023).

Virtual Reality

AI technology, particularly smart mirror technology, is transforming the retail experience by integrating with various customer touchpoints on the shop floor. Smart displays offer interactive features such as virtual try-ons, styling advice, and visual merchandising, enhancing the in-store shopping experience. As a part of the retail staff team, these smart mirrors help clients browse products, determine sizes, and recommend complementary ensembles. This guarantees that clients receive support even when employees are preoccupied with other duties (Kotouza et al. 2020). Additionally, smart mirrors can function as interactive installations that educate and inspire consumers, telling a brand's story. These exhibits, which can be found in storefront windows or somewhere else, attract customers, promote return business, and highlight a company's moral values and ethical standards. Dior has launched an immersive VR experience, allowing customers to explore its fashion show venue and discover the latest collections within a virtual showroom (Priya, 2023).

D. AI In Fashion Marketing & CRM

Retargeting Campaigns

AI has many benefits for the fashion business, especially in marketing, where it can be used to build customized campaigns by using client data. AI makes accurate predictions about future purchasing trends by examining browsing patterns, individual preferences, and historical purchases. This customized strategy promotes repeat business and improves customer retention. AI, for example, can offer products to 'complete the look' based on previous purchases, encouraging buyers to return to the internet site or store. AI also evaluates online behavior, hobbies, and customer demographics to maximize advertising efforts. AI maximizes campaign performance by ensuring that ads are viewed by the right audience at the right moment by targeting them to the most suitable target groups.

Loyalty Programs

Retailers utilize loyalty programs to enhance customer retention and encourage repeat purchases by offering tailored discounts, rewards, and incentives. With the advancement of AI technology, these programs can now deliver personalized benefits to each customer. AI creates deals and discounts based on a customer's brand preferences and previous purchases to match their behavior. Customers can receive these personalized discounts by text, email, or postal mail, and they can usually be used online and in-store as well. For instance, Boots Advantage card is a prime example of a loyalty program that utilizes AI to personalize promotions based on customers' purchase history. By earning points with each purchase, customers receive tailored incentives to encourage continued engagement with the brand (FRA News, 2023).

Content Creation

Artificial intelligence is transforming the generation of content in a variety of businesses by producing artificially generated material in natural language with distinct tones and quickly researching competitors. Retailers use AI for a range of marketing tasks, such as creating content ideas, proofreading, product descriptions, and category material. Also, retailers can enhance operations and free-up copywriters to concentrate on other creative duties and strategic planning. Hence, by using AI for the development of short-form content. This strategy not only saves money, particularly for stores with tight budgets, but it also helps firms create data-driven promotional material that effectively transforms viewers into brand ambassadors.

Verifying Authenticity & Detecting Counterfeits

AI helps verify the authenticity of products and prevent counterfeit goods by examining features such as stitching and material quality. This technology aids in stopping the sale of fake fashion items like shoes and bags as well. Utilizing algorithms capable of detecting imperceptible details, AI safeguards retailers and consumers from counterfeit goods. For instance, Entrupy provides a machine-learning app that assists brands in identifying counterfeit items by leveraging a vast database of genuine luxury products. The app provides step-by-step guidance for users to capture photos of different aspects of the item, including fabric and logos, utilizing AI to authenticate them. There are numerous advantages of artificial intelligence for the fashion business, which includes improved inventory management, trend forecasting, and personalized recommendations. AI has limitless possibilities in the fashion industry as long as technology keeps progressing (Loboda, 2024).

Indian Fashion Entrepreneurs Integrating AI: Case Studies

In the swiftly changing realm of the fashion business, innovative brands are increasingly employing artificial intelligence to transform their approaches to design, production, and promotion. The subsequent instances highlight how trailblazing companies are managing the intricacies of AI implementation to amplify imaginative flair, enhance customer interactions, and simplify processes. It is to be noted that through scrutinizing of these practical instances, there has been a can glean valuable perspectives on the triumphs, hurdles, and inventive

strategies adopted by influential figures who are molding the fashion future with AI. Among the prominent contenders in India's AI-driven fashion sector are: Stylumia, Fashinza, Streamoid, Vue.ai, and Fabulyst. These start-ups specialize in leveraging AI to offer solutions like predicting fashion trends, analyzing styles, recommending outfits, enabling visual searches, forecasting fit, optimizing inventory, and ensuring quality control.

- ❖ AI is used in the design process by Indian fashion designers **Falguni & Shane Peacock** and **Gaurav Gupta**. Gupta worked with Watson, an IBM cognitive tool, to create an Indian sari dress. With the use of this program, he has been able to analyze data from multiple platforms, including social media, and find trends and patterns that helped him create a distinctive design.
- ❖ **Stylumia** is a fashion analytics company established in Bengaluru, which has helped its clients increase sales and decrease the manufacture of over 60 million articles of clothing. Stylumia employs artificial intelligence (AI) to evaluate consumer trends, give fashion designers up-to-date knowledge about client preferences, and increase the precision of style and color selection by up to 30 per cent.
- ❖ AI is used by Gurugram-based **Fashinza**, a B2B fashion marketplace, to link fashion brands with suppliers and manufacturers in Bangladesh and India. Additionally, Fashinza uses AI to track order progress, automate production, and uphold compliance and quality standards.
- ❖ **Streamoid** is a Bengaluru-based fashion start-up that uses artificial intelligence (AI) to create a visual search engine. With the help of this application, customers can upload a photo of a product and find related or complimentary products from numerous online merchants. Additionally, Streamoid offers a chatbot that serves as a personal stylist for clients, interacting with them and making style recommendations based on their tastes, body shape, and occasion.
- ❖ Based in Chennai, **Vue.ai** is an AI fashion firm that offers an extensive retail management platform covering merchandising, analytics, product tagging, catalog management, and personalization, among other facets of the fashion industry. Additionally, Vue.ai uses AI to create virtual human avatars and realistic product photographs, doing away with the need for conventional photoshoots.
- ❖ The AI fashion firm called **Fabulyst**, having its headquarters in Hyderabad helps women find their style and choose clothes that fit their body type, skin tone, and event. Fabulyst provides carefully curated recommendations from a variety of online retailers after using artificial intelligence (AI) to evaluate the user's profiles and preferences.
- ❖ An AI-powered chatbot has been unveiled by Indian fashion brand **W** to help clients find their perfect ensembles. This chatbot understands client preferences and makes outfit recommendations based on each person's style and body type using the use of natural language processing and machine learning.
- ❖ **Myntra**, one of the Indian apparel brands, launched 'Style Mynt', an AI-powered tool that helps users choose their perfect ensembles. This feature analyzes consumer data using machine learning algorithms to recommend clothes that are tailored to each person's unique taste and body type (Nangia, 2024).

Challenges Faced in the Application of Artificial Intelligence (AI) in the Fashion Industry

Despite numerous advantages AI presents to the fashion sector, there exist several hurdles associated with its application. There are some of the challenges encountered when employing AI in fashion:

Acquiring & Ensuring Quality of Data

One of the biggest challenges in using AI in fashion is the lack of high-quality data, which can hinder the efficacy of machine-learning algorithms. Additionally, the subjective nature of creativity and the disparity in skillsets between fashion designers and computer scientists can pose challenges for effective collaboration.

Bias & Diversity

If the data that AI systems gather is not diverse, they might show prejudicial views and produce discriminatory outcomes. This is especially important because traditional beauty standards have historically excluded certain populations from the fashion industry. With generative AI systems that run the risk of reinforcing pre-existing prejudices in the data, it is particularly challenging to remove bias and promote diversity in the fashion sector. The reliance on such technologies exposes brands to reputational concerns because of unjust results. An image-generation technology can damage a brand's reputation if it produces advertising content that uses obscene or unsuitable imagery and is shared widely. Additionally, there is worry that AI could lead to a more uniform fashion industry. AI algorithms can reduce uniqueness and originality in design and marketing decisions.

Intellectual Property Protection & Legal Compliance

Trademark laws, copyright, and intellectual property rights are major issues that are brought up by the use of AI-generated designs in sectors like fashion and retail. Businesses are using AI and machine learning more and more to do things like forecast customer behaviour, fix garment size problems, and create digital and physical designs; nevertheless, these technologies must be used respectfully towards other people's intellectual property. To implement AI systems in a way that prevents unintentionally violating intellectual property rights and running the risk of being accused of infringement, it is imperative to exercise caution.

Ethical Considerations on AI Implementation

Retailers need to give ethical concerns about algorithmic bias and data protection top priority as artificial intelligence (AI) grows more common in the fashion sector. Since customers are becoming more conscious of and protective of their data, businesses need to find a balance between efficiency and innovation while upholding the rights of privacy. Transparency and accountability ought to be the main priorities when integrating AI in fashion retail. This guarantees that new technologies should be advantageous to businesses and customers alike,

all the while reducing risks associated with them, such as theft of information that may reveal users' biometric data.

Proficiency in Technical Abilities & Underlying Support Systems

Fashion businesses face challenges in adopting AI due to technical skills gaps, infrastructure limitations, and a scarcity of data science proficiency among fashion professionals. Investment in training initiatives and robust technology infrastructure is crucial to overcome these obstacles.

Essence of Human Connection & Originality

The fashion industry relies heavily on human creativity and ingenuity, which AI can assist with, but some claim that technology cannot completely replace these qualities. AI is now present in many artistic fields, including fashion design. However, there is concern that AI may not have the inherent originality and human touch that are essential to fashion design. For AI-driven fashion design to create high-quality apparel that seamlessly integrates into the production supply chain, human interaction is still necessary. Additionally, internet compliance can be difficult, using AI in fashion design may unintentionally violate copyright rules. AI has already made a name for itself in the fashion retail industry, notably as virtual personal stylists in shops, despite these reservations. These AI systems recommend the best products to clients (Giri et al. 2019).

Addressing Fashion Industry Job Loss Concerns Amid AI Implementations

Although there are valid concerns about the fashion industry losing jobs as a result of AI adoption, it is crucial to remember that AI is not supposed to take the place of humans in the design process entirely. Instead, AI is meant to support and expedite creative procedures, giving designers more time to focus on originality and creativity. Designers can quickly produce multiple versions of a design with AI's help, a process that would normally take a long time to do by hand. With this capacity, designers may come up with more ideas, investigate new possibilities, and eventually make better clothes.

Suggestions

- AI-driven personalization enhances the shopping experience by offering tailored recommendations and improving product discovery, fostering a more customer-centric approach in fashion.
- AI fosters diversity and inclusivity in fashion through accurate sizing recommendations for diverse body types and inclusive language models in marketing campaigns, promoting representation and accessibility.
- AI-powered supply chain optimization can lead to more sustainable production practices, but personalized recommendations may raise questions about consumer manipulation, highlighting ethical implications in the fashion industry.

- AI raises concerns about the security and ethical use of consumer data, highlighting the importance of investing in training programs to equip professionals with AI skills.
- In the future powered by AI, the fashion industry will evolve into a sustainable, inclusive, and personalized ecosystem, catering to the diverse needs and preferences of consumers worldwide.

Conclusion

Artificial intelligence has the potential to completely transform the garment business by improving productivity, creativity, and sustainability. Moreover, its applications provide new chances for designers, retailers, and customers along the whole fashion value chain, from production to marketing and sales. Virtual try-on technology improves the online buying experience, while AI-driven algorithms analyze social media data for trend prediction. Nevertheless, small fashion enterprises continue to face financial difficulties due to AI technology, and employment displacement in traditional fashion positions is a problem. Also, promoting skill development and responsible AI deployment is essential to reducing these difficulties. AI can support a diverse and sustainable fashion industry with the appropriate methodology, providing a bright future where fashion is more accessible, individualized, and ethical.

References

- FRA News. (2023). How artificial intelligence is used in the fashion industry. *Fashion Retail Academy*, March 1, London, United Kingdom.
- Giri, C., Jain, S., Zeng, X., & Bruniaux, P. (2019). A detailed review of artificial intelligence applied in the fashion and apparel industry. *IEEE Access*, 7, 95376-95396.
- Kotouza, M. T., Tsarouchis, S., Kyprianidis, A., Chrysopoulos, A. C., & Mitkas, P. A. (2020). Towards fashion recommendation: An AI system for clothing data retrieval and analysis. *Artificial Intelligence Applications and Innovations (AIAI 2020)*, In: Maglogiannis, I., Iliadis, L., Pimenidis, E. (Eds.). *IFIP Advances in Information and Communication Technology*, Springer, Cham, 584, 433-444.
- Laskowski, N., & Tucci, L. (2023). Artificial Intelligence (AI). *TechTarget*, November 13, Newton, Massachusetts, USA.
- Loboda, V. (2024). Artificial intelligence in fashion: Reshaping the entire industry. *3DLOOK*, March 22, San Mateo, California, USA.
- Nangia, S. (2024). AI in the Fashion-Verse: Transforming the Indian industry scape, unique use cases & challenges. *Technopak*, February 20, Gurugram, Haryana.

Priya, K. (2023). Artificial intelligence in fashion: The future of innovation. *Fibre2Fashion*, March 29, Bopal, Ahmedabad, Gujarat.

Renaningtyas, L., Dwitasari, P., & Ramadhani, N. (2023). Implementing the use of AI for analysis and prediction in the fashion industry. *ARCHive-SR*, 7(1).

Sajja, S., Aggarwal, N., Mukherjee, S., Manglik, K., Dwivedi, S., & Raykar, V. C. (2020). Explainable AI based interventions for pre-season decision making in fashion retail. *arXiv:2008.07376 [cs.CY]*.

Webliography

<https://3dlook.ai/content-hub/artificial-intelligence-in-fashion/>

<https://www.fashionretailacademy.ac.uk/news/how-artificial-intelligence-is-used-in-the-fashion-industry>

<https://www.fibre2fashion.com/industry-article/9604/artificial-intelligence-in-fashion-the-future-of-innovation>

<https://www.technopak.com/ai-in-the-fashion-verse-transforming-the-indian-industry-scape-unique-use-cases-challenges/>

<https://techpacker.com/blog/design/how-artificial-intelligence-is-revolutionizing-the-fashion-industry/>

<https://www.techtarget.com/searchenterpriseai/definition/AI-Artificial-Intelligence>

Ecofriendly Insect Repellent Incense Sticks and Cones

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Abstract

Incense is widely used in many religious practices to deepen attention, highlighting senses and uplift one's own spirit when practicing meditation. The ultimate goal of this research study is to create incense sticks and cones from marigold which are collected from temple waste, that will repel insect such as mosquitoes and to fill the air around with distinct aroma. The marigold powder and neem powder are mixed with additives like Jigit Powder, Benzoin, Charcoal Powder and White Wood Powder. Different solid formulations were rolled in the form of incense cones and sticks. Furthermore, to add value it is scented with Patchouli oil and fragrance. The marigolds were used here because its fragrance deters mosquito, beetles, and other insects. Mosquitoes are most irritating and blood sucking insect disturbing human beings. Some of the mosquito species which belongs to genera Anopheles, Aedes and Culex are known to be vectors for most of the disease pathogens like malaria, dengue fever, Myiasis, yellow fever, encephalitis etc. The objective of this project is to prepare incense sticks and cones from marigold and carry out repellency test against mosquito and to test the stability of prepared product.

Keywords: Incense, Additives, Pathogens, Formulations, Species.

Introduction

Incense is widely used by many communities during religious ceremonies in temples, churches, and other religious places. In Indian culture, the incense sticks hold a prominent place in religious as well as non-religious practices. They are mostly lit during worshipping hours to spread the positivity and pleasant aroma in the surroundings. It is an age-old air purifier that is made with all plant based natural components (Ponkiya et al. 2018). The smoke of incense fills the environment with not only fragrance but also with health benefits. Lighting incense sticks or dhoop is a common practice in most households. They have been used to deepen one's attention, highlighting senses and uplift one's mood when practicing meditation. In modern time incenses are available in many forms including cone, coil, powder, sticks and joss sticks. They are used for aesthetic reasons, religious worship, aromatherapy, meditation, and ceremony (Palermo et al. 2021). Also, it is being used as a simple deodorant or insect repellent.

The goal of this research is to form organic/chemical free incense sticks and cones to repel the mosquitoes, which are the carrier of many dangerous diseases such as malaria, dengue, filariasis, yellow fever, ancephalitis, Myiasis, Chikunguniya, helminthiasis and many more. According to World Health Organization (WHO) such diseases cause more than 3 million deaths annually (Prasanna et al. 2018). There are many treatments for Malaria and Other mosquito transmitted diseases. Hence, the term mosquito repellent came into existence. Topical or other application of mosquito repellent repels the mosquito to bite (Aparajita et al. 2019). Mosquito repellent can be prepared synthetically or naturally. Most synthetic chemical repellents, especially DEET, can be readily absorbed through the skin, causing many accidental poisonings, especially in children. There are many plants which show anti-repellent activity, this is required for protection against diseases.

Literature Review

Incense is an aromatic biotic material that releases smoke, a fragrant smoke when burned. The term is used for either the material or the aroma. Incense is used for aesthetic reasons, for religious worship, aromatherapy, meditation, and other rituals. Incense can also be used as a deodorant and insect repellent. The antimicrobial herbal based incense sticks are prepared for fumigation against infectious bacteria, wherein incense formulation is characterized for antimicrobial activity. The incense sticks thus formulated has the satisfactory degree of inhibition along with the advantages of the being non-toxic, economical, and easy to prepare and thus can effectively replace the chemical hazardous fumigations. Pure ghee was added to one of the formulations to see if it has any effect on the activity. After getting a wet mass, volatile oils [neem oil, eucalyptus oil, lavender oil] are added and making three equal parts of the wet mass. Also, different oil is added to each part. Perfumes used in industries for good fragrance were added in one of the formulations. The result showed that lavender oil is more effective than the neem oil and eucalyptus oil showed intermediate activity, which is same for both formulations (Chillas et al. 2013).

The study on mosquito repellent incense sticks and coils has been prepared using various parts of the marigold plant such as shoots, stems, leaves, and flowers. The repellency test was performed in a glass box of cuboidal shape with an opening so that the mosquitoes can escape through. This box mimied the room of a house, the six mosquitoes are transferred into the box. The time taken by the mosquitoes try to escape or to get number or to be killed was noted. The smoke toxicity experiment is conducted in a chamber and the mortality data are recorded after every 15 minutes then the smoke toxicity is compared with the commercially available citronella incense stick. For larvicidal activity the prepared powder of leaf was soaked in each of water, petroleum ether, chloroform, and ethyl acetate solvents (plant material to solvent ratio was 1:10, w/v) and extracted for 24 hours at room temperature with shaking at 150 rpm. All experimental exposures are made in petri-plate. The observed mortality was recorded at 24 hours of exposure to test solution (Kaur et al. 2022). Moreover, the study of incense sticks through crushed flowers contains carbon elements, which act as a burning material. The other requirements used are Charcoal, Jigit Powder, White Wood Powder, Gaur Gum and Gum Benzoin. When blinded with oil, the powder generated from dry flowers can be hand rolled and used as incense sticks emanating fragrance. The dough is then kneaded, and then small quantity is taken and hand pressed and rolled around the small thin bamboo sticks. It is rolled till the incense sticks become uniform. These incense sticks are then allowed to dry at room temperature overnight. Also, these sticks are then dipped in diluted perfume oil for fragrance. Now sticks are dried for few minutes and now are ready for use (Sharma et al. 2021).

Need & Relevance

Whenever there is a climate change this leads to expand the occurrence of various vector borne disease like malaria and dengue. Worldwide, Malaria is one of the most major health related issues. The mostly affected group consists of young children and pregnant women. One of the important methods for limiting the spread of transmissible disease is mosquito control and personal protection from mosquito bites. The market is currently saturated with chemical-based mosquito repellents products, which are not only more expensive but also more dangerous to the human body. The present research has taken effort to develop economically affordable herbal mosquito repellent sticks and cones entirely comprised of herbal ingredients. Since ingredients used are almost herbal hence, it has low side effects on inhalation.

Objective

To develop insect repellent incense sticks and cones from marigold flower

Materials & Methods

The study adopted experimental research design, wherein the results are based on observations through different experiments and are discussed accordingly.

Raw Materials

The present study has utilized Marigold Flowers from temples thereby adhering to waste management. Moreover, Marigold is less harmful to humans and allergic reactions. The repellent has been prepared from natural products through natural ingredients such as Marigold Flower Powder, Neem Leaf Powder, Jigit Powder, White Wood Powder, and Benzoin are obtained from the natural sources. The other ingredients that are used in the present experimental study are charcoal, patchouli fragrance perfume, distilled water, and water.

Experimental Procedure

The waste marigold flowers are collected from different temples of South Goa, they are dried at room temperature for 15 days and converted into petals. Also, the neem leaves are harvested from neem trees (Colomba Village, Goa) and dried for 10 days under room temperature. Both dried materials are crushed into mixer and passed through sieves to get fine powder. The two formulations of incense sticks are prepared i.e. A1 and B1. For A1 formulation, all the ingredients are accurately weighed and mixed. Water is added in different quantities till powder becomes dough. In furtherance, the dough is kneaded, wherein small quantity is taken and hand pressed and rolled on the small bamboo stick till incense sticks become uniform. These incense sticks are then allowed to dry at room temperature overnight and are then dipped into the Patchouli fragrance oil for 30 min and dried for 36 hours. The same procedure is followed for B1 formulation but using the required material in different quantity. Two formulations of incense cones are prepared i.e. A2 and B2. For formulation A2 all the ingredients are accurately weighed and mixed. Water is added in different quantities till the powder becomes dough. In furtherance, the dough is kneaded, and small quantity is taken and rolled on the palm to make cones are then dried overnight and dipped into the Patchouli fragrance oil for 30 minutes and dried for 36 hours. The same procedure has been followed for formulation B2 by using required material in different quantity. The developed incense sticks and cones are effective in repelling mosquitoes, which are the carrier of many dangerous diseases such as malaria, yellow fever, dengue, etc.

Evaluation of Incense Sticks and Cones

The Physical Evaluation for incense sticks and cones are carried out for incense sticks considering its colour, odour, burning time and smoke visibility. Moreover, the Irritability Test on incense sticks and cones has been done by burning them to see whether it shows any allergic reactions like coughing, sneezing, and watering of eyes when one is exposed to them (Specos et al. 2010). The pH of incense sticks and cones are checked using digital pH meter for that each formulation was dissolved into 100 ml of distilled water and allowed to stand for 30 minutes. The Smoke toxicity test has been carried out, wherein mosquitoes are caught by big plastic cover and transferred carefully to two net cages each containing 12 mosquitoes, then incense sticks and cones were burned for two hours separately, and behaviour of the mosquitoes is observed (Sakulku et al. 2009).

The Larvicidal activity has been carried out in order to find whether the plant material is effective in killing larvae when combined with solvents like Petroleum ether, Chloroform and Ethyl acetate. The mosquito larvae are collected from the mining area of Colomba Village, which is situated in Sanguem taluka of Goa (Gillij et al. 2008). The Biological assay has been carried out and observed mortality is recorded at 24 hours and percentage mortality is recorded. The Smoke toxicity test for eco-friendly and marketed products is carried out by transferring mosquitoes in net cages separately, then incenses are burned, and behaviour of mosquitoes is observed for 2 hours. The Public survey has been carried out to study safety and efficacy of the formulations. The formulations are distributed amongst people and feedback is collected (Trivedi et al. 2018).

Results & Interpretations

The ecofriendly incense sticks and cones are good alternative for repelling mosquitoes rather than using chemical insect repellents, which are harmful for the environment and human beings. The incense sticks and cones are prepared by using Marigold flowers waste, which is collected from temples. Also, neem leaves are harvested from the neem tree. These plants are selected depending upon their antibacterial, antiviral, anti-inflammatory and anti-insecticidal properties. The other ingredients such as Jigit Powder, White Wood Powder, Charcoal, and Benzoin are added to it as additive and then the product formed is scented with Patchouli Oil. All the above ingredients were accurately weighed, and different formulations is prepared for incense sticks and cones separately such as A1 & B1 formulation for incense sticks as well as A2 & B2 formulation for incense cones.

Table: 1 Physical Evaluation of Incense Sticks & Cones

Formulation (Incense Sticks)	Formulation A1	Formulation B1	Marketed Product 1	Marketed Product 2	Marketed Product 3
Colour	Black	Black	Brown	Brown	Brown
Odour	Pleasant	Pleasant	Pleasant	Pleasant	Pleasant
Burning time	43 min	40 min	48 min	63 min	38 min
Smoke Visibility	Good	Good	Good	Good	Good
Formulation (Incense Cones)	Formulation A2	Formulation B2	Marketed Product1	Marketed Product 2	Marketed Product 3
Colour	Black	Black	Brown	Brown	Brown
Odour	Pleasant	Pleasant	Pleasant	Pleasant	Pleasant
Burning Time	46 min	50 min	45 min	37 min	40 min
Smoke Visibility	Good	Good	Good	Good	Good

The formulated incense sticks and cones are observed for its colour, odour, burning time and smoke visibility. The colour varied from brown to black with a pleasant odour and good smoke visibility. The burning time varied from 27 mins to 36 mins.

Table 2: Irritability Test of Incense Sticks & Cones

Formulation (Incense Sticks)	Formulation A1	Formulation B1	Marketed Product 1	Marketed Product 2	Marketed Product 3
Irritability	Non-Irritant	Non-Irritant	Non-Irritant	Non-Irritant	Non-Irritant
Formulation (Incense Cones)	Formulation A2	Formulation B2	Marketed Product 1	Marketed Product 2	Marketed Product 3
Irritability	Non-Irritant	Non-Irritant	Non-Irritant	Non-Irritant	Non-Irritant

All the formulations are found to be non-irritant for incense sticks and cones, whereas no coughing, sneezing, and watering of eyes are observed.

Table 3: pH of Incense Sticks & Cones

Formulation (Incense Sticks)	Formulation A1	Formulation B1	Marketed Product 1	Marketed Product 2	Marketed Product 3
pH	8.10	7.73	7.00	8.90	7.60
Formulation (Incense Cones)	Formulation A2	Formulation B2	Marketed Product 1	Marketed Product 2	Marketed Product 3
pH	7.80	8.40	8.50	8.26	7.89

The pH of the formulated products has been between the range of 7 to 9, which is a good indication of an effective product.

Table 4: Smoke Toxicity Using Incense Sticks

Smoke Toxicity Using Incense Sticks (Formulation A1)		
Behaviour of Mosquitoes	7 to 8 pm	8 to 9 pm
Mosquitoes Freely Moving in net	4	3
Mosquitoes Align on Net	6	5
Mosquitoes Died	2	2
Smoke Toxicity Using Incense Sticks (Formulation B1)		
Behaviour of Mosquitoes	7 to 8 pm	8 to 9 pm
Mosquitoes Freely Moving in Net	5	3
Mosquitoes Align on Net	7	8
Mosquitoes Died	0	1

The smoke toxicity test showed that incense sticks and cones are effective in killing mosquitoes. Also, smoke toxicity tests have been carried out between ecofriendly prepared incenses and marketed products. This test also showed a good result, wherein formulation A1 has been effective in killing 4 mosquitoes in 2 hours and Formulation B1 is effective in killing only 1 mosquito in 2 hours.

Table 5: Smoke Toxicity Using Incense Cones

Smoke Toxicity Using Incense Cones (Formulation A2)		
Behaviour of Mosquitoes	7 to 8 pm	8 to 9 pm
Mosquitoes Freely Moving in Net	5	3
Mosquitoes Align on Net	6	7
Mosquitoes Died	1	1
Smoke Toxicity Using Incense Cones (Formulation B2)		
Behaviour of Mosquitoes	7 to 8 pm	8 to 9 pm
Mosquitoes Freely Moving in Net	6	4
Mosquitoes Align on Net	6	5
Mosquitoes Died	0	3

Formulation A2 is effective in killing 2 mosquitoes in 2 hours and Formulation B2 has been effective in killing 3 mosquitoes in 2 hours.

Table 6: Larvicidal Activity Using Marigold Flower & Neem Leaf Extract

Larvicidal Activity Using Marigold Flower Extract				
Solvent	Concentration in (g/l)	No. of Larvae Exposed Dead	Time Duration (In Hours)	Percentage of Larvae Mortality
D.W (Control)	0.1	10 0	24	0
	0.3	10 0	24	0
Petroleum Ether	0.1	10 2	24	20
	0.3	10 4	24	40
Chloroform	0.1	10 1	24	10
	0.3	10 2	24	20
Ethyl Acetate	0.1	10 6	24	60
	0.3	10 9	24	90

Larvicidal Activity Using Neem Leaf Extract				
Solvent	Concentration in (g/l)	No. of larvae Exposed Dead	Time Duration (In Hours)	Percentage of Larvae Mortality
D.W (Control)	0.1	10 0	24	0
	0.3	10 0	24	0
Petroleum Ether	0.1	10 3	24	30
	0.3	10 3	24	30
Chloroform	0.1	10 2	24	20
	0.3	10 2	24	20
Ethyl Acetate	0.1	10 10	24	100
	0.3	10 10	24	100

The larvicidal activity has been carried out using plant and flower extract prepared in petroleum ether, chloroform, and ethyl acetate and distilled water as control at concentration 0.1 g/l and 0.3g/l. Ethyl acetate extract has shown highest mortality rate i.e. 90 percent with 0.3g/l concentration with marigold extract and it also shows highest mortality i.e. 100 percent again with 0.3g/l using neem extract.

Table 7: Survey for Incense Sticks & Cones

Feedback from 10 People About Effectiveness of Incense Sticks				
Parameters	Excellent	Good	Average	Poor
Product Elegance	2	2	4	2
Mosquito Repellency	3	2	3	2
Odour of Incense	2	2	5	1
Allergy Related Issue	-	-	1	1
Product Satisfaction Rating of 1 To 5 Score	3	-	-	-
Feedback from 10 People About Effectiveness of Incense Cones				
Parameters	Excellent	Good	Average	Poor
Product Elegance	3	5	2	-
Mosquito Repellency	6	4	—	-
Odour of Incense	3	2	2	3
Allergy Related Issue	-	-	-	-
Product Satisfaction Rating of 1 To 5 Score	4	-	-	-

Table 7 indicates the feedback of the product, which is found satisfactory when given to 10 people and the product satisfaction score given is 3 out of 5 for incense sticks and 4 out of 5 for incense cones. Accelerated stability studies conducted on A1 and B1 formulation of incense sticks and A2 and B2 formulation of incense cones at room temperature for 30 days.

Table 8: Accelerated Stability Testing

pH Measurement				
Day	Room Temperature (Incense Sticks)		Room Temperature (Incense Cones)	
	Formulation A1	Formulation B1	Formulation A2	Formulation B2
0 th	8.10	7.73	7.80	8.40
10 th	8.12	7.68	7.62	8.42
20 th	8.12	7.54	7.89	8.40
30 th	8.11	7.60	7.82	8.35
Colour Change				
Day	Room Temperature (Incense Sticks)		Room Temperature (Incense Cones)	
	Formulation A1	Formulation B1	Formulation A2	Formulation B2
0 th	No Change	No Change	No Change	No Change
10 th	No Change	No Change	No Change	No Change
20 th	No Change	Slightly Change	No Change	No Change
30 th	No Change	Slightly Change	No Change	No Change
Irritability				
Day	Room Temperature (Incense Sticks)		Room Temperature (Incense Cones)	
	Formulation A1	Formulation B1	Formulation A2	Formulation B2
0 th	Non-Irritant	Non-Irritant	Non-Irritant	Non-Irritant
10 th	Non-Irritant	Non-Irritant	Non-Irritant	Non-Irritant
20 th	Non-Irritant	Non-Irritant	Non-Irritant	Non-Irritant
30 th	Non-Irritant	Non-Irritant	Non-Irritant	Non-Irritant

Table 8 indicates the observations on 0th, 10th, 20th and 30th day for parameters like pH, irritability and colour change. Comparison between marketed herbal insect sticks and formulated ones such as “Comfort”, “Relax”, and “Current Citronella Incense Sticks” showed satisfactory results for all parameters. Also, comparison between marketed herbal incense cones such as “lemon grass”, “Citronella” and “Phool” incense cones showed quite little difference in all parameters.

Discussion

Significantly, there will be reduction in air borne disease due to the smoke produced by incense stick, which contains herbal drugs where the chemical composition of these drugs has been shown the germicidal effects. Repellents available in the market contain toxic material, which have an ill-effect on the health of a person. The smoke and fumes produced by these herbal drugs acts as germicidal and thereby do not produce toxic complications to the people around.

Incense sticks and cones prepared is cost effective, easily portable and more aesthetic in comparison with chemical fumigation methods. Incense sticks and cones prepared out of herbs have showed good mosquito repellent property. Many such incenses are available in the market from one or more of the following plants: Neem, Marigold, citronella, lemon grass, camphor, *Acorus calamus* etc. (Saoji et al. 2021). Hence, it is very safe to use and is non-toxic in nature. One can use these sticks and cones for regular repellent in houses and laboratories. Furthermore, an investigation of polyherbal incense sticks incense sticks are prepared using different herbs such as neem, lemon grass, camphor and acorns and other additives such as Charcoal, Jigit Powder and Benzoin have been added to it for binding and then they are tested against the adult mosquito using the mosquito net cage method. The feedback from 20 people has been taken, and ratings are observed for the product. The product is also tested against any allergic symptoms such as discomfort, sneezing and wheezing. The behavior of mosquitoes has been assessed and the net cage method is effective against mosquitoes. The feedback is also satisfactory when given to 20 people and the product rating score is 4 out of 5. The product is also effective against allergic symptoms such as discomfort, sneezing and wheezing. (Sarvamangala et al. 2014).

Mosquito repellent prepared with different quantity of ingredients has been given for use to people. The testing of formulation has been conducted in a group of 10 people to check the mosquito repellent activity of both types of formulation. The plant material used in formulation was selected based on scientifically reported property. In the present study the researchers have selected marigold flower (*Tagetes erecta*) because it is a source of pyrethrin, which can be used as a mosquito repellent, and it contains a particular smell that many insects find unappetizing. Also, Neem leaves are used because they have antibacterial, insecticidal, anti-allergic, anti-microbial and antiviral properties (Makhaik et al. 2021). Thus, to compare the effectiveness of both formulations the study used both formulations in different areas. The incense stick made with the aforesaid medications demonstrated mosquito-repellent activity and had no negative side effects. The prepared incense stick is quite economical, safe, and environmentally beneficial. It is easily transportable and suitable for usage by people of all ages. This study led to the creation of a natural mosquito repellent that is risk-free for people and has no negative side effects.

Suggestions

Repellent technologies are important tools in the arsenal for preventing the spread of mosquito-borne disease. Spatial repellents represent a novel approach that could provide long-lasting repellency without the need for continual reapplication of formulations to human skin. Botanical repellents are numerous and target a wide variety of odorant receptors and physiological targets, suggesting that the potential for resistance to these chemistries is sufficiently low. The current and future technologies are directed toward the development of long-lasting botanical or biorational repellents. This could lead to promising alternatives to repellent formulations that are currently on the market via optimization of repellent character by promoting the binding of these compounds to odorant receptors on the mosquito antennae and lowering their volatility. Moreover, a logical and exploitable paradigm exists for the

development of new repellent formulations that could be deployed as spatial repellents in integrated pest management strategies throughout the world.

Conclusion

Incense Sticks have been used for many years for many different reasons including rituals, spiritual, meditation and well-being. It is our tradition to use incense sticks, but today's people like more natural incense sticks and cones, which are more beneficial for everyone. Moreover, when burning natural incense sticks it releases the smoke, which has spread across the whole area and created positivity. The smoke has its own beautiful energy, and it feels like that whole soul gets refreshed. Also, it brings positivity to the body and mind as well. Incense sticks smoke not only fills the environment with fragrance but also with health benefits.

References

Aparajita, P, A. P., Raja, A. S. M., & Shah, N. (2019). Current developments in (Malaria) mosquito protective methods: A review paper. *International Journal of Mosquito Research*, 6(1), 38-45.

Chillas, S. M. (2013). *The formulation and evaluation of orally disintegrating tablets: Diphenhydramine HCl*. Master's thesis, University of Toledo.

Gillij, Y. G., Gleiser, R. M., & Zygadlo, J. A. (2008). Mosquito repellent activity of essential oils of aromatic plants growing in Argentina. *Bioresource Technology*, 99(7), 2507-2515.

Kaur, S., Kumar, M., Sharma, P., Sharma, I., Upadhyay, S. K., & Singh, R. (2022). Preparation and applications of anti-mosquito herbal dhoopwati by using mosquito repellent plants. *Bulletin of Pure & Applied Sciences-Botany*, 41(1), 66-70.

Makhaik, M., Naik, S. N., & Tewary, D. K. (2005). Evaluation of anti-mosquito properties of essential oils. *Journal of Scientific and Industrial Research*, 64, 129-133.

Palermo, D., Giunti, G., Laudani, F., Palmeri, V., & Campolo, O. (2021). Essential oil-based nano-biopesticides: Formulation and bioactivity against the confused flour beetle *Tribolium confusum*. *Sustainability*, 13(17), 9746.

Ponkiya, N., Desai, S., Mistry, J., Patel, S., & Ingalhalli, R. (2018). Development of economical mosquito repellent using marigold plant. *International Journal for Research Trends and Innovation*, 3(11), 47-54.

Prasanna, H. S., Swami, D. V., Bhagya, H. P., Bhavishya, A., & Shivakumar, S. N. (2018). Botanicals: Potential plant protection chemicals: A review. *International Journal of Chemical Studies*, 6(3), 217-222.

Sakulku, U., Nuchuchua, O., Uawongyart, N., Puttipipatkachorn, S., Soottitantawat, A., & Ruktanonchai, U. (2009). Characterization and mosquito repellent activity of citronella oil nanoemulsion. *International Journal of Pharmaceutics*, 372(1-2), 105-111.

Saoji, R. Y., Zalte, A., & Guleccha, V. (2021). Preparation of Incense Stick using Marigold floral waste from Nasik region. *Journal of Pharmaceutical Sciences and Research*, 13(10), 635-637.

Sarvamangala, D., Sharma, G. V. R., Prasad, K. R. K., Srinivas, K., Krishnarao, V., & Udaybhaskar, K. (2014). Novel herbal formulation with insect repellent activity. *International Journal of Life Sciences Biotechnology and Pharma Research*, 3(4), 118-123.

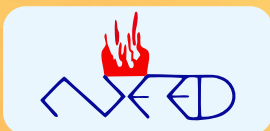
Sharma, M., Alexander, A., Saraf, S., Saraf, S., Vishwakarma, U. K., Nakhate, K. T., & Ajazuddin (2021). Mosquito repellent and larvicidal perspectives of weeds *Lantana camara* L. and *Ocimum gratissimum* L. found in central India. *Biocatalysis and Agricultural Biotechnology*, 34, 102040.

Specos, M. M., García, J. J., Tornosello, J., Marino, P., Vecchia, M. D., Tesoriero, M. D., & Hermida, L. G. (2010). Microencapsulated citronella oil for mosquito repellent finishing of cotton textiles. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 104(10), 653-658.

Trivedi, A., Rai, P., Kumar, J., & Trivedi, C. A. (2018). Formulation of low smoke herbal mosquito repellent sticks by using different essential oils. *The Pharma Innovation Journal*, 7(4), 173-175.



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